Clear Creek Watershed Protection Plan Modeling Quality Assurance Project Plan (QAPP) Revision #0

Houston-Galveston Area Council
Houston, Texas 77227

Funding Source:

Nonpoint Source (NPS) Program CWA §319(h)
Prepared in cooperation with the Texas Commission on Environmental Quality
and the U.S. Environmental Protection Agency
Federal ID # 99614625
QTRAK#_____

Effective Period: Three years from date of final approval

Questions concerning this QAPP should be directed to:

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SECTION A: PROJECT MANAGEMENT

A1 Approval Page:

By signing this document, signatories acknowledge their respective organizations' awareness of and adherence to requirements contained in this QAPP in accordance with roles and responsibilities as described in Section A4 Project/Task Organization and throughout.

Texas Commission on Environmental Quality

Monitoring Division
Laboratory and Quality Assurance (QA) Section

6/23/2021

Sharon R. Coleman, TCEQ QA Manager Date

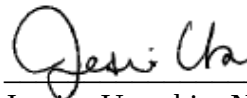
6/23/2021

Sharon Coleman Date
Acting Lead NPS QA Specialist

Water Quality Planning Division

6/22/2021

Faith Hambleton, Team Leader Date
Nonpoint Source (NPS) Program



6/22/21

Jessica Uramkin, NPS QA Coordinator, Date
NPS Program

6/8/21

Emily Sanchez, TCEQ NPS Project Manager, Date
NPS Program

Houston-Galveston Area Council

6/7/21

Justin Bower, Project Manager Date

6/7/21

Jean Wright, QA Officer Date

Thushara Ranatunga 6/7/21

Thushara Ranatunga, Lead Modeler Date

Jessica Casillas 6/7/21

Jessica Casillas, Data Manager Date

The Houston-Galveston Area Council (H-GAC) will secure written documentation from additional project participants stating the organization's awareness of and commitment to requirements contained in this QAPP and any amendments or revisions of this plan. H-GAC will maintain this documentation as part of the project's quality assurance records. This documentation will be available for review. Copies of this documentation will also be submitted as deliverables to the TCEQ NPS Project Manager within 30 days of final TCEQ approval of the QAPP. (See sample letter in Appendix D of this document.)

ACRONYMS AND ABBREVIATIONS

AU	**Assessment Unit**
AVMA	**American Veterinary Medicine Association**
CAFO	**Concentrated animal feeding operation**
CAP	**Corrective Action Plan**
CRP	**Clean Rivers Program**
CWA	**Clean Water Act**
DM	**Data manager**
DMR	**Discharge monitoring report**
DO	**Dissolved oxygen**
EPA	**United States Environmental Protection Agency**
GIS	**Geographic information system**
H-GAC	**Houston-Galveston Area Council**
LOADEST	**(USGS) Load Estimator Tool**
LDC	**Load duration curve**
MS4	**Municipal separate storm sewer system**
NASS	**National Agricultural Statistics Service**
NOAA	**National Oceanic and Atmospheric Administration**
NPS	**Nonpoint Source**
OSSF	**Onsite sewage facility**
PCB	**Poly-chlorinated biphenyls**
PM	**Project manager**
QA	**Quality Assurance**
QAO	**Quality assurance officer**
QAPP	**Quality Assurance Project Plan**
QAS	**Quality assurance specialist**
SAS	**Statistical Analysis Software**
SELECT	**Spatially Explicit Load Enrichment Calculation Tool**
SH	**State highway**
SOP	**Standard operating procedure(s)**
SSO	**Sanitary sewer overflow**
SWQMIS	**Surface Water Quality Monitoring Information System**
TCEQ	**Texas Commission on Environmental Quality**
TPDES	**Texas Pollutant Discharge Elimination System**
TPWD	**Texas Parks and Wildlife Department**
TSSWCB	**Texas State Soil and Water Conservation Board**
USGS	**United States Geological Survey**
WPP	**Watershed protection plan**
WWTF	**Wastewater treatment facility**

A2 TABLE OF CONTENTS

A3 DISTRIBUTION LIST

The Lead NPS QA Specialist will provide approved versions of this QAPP and any amendments or revisions of this plan to the TCEQ NPS Project Manager. The TCEQ NPS Project Manager will provide approved copies to the H-GAC Project Manager and EPA Project Officer within two weeks of approval. The TCEQ NPS Project Manager will document transmittal of the plan to EPA and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review in the event of an audit.

Anthony Suttice, Project Officer
Suttice.Anthony@epa.gov
EPA Region 6
(214) 665-8590

H-GAC will provide copies of this project plan and any amendments or revisions of this plan to each project participant defined in the list below. H-GAC will document receipt of the plan by each participant and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review in the event of an audit.

H-GAC
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A4 PROJECT/TASK ORGANIZATION

TCEQ

Monitoring Division

Sharon Coleman, Acting Lead NPS QA Specialist
Assists the TCEQ NPS Project Manager in QA related issues. Participates in the planning, development, approval, implementation, and maintenance of the QAPP. Determines conformance with program quality system requirements. Coordinates or performs audits, as deemed necessary and using a wide variety of assessment guidelines and tools. Concurs with proposed corrective actions and verifications. Provides technical expertise and/or consultation on quality services. Recommends to TCEQ management that work be stopped in order to safeguard project and programmatic objectives, worker safety, public health, or environmental protection.

Water Quality Planning Division

Faith Hambleton, Team Leader
NPS Program
Responsible for management and oversight of the TCEQ NPS Program. Oversees the development of QA guidance for the NPS program to be sure it is within pertinent frameworks of the TCEQ. Monitors the effectiveness of the program quality system. Reviews and approves all NPS projects, internal QA audits, program corrective actions, work plans, and contracts. Enforces program corrective action, as required. Ensures NPS personnel are fully trained and adequately staffed.

Emily Sanchez
TCEQ NPS Project Manager
Maintains a thorough knowledge of work activities, commitments, deliverables, and time frames associated with projects. Develops lines of communication and working relationships between the contractor, the TCEQ, and the EPA. Tracks deliverables to ensure that tasks are completed as specified in the contract. Responsible for ensuring that the project deliverables are submitted on time and are of acceptable quality and quantity to achieve project objectives. Serves on planning team for NPS projects. Participates in the development, approval, implementation, and maintenance of the QAPP. Conducts independent technical review of the QAPP to ensure compliance with project needs and requirements. Responsible for verifying that the approved QAPP is implemented by the contractor. Notifies the TCEQ Lead NPS QA Specialist of particular circumstances which may adversely affect the quality of data derived from the collection and analysis of samples. Monitors and enforces corrective action.

Jessica Uramkin
NPS Quality Assurance Coordinator

Assists Lead QA Specialist with NPS QA management. Serves as liaison between NPS management and Agency QA management. Responsible for NPS guidance development related to program quality assurance. Assists with development and maintenance of data management-related standard operating procedures (SOP) for NPS data management. Participates in the development, approval, implementation, and maintenance of the QAPP. Provides input and oversight regarding corrective actions. Maintains record of corrective actions.

Houston-Galveston Area Council

Justin Bower
H-GAC Project Manager
Responsible for ensuring tasks and other requirements in the contract are executed on time and are of acceptable quality. Monitors and assesses the quality of work. Coordinates attendance at conference calls, training, meetings, and related project activities with the TCEQ. Responsible for verifying the QAPP is followed and the project is producing data of known and acceptable quality. Ensures adequate training and supervision of all monitoring and data collection activities. Complies with corrective action requirements.

Jean Wright
H-GAC QAO
Responsible for coordinating development and implementation of the QA program. Responsible for ensuring the most recent version of the NPS QAPP shell document is acquired from the TCEQ NPS Project Manager and used for writing and maintaining the QAPP. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Responsible for maintaining written records of sub-tier commitment to requirements specified in this QAPP. Responsible for identifying, receiving, and maintaining project quality assurance records. Responsible for coordinating with the TCEQ NPS Project Manager to resolve QA- related issues. Notifies the H-GAC Project Manager and TCEQ NPS Project Manager of and documents particular circumstances which may adversely affect the quality of data. Responsible for validation and verification of all data modeled, collected and acquired . Coordinates the research and review of technical QA material and data related to water quality monitoring system design and analytical techniques. Facilitates, conducts, and documents any technical systems audits.

Thushara Ranatunga
H-GAC Lead Modeler
The Lead Modeler is responsible for the operation of all computer models and associated documentation of model operation. Responsible for accuracy of input data to models. Performs operation of the models to ensure valid results are being predicted. Responsible for formulating model input to reflect the scenarios and situations to be emulated by each model.

The Project Data Manager is responsible for acquisition and verification of data, documentation of data sources, ensuring the accuracy of data, and for the transfer of data to the TCEQ. Responsible for maintaining project quality assurance records. Oversees data management for

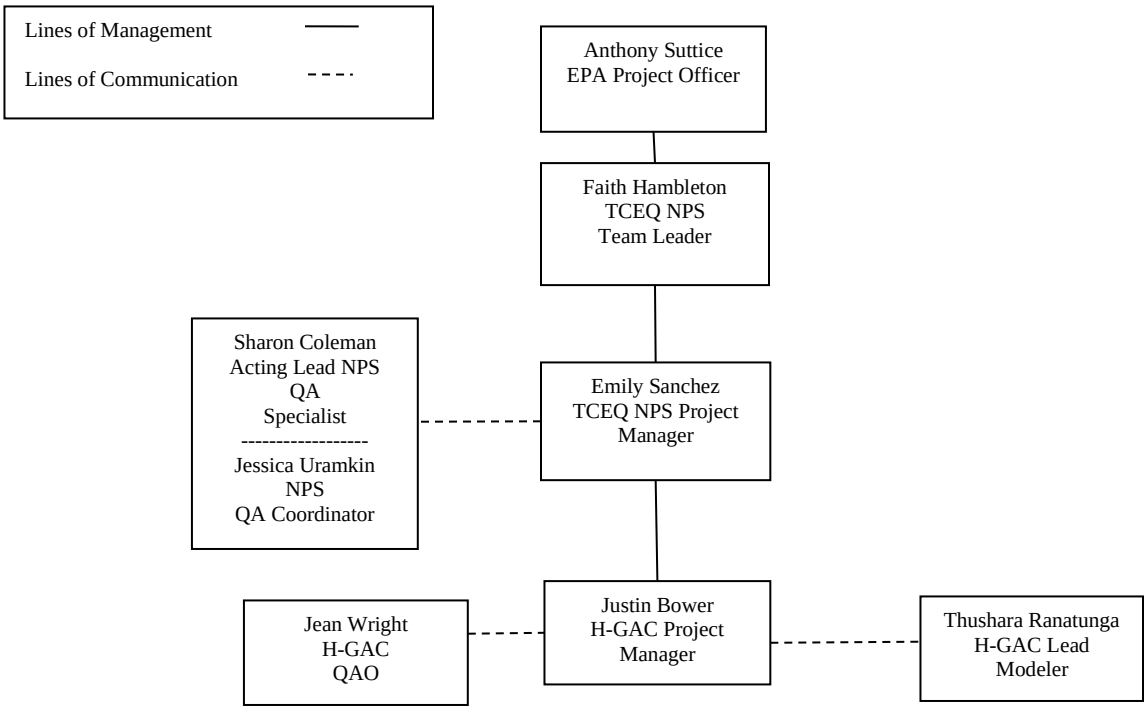
the study. Performs data quality assurances prior to transfer of data to the TCEQ. Responsible for transferring data to the TCEQ in an acceptable format. Ensures data are submitted according to work plan specifications. Provides the point of contact for the TCEQ Data Manager to resolve issues related to the data.

Jessica Casillas
H-GAC Data Manager
The Project Data Manager is responsible for acquisition and verification of data, documentation of data sources, ensuring the accuracy of data, and for the transfer of data to the TCEQ. Responsible for maintaining project quality assurance records. Oversees data management for the study. Performs data quality assurances prior to transfer of data to the TCEQ. Responsible for transferring data to the TCEQ in an acceptable format. Ensures data are submitted according to work plan specifications. Provides the point of contact for the TCEQ Data Manager to resolve issues related to the data.

U.S. EPA Region 6

Anthony Suttice
EPA Project Officer
Responsible for managing the CWA Section 319 funded grant on behalf of EPA. Assists the TCEQ in approving projects that are consistent with the management goals designated under the State's NPS management plan and meet federal guidance. Coordinates the review of project workplans, draft deliverables, and works with the State in making these items approvable. Meets with the State at least annually to evaluate the progress of each project and when conditions permit, participates in a site visit on the project. Fosters communication within EPA by updating management and others, both verbally and in writing, on the progress of the State's program and on other issues as they arise. Assists in grant close-out procedures ensuring all deliverables have been satisfied prior to closing a grant.

Figure A4.1. Organization Chart - Lines of Communication



A5 PROBLEM DEFINITION/BACKGROUND

The Clear Creek Watershed is composed of the drainage area of Clear Creek Above Tidal (Segment 1102) and Clear Creek Tidal (Segment 1101), including their tributaries Cowart Creek (1102A), Mary's Creek/North Fork (1102B), Hickory Slough (1102C), Turkey Creek (1102D), Mud Gully (1102E), Mary's Creek Bypass (1102F), an Unnamed Tributary of Mary's Creek (1102G), Magnolia Creek (1101A), Chigger Creek (1101B), Cow Bayou (1101C), Robinson Bayou (1101D), two Unnamed Tributaries of Clear Creek Tidal (1101E and 1101F), and a network of natural and manmade drainage channels (Figure A5.1). Clear Creek is one of the primary tributaries of the Clear Lake, part of the greater Galveston Bay system.

The land cover in the watershed has some remaining undeveloped areas in its western headwaters but is primarily composed of dense suburban and urban uses including the rapidly growing areas of Pearland and Friendswood. The watershed has been the focus of robust growth over the last few decades as growth has expanded from the City of Houston along SH 288, the Sam Houston Tollway/SH 8, and I-45/Gulf Freeway between the Houston and Galveston urban centers.

Water quality in the watershed varies between subwatersheds but includes several assessment units that fail to meet one or more state water quality standards, or which have concerns for a variety of constituents (Table A5.1).

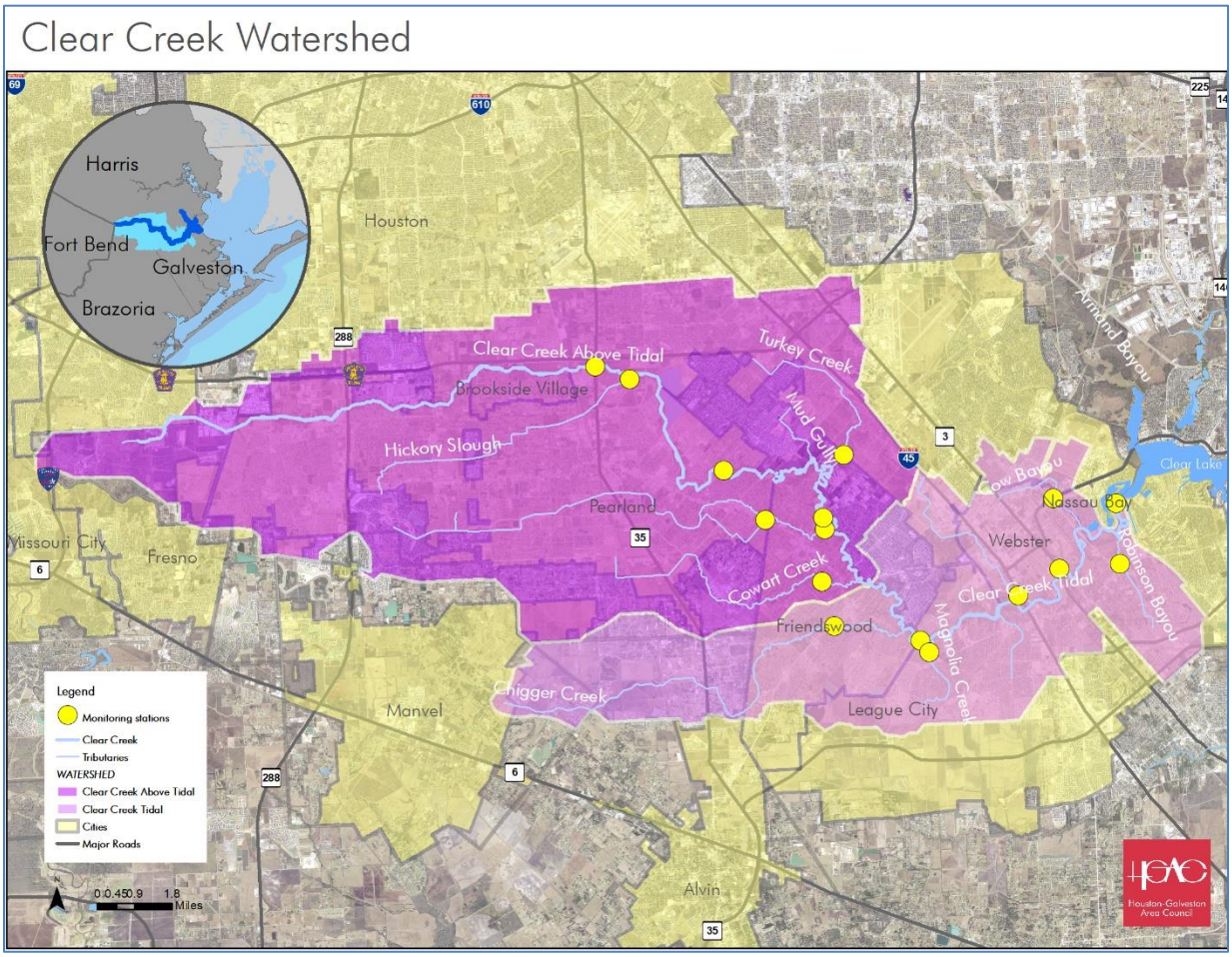


Figure A5.1 – The Clear Creek Watershed

Table A5.1 – Water Quality Issues in the Cypress Creek Watershed[1]

Impairments			
Segment or Tributary	**AU(s)**	**Parameter(s)**	**Categor(ies)**
1101	• 01, 02, 03 • 01, 02, 03, 04	• *Enterococcus* • Dioxin in edible tissue • PCBs in edible tissue	• 4a • 5a • 5a
1101B	• 01	• *Enterococcus*	• 4a

[1] The impairments and concerns represented in this table are based on the 2020 Integrated Report as referenced at https://www.tceq.texas.gov/waterquality/assessment/20twqi.

1101C	• 01	• *Enterococcus*	• 4a
1101D	• 01, 02	• *Enterococcus*	• 4a
1101E	• 01	• *Enterococcus* • Dissolved Oxygen 24hr. Avg • Dissolved Oxygen 24hr Min	• 4a • 5c • 5c
Segment or Tributary	**AU(s)**	**Parameter(s)**	**Categor(ies)**
	•	•	•
1102	• 01, 02, 03, 04, 05 • 02, 03, 04	• PCBs in edible tissue • *E. coli*	• 5a • 4a
1102A	• 01, 02	• *E. coli*	• 4a
1102B	• 01	• *E. coli*	• 4a
1102D	• 01	• *E. coli*	• 4a
1102F	• 01	• *E. coli*	• 4a
1102G	• 01	• *E. coli*	• 4a

Concerns

Segment	**AU(s)**	**Parameter**	**Level(s) of Concern**
1101	• 02, 03, 04, • 02, 03 • 03 • 04	• Nitrate • Total Phosphorus • Dissolved Oxygen Grab • Chlorophyll-a	• CS • CS • CS • CS
1101A	• 01	• Nitrate • Total Phosphorus	• CS • CS
1101C	• 01	• Dissolved Oxygen Grab	• CS
1101D	• 01, 02	• Dissolved Oxygen Grab	• CS
1101F	• 01	• Dissolved Oxygen Grab	• CS
1102	• 02 • 02, 03 • 02, 03, 04, 05 • 02, 03, 04 • 05	• Impaired Habitat • Ammonia • Nitrate • Total Phosphorus • Dissolved Oxygen Grab	• CS • CS • CS • CS • CS
1102A	• 02	• Ammonia	• CS
1102B	• 01	• Nitrate • Total Phosphorus	• CS • CS
1102C	• 01	• Dissolved Oxygen Grab	• CS
1102D	• 01	• Dissolved Oxygen Grab • Ammonia • Nitrate • Total Phosphorus	• CS • CS • CS • CS
1102E	• 01	• Dissolved Oxygen Grab • Nitrate	• CS • CS
1102F	• 01	• Dissolved Oxygen Grab • Total Phosphorus	• CS • CS

Prior work in this watershed[1] indicated that a mix of bacteria and nutrient sources contributed to issues in the watershed and were projected to increase in the future. Local concern over the advancing degradation of water quality in the project area led H-GAC to propose the development of a watershed protection plan (WPP) for the Clear Creek Watershed. The WPP will identify and characterize causes and sources of pollution in the watershed through modeling efforts, as informed by acquired data and stakeholder input and feedback and identify management measures to address them.

To facilitate the development of the WPP, H-GAC needs to provide enough information to guide stakeholder discussion, characterize the causes and sources of pollution in the watershed, identify the reductions needed to meet state standards, and offer additional information to achieve other water quality goals identified by the stakeholders[2]. The efforts outlined in this QAPP are designed to generate the information needed to guide decisions and allow for feedback and revision from the stakeholders. To ensure that the data generated (and the subsequent decisions which rely on it) are defensible and of appropriate quality, H-GAC will conduct its modeling and data evaluation tasks as detailed in this QAPP.

The purpose of the QAPP is to clearly delineate H-GAC's QA policy, management structure and procedures to implement the QA requirements necessary to verify, calibrate, and validate the output of the modeling process associated with this project. This QAPP is reviewed and approved by 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 NPS program and other programs deemed appropriate by TCEQ.

A6 PROJECT/TASK DESCRIPTION AND SCHEDULE

The data needs described in A5 relate to characterizing water quality and developing modeling data regarding causes and sources of pollution to guide stakeholder decisions in the development of the WPP. Based on a review of the concerns and impairments, fecal indicator bacteria, depressed dissolved oxygen (DO) and nutrients are the water quality issues of greatest concern to the waterways.

Specifically, H-GAC will conduct modeling and data evaluation efforts to:

[1] Including the existing *Nine Total Maximum Daily Loads for Bacteria Clear Creek and Tributaries*, approved 3/6/2009, and available for review at www.tceq.texas.gov/assets/public/waterquality/tmdl/68ccbact/68-adopted-ccbacteriatmdl.pdf and subsequent analysis of the waterways as part of the Clean Rivers program, most recently summarized in the 2020 *Basin Highlights Report*, available for review at www.h-gac.com/getmedia/c2264337-093e-4fe1-81ab-b620394d5a57/2020-Basin-Highlights-Report.pdf.

[2] Water quality goals for this WPP will always include compliance with state water quality standards. Compliance with state standards is always the primary purpose of the WPP, and the development of data therefore. Additional goals may be developed by the stakeholders as part of the public engagement process, for contaminants or issues for which standards and/or numeric criteria do not exist (nutrients, trash, etc.). Data generated under the efforts covered by this QAPP (water quality analysis, etc.) may assist stakeholders in identifying solutions that achieve multiple benefits, or coordinate efforts with existing programs.

- Evaluate trends and variability in current and historical water quality data, including the use of Statistical Analysis Software (SAS).
- Conduct modeling efforts to define the spatial distribution and amount of fecal bacteria[1] loading using the Spatially Explicit Load Enrichment Calculation Tool (SELECT) model.
- Characterize fecal bacteria and dissolved oxygen concentrations in varying flow conditions and identify the bacteria reductions necessary to meet applicable standards instream using load duration curves (LDCs).

Water Quality Data Acquisition and Analysis

The acquisition and analysis of water quality data will be conducted for Clear Creek Tidal and Clear Creek Above Tidal (referred to collectively as Clear Creek in this document) based on existing data in the Surface Water Quality Monitoring Information System (SWQMIS), data collected during the project under the Clean Rivers Program's (CRP) existing monitoring QAPP, and sanitary sewer overflow (SSO) and discharge monitoring reports (DMRs) from TCEQ data. SWQMIS/CRP data; indicator bacteria, nutrients, temperature, pH, chlorophyll-a, total suspended solids, flow, and DO data will be evaluated for trends, seasonal variation, and spatial patterns. Data for current 24-hour DO monitoring will be reviewed for at least one CRP site in each segment if sufficient data is available. H-GAC will evaluate TCEQ's DMR/SSO data for the last 5 years. The output of this effort will be the acquired datasets, the trends and variability analyses, a report on the data to be used for modeling efforts, and a report on the trend and variability analyses results. This effort will identify trends, guide decision-making, and provide inputs for the SELECT and LDC modeling efforts.

Load Characterization with SELECT

The SELECT[2] model will be developed based on currently available data and stakeholder feedback. SELECT uses existing spatial data in a geographic information system (GIS) framework and literature values to characterize the extent and spatial distribution of bacteria sources. This methodology was originally selected for this purpose based on use in other similar projects and because it represented a good match between the level of precision needed for the project with the complexity of the model (and the resources available). Spatial data used in SELECT include land use/land cover, point sources, roads, hydrology/stream network, subwatershed boundaries, aerial imagery, Texas Pollutant Discharge Elimination System (TPDES) permit outfall locations (including wastewater treatment facilities [WWTFs], concentrated animal feeding operations [CAFOs], and municipal separate storm sewer [MS4s] permits), on-site sewage facility (OSSF) locations, soil data, census tracts, regional demographic projections (spatial), elevations, and other related watershed-specific spatial locations (impoundments, etc.). Non-spatial data, or spatial data not used wholly in a spatial context, will include agricultural census data, discharge monitoring

[1] Throughout this QAPP, "fecal bacteria" will generally refer to the indicators specific to each segment/tributary. For Clear Creek these indicators are *Enterococcus* for the 1101 segment and related tributaries, and *E. coli* for the 1102 segment and related tributaries.

[2] Additional information on the purpose, methodology, and use of the SELECT model from which this SELECT approach is derived can be found at https://ssl.tamu.edu/media/11291/select-aarin.pdf .

reports (DMRs), sanitary sewer overflow (SSO) violation data, wildlife population data or assumptions, and non-domestic animal population data (feral hogs). Literature values or assumptions derived from data to be used will include population and loading rates for all sources, unpermitted septic and aerobic system locations, pollutants in WWTF flows, and prevalence of specific sources in different land cover types.

H-GAC will use SELECT to develop analyses for the project area for current and future conditions. The analyses will be broken out by subwatershed. Assumptions and results will be reviewed with stakeholders, TCEQ, and other partners to ensure that they reflect local knowledge and provide an accurate reflection of pollutant loading in the watershed. The output of this effort will be visual displays of loading data, potential load estimates, and characterization of relative contribution by sources for current and future conditions. These outputs will guide stakeholder decisions concerning the identification and prioritization of management measures and serve as a basis for developing derived reduction targets in conjunction with the LDC analyses.

For all analyses, the scenarios will include a weighting factor in which loads generated within 100 meters of waterways will be weighted as 100%. Loads originating outside this "buffer" area will be weighted as 25%. The "buffered" approach utilizes a weighting factor to accentuate the probability of proximate load to waterways having greater impact[1].

Load Duration Curves

This project effort will develop LDCs for fecal bacteria and DO. The LDCs will be used to evaluate any patterns in exceedances of the water quality standard based on flow conditions for all constituents and to derive load reductions for bacteria and improvement goals for DO. The LDC(s) for Segment 1102 will be developed using a standard LDC approach[2] using USGS' LOAD ESTimator tool (LOADEST)[3]; the LDC(s) for Segment 1101 will be developed using a modified LDC approach[4] used in other local coastal watersheds, to account for tidal exchange and flows.

LDCs will be completed for at least one station in each of the segments (1101, 1102) of the project watershed, utilizing quality assured water quality data from SWQMIS and/or CRP sources and flow data from USGS gauges. Additional LDCs will be developed as needed from the list of LDCs in Table A6.1 depending on the results of the water quality analyses, evaluation of sources, and the need to characterize individual tributaries, subwatersheds, or sections of a segment. If a

[1] This relationship would be detailed in more complex modeling approaches like SWAT, which are not being utilized for this project. SELECT does not account for the effects of proximity on bacteria transmission, which may skew source contribution ratios and impact stakeholder decisions. The weighting approach is based on previous WPP approaches (Plum Creek, Bastrop Bayou, San Bernard River, Cedar Bayou, West Fork San Jacinto River and Lake Creek, Cypress Creek, and Spring Creek) using some extent of the same approach, as developed by, and approved by, stakeholders.

[2] Additional information on the use and methodology of the load duration curve model being used for this and previous efforts can be found at https://www.epa.gov/sites/production/files/2015-07/documents/2007_08_23_tmdl_duration_curve_guide_aug2007.pdf .

[3] More information about the USGS LOADEST software can be found at https://water.usgs.gov/software/loadest/

[4] The full methodology for the modified LDC approach can be found in Appendix F.

representative flow gauge is not available and there is sufficient flow data available, H-GAC will use LOADEST to generate a 10-year period of estimated flow data. Prior to developing the LDCs, H-GAC will evaluate the preliminary information from water quality data analyses to confirm that selected LDC sites are appropriate for characterizing their respective water bodies. If they are not, or if stakeholders indicate an LDC is needed for an additional area[1], the QAPP will be amended prior to work being initiated on amended locations. The outputs of the LDC analysis will be visual characterizations of the relationship between flow levels and constituent concentrations, and reduction estimates for fecal bacteria loading and DO improvement. The use of this effort will be to help identify variation in loading based on flow and to inform stakeholder decisions regarding scale and type of management measures. The USGS stream gauge and potential monitoring site locations for LDCs are summarized in Table A6.1.

Table A6.1. Potential LDC Monitoring Site Locations

USGS Gage[2]	Segment or Tributary ID	Site Description	TCEQ Site ID
NA[3]	1101	Clear Creek Tidal at SH3 near Webster	11446
NA	1101	Clear Creek Tidal at the confluence with Clear Lake 30M north and 266M west of Davis Road at Vega Court in League City in Harris County	16573
NA	1101	Clear Creek Tidal at Brookdale Drive approximately 0.1 mi downstream of Grissom Road in Countryside Park in canoe launching area in League City	16576
NA	1101A	Magnolia Creek at W. Bay Area Boulevard League City approx. 250M upstream of WWPT Permit WQ0010568-003	16611
NA	1101B	Chigger Creek at FM528 Bridge in Friendswood	16493
NA	1101D	Robinsons Bayou at Fm 270 in League City	16475
NA	1101F	Unnamed Tributary of Clear Creek Tidal in Forest Park Cemetery immediately upstream of S. feeder rd of I-45/Gulf Fwy s of NASA Rd 1 in Webster	18591
NA	1102	Clear Creek at FM 2351/Choate RD near Friendswood	11450
08076997	1102	Clear Creek at Telephone RD SH35 in South Houston (*USGS*	11452

[1] Potential additional LDC sites include CRP monitoring stations 11446, 16573, and 16576 on Clear Creek Tidal; 16611 on 1101A; 16493 on 1101B; 16475 on 1101D; 18591 on 1101F; 11450, 11452, and 20010 on 1102; 16677 on 1102A; 16473 and 17914 on 1102B; 17068 on 1102C; and 21925 on 1102F.

[2] There are two USGS gauges in the watershed, one in Segment 1102 (viewable at https://waterdata.usgs.gov/nwis/inventory?agency_code=USGS&site_no=08076997) which is not representative of most of the Above Tidal portion of the watershed, and one at the start of Segment 1101 which is representative of the boundary conditions for flow between 1102 and 1101 but does not have a monitoring station upstream or downstream that it can relate to (in both directions, there are inputs from tributaries between the monitoring stations and the USGS gauge). As part of the QAPP-covered LDC project, staff will evaluate whether these gauges are representative of either segment.

[3] For this table, NA indicates no representative continuous flow gauge data is available for this station, and flows will need to be extrapolated.

		gauge – Clear Creek at Mykawa St nr Pearland, TX)	
NA	1102	Clear Creek Above Tidal at Yost Road Terminus in Pearland in Brazoria County	20010
NA	1102A	Cowart Creek 9 meters upstream from Castlewood Drive Bridge in Friendswood	16677
NA	1102B	Mary's Creek at Mary's Crossing in North Friendswood	16473
NA	1102B	Mary's Creek at FM 1128/Manvel Road in Pearland	17914
NA	1102C	Hickory Slough at Robinson Drive in Pearland	17068
NA	1102D	Turkey Creek at Beamer Road 1.5km southeast of FM 1959/Dixie Farm Road in Friendswood	21925
NA	1102F	Mary's Creek Bypass at East Broadway Street/FM 518 west of Sunset Meadows Drive in Pearland	18639

This modeling approach was chosen based on applicability of the models to the project questions; level of precision needed for development of the watershed protection plan; similarity to other WPP modeling efforts; and through discussions with TCEQ project staff. The fundamental goal of these modeling efforts remains to inform staff understanding of the watershed and stakeholder decisions. The timeline for these efforts is defined in the contractual agreement between H-GAC and TCEQ, as amended from time to time, and summarized in Table A6.2.

Table A6.2. Modeling and Data Analysis Schedule of Deliverables

Contract Task No.	Deliverable	Due Date
3.1	Documentation of data compilation and review	8/31/21
3.2	Documentation of DMR/SSO analysis	8/31/21
3.3	Draft Data Analysis Summary Report	9/30/21
3.3	Final Data Analysis Summary Report	8/31/22
4.1	Load Duration Curves	10/29/21
4.2	SELECT results	10/29/21
4.3	Draft Modeling Report	10/29/21
4.3	Final Modeling Report	12/10/21

This project started in January 2021 and is estimated to be completed in February 2024. All task and deliverable dates are estimates based on the most current due dates agreed to by H-GAC and TCEQ as of 4/5/21. Work covered under this QAPP will not be initiated until final approval of the QAPP by TCEQ.

See Appendix A for the contract scope of work and schedule of deliverables associated with work defined in this QAPP.

Revisions to the QAPP

Amendments

Amendments to the QAPP must be approved to reflect changes in project organization, tasks, schedules, objectives, and methods; address deficiencies and nonconformances; improve operational efficiency; and accommodate unique or unanticipated circumstances. Requests for amendments are directed from the H-GAC Project Manager to the TCEQ NPS Project Manager in writing using the NPS QAPP Amendment Shell. The changes are effective immediately upon approval by the TCEQ QA Manager, TCEQ NPS Project Manager, and TCEQ Lead QA Specialist, or their designees.

Amendments to the QAPP and the reasons for the changes will be documented, and full copies of the amendments will be forwarded to all persons on the QAPP distribution list by the H-GAC 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.

Annual QAPP Reviews and Revisions

This QAPP shall be reviewed in its entirety and certified annually by the H-GAC Project Manager and the TCEQ NPS Project Manager. A letter certifying this annual review must be submitted to the TCEQ NPS Project Manager no later than 90 days prior to the QAPP anniversary date. Amendments approved since QAPP approval (or most recent annual review, if applicable) should be included as an attachment along with the letter. Only non-substantive changes not affecting the project design or quality or quantity of work to be performed can be included in the annual certification letter. This includes organizational changes or schedule changes based on a contract amendment that do not impact data deliverables. If changes beyond these are necessary, a QAPP amendment must be submitted and approved before the annual review may be certified. The TCEQ NPS Project Manager is required to review the QAPP and provide certification of annual reviews to the TCEQ QA Manager and EPA Region 6 Project Officer no later than 30 days before QAPP anniversary dates. If the QAPP expires, work described within this document must be halted.

If the project will extend beyond the third QAPP anniversary date, a full QAPP revision is required. This is accomplished by submitting a cover letter, a document detailing changes made if any, and three full copies of the fully updated QAPP (including three sets of signature pages).

A7 QUALITY OBJECTIVES AND CRITERIA FOR MODEL INPUTS/OUTPUTS

The general quality objectives for the project are to produce data analyses and modeling outcomes that accurately characterize conditions in the watershed and are a sufficient platform on which to base stakeholder decisions concerning the selection and scale of management measures. This is

achieved using the best available data (quality-assured[1] as applicable), review of products and inputs with stakeholders and knowledgeable partners and adhering to the preponderance of literature (as amended by reasonable stakeholder review) for modeling assumptions. These goals are fostered by continual and robust engagement with stakeholders, especially partners with specific technical experience.

Data quality objectives for each component effort are described below. For all acquired/existing data sources, quality assured data from SWQMIS as collected through CRP or other submitting programs will be used if available.

Water Quality Analysis

The primary data quality objectives for this effort are to ensure data inputs are from quality-assured sources, and that analysis outputs accurately reflect water quality trends in the watershed. The focus of the analyses are long-term trends, although short-term or seasonal trends may be reviewed based on a review of the available dataset, requirements of the stakeholders, and area-specific circumstances. Performance criteria for inputs are quality-assured status for water quality data (e.g. data collected under existing TCEQ/EPA approved QAPP or another similar source). Data that is not quality assured may be used to help characterize the watershed in a qualitative sense, or as indicators where additional analysis may be needed, but will not be considered equal to data produced under a QAPP. These data sources will not be used for the water quality analyses or mingled with quality-assured data, but only for informal/informative review of potential problem areas not covered by formal monitoring.

Performance criteria for outputs include a proper data management trail (per Appendix E and relevant document retention requirements of this QAPP) of the data evaluation process, and trends/variability analyses that properly utilized SAS methods (See Appendix E), performed by experienced staff. The outputs will be acceptable if the performance criteria are met (this is a qualitative measure, as no calibration or validation of data other than initial validation in submission to SWMQIS is performed on these analyses). The intended use of these outputs will be to display water quality trends for stakeholder decision-making processes, including the development of pollutant reduction targets based on the results of the SELECT modeling outputs.

Hardware and software to be used will conform to industry standards (e.g. Microsoft Office products and SAS utilized in a current Windows environment). Configuration of SAS analyses will be based on similar water quality analyses conducted by CRP staff using the same data management and data evaluation processes and tools to ensure the data is comparable with those of other regional and regulatory efforts.

[1] For the purpose of water quality trends analyses, modeling inputs, and in support of decision-making for the WPP, water quality data used will be limited to quality-assured data processed through a TNI-accredited lab, unless it meets an exception as indicated in 30 TAC, Chapter 25.6. Volunteer data (e.g. Texas Stream Team, or other non-accredited lab data) will only be used for anecdotal purposes or for general watershed information.

Data completeness will be evaluated based on whether all existing data as submitted to SWQMIS has been used. Data representativeness will be based on whether all available data from stations in the watershed is utilized, thus representing the broadest picture of conditions throughout the area.

Trend analysis will include assessment of which ambient monitoring constituents have statistically significant trends. Information about each constituent will include the number of samples evaluated. Evaluation of constituents will be based on their respective water quality standard numeric criteria or equivalent measure (e.g., screening level). Analyses will mirror the approach taken in the development of water quality trends analyses for similar area WPPs. Because the data and methods to be used have previously been reviewed as part of quality-assured processes, no appreciable bias in the data is expected. Systemic bias in water quality sampling data is based on skewing of data collection to daylight hours and away from extreme storm events. Systemic uncertainty is found in the lack of continuous data (i.e. periodic grab samples under CRP, etc.). However, these sources of uncertainty are endemic to monitoring programs, and are not expected to produce serious issues for data analysis acceptability.

Load Characterization with SELECT

The primary data quality objectives for this effort are to ensure data inputs are from the best available sources (quality assured or industry standard), that assumptions are scientifically defensible and vetted by stakeholders, and that outputs are driven by appropriate data and stakeholder review. Performance criteria for inputs are that they represent the best available data, and in the case of data sources which may differ from place to place, the most locally-appropriate data (e.g. deer population numbers for the specific area as opposed to a statewide average). All spatial data used in SELECT are from sources that are quality-assured, widely used data products appropriate for this task, or based on assumptions used and vetted under previous area WPPs. Performance criteria for outputs include modeling outcomes that are sufficient to guide stakeholder discussion, and which are demonstrably defensible based on the source and vetting of data and assumptions. The outputs will be acceptable if these criteria are met (this is a qualitative measure, as no model calibration or validation of data other than initial validation in submission to SWMQIS is performed for SELECT). The intended uses of these outputs will be to generate potential pollutant load estimates and characterize their spatial relationship, and to guide stakeholder discussions of the scope of management measures. Hardware and software to be used will conform to industry standard (e.g. Microsoft Office products, and the SELECT model utilized in a Windows/ArcGIS environment). Configuration of SELECT assumptions analyses will be based on similar SELECT analyses to ensure the data are comparable with those of other regional and regulatory efforts.

Data completeness will be based on whether enough data are available to generate loads using SELECT. Data representativeness will be evaluated based on whether spatial data and assumptions are indicative of conditions throughout the watersheds. Because the selection of assumptions and the stakeholder review process can introduce some subjectivity in decision-making, some level of bias in the outcomes is expected. Bias will be considered reasonable if modifications to outputs or assumptions are based on reasonable expectations that local knowledge or data is more appropriate

than more general values. Systemic uncertainty is inherent to the use of assumptions and literature value. However, these sources of uncertainty are endemic to SELECT modeling and do not compromise the objectives for this modeling effort. SELECT is not intended to be a model of a precision level that would be impacted by these levels of bias and/or uncertainty. Table A7.1 indicates all foreseeable assumptions or literature values that will be applied to the models.

Table A7.1 Modeling Assumptions

Assumption/ Literature Value	Model	Review with Stakeholders?	Source	Value
Feral Hog Density	SELECT	Yes	Texas A&M AgriLife Research (AgriLife) Densities	AgriLife has used a variety of hog densities, with a generic Texas range of 1.3-2.5 hogs per square mile[1], depending on land cover type. This value is expected to be heavily modified by local stakeholders to reflect area or subwatershed populations.
Livestock Populations	SELECT	Yes	United States Department of Agriculture National Agricultural Statistics Service (NASS) Agricultural Census Data (most recent)	County-level data are used to derive a ratio of animals per land cover type. This ratio is then applied to the area of the watershed in each county. Technical experts (Soil and Water Conservation Districts, et al.) help refine numbers to reflect the relative densities of livestock within the watershed as opposed to the whole county.
OSSFs Number and Location	SELECT	Yes	H-GAC OSSF Database	Permitted systems are based on actual location data. Unpermitted systems are based on occupied locations

[1] http://agrilife.org/feralhogs/files/2011/05/FeralHogFactSheet.pdf

Assumption/ Literature Value	Model	Review with Stakeholders?	Source	Value
				outside of service areas, without permitted OSSFs.
OSSF Failure Rates	SELECT	Yes	H-GAC OSSF Data, Stakeholder Input	As these rates are highly variable by location, failure rates will be heavily modified by stakeholder (especially Authorized Agent) input. An estimated 10-15% failure rate was used in SELECT outputs for other local watersheds.
Animal Excretion/Bacterial Densities	SELECT	No	Literature Value	Based on values indicated in Teague, 2009[1].
WWTF Discharge Concentrations	SELECT	Yes	DMR Data from Each Plant (TCEQ)	Geomean of DMR data, using an assumed 60% of permitted flow as daily average flow to determine total load.
Land Cover Change	SELECT	Yes	H-GAC Regional Demographic Projections	Proprietary H-GAC data used in most regional WPPs.
Pet Populations	SELECT	Yes	American Veterinary Medicine Association (AVMA)	AVMA estimates of household ownership (0.8 pets/household) used as a starting figure, multiplied by number of households. This will be modified by stakeholders and area-specific reconnaissance. A decrease factor in load may be applied if pet

[1] "Spatially explicit load enrichment calculation tool to identify potential *E. coli* sources in watersheds." A. Teague, et al. 2009. http://ssl.tamu.edu/media/11291/select-aarin.pdf

Assumption/ Literature Value	Model	Review with Stakeholders?	Source	Value
				waste station/pet bag use is found to be common in the watershed, based on research and stakeholder input.
Deer Populations	SELECT	Yes	Texas Parks and Wildlife Department (TPWD)	TPWD Resource Management Unit (RMU) data are used to define regional deer population estimates, which are applied to appropriate land cover types, as in Teague, 2009.
Bird Populations/Fecal Concentrations	SELECT	Yes	TPWD, Stakeholders, EPA, Texas State Soil and Water Conservation Board (TSSWCB)	Bird populations are based primarily on TPWD staff knowledge (if available) and stakeholder knowledge. Of primary concern are the presence of colonial rookeries, swallow nesting sites over water, gulls concentrated at landfills, and other large concentrations of birds. EPA values[1] for bird fecal rates are used if stakeholder input indicates substantial, or substantially proximate (swallow colonies over bridges, etc.), numbers of birds exist on an annual basis to model. Values dependent on species of concern.
Waste Water Treatment Facility	SELECT	No	TCEQ Spatial Data	WWTF outfalls are spatially explicit data.

[1] Based on studies referenced by EPA, including http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2771205/

Assumption/ Literature Value	Model	Review with Stakeholders?	Source	Value
(WWTF) Outfall Locations				
Other Wildlife	SELECT	Yes	TPWD, Stakeholder input	If data for other wildlife populations exist, they will be considered for inclusion with stakeholders. If it does not, a conservative background load expressed as a percent of total load may be applied based on stakeholder input and/or microbial source tracking studies in the state and local area.

Load Duration Curves

The primary data quality objectives for this effort are to ensure data inputs are from quality assured sources; that modeling assumptions are based best available literature, established methodologies for specific circumstances, and best professional judgment; and that outputs reflect load durations and related reduction needs (for bacteria, and improvement needs for DO) in a manner that is reflective of the diverse conditions of the project area. LDCs for the station(s) in Segment 1101 will use a modified approach[1] to account for tidal action. Performance criteria for inputs are quality-assured status for water quality data (e.g. data collected under existing TCEQ/EPA approved QAPP or other similar source) and outputs from LDC runs. Performance criteria for outputs include a proper data management trail of the data evaluation process, and LDC analysis using established methods[2], performed by experienced staff. The outputs will be acceptable if these criteria are met (this is a qualitative measure, as no calibration or validation of data other than initial validation in submission to SWMQIS is performed on these analyses).

The intended use of these outputs will be to develop target bacteria reductions and DO improvements, and define impacts to bacteria, DO and related constituents under various flow conditions. Hardware and software to be used will conform to industry standards (e.g. Microsoft Office products and LOADEST in a current Windows environment). Configuration of LDC assumptions will be based on TCEQ guidance and the existing preliminary analyses to ensure the data is comparable with those of other regional and regulatory efforts. However, specific

[1] The modified LDC approach methodology is explained further in Appendix F.
[2] http://www.epa.gov/tmdl/approach-using-load-duration-curves-development-tmdls

configuration of assumptions will be based on best available data, professional judgment, and stakeholder review. Data completeness will be based on whether enough data are available to generate LDCs. Data representativeness will be evaluated based on whether selected LDC sites have enough data to be representative of the watershed(s) in general. Because the selection of assumptions and the stakeholder review process can introduce some subjectivity in decision-making, some level of bias in the outcomes is expected. Bias will be considered reasonable if modifications to outputs or assumptions are based on reasonable expectations that local knowledge or data is more appropriate than more general values or specific choices (e.g., level of reduction to be used in relation to bacteria). Systemic uncertainty is inherent to the simplicity of the model and the complexity of real-world systems. However, these sources of uncertainty are endemic to LDC modeling and do not compromise the objectives for this modeling effort. LDCs are not intended to be a modeling approach of a precision level that would be impacted by these levels of bias and/or uncertainty. If insufficient USGS flow data are available, estimated flow data will be projected using LOADEST. The data objectives for the estimated flow conform to the same intended uses as the other LDC inputs and outputs. The intent of estimating flow is to provide stakeholders with information for an area that may otherwise not have enough flow data on which to base an LDC.

A8 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

No formal certification is required for the efforts to be conducted under this QAPP. The modeling and project management staff have conducted previous training in all modeling and data evaluation efforts discussed throughout their careers. Any additional staff members that conduct work under this project will have, or receive, training specific to their work. Training taking place within the time frame of this contract will be recorded and maintained by the H-GAC PM.

The H-GAC Lead Modeler and PM have conducted SELECT and LDC analyses (including the use of LOADEST in general and for the specific purpose of generating flow data) on a variety of watershed projects and have attended multiple formal training events on SELECT and LDCs. Additionally, they have advanced knowledge of data quality needs and objectives common to modeling approaches in general based on experience and training. LOADEST will use existing data resources, and staff are already trained in its use and application for these purposes, so no additional training is required.

The Data Manager and QAO for this project are the H-GAC lead staff for CRP data analysis, and have extensive training in data management, quality assurance, and SAS operation (data manager). They routinely attend training specific to SWQMIS procedures, and/or SAS operation. Their daily activities have heavy focus on this type of data analysis and quality assurance. Descriptions of educational credentials, training, demonstrations of competency, assessments, and corrective actions can be provided by project management upon request.

All staff members have worked with QAPPs under prior projects. No additional training is expected to be needed to complete the project efforts.

A9 DOCUMENTATION AND RECORDS

All digital and paper documentation for the project is kept for a period of seven years. The H-GAC PM has final responsibility for ensuring project files are compiled in accordance with this QAPP. The QAO and Data Manager will ensure that the PM has appropriate documentation for water quality data analyses and records for data from acquired data sources including but not limited to SWQMIS and CRP data. The Lead Modeler will ensure that all modeling records, notes, literature referenced, and other records from modeling efforts are maintained during the project and relinquished to the PM for proper retention. Electronic data on the project computers and the network server are backed up daily to the network drive and weekly to external storage. In the event of a catastrophic systems failure, the tapes can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost but can be reproduced from raw data in most cases. Quarterly progress reports disseminated to the individuals listed in section A3 will note activities conducted in connection with the water quality modeling project, items or areas identified as potential problems, and any variations or supplements to the QAPP.

In addition to general information regarding data and modeling activities, any stakeholder input received, or notes generated regarding input, will be included with modeling files and project documentation.

Modeling Log

Modeling notes created by the Lead Modeler will be recorded electronically with model files, on paper, or in a separate electronic file (e.g., Word document). All electronic files will be stored in the same folder as the modeling files, and all paper files will be retained by the modeler until the end of the project. At that time, they will be included with project files maintained by the PM.

The Lead Modeler will document references for model assumptions (and adjustments thereof), stakeholder feedback provided by the PM, and model runs. The level of detail will be sufficient to allow another modeler to duplicate the modeling method given the same data and model.

The documents and records that describe, specify, report, or certify activities, requirements, procedures, or results for this project and the items and materials that furnish objective evidence of the quality of items or activities are listed in Table A9.1. All project staff will develop and retain documentation as described in Table A9.1.

Table A9.1 Project Documents and Records

Document/Record	Location	Retention*[a]	Form*[b]
QAPPs, amendments, and appendices	H-GAC	7 years	Paper/Electronic
QAPP distribution documentation	H-GAC	7 years	Paper/Electronic
Standard Operating Procedures	H-GAC	7 years	Paper/Electronic
Model User's Manual or Guide (including application-specific versions)	H-GAC	7 years	Paper/Electronic

Document/Record	Location	Retention*[a]	Form*[b]
Assessment reports for acquired data	H-GAC	7 years	Paper/Electronic
Raw data files	H-GAC	7 years	Paper/Electronic
Model input files	H-GAC	7 years	Electronic
Model output files	H-GAC	7 years	Electronic
Code Verification Reports	H-GAC	7 years	Paper
Model Assessment Reports	H-GAC	7 years	Paper
Progress report/CAR/final report/data	H-GAC/TCEQ	3 years	Paper/Electronic

*a – After the close of the project
*b – Electronic files should be American Standard Code for Information Interchange Disk Operating System (ASCII DOS) pipe delimited text files or Microsoft Word/Excel; model input and output files can be archived in the format used by the modeling software, provided the capability of conversion to ASCII DOS pipe delimited text files or Microsoft Word/Excel (TCEQ compatible version) is maintained over the time of retention.

TCEQ may request records at any time and/or elect to take possession of records at the conclusion of the specified retention period.

SECTION B: MEASUREMENT AND DATA ACQUISITION

The primary source of data for these data analysis and modeling efforts will be SWQMIS data produced under previous QAPPs (e.g. CRP data, etc.).

B1 SAMPLING PROCESS DESIGN
Not Relevant .

B2 SAMPLING METHODS
Not Relevant.

B3 SAMPLE HANDLING AND CUSTODY
Not Relevant.

B4 ANALYTICAL METHODS
Methods of analysis used for this effort are described in Section A6.

B5 QUALITY CONTROL
Quality control and acceptance criteria for data and analyses used in this effort are described in Section A7.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE
Not Relevant

B7 MODEL CALIBRATION
No formal calibration (or sensitivity analysis) is used for the primary data analyses (SAS), SELECT, or standard LDCs, including the generation of continuous flow data in absence of representative USGS gauge data by LOADEST. Informal adjustment of the model inputs or outputs may be applied based on stakeholder feedback and more specific local knowledge compared to general assumptions.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES
Not Relevant.

B9 NON-DIRECT MEASUREMENTS (DATA ACQUISITION REQUIREMENTS)
The modeling and water quality data analysis efforts described in this QAPP will make use of non-direct/acquired data from a variety of sources. The sources and their characteristics are included in Table B9.1.

The primary sources of data for model development are:

- Water quality and flow monitoring data from SWQMIS;
- DMRs, SSO violation data, other permit reporting data from TCEQ databases;
- Regional demographic forecasting data created by H-GAC;

- OSSF location data created by H-GAC for TCEQ;
- Spatial datasets and databases created by other state and federal agencies (e.g. H-GAC land cover data, USGS flow data and precipitation data, etc.); and
- Literature values for model assumptions (see Table A7.1[1]).

All non-direct data being used have been previously deemed to be acceptable acquired data sources under other QAPP efforts or were prepared under QAPP coverage or similar quality-assured processes. In all instances, the best available data in terms of quality, quality control, and comparability with other QAPP covered modeling efforts have been selected for use.

Ambient Water Quality Data

No data will be collected specifically for this project nor submitted for inclusion in SWQMIS. The collection and qualification of the TCEQ and USGS data are addressed in the TCEQ Surface Water Quality Monitoring QAPP[2]. The collection and qualification of the Texas CRP data are addressed in the Texas CRP QAPPs[3]. Data acquired for this project will include those parameters described in section A6 as well as any other data needed to characterize the watershed; develop, operate, or validate models; or meet other user requirements. These data include conventional parameters, field parameters, bacteriological parameters, and biased sampling conducted under special projects.

TCEQ's SWQMIS is the largest and most complete repository for water quality data collected under accepted QAPP procedures in the State of Texas and was selected for that reason for these efforts. The water quality data to be acquired for this project will include routine water quality data collected by TCEQ and sampling partners such as the CRP, the United States Geologic Survey (USGS), and the Texas State Soil and Water Conservation Board, including available 'non-qualified,' routine or special study, ambient, fixed station water quality data and associated field parameters.

The FY2020-2021 CRP QAPP Section B9 explains which TCEQ method codes are used to describe comparable parameters contributing to the CRP dataset. Sections A7, B5 and Appendix A of the FY2020-2021 CRP QAPP also describe limits of quantitation and the process by which analytical results reported to the CRP are required to reflect parameter ranges in excess of those limits. Assessments of CRP data conducted under the Basin Highlights Report(s) and Basin Summary Report falling within this project timeline may be used to supplement analyses conducted under this project. All CRP work is conducted under its own QAPP and is not intended to be covered under this QAPP. However, the data, staff, and processes used are identical to those intended for this project.

[1] Table A7.1 includes preliminary model assumptions and literature values. Additional values, assumptions, or modifications thereof may be utilized depending on stakeholder input. The project modeling process relies strongly on working with stakeholders to refine assumptions to best suit local conditions and knowledge.
[2] www.tceq.state.tx.us/waterquality/monitoring/swqm_guides.html
[3] www.tceq.texas.gov/waterquality/clean-rivers/qa/index.html

TCEQ Permit and Violation Data
This project will make use of data from TPDES and other permittees acquired and maintained by TCEQ. This will include DMRs, SSO violation data, TPDES permit information and compliance history, and other data relevant to TCEQ or EPA-permitted facilities in the watershed. These data are assumed to be of acceptable quality based on inclusion in TCEQ- or EPA-approved datasets, including those prepared by H-GAC for TCEQ under QAPP-covered efforts funded by 604(b) Water Quality Management Plan projects. H-GAC will work with TCEQ staff to identify, acquire, and update these data sources.

Regional Demographic Forecasting and Land Cover Data
H-GAC conducts regional demographic forecasting as part of a quality-assured effort. Data to be used for this project include current and future population projections, land cover change projections, and household and job change projections. Additionally, H-GAC develops proprietary land cover data based on LANDSAT satellite imagery that is more current and regionally specific than other land cover data sources. This data source is the standard for the other similar projects in the region and is used in comparable QAPP-covered planning efforts as well as broader regional planning efforts.

OSSF Location Data
H-GAC maintains a spatial database of permitted OSSF locations for the region, including the project area. This database was developed and maintained under a TCEQ-approved QAPP as part of an ongoing Clean Water Act 604(b) Water Quality Management Plan partnership between H-GAC and TCEQ.

Geospatial Data
The H-GAC Community and Environmental Planning Department's (C&E) Data Management Plan (DMP; Appendix E) outlines how both tabular (non-geographic) and spatial (geographic) datasets are captured, manipulated, analyzed, stored, and displayed within the Geospatial/ GIS environment as it relates to sharing of data, development of geospatial applications, cartography, and underlying GIS resources (see Appendix E for more detail). Existing geospatial data resources at H-GAC will be combined with additional data from appropriate local, regional, state, and federal organizations as needed. Geospatial data used for modeling exercise will be of acceptable quality based on the data quality objectives of this project and will have been published with appropriate metadata. The publishing of geospatial data by various organizations implies that the data is of known quality, that is has been subject to review and approval by the publishing organization and has required metadata to prove its accuracy and completeness.

All outside data sources will be reviewed to determine level of quality, compatibility, and completeness. Procedures used to collect these outside sources will also be reviewed to determine compatibility and determine level of sampling bias and uncertainty. Generally, data used from outside sources will be acceptable if it was collected under an existing QAPP, published in peer review literature or if sufficient and documented quality assurance/quality control (QA/QC)

procedures were employed during project data collection and analysis.

H-GAC utilizes ESRI's ArcGIS 10 platform for all geospatial analysis and mapping needs. The ESRI ArcGIS 10.X platform includes integrated Python programming capabilities, which allows for the creation of programming scripts or batch programs to improve efficiency and documentation of processes. The Python programming language is an Open Source platform and is freely distributable.

Derived GIS layer data from other QAPP-covered CRP assessments (e.g. potential sources of contamination in a watershed identified under a Basin Highlights Report or Basin Summary Report) may be utilized if it is of equal or greater adherence with the data quality objectives for this project.

Modeling Assumptions and Literature Values

The SELECT and LDC models rely on a mix of actual measurements and assumptions/literature values. The application of the LOADEST tool to generate a simple hydrological runoff estimation relies on values internal to the tool. Some model values are integral to the models, while others can be modified or are based on local data/accounts. Literature values intended to be used for these modeling efforts include rate, volume and character of fecal deposition by various sources; event mean bacteria concentrations specific to land cover types; nutrient loading characteristics of land cover types; source population estimates (e.g. number of feral hogs per mile) and impacts of various best management practices. Selection of literature values will show preference to peer-reviewed scientific literature, most locality-specific references, and currency of reference, as modified by agency and stakeholder feedback. User-selected assumptions for SELECT include the use of the buffer approach in discounting loading outside a defined buffer distance from the waterway, and the distribution of some sources for which data is not specific to the watershed (e.g. cattle populations based on county-level data).

Other Data

Data used for qualitative assessment, stakeholder discussion, and watershed characterization not related to modeling efforts covered under this QAPP may include Texas Stream Team volunteer monitoring data, spatial data generated by other entities active in the Clear Creek Watershed (e.g., habitat data generated by local non-governmental organizations), and other local data as encountered during the course of the WPP development project. These data sources are not intended to be used directly for the modeling efforts covered under this QAPP, but may influence staff and stakeholder decisions regarding assumptions, etc.

Table B9.1 Non-Direct Measurements

Type of Measurement or Analysis	Type of Data (time series, rate, constant, statistic, taxa, etc.)	Units	Source (web link when available)	Quality Assurance Documentation	Use	Date Range
Ambient water quality monitoring data	Periodic water quality	Various	SWQMIS	https://www.tceq.texas.gov/waterquality/monitoring/swqm_guides.html	Used as observed values for modeling efforts	Various, depending on station
DMRs	Periodic water quality reporting	Various	TPDES permittees via TCEQ	N/A	Used to characterize WWTF loading	Various, depending on station
SSO violation data	Episodic violation reporting	Various	TPDES permittees via TCEQ	N/A	Used to characterize collection system loading	Various, depending on station
Regional growth forecast	Modeled projections	Various	H-GAC	https://www.h-gac.com/getmedia/6f706efb-9c6d-4b6a-b3aa-7dc7ad10bd26/read-documentation.pdf	Used to characterize land cover and population change	2020-2045
Regional Land Cover	Spatial database	Various	H-GAC	https://www.h-gac.com/land-use-and-land-cover-data	Used to characterize land cover	Various
OSSF locations	Spatial database	Individual OSSF records	H-GAC	Completed under H-GAC Regional Geospatial Data QAPP	Used to characterize OSSF loads	Various-2021
GIS layers	Geospatial datasets	Various	Various	The quality assurance processes are specific to the individual layers. More information on the quality of geospatial source data follows this chart.	Used to develop models and for cartographic purposes	Various
Literature values	Various	Various	Various	The quality assurance for the studies and other methods that developed literature values are specific to each value, as noted in project reports.	Used to develop models/tools	Various

Existing geospatial data available from various local, regional, state, and federal organizations may be used for project cartographic and illustrative purposes. These types may include land use, precipitation, soil type, ecoregion, TCEQ monitoring location, TCEQ permitted outfall, gage location, city/county/state boundary, stream hydrology, reservoir, drought, road, watershed, municipal separate storm sewer system, urbanized area, basin, railroad, recreational area, area landmark, aerial photography, and park information. The above data come from the following reliable sources: USGS, Texas Natural Resource Information System, TCEQ, TSSWCB, USGS, U.S. Department of Agriculture National Resources Conservation Service, TPWD, EPA, NOAA, General Land Office, and U.S. Census Bureau. Geospatial data from these sources are accepted for use in project maps based on the reputability of these data sources and the fact that there are no known comparable sources for these data. Geospatial data will be cited in reports.

As the project progresses, additional data sources and/or data types may be identified as necessary to complete project tasks. Once identified, H-GAC will notify the TCEQ NPS Project Manager and request approval prior to use. If data will be analyzed or used for any purposes beyond cartographic or illustrative purposes, the QAPP must be amended and approved prior to use. All approved data sources will be clearly documented where such data sources are reported (e.g. technical documents, technical reports, and final reports).

B10 DATA MANAGEMENT AND HARDWARE/SOFTWARE CONFIGURATION

Data evaluated, acquired, produced, or maintained under this QAPP will be handled in accordance with the DMP (attached as Appendix E). H-GAC uses this DMP for all related water quality efforts requiring QAPP coverage (e.g., CRP).

B10 (A) Data Management

H-GAC data management procedures are discussed at length in Appendix E.

Data Dictionary
H-GAC standard data terminology and definitions are discussed at length in Appendix E.

Migration/Transfer/Conversion
Migration, transfer, and conversion of data, as well as data history and model outputs, are discussed at length in Appendix E.

Information Dissemination
Project updates will be provided to the TCEQ NPS Project Manager in progress reports and the information will be made available at stakeholder meetings. Input data and model outputs resulting from the project described in this QAPP will be accessible to the general public and the TCEQ. Additional procedures are discussed at length in Appendix E.

B10 (B) Hardware/Software Configuration

Archives/Data Retention

Complete original data sets are archived on permanent media (tape drives) and retained on-site by H-GAC for a retention period specified in Table A9.1 Project Documents and Records. Additional discussion of archiving procedure is indicated in Appendix E.

Backup/Disaster Recovery

All work and file storage takes place on a shared network drive(s) which are continuously backed up on the network servers and archived on a regular basis. In the event of a catastrophic systems failure, the archival backups can be used to restore the data in less than one day's time. Data generated on the day of the failure may be lost but can be reproduced from raw data in most cases.

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
Status Monitoring Oversight, etc.	Continuous	H-GAC PM	Monitoring of the project status and records to ensure QAPP requirements are being fulfilled. Monitoring and review of subcontractor's performance 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

Internal Assessment

Since this 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. H-GAC and the TCEQ NPS Program will continually assess model performance by evaluation of tasks listed in Section D.

Modeling data and project deliverables will be internally quality controlled by the TCEQ NPS Project Manager's in-house review. The TCEQ NPS 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.

Corrective Action

Deficiencies are any unauthorized deviations from the approved QAPP and procedures referenced in the QAPP. Deficiencies may invalidate resulting data. All deficiencies from the QAPP require documentation of the nonconformance and corrective action. Deficiencies must be documented in a Corrective Action Plan (CAP) (See Appendix B for the form and an example) and corrected in a timely manner. Corrective action may include the need for additional model

runs. Deficiencies are documented in logbooks, field data sheets, etc. by field, laboratory, or modeling staff. It is the responsibility of the H-GAC Project Manager, in consultation with the H-GAC QAO and H-GAC Data Manager, to ensure that the actions and resolutions to the problems are documented and that records are maintained in accordance with this QAPP.

Nonconformances must be communicated to the TCEQ NPS Project Manager immediately via email. A CAP must be submitted to the TCEQ NPS Project Manager within 14 days of the deficiency occurring. Once it is approved, the TCEQ NPS PM will send the CAP to the QA Coordinator who will then email the CAP to the Lead NPS QAS within 30 days of the initial notice of deficiency per TCEQ QMP and after it is reviewed by the TCEQ NPS Project Manager. The deficiency must also be communicated to the TCEQ NPS Project Manager through the Corrective Action Status Table (see Appendix C for the table and an example) to be included with the quarterly progress report.

The H-GAC Project Manager is responsible for implementing and tracking corrective actions. All Corrective Action Plans will be documented on the Corrective Action Status Table, which will be submitted to the TCEQ NPS Project Manager with the quarterly progress report for review and approval. Records of TCEQ audit findings and corrective actions are maintained by both the TCEQ and the H-GAC QAO. Documentation of corrective action to address audit findings will be submitted to the TCEQ within 30 days of receipt of audit report.

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

Corrective Action Plans

Corrective Action Plans should:

- Identify the deficiency, problem, nonconformity, or undesirable situation
- Identify immediate remedial actions if possible
- Identify the underlying cause(s) of the problem
- Identify whether the problem is likely to recur, or occur in other areas
- Include a description of the need for Corrective Action
- Include a description of cause(s), determine solution, and propose an action plan
- Identify personnel responsible for action
- Establish timelines and provide a schedule
- Document the corrective action

C2 REPORTS TO MANAGEMENT

Reports to H-GAC Project Management

H-GAC project staff will report to the H-GAC PM on an ongoing basis, but at a frequency no less than once a week. These reports will be informal unless corrective action, relevant modeling notes, or other documentation as discussed in this QAPP apply

Reports to TCEQ Project Management

Progress Report – Submittal of progress reports will be at least quarterly. Format of the submitted progress report will be as specified in the contract or work orders. Reports should provide enough information so the TCEQ NPS PM can evaluate the modeling effort.

Data Analysis Summary Report – H-GAC will submit a draft Data Analysis Summary Report, subsequent to the water quality trends analysis, and a final version with TCEQ PM comments addressed.

Modeling Report – H-GAC will submit a draft Modeling report at the culmination of modeling activities and a final version with TCEQ comments addressed.

Watershed Protection Plan – H-GAC will submit to TCEQ a WPP for Clear Creek subsequent to stakeholder approval of the draft WPP by the end of the project period.

Final Report – H-GAC will submit a final report, in the form of a Final Quarterly Progress Report with substantive summary of the project, within 15 days of the end of the last fiscal quarter of the project. Any comments from TCEQ will be summarized in a comment response document in the interim.

CAP – Identifies any deficiencies and nonconformances. The cause(s) and program impacts are discussed. The completed corrective actions are documented, and the report is submitted to the TCEQ NPS PM within 14 days of the deficiency occurring.

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

Reports by TCEQ Project Management

Contractor Evaluation - H-GAC 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

Validation - Validation is an extension of the calibration process that reduces uncertainty. No calibration processes are used for the tools and approaches selected for this project and covered under this QAPP other than routine electronic and/or visual screening for errors .

D1 DEPARTURES FROM VALIDATION CRITERIA

Data collected by the TCEQ, the USGS, Texas CRP partners, and other listed sources have been verified and validated according to the requirements of the respective programs prior to their use in this project. Data compilations created for this project will be electronically and/or visually screened for errors. For more information on data management procedures see Appendix E.

D2 VALIDATION METHODS

Model Validation

The water quality data analyses are not subject to model validation. The SAS outputs are reviewed by H-GAC staff, as part of normal data management procedures.

LDCs are also not validated in a traditional sense, as they are not predictive models. The results of LDC runs are similarly validated by H-GAC staff, and through review with TCEQ project staff and stakeholders. Because LDCs are descriptive rather than predictive, no validation against additional data is possible.

The SELECT runs are predictive of potential load, but without linkage to observed data (i.e. they are not predictive of instream concentrations.) SELECT results are not calibrated to observed data because potential load is not a measurable/measured constituent. Non-technical validation of SELECT inputs and outputs is primarily based on H-GAC, TCEQ, and stakeholder review of model assumptions and outputs. Criteria in these reviews include the applicability and sufficiency of assumptions and subjective comparison of model outputs with local conditions as experienced by stakeholders. This process is not intended as a technical validation.

D3 RECONCILIATION WITH USER REQUIREMENTS

The primary purposes of the data outputs from these analysis and modeling efforts are to characterize the conditions in the watershed and guide stakeholder decision-making. The user requirements for WPP development are to provide a high-level understanding of the causes and sources of pollutants in spatial and flow contexts. The modeling framework developed for this project will be used to evaluate contaminant loading in the Clear Creek Watershed. It will provide information pertaining to historical trends in water quality[1], relationship of pollutant

[1] The methodology, uses, and data types for the water quality trends analysis are described in detail in Section A7, under the subsection Water Quality Analysis.

loads to flow regimes and bacteria reductions (LDCs), and potential loading from pollutant within the watershed (SELECT). These analyses will provide critical information for the stakeholders to support the development of the Clear Creek WPP.

The user requirements do not assume a detailed and complex hydrologic model with predictive linkage between source loading and instream concentrations. Source load reduction projections sufficient to guide stakeholder decisions will be obtained by applying load reduction percentages generated through LDCs to source loads generated in SELECT analyses.

The outputs will be evaluated at several levels. First, H-GAC project staff will review outputs for obvious inconsistencies and errors, for compliance with QAPP procedures, and against best professional judgment. Secondly, outputs will be reviewed with TCEQ project staff. Lastly, outputs will be reviewed with stakeholders and technical advisors to ensure local input is acquired and incorporated as appropriate. Additional review will follow revised model runs and scenarios. The final data will be reviewed to ensure that it meets the requirements as described in this QAPP. CARs will be initiated in cases where invalid or incorrect data have been detected. Data that have been reviewed, verified, and validated will be summarized for their ability to meet the data quality objectives of the project and the informational needs of water quality agency decision-makers. The sufficiency of the data to support stakeholder requirements will be based on review of the data with the stakeholders and agency staff.

Some limitations are assumed for the use of the model outputs. The usability of the modeling results will be limited to their intended purposes as part of an EPA 9-element WPP development process. The model results are not intended or designed to provide a level of accuracy or precision beyond what is described or the stated ability of the models. Model results are not intended to be used for legal purposes, to describe property conditions in lieu of environmental assessments, or to be used for other official purpose not stated in this QAPP. The design of the modeling approach is intended to allow the flexibility, as described, to incorporate stakeholder input on assumptions, outputs, and specific locales or events in the watershed.

Model results may be subsequently analyzed and used by the TCEQ for calculating estimated reductions in pollutant loadings resulting from management measures implemented.

APPENDIX A.
CONTRACT SCOPE OF WORK AND SCHEDULE OF DELIVERABLES

Appendix A. Scope of Work

The dates indicated in the following scope of work are those referenced in the signed agreement (582-21-10101), authorized on 1/14/21. Subsequent to this agreement, TCEQ PM and H-GAC PM have revised dates to account for delayed initiation of the project. Dates pertinent to deliverables in this QAPP are presented in Table A6.2 and Section C2.

SCOPE OF WORK

The Performing Party, in collaboration with project partners, will use existing water quality data, conduct new water quality modeling, and engage stakeholders to complete a stakeholder-driven WPP for the Clear Creek Watershed. The WPP will satisfy the expectations of the nine key elements fundamental to watershed-based plans as described in EPA's *2014 Nonpoint Source Program and Grants Guidelines for State and Territories.*

Task 1: Project Administration

Objective: To effectively administer, coordinate, and monitor all work performed under this project including technical and financial supervision and preparation of status reports.

Subtask 1.1: Project Oversight — The Performing Party will provide technical and fiscal oversight of the staff and/or subgrantee(s)/subcontractor(s) to ensure Tasks and Deliverables are acceptable and completed as scheduled and within budget. With the TCEQ Project Manager's authorization, the Performing Party may secure the services of subgrantee(s)/subcontractor(s). The Performing Party shall comply with applicable requirements of 40 CFR Part 33 related to Disadvantaged Business Enterprises in connection with procurements of goods or services, as set out in the Federal Conditions and Forms section of this Contract. Project oversight status will be provided to the TCEQ Project Manager with the quarterly Progress Reports (PRs).

Subtask 1.2: PRs — The Performing Party will submit PRs to the TCEQ Project Manager by the 15th of the month following the end of the quarter. PRs will include reporting on the status of Deliverables and proposed revisions to due dates, narrative description of progress by Task, and status of nonconformances/corrective actions. The TCEQ Project Manager will provide a template for the PR to the Performing Party.

Subtask 1.3: Reimbursement Forms — The Performing Party will submit reimbursement forms in accordance with Special Terms and Conditions.

Subtask 1.4: Contract Communication — The Performing Party will maintain regular telephone and/or e-mail communication with the TCEQ Project Manager regarding the status and progress of the project and any matters that require attention between PRs. Communications will include a quarterly conference call to discuss items such as project Tasks, financial status, Quality Assurance Project Plans (QAPP), corrective actions and any other matters that require attention. The TCEQ Project Manager may request additional information from the Performing Party prior to the call or meeting. The Performing Party will provide meeting notes, identifying action items, for the telephone calls within five days of the call.

The first conference call held each fiscal year of the project will cover, as applicable, any staff changes, the previous year's performance, budget estimates, and overall project progress.

Matters that will be communicated to the TCEQ Project Manager include, but are not limited to:

- Notification a minimum of 14 days before the Performing Party has scheduled public meetings or events or other major Task activities.
- Notification within 48 hours following events or circumstances that may require changes to the Budget, Scope of Work, or Schedule of Deliverables.
- Requests for prior approval of activities or expenditures for which the Contract requires advance approval or that are not specifically included in the Scope of Work.

Subtask 1.5: Contractor Evaluation — The Performing Party will participate in an annual Contractor Evaluation at the end of each state fiscal year.

Subtask 1.6: Coordination Call with EPA — Upon request by TCEQ and EPA, the Performing Party will participate in a call with EPA to share progress on goals, measures of success, challenges, and draft documents.

Subtask 1.7: Project Article — Upon request by TCEQ, the Performing Party will provide a project article. The article will state the project's purpose, describe the activities of the past fiscal year and include photographs of the project. The Performing Party will address TCEQ comments on the article and provide a final article.

Subtask 1.8: Contract Budget Updates — The Performing Party will discuss annual fiscal year budgets with the TCEQ Project Manager on a quarterly basis at a minimum. Starting in the second year of the project, the Performing Party will provide an Annual Budget Update that details state fiscal year spending projections associated with planned project activities. These updates will be revised when fiscal year spending projections change by 10% or more, or upon request by the TCEQ Project Manager. The update in the final year of the project will include a budget for all remaining project activities. The TCEQ Project Manager will provide a template for the Annual Budget Update.

Deliverables:

1.2 PRs (by the 15th of the month following the end of each state fiscal quarter).
1.3 Reimbursement forms (see Special Terms and Conditions).
1.4 Conference calls with meeting notes and action items (calls within 30 days of the end of each quarter, notes within five days of meeting).
1.5 Contractor Evaluation (at the end of each state fiscal year).
1.6 Coordination call with EPA (upon request).
1.7 Project Article and photographs (upon request).
1.8 Contract Budget updates (by the 15th of the month following the end of each state fiscal quarter).
1.8 Annual Budget Updates (upon request).

Task 2: Quality Assurance

Objective: To refine, document, and implement data quality objectives (DQOs) and quality assurance/quality control (QA/QC) activities that ensure data of known and acceptable quality are generated by this project.

Subtask 2.1: QAPP Planning Meetings — The Performing Party will schedule a QAPP planning meeting with the TCEQ Project Manager, QA staff, technical staff, and contractors within 30 days of Contract execution, to implement a systematic planning process based on the elements in the applicable QAPP shell. A QAPP shell/examples will be provided by the TCEQ Project Manager. The information developed during this meeting will be incorporated into a QAPP by the Performing Party. The Performing Party may conduct additional meetings to determine whether changes to an existing QAPP are needed. The Performing Party will provide meeting notes within seven days of the meeting.

Subtask 2.2: QAPP — The Performing Party will develop and submit to TCEQ a QAPP with project-specific DQOs and other components consistent with the following documents:

- TCEQ NPS QAPP Shell(s)
- EPA Requirements for QAPPs (QA/R5)
- EPA Guidance for Modeling QA/G-5M
- EPA Guidance for Geospatial Data QAPPs (QA/G-5G)
- EPA QAPP Requirements for Secondary Data Research Projects

The Performing Party will develop the QAPP in consultation with the TCEQ Project Manager, QA staff, and contractors. The Performing Party will address comments and submit a final QAPP for review. The QAPP must be signed/fully approved by TCEQ and, if necessary, EPA, before any environmental data operations begin.

Subtask 2.3: QAPP Annual Reviews, Revisions, and Updates — The Performing Party will submit documentation certifying its annual review of the QAPP at least 90 days prior to the QAPP anniversary date. Amendments approved since the initial QAPP approval or a subsequent certified annual review (if applicable) must be submitted along with the certification. If extensive changes to a QAPP are necessary, a full revision/update is required. Once TCEQ certifies the annual review or approves the full revision/update, the QAPP effective period is extended an additional year. No work described in a QAPP will be conducted outside the effective period for the QAPP.

Subtask 2.4: QAPP Amendments — The Performing Party will submit Draft QAPP Amendments for TCEQ review when changes to the QAPP are necessary. Draft QAPP Amendments should be submitted at least 90 days prior to the scheduled initiation of changes and must be accompanied by a justification, summary of changes, and detail of changes. The Performing Party will submit Final QAPP Amendments within 30 days of receipt of any comments provided by TCEQ. Final QAPP Amendments will be submitted to TCEQ with the Performing Party's signatures and responses to comments and circulated for appropriate TCEQ signatures. The QAPP Amendments must be signed/fully approved by TCEQ and, if necessary, EPA, before any changes conveyed within Amendments are implemented.

Subtask 2.5: CARs— The Performing Party will provide CARs, as needed, to document deviations from data acquisition procedures, sampling method requirements or sample design, failures associated with chain-of-custody procedures or in field and laboratory measurement systems. The Performing Party will submit CARs with PRs.

Deliverables:

2.1 QAPP Planning Meeting and notes (meeting within 30 days of Contract execution; notes within seven days of meeting).
2.2 Draft QAPP (at least 120 days prior to the scheduled initiation of environmental data operations).
2.2 Final QAPP (30 days prior to the scheduled initiation of environmental data operations).
2.3 QAPP Annual Reviews and Revisions (at least 90 days prior to the QAPP approval anniversary).
2.4 Draft QAPP Amendments (at least 90 days prior to the scheduled initiation of changes or additions to activities listed in the current QAPP).
2.4 Final QAPP Amendments (within 30 days of receipt of TCEQ comments).
2.5 CARs (as needed with PRs).

Task 3: Water Quality Data Acquisition and Evaluation

Objective: To acquire, compile, and evaluate existing data, historical information, and other related information for use in watershed characterization, stakeholder education, and development of the Clear Creek WPP. The Performing Party will work with stakeholders to refine these evaluations.

Subtask 3.1: Compile and Evaluate Existing Data/Watershed Information — The Performing Party will acquire, compile, and evaluate existing data and information pertaining to water quality impairments and concerns in the watershed. The acquired data will be used for the purposes of evaluating water quality trends, determining potential sources of pollution, modeling efforts, and identifying management needs in Clear Creek.

The Performing Party will acquire and evaluate routine ambient sampling data from the Clear Creek watershed (collected under an approved Clean Rivers Program (CRP) QAPP) prior to and during the term of the project.

Water quality data to be acquired will include dissolved oxygen, temperature, pH, nutrients, chlorophyll-*a*, bacteria, total suspended solids, flow, and other constituents detailed in the approved QAPP. The Performing Party will evaluate data trends in indicator bacteria, applicable nutrients, and dissolved oxygen levels. Analyses will look for a general trend toward or away from compliance, seasonal variation, and any other aspect defined as pertinent by the Performing Party, TCEQ, and local partners during the development of the project.

The Performing Party will assess the existing data and information to determine if it allows for determination of sources and quantities of pollution. If data gaps are identified, the Performing Party will work with stakeholders to determine how to address them.

Subtask 3.2: Discharge Monitoring Report (DMRs) and Sanitary Sewer Overflow (SSO) Analysis — The Performing Party will acquire DMR and SSO data for the last five years for all permitted wastewater entities in the Clear Creek watershed. The Performing Party will evaluate the data for trends in volume by year, volume by cause, number of events by year, and number of events by cause for each reporting permitted entry.

The data evaluations for Clear Creek will be used to inform stakeholder discussions, evaluate wastewater as a pollutant source, and as inputs for Spatially Explicit Load Enrichment Calculation Tool (SELECT) and revised load duration curve (LDC) analyses for the Clear Creek WPP. Previous LDCs were developed under the Total Maximum Daily Load (TMDL) project.

Subtask 3.3: Data Analysis Summary Report — The Performing Party will develop a report describing, detailing, and summarizing all data evaluations to be presented in the Clear Creek WPP. The report will document the data acquired, the evaluation methodologies, and the analysis results.

Deliverables:

3.1 Documentation of data compilation and review (quarter 2, in Data Analysis Summary Report; updated in quarter 8).
3.2 Documentation of DMR/SSO analysis (quarter 2, in Data Analysis Summary Report; updated in quarter 8).
3.3 Draft Data Analysis Summary Report (quarter 3).
3.3 Final Data Analysis Summary Report (quarter 8).

Task 4: Modeling

Objective: To develop and refine modeling efforts for the Clear Creek watershed to identify extent, causes, and spatial distribution of bacterial contamination and reduction goals.

Subtask 4.1: LDCs — The Performing Party will develop LDCs (using a modified LDC approach for tidal segments) as needed for water quality impairments in the Clear Creek watershed to define conditions under which loading is occurring and to calculate the pollutant load reductions (or percent improvement) needed to meet water quality standards in the Clear Creek

watershed. The LDCs developed as part of the prior TMDL efforts will inform the development of the WPP effort.

Subtask 4.2: SELECT — The Performing Party will develop a SELECT model for Clear Creek to include the most current version of its data sources, and revise findings based on stakeholder feedback. SELECT will be used in the WPP to identify the relative prominence of bacteria sources, their spatial distribution, and the total potential bacterial load to the watershed. Both current and future condition runs will be updated.

Subtask 4.3: Modeling Report —The Performing Party will develop a report detailing activities conducted under this Task and summarize the results of the modeling for inclusion in the WPP.

Deliverables:

4.1 LDCs (quarter 4, month 2 in Modeling Report).
4.2 SELECT results (quarter 4, month 2 in Modeling Report).
4.3 Draft Modeling Report (quarter 4, month 2).
4.3 Final Modeling Report (30 days following TCEQ comments on the Draft Modeling Report).

Task 5: Stakeholder Coordination

Objective: To engage and maintain a stakeholder group representative of interests in the watershed, for the purpose of developing the WPP and coordinating related partnerships.

Subtask 5.1: Public Participation Plan (PPP) — The Performing Party will develop a PPP that details the strategy for engaging the public and stakeholders in the watershed planning process for the Clear Creek watershed. The PPP will, at a minimum, include 1) stakeholder group ground rules, 2) stakeholder group structure (i.e., steering committee, work groups) and membership, 3) stakeholder meetings topic/purpose and tentative schedule, and 4) a targeted outreach plan to increase public participation in the process.

Subtask 5.2: Clear Creek Watershed Partnership Formation — The Performing Party will compile and maintain a database of stakeholders and affected parties for use in engaging the public in the watershed planning process for each primary subwatershed area. A stakeholder group (the Clear Creek Watershed Partnership) will be established from this list and other interested parties and will represent a diverse cross section of the watershed stakeholders.

The Performing Party will maintain a record of individuals and organizations invited to meetings, as well as a sign-in sheet of attendees. The Performing Party will maintain a record of public comments via meeting notes, and coordinate with partners to document response to stakeholders.

Subtask 5.3: Communication with Stakeholders — The Performing Party will facilitate communication with stakeholders to engage the public and affected entities in the watershed planning process, assisted by local organizations helping to advertise and host meetings. The Performing Party will utilize all appropriate communication mechanisms including direct mail, e-mail, a project website, and mass media (print, radio, television) to the extent necessary to meet project communication goals. The Performing Party will submit all promotional material to the TCEQ Project Manager for review and approval at least two weeks prior to distribution or release.

Subtask 5.4: Stakeholder Facilitation — The Performing Party will facilitate public participation and stakeholder involvement in the watershed planning process, specifically through project meetings and related outreach activities. The Performing Party will coordinate meetings, secure

meeting locations, and prepare and disseminate meeting notices and agendas. Meeting summaries will be prepared and posted to the project website within 30 days after a meeting is held. Public meetings will be held at a minimum of every two months. The Performing Party will submit all meeting presentations, notices, agendas, and meeting summaries to the TCEQ Project Manager for review and approval at least two weeks prior to public dissemination.

Subtask 5.5: Attend Public Meetings — The Performing Party will attend and participate in other public meetings as appropriate to communicate project goals, activities, and accomplishments to affected parties. Such meetings may include, but are not limited to, city councils, county commissioners' courts, regional water supply planning, environmental flows, CRP Basin Steering Committee and Coordinated Monitoring, local soil and water conservation districts (SWCDs), Galveston Bay Council and subcommittee meetings, and other appropriate meetings of critical watershed stakeholder groups. Written approval from the TCEQ Project Manager will be required prior to attendance. The Performing Party will submit all meeting presentations, notices, agendas, and meeting summaries to the TCEQ Project Manager for review and approval at least two weeks prior to public dissemination. The Performing Party will attend a minimum of six of these types of meetings.

Subtask 5.6: Education and Outreach Events — The Performing Party will engage in education and outreach events whose purpose is to engage stakeholders, raise general awareness of watershed issues, or address specific water quality concerns raised in the WPP development process. The Performing Party will submit all meeting presentations, notices, agendas, and meeting summaries to the TCEQ Project Manager for review and approval at least two weeks prior to public dissemination.

The Performing Party will seek to support and coordinate with events and meetings held by partners that are relevant to WPP goals (e.g. Texas Watershed Stewards, etc.). The Performing Party will attend at least two partner events in the watershed for the purpose of public outreach and education and will seek to attend and present information on the project at local events, festivals or other appropriate venues as determined by approval from TCEQ. The Performing Party will host a Trash Bash event (at a location in or adjacent to a park west of Interstate-45) and Texas Stream Team training event within the watershed as specific outreach and stakeholder engagement activities.

Subtask 5.7: Stakeholder Outreach Task Report — The Performing Party will submit a report summarizing activities completed under this Task.

Deliverables:

5.1 Draft PPP (quarter 1, month 2).
5.1 Final PPP (30 days following TCEQ comments on the Draft PPP).
5.2 Stakeholder outreach list (with PRs).
5.3 Documentation of communication with stakeholders (with PRs).
5.4 Documentation of project stakeholder meetings, including meeting notices, materials, presentations, agendas, attendance lists, and summaries (held once every two months, documented within 30 days to TCEQ).
5.5 Documentation of public meetings attended, including dates with brief summaries of topics discussed (minimum of 6; summaries submitted within 30 days of meeting to TCEQ).
5.6 Documentation of education and outreach events attended (within 30 days of event to TCEQ).
5.6 Documentation of partner events attended, including dates with brief summaries (documented within 30 days of event to TCEQ).
5.6 Documentation of Trash Bash and Stream Team training events hosted (within 30 days of event to TCEQ).

5.7 Draft Stakeholder Outreach Task Report (quarter 8, month 1).
5.7 Final Stakeholder Outreach Task Report (30 days following TCEQ comments on Draft).

Task 6: On-site Sewage Facility (OSSF) Outreach and Remediation

Objective: To provide OSSF outreach and education to homeowners and to coordinate the replacement or repair of at least two failing OSSFs.

Subtask 6.1: OSSF Outreach — The Performing Party will provide targeted outreach material for OSSFs through existing homeowner and real estate inspector training courses utilized under prior WPP projects. A summary of workshop attendance and sign-in sheets will be provided to TCEQ.

Subtask 6.2: OSSF Remediation — The Performing Party will facilitate the replacement or repair of at least two failing OSSFs in coordination with their Failing OSSF Replacement Program. The Performing Party will solicit bids from licensed OSSF approved installers maintained by local Authorized Agents (AA). The OSSF professional and homeowner will apply directly to the AA for a permit, which will be issued before any work commences. The Performing Party will inspect the system prior to any work being performed and will also inspect the installation/repair as it occurs, including photographic documentation of the work being performed. Performing Party will comply with federal and applicable state law in connection with procurement of any services under the Contract (including 2 CFR 200.318 through 200.327).

Deliverables:

6.1 Documentation of OSSF Outreach (with PRs).
6.2 Documentation of OSSF Remediation (with PRs).

Task 7: WPP Development

Objective: To facilitate the development of a WPP through a stakeholder-driven process.

Subtask 7.1: Timeline Development and Review Plan — The Performing Party will develop a timeline and stakeholder document review plan at the beginning of the project. The review plan will include submittal of the WPP to TCEQ for review, submittal of the WPP to EPA for review, and submittal by TCEQ of the final WPP to EPA for acceptance. The Performing Party will work with stakeholders to address all comments received by the public, TCEQ, and EPA.

Subtask 7.2: WPP Development — The Performing Party in collaboration with stakeholders and partners, will develop a WPP for the Clear Creek watershed that is consistent with and satisfies the nine key elements fundamental to watershed-based plans. The Performing Party will submit a draft WPP to TCEQ for review and respond to comments. The WPP will address all parameters of impairment and concern as listed in the 2016 *Texas Integrated Report of Surface Water Quality*.

Subtask 7.3: Respond to EPA Comments — The Performing Party will respond to comments received from EPA and if needed, conduct conference calls to address comments. A final revised draft will be submitted to TCEQ, who will subsequently submit to EPA.

Subtask 7.4: Executive Summary — The Performing Party will develop an executive summary style document, based on the WPP, which will serve as a public outreach tool to garner support

for the implementation of the WPP and achieve long term sustainability. This document will be reviewed by stakeholders and TCEQ for approval prior to distribution.

Subtask 7.5: Disseminate Documents — The Performing Party will make the WPP and Executive Summary documents available to stakeholders through the project website. The Performing Party will submit two hard copies and one electric copy of the EPA-accepted WPP to the TCEQ Project Manager.

Deliverables:

7.1 WPP timeline and document review plan (quarter 2, month 3).
7.1 Draft WPP sections to stakeholders (quarters 3-9).
7.1 Draft WPP to stakeholders (quarter 9, month 2).
7.1 Address stakeholder comments (within 30 days after receipt of comments).
7.2 Draft WPP to TCEQ (quarter 10, month 2).
7.2 Address TCEQ comments (within 30 days after receipt of comments).
7.2 Final WPP to TCEQ (quarter 10, month 2).
7.3 Address EPA comments (within 30 days after receipt of comments).
7.3 Final WPP To TCEQ for submittal to EPA (quarter 11, month 2).
7.4 Draft Executive Summary (30 days following WPP acceptance from EPA).
7.4 Final Executive Summary (15 days following receipt of TCEQ comments).
7.5 Executive Summary and EPA-accepted WPP posted to the website (within 90 days following EPA acceptance of WPP).
7.6 Two hard copies and one electronic copy of EPA-accepted WPP submitted to TCEQ (at least one week prior to the end of the Contract).

Task 8: Final Report

Objective: To produce a Final Report that summarizes all activities completed and the amount of funds spent on the project.

Deliverables:

8.1 Final approved PR as Final Report (at least one week prior to the end of the Contract).

APPENDIX B.
CORRECTIVE ACTION PLAN FORM

Appendix B - Corrective Action Plan Form

Nonconformance Report and Corrective Action Plan
QAPP Title:_____ **QAPP Contractor: _____** **Issued by:_____ Date of Occurrence:_____** **Report No.:_____ Date Issued:_____**
Description of deficiency
Root Cause of deficiency
Programmatic Impact of deficiency
Does the seriousness of the deficiency require immediate reporting to the TCEQ? If so, when was it reported?
Corrective Action to address the deficiency and prevent its recurrence
Proposed Completion Date for Each Action
Individual(s) Responsible for Each Action
Method of Verification
Date Corrective Action Plan Closed?

Example Corrective Action Plan Form

Nonconformance Report and Corrective Action Plan
QAPP Title: Watershed Protection Plan Implementation – LID BMP Monitoring QAPP **QAPP Contractor:** River Authority **Issued by:** Jane Doe **Date of Occurrence:** 7/15/2014 **Report No.:** 1 **Date Issued:** 7/25/2014
Description of deficiency The pavement monitoring station at the university is measuring a larger runoff volume than is estimated possible. Runoff measured is higher than the total precipitation volume calculated by multiplying the catchment area by the precipitation measured at the site.
Root Cause of deficiency (1) It is possible that the drainage area was not measured accurately, it may be larger. (2) The outfall of the monitoring station might not adequately allow runoff to flow through causing pooling around the flow-measuring point. The accumulation of non-flowing water could be confounding the flow meter since its physical principal of measurement is hydrostatic pressure caused by water depth.
Programmatic Impact of deficiency The illogical results of the pavement runoff measurement indicate that further calibration of the equipment is necessary. Data collected at this event are not able to be used in analysis or results.
Does the seriousness of the deficiency require immediate reporting to the TCEQ? If so, when was it? Yes, it was reported to the TCEQ NPS Project Manager via email on 7/18/2014.
Corrective Action to address the deficiency and prevent its recurrence A survey will be conducted on the site to determine the ridge of the catchment area. A wider and deeper channel will be dug out at the monitoring point outfall to ensure all the flow drains away from the measuring point. Storm event runoff will not be measured at this site until this work has been completed.
Proposed Completion Date for Each Action 8/15/2014
Individual(s) Responsible for Each Action David Lopez, Contractor Project Manager
Method of Verification Results of the catchment area survey will be emailed to the TCEQ NPS Project Manager. Photos of the modified measurement site will be emailed to the TCEQ NPS Project Manager.
Date Corrective Action Plan Closed? *The TCEQ NPS Project Manager will provide a closed date once the corrective action has been verified.*

APPENDIX C.
CORRECTIVE ACTION PLAN STATUS FORM

Corrective Action Status Table

Corrective Action #	Date Issued	Description of Deficiency	Action Taken	Date Closed

Corrective Action Status Table Example

Corrective Action #	Date Issued	Description of Deficiency	Action Taken	Date Closed
1	7/25/2014	Runoff measured at pavement was greater than total area runoff.	The area is being surveyed to ensure the catchment area size is correct. The monitoring station location is being modified to ensure runoff flows through properly.	
2	8/1/2014	Sample residual insufficient for analysis of TSS.	Data estimated but questionable, not will not be submitted to TCEQ.	8/8/2014

APPENDIX D.
ADHERENCE LETTER

Appendix D. Example Letter to Document Adherence to the QAPP

TO: *(name)*
(organization)

FROM: *(name)*
(organization)

RE: Houston-Galveston Area Council, Clear Creek Watershed Protection Plan Modeling Quality Assurance Project Plan

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

(*Address)*

I acknowledge receipt of the "Clear Creek Watershed Protection Plan Modeling Quality Assurance Project Plan". I understand the document describes quality assurance, quality control, data management, and reporting, and other technical activities that must be implemented to ensure the results of work performed will satisfy stated performance criteria.

My signature on this document signifies that I have read and will comply with the document contents pertaining to my program. Furthermore, I will ensure that all staff members participating in modeling activities will be required to familiarize themselves with the document contents and adhere to them as well.

_____

Signature Date

Note: Copies of the signed letter should be sent by the Lead Organization to the TCEQ NPS Project Manager within 30 days of the final TCEQ approval the QAPP. This letter should be submitted for all subcontractors that did not sign the QAPP (under section A1 of this QAPP).

Appendix E.

H-GAC DATA MANAGEMENT PLAN

Appendix E. H-GAC Data Management Plan

GEOSPATIAL DATA MANAGEMENT PLAN

Community and Environmental Planning Department
Houston-Galveston Area Council
3555 Timmons Lane
Houston, TX 77277

February 2019

INTRODUCTION

The Geospatial Data Management Plan (GDMP) outlines the standard policies and procedures for data management within the Community and Environmental Planning (C&E) Department. The GDMP covers the management of both tabular (non-geographic) and spatial (geographic) datasets. Its primary purpose is to ensure the efficient access and maintenance of these datasets within the C&E Geospatial/Geographic Information Systems (GIS) environment.

GIS technology provides a systematic means to capture, manipulate, analyze, store, and display spatially referenced data. GIS supports a wide variety of applications ranging from site assessments, environmental planning, urban planning, and spatial analysis to support organizational strategies. In general, GIS supports the overall departmental goals of guiding regional planning, enhancing the quality of the region's natural environment, and public education through outreach programs. The C&E GIS team supports various programs within the C&E department through data development, spatial analysis, geospatial applications development, cartography in support of departmental goals.

The GDMP is considered a dynamic working document which responds to changing technology, funding, staffing, and project requirements. Consequently, the GDMP is reviewed on an annual basis and amended as necessary.

GEOSPATIAL SERVICES

The following section explains the geospatial services provided by the H-GAC C&E GIS team as it relates to the sharing of data, development of geospatial applications, cartography, and underlying GIS resources. The C&E GIS team is responsible for the development of data and sharing of many publicly viable datasets, developing geospatial applications, cartography, and coordination of maintenance of underlying geospatial hardware and software for C&E.

The C&E GIS team maintains a centralized geospatial warehouse (C&E Spatial Database Engine (SDE)), an online mapping platform for web-based geospatial applications (Mapping Application), and a file transfer protocol (FTP) download site (Data Clearinghouse). The C&E spatial database engine (SDE) utilizes ESRI's ArcSDE software running on a Microsoft SQL server relational database management system. The mapping application uses ESRI's ArcGIS.com & ArcGIS Server platform running on .NET. The Data Clearinghouse is an FTP server (h-gac.sharefile.com) that provides C&E with storage space where it can post publicly available datasets for downloading.

The C&E SDE, Mapping Application, and Data Clearinghouse platforms are installed by the H-GAC Data Services department (Data Services), with Data Services maintaining only the lower-level technology components such as the physical hardware, software installation, and low-level server and relational database management system functions. All upgrades and maintenance are coordinated by the C&E GIS Manager. All geospatial content stored in the C&E SDE, the Data Clearinghouse, and Mapping Application, are the responsibility of the C&E GIS staff, which resides within the C&E Socio-Economic Modeling program. However, Data Service department maintains some of the other GIS data such as transportation, 911 address, and workforce solutions, and stored in a separate SDE that everybody in H-GAC has access to them. A detailed schematic of the geospatial technical architecture and how the various systems are interconnected can be found in the *System Architecture* section below.

DATA SHARING

The C&E SDE serves as the primary internal repository for geospatial data, metadata, and other information relevant to the activities and goals of the C&E department. All GIS users within C&E Socio-Economic Modeling program and users from other H-GAC departments are provided *Editor* access to data in the C&E SDE. All other users have only viewer access to data in the C&E SDE. H-GAC C&E staffs without *Editor* access to the C&E SDE server can access a copy of the geospatial data through a separate server that houses imported versions of the original SDE data to develop GIS layers for project specific editing. This system ensures that the original formatting of geospatial data on the C&E SDE remains unchanged. All user access privileges are assigned by the C&E GIS Manager based upon business needs, GIS skills, and role within the organization. No users outside of the C&E department have editor level access to any GIS data in the C&E SDE, and in some instances there are datasets that are viewable by only C&E GIS users. Instructions for connecting to the C&E SDE are provided to authorized users.

Datasets determined to be viable for publication to the public are exported to the Data Clearinghouse, thereby allowing the general public widespread access to this information via the internet. Members of the public may view metadata and download any of the datasets that are posted to the Data Clearinghouse. In some instances, these datasets are used in web-based interactive mapping applications and can be accessed online via the Mapping Server's services directory, or accessible via the Data Clearinghouse for downloading. The data sharing through downloading is facilitated through H-GAC's Sharefile system. All public C&E GIS data, applications, cartographic products, and the C&E map services directory can be accessed via "GIS, Imagery, & Online Mapping Tools" section of the H-GAC website. A screen shot of the website can be found in Appendix E.7.

GEOSPATIAL APPLICATIONS

The C&E department has made a strategic decision to incorporate internet-based mapping applications into its deliverables for many programs and projects. Before, the results of most projects consisted of a large-format map printed on a plotter up to 48"x36" in diameter. This form of cartography although still useful in many settings, did not allow programs to communicate results to the public or external organizations that had an interest in our analysis results. By taking results from C&E projects and coupling this with base map data and imagery, C&E has been able to share the results of projects to a far greater audience and has created opportunities whereby map layers published on the C&E mapping server can be utilized in other organizations mapping applications.

Currently there are two platforms upon which C&E provides web-based mapping solutions. The first platform is based on the JavaScript programming technology, and all mapping applications developed using this platform run on various operational systems including Windows, MacOS, ISO, and Android. This platform is intended to provide users with a graphics rich user interface whereby the map can be navigated, layers turned on/off, and information obtained on each feature. In some instances, features have links to additional resources such as photos of monitoring stations, external websites, and detailed reports. This mapping application technology allows the users to display its information on different screen-size devices including desktop, laptop, tablet, and mobile phone.

The second platform utilizes the capabilities of the ArcServer/Arcgis.com platform to allow users to directly access map layers published on the mapping server. This method of delivery is called ‘streaming’ and allows end users access to individual map layers and geoprocessing tools published on the server. Typical users of this method of delivery are other GIS users using ArcMap GIS, whereby they can connect directly to our ArcServer platform for read-only access and view our map layers. Other instances whereby www.arcgis.com’s users may utilize this method is where they are including our map layers in their own mapping applications.

MAPPING AND CARTOGRAPHIC PRODUCTS

The C&E produces a variety of static cartographic maps for the region because of project activities and for general usage. To facilitate the sharing of these maps in an electronic format, C&E has implemented a Map Book as part of their C&E GIS page. Maps can be downloaded in multiple formats. The C&E Map Book can be accessed via our C&E GIS page at https://www.h-gac.com/map-book/default.aspx.

SYSTEM RESOURCES/SYSTEM ARCHITECTURE

The C&E department uses an integrated architecture to support the development, analysis, and dissemination of spatial information. The diagram below (Figure B.1) illustrates this system architecture at a high level. The goal of the overall system is to allow for a streamlined workflow to develop/maintain data, optimize the data for use in online applications, and the consumption of applications via multiple platforms.

Currently the C&E GIS platform supports sharing of geospatial data via the ArcServer mapping server platform. This allows end users internally or externally to consume map layers and geoprocessing tools via GIS desktop, mobile, tablet, or interactive applications.
In some instances, applications are configured with public feedback and volunteer GIS workflows that allow the C&E GIS team to obtain information for the public on various geographic features in the region. This public feedback loop allows C&E to investigate feedback and verify its validity prior to incorporating the information into the data warehouse.

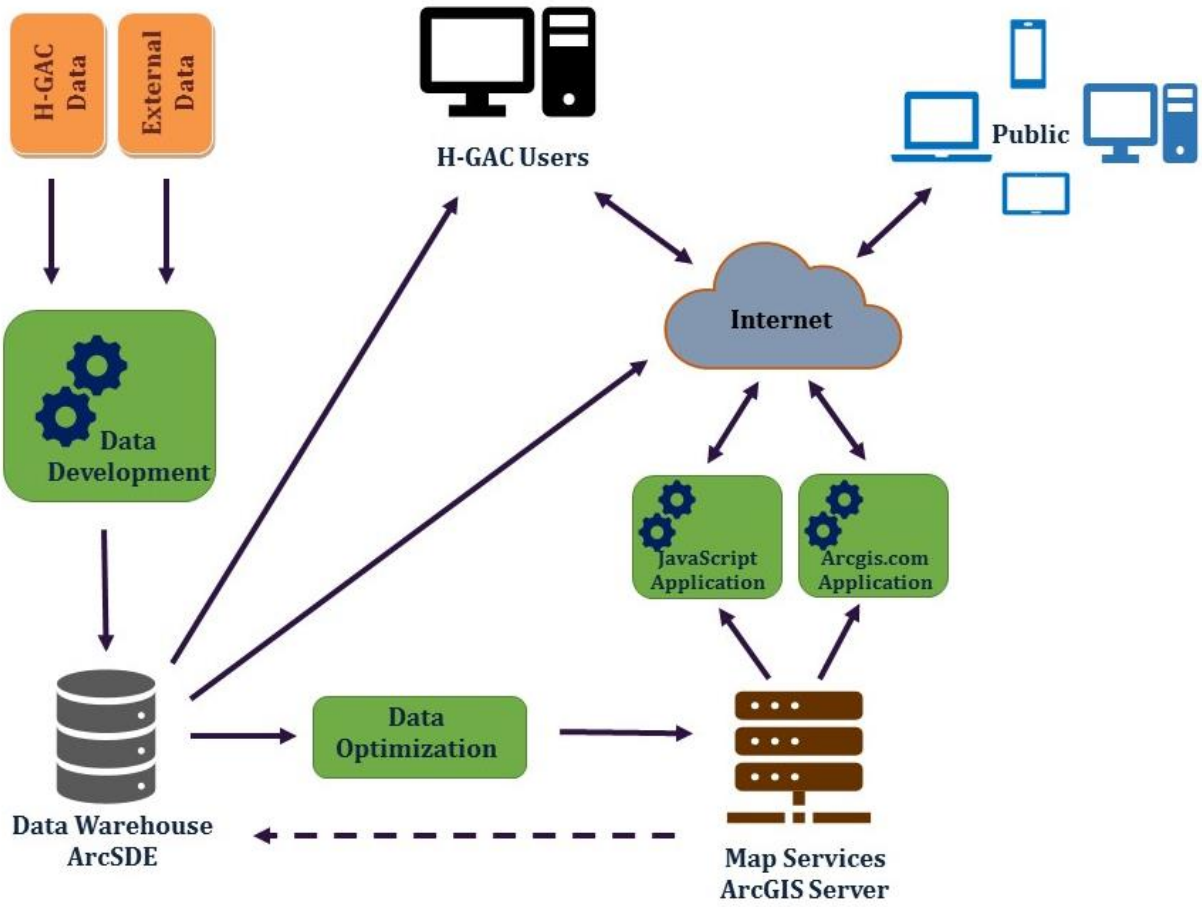


Figure B.1: H-GAC Geospatial System Architecture

HARDWARE

The configuration of the hardware used by staff that performs GIS and data Management work is a distributed network. This network consists of several PC's which are connected to central file servers. The department also uses a central web mapping server for online mapping applications.

A complete listing of departmental hardware is found in Appendix E.3.

SOFTWARE

The C&E department relies upon the H-GAC Data Services department (Data Services) for its end user workstation configuration, installation, and maintenance. Each workstation for users comes with the Microsoft Office software package which includes Outlook (e-mail), Word (word processing), Excel (spreadsheets), PowerPoint (presentations), and in some instances Access (desktop database) should the user require desktop database capabilities. Each workstation is pre-configured and setup to operate within the H-GAC internal network and has access to central servers for file storage.

The C&E GIS staff utilizes ESRI's ArcGIS 10.5 platform for all geospatial analysis and mapping needs. In addition, as needed, the staff also utilizes the SAS and ENVI software platforms for further analysis and data development as deemed necessary. The ESRI ArcGIS 10.5 platform includes integrated Python programming capabilities, which allows for the creation of programming scripts or batch programs to improve efficiency and documentation of processes.

The Python programming language is an Open Source platform and is freely distributable.

The centralized SDE is also provided by ESRI and provided for a centralized geospatial database where GIS staff can store geospatial data for either read-only or editable access by GIS users in the C&E department. The C&E GIS staff maintains access privileges to the SDE datasets and assigns individual users to various SDE access groups to grant approved accessed to data in the SDE. The SDE is considered the central warehouse where GIS users can go to for geospatial data to use in their analysis or mapping projects.

The software products currently used to accomplish the department's data management objectives are listed in Appendix E.4.

PROGRAMMING LANGUAGES

Programming services will be provided on an as needed and resource available basis. All programming efforts will follow a standard procedure from needs assessment, program planning, development and testing, to refinement and documentation. The principal programming languages to be used in task automation and project customization will depend on the nature of the need and the current state of the technology. At this time, all web-based GIS applications are developed using the ESRI ArcGIS Server platform, and user interface components to that platform are developed using the ESRI JavaScript API. Automated data development and analysis workflows utilize the Python programming language and the SAS programming platform as needed.

DATA

Department staff members will be consulted annually to determine priority needs for data management. Based on this consultation, specific data sets will be acquired or further developed for the various program areas represented in the department. The current list of department-specific data sets is shown in Appendix E.5.

A separate database lists all datasets regularly obtained from external sources, contact information, as well as the frequency of the datasets availability, and its cost. This database is developed using Microsoft Excel and is available to the C&E GIS team for tracking when updates to dataset may be available.

PERSONNEL

The Data Management staff will be responsible for the maintenance and development of the C&E SDE, mapping server, geospatial applications, C&E GIS page, and Data Clearinghouse. These data management responsibilities cover a wide range from original data creation, acquisition and integration, data archiving and distribution. Additional responsibilities include enhancing the geographic extent, feature attributes, and metadata of the datasets.
The C&E GIS team is comprised of 9 full-time GIS and data analysis professionals. The C&E GIS team supports all programs within the C&E department, which include CRP/Water Quality, Sustainability, Economic Development, Solid Waste, Ped/Bike, Socio-Economic Modeling, and special project. The C&E GIS team is part of the Socio-Economic Modeling program within C&E.

H-GAC's Data Services Department plays an indirect role in the implementation and maintenance of GDMP. The Data Services Department is responsible for managing the

underlying hardware and network upon which C&E stores GIS data and implements GIS-based applications.

TRAINING
Training for all users of the system is a critical part of the GDMP. C&E staff directly responsible for data management will attend conferences, seminars, and software/hardware training courses as needed. H-GAC users of the system will be trained and/or receive technical support by the C&E GIS Manger and other C&E subject matter experts.

BUDGET
Budgetary requirements to sustain data management efforts will be reviewed annually.

DATA MAINTENANCE, MANIPULATION, AND USE
Quality Assurance/Quality Control
QA/QC is designed to standardize screening, documentation, entry, output, analysis, correction, and updating of data in the system. QA/QC will document those responsible for data and system maintenance.

DATA LIMITATIONS
Prior to the integration of data within the C&E SDE and posting to the Data Clearinghouse, a review of the data set will be completed to determine predefined data limitations such as missing values, different sampling frequencies, multiple measurements, analytical uncertainty, censored or unavailable data, and duplicated data with existing data sets. After review of the data set, a report will be generated which records any errors detected and any corrections that may be necessary.

DATA DEVELOPMENT PROTOCOL
The C&E GIS staff works to update existing dataset, acquire new data, and perform geospatial analysis in support of various C&E programs. All new data generated from the result of an analysis is a candidate to be stored not only in the SDE as a new dataset, but also as a layer with a mapping application should the need arise. All data development and analysis are done internally to C&E, and at times leverages outside resources such as consultants, other non-profits whom H-GAC is partnering with, as well as with other H-GAC departments to obtain necessary data. Two datasets that the C&E department uses regularly outside the C&E SDE are the Data Services StarMap road centerline dataset and the Data Services aerial imagery database.

The C&E GIS staff uses a hybrid approach to conducting geospatial analysis. Much of the analysis being performed may need to be re-processed later as new versions of datasets become available, or as inputs to the analysis models are updated themselves. Thus, to minimize the time spent re-running analysis models, the C&E GIS staff utilizes the ESRI ArcGIS platform in conjunction with SAS and Python to develop repeatable and documented workflows. This approach saves more time than interactive methods whereby a user must remember the process to follow, and then execute each step in the analysis independently.
Documentation related to data management efforts such as system evolution, structure, and procedures for use will be compiled and made available for the end user. Documentation will be made available online and in hard copy format.

DATA INPUT

Standard conventions for data input will be determined on a per project and/or individual data set basis. To ensure Year 2000 Compliance, all data sets with date/time fields will include a four-digit year (YYYY). Either of the following formats will be used: International Standard Date notation where the date field is represented as MM/DD/YYYY (Month/Day/Year), or an ordinal format where the date field is represented as YYYYDDD.

DATA DICTIONARY

A list of all H-GAC data available in either the C&E SDE or other agency wide SDE can be found in Appendix E.5.

METADATA

Metadata is data about the original source, quality, content, history, condition, and other characteristics of the geospatial data. All GIS datasets generated by H-GAC have been fully documented as per Federal Geographic Data Committee (FGDC) compliant metadata and follow Content Standards for Digital Geospatial Metadata (CSDGM) for all geospatial data. Similarly, data obtained from outside sources and used by H-GAC will include FGDC-compliant metadata from the source agency. Datasets without a known history and documented quality will be identified as provisional and used only when noted as such. The diagram below illustrates elements of the CSDGM standards (Figure B.2). This standard is applied to all Point, Line, Polygon, Raster, and Tabular data that are stored in the C&E SDE. The C&E GIS data manager and/or point of contact (designee) has the authorized access to edit/change the metadata when a new dataset is created or updated in the SDE. Metadata for each dataset in the C&E SDE is stored with the datasets and can be viewed by GIS users via their GIS desktop software. Any data provided for public download via the Data Clearinghouse also has a metadata html page that can be viewed via internet browsers.

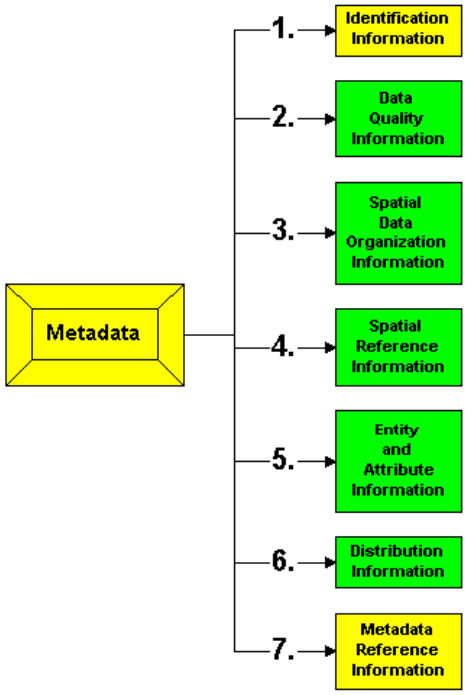


Figure B.2: Elements of CSDGM Standards

DATA CONVERSION

Data to be imported into the C&E SDE from hard copy, digital or by manual data entry, will

follow a uniform conversion protocol to comply with the structure of current data sets. The type of data being converted will determine the protocol. All data is stored in ESRI geodatabase format within the C&E SDE, and when posted to the Data Clearinghouse the data is stored in the ESRI File Geodatabase file format, unless there is a specific requirement to provide the data in another format such as Shapefile or GIS Coverage.

COORDINATE SYSTEMS
The Texas Stateplane Coordinate System, North American Datum 1983 (NAD83) will be the standard for geographic data at H-GAC. This coordinate system is based on the Cartesian coordinate system, or rectangular coordinates. When receiving geographic data from other sources the data will be transformed into the Stateplane Coordinate System to ensure compatibility with current data sets.

When publishing mapping services for use in web-based GIS mapping applications, the Web Mercator Auxiliary Sphere projection is used for all Data Frame projections. However, the underlying GIS data within these mapping services still use the Texas Stateplane Coordinate System, NAD83 projection.

DATA VALIDATION/DATA QUALITY CONTROL
When data are received from any source, documentation will be created to include the source name, date received, format of data and a brief description of the contents. Data will be loaded onto the system from the media received and a review of the data will be made along with any corrections being made to the source documentation. An analysis will be made to determine the means of data entry into the system whether it is only a stand-alone database, a number of linked tables, or a geographic database.

The data will be converted to the appropriate format for integration with the current system whether it is a conversion into Microsoft Access, Excel, SAS, or ESRI ArcGIS. The data will be visually examined to determine its validity and accuracy. If the data is invalid it will be corrected (if possible) otherwise the data will be incorporated into the C&E SDE, and then if applicable, posted to the Data Clearinghouse and used in conjunction with existing data. A QA/QC report of all procedures and a detailed description of how the data was incorporated into the current system (from the date received to the date of integration) will be generated.

EQUIPMENT QUALITY CONTROL
All printers, workstations, and server hardware and operating systems are maintained by the Data Services department, unless otherwise noted in Appendix E.3.

GENEALOGY
Upon receipt of data from outside sources, all data will be screened for integrity and completeness. After the preliminary evaluation of the data, a log of the data source, type and completeness is created and maintained with the associated data. A description of the data and the responsible personnel are documented.

MIGRATION/TRANSFER
A copy of every C&E generated GIS dataset will be housed in the C&E SDE which C&E GIS staff manage the contents and structure of datasets. The underlying hardware and network connections for the C&E SDE are maintained by the Data Services Department. Datasets that are

of public interest will be placed in the Data Clearinghouse for public access. Transfer from the C&E SDE to the Data Clearinghouse will occur on an as needed basis following department QA/QC measures and is handled by the C&E GIS team.

DATA SECURITY & ACCESS

Data placed on the Data Clearinghouse will be available to those with Internet browsing and/or FTP capability. Data requests for non-public data from other agencies and the public will be evaluated on an individual basis. When the data requests are received, a preliminary evaluation of the deliverable will be determined and a timeline and cost if applicable will be provided to the requesting agency or individual.

GIS and tabular data will be secure through directory permissions. H-GAC will employ Firewall or Proxy Server Technology to filter and severely restrict access to internal networks and database systems. Virus protection will be implemented to ensure system and data integrity.

ARCHIVES/BACKUP

Each week the C&E GIS team runs a schedule backup program to store a copy of all C&E SDE datasets on a portable hard drive with resides in a secure location within the H-GAC office. In addition, Data Services backs up and archives C&E SDE data and server configuration at regular intervals.

DISASTER RECOVERY

In the event of a disaster, the C&E will have access to all C&E SDE data which is stored on the portable hard drive. The C&E GIS team will restore or provide needed data to GIS users from this portable hard drive until such as time that Data Services can restore the C&E SDE onto either a new server or a temporary server.

APPENDICES
APPENDIX E.1 DATA SOURCE INFORMATION SHEET
Data Title:

Source Agency:
Contact:
Title:
Address
Phone:

Data Description:
Data source:
Date created:
Accuracy:
Media:
Data items:

Description of data:

Format (specify what software)
Map:
Tabular:
Image:
Text:

Retrieval Procedure:

Command(s):

APPENDIX E.2 DATA LOG SHEET

Date received: _____

Report Prepared by: _____

Source Name and Phone: _____

Format: _____

Media: _____

Check the following steps to determine the validity of the data:

1. What is the extent of the geographic area? _____
_____

2. Structure (Circle One) Vector Raster

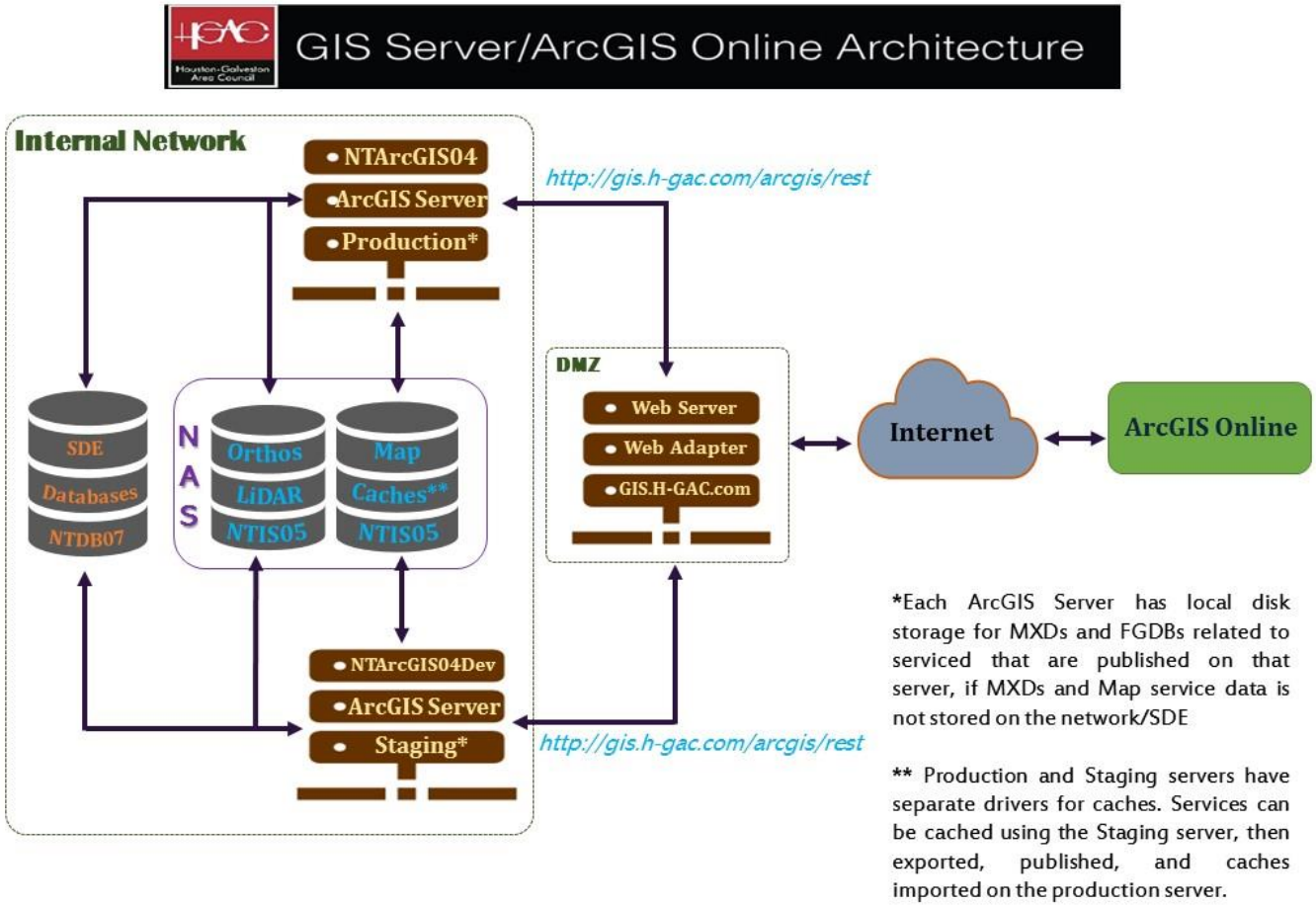
3. Scale? _____

4. Projection and Datum? _____

1. Do any of the key fields have missing values? If so, which parameters have missing values? Yes ___ No ___
_____
_____
_____

2. Any known duplicate records? Yes ___ No ___

APPENDIX E.3 HARDWARE
FTP SERVER
h-gac.sharefile.com
MAPPING APPLICATION SERVERS



PLOTTERS, PRINTERS AND SCANNERS
HP1055CM Plotter - Used by all H-GAC staff for large format printing of maps and schematics.
Xerox Workcenter 7845 and Cannon Advanced 4545 Printers and scanners. C&E maintains both printers.

GLOBAL POSITIONING SYSTEM (GPS) UNITS
The C&E Department possesses two GPS units.

FAX EQUIPMENT
Brother Intellifax 4750e. The C&E Department owns one fax machine.

APPENDIX E.4 SOFTWARE

OFFICE PRODUCTIVITY SOFTWARE
Microsoft Office 365 - Word, Excel, Access, PowerPoint, publisher, InfoPath and Outlook.

GRAPHICS AND DESKTOP PUBLISHING
Adobe Illustrator (ver 8.01) – Graphics
Adobe Photoshop (ver 5.0) – Graphics
Camtasia Studio (ver 7.0) – Screen capture and video tutorial production

PROGRAMMING
Microsoft Visual Studio – Web Mapping Development Tool.
Web AppBuilder for ArcGIS (ver 1.8) – Web-based GIS application development tool
SAS (ver 9.4) – Data development and analytics.

GIS
ESRI ArcGIS (ver 10.5) – Computer mapping and database manipulation capable of using ArcView, ArcInfo, and ArcEditor licenses as needed.
ESRI ArcGIS Server (ver 10.2, SP3) – Internet Mapping Application Server.
ESRI ArcSDE (ver 10.2, SP1) – Spatial data warehouse.
ENVI Remote Sensing Data Analysis Package – Harris Geospatial

DATA MANAGEMENT
Microsoft Access (365) - Relational Database.
SQL Server (2012) - Relational Database.

OPERATING SYSTEMS
Windows 7 - PC working environment/Operating System
Windows 10 - PC working environment/Operating System
Windows 2012 & 2016 - Server Operating Systems

APPENDIX E.5 DATA LIST

H-GAC SPATIAL DATA WAREHOUSE (SDE) DATASETS

Dataset Name	Type
ACE_2017\ACE_HEX_2017	Polygon
ACE_2017\ACE_HEX_2017_pt	Point
Apartment_Input	Point
Appraisal_2014\BZ_2014_org	Polygon
Appraisal_2014\CH_2013_org	Polygon
Appraisal_2014\FB_2014_org	Polygon
Appraisal_2014\GV_2014_org	Polygon
Appraisal_2014\HR_2014_org	Polygon
Appraisal_2014\LB_2014_org	Polygon
Appraisal_2014\MG_2013_org	Polygon
Appraisal_2014\WA_2014_org	Polygon
Austin_County_Commissioner_Precincts	Polygon
Barker_and_Addicks_Reservoir_Watersheds	Polygon
BlueMap \ActivityPopulationDensity	Polygon
BlueMap \EmploymentDensity	Polygon
BlueMap \HouseholdPopulationDensity	Polygon
BlueMap \IntersectionDensity	Polygon
BlueMap \Jobs_Household_Ratio_1500	Polygon
BlueMap \Jobs_Household_Ratio_above_1500	Polygon
BlueMap\RoadwayDensity	Polygon
BlueMap_2000\ActivityPopulation_2000	Polygon
BlueMap_2000\Employment_2000	Polygon
BlueMap_2000\HouseholdPopulation_2000	Polygon
BlueMap_2000\Intersection_2000	Polygon
BlueMap_2000\Job_HH_Ratio_2000	Polygon
BlueMap_2015\ActivityPopulation	Polygon
BlueMap_2015\Employment	Polygon
BlueMap_2015\HouseholdPopulation	Polygon
BlueMap_2015\Intersection	Polygon
BlueMap_2015\Job_HH_Ratio_above_2000	Polygon
BlueMap_2016\Accessibility_Score_2016	Polygon
BlueMap_2016\ActivityPopulation_2016	Polygon
BlueMap_2016\Amenity_Index_2016	Polygon
BlueMap_2016\Employment_2016	Polygon
BlueMap_2016\HouseholdPopulation_2016	Polygon
BlueMap_2016\Intersection_2016	Polygon
BlueMap_2016\Job_HH_Ratio_2016	Polygon
BlueMap_ActivityPopulation	Polygon
BlueMap_Comparison\HP_2000	Polygon

BlueMap_Comparison\HP_2016	Polygon
BlueMap_Comparison\INT_2000	Polygon
BlueMap_Comparison\INT_2016	Polygon
BlueMap_Comparison\J_2000	Polygon
BlueMap_Comparison\J_2016	Polygon
BlueMap_Comparison\JP_2000	Polygon
BlueMap_Comparison\JP_2016	Polygon
BlueMap_Comparison\Ratio_2000	Polygon
BlueMap_Employment	Polygon
BLUEMAP_HEX	Polygon
BLUEMAP_HEX_2015	Polygon
BLUEMAP_HEX_2016	Polygon
BLUEMAP_HEX_2016_Pedestrian_Demand_Index	Polygon
BLUEMAP_Property_Value_HEX	Polygon
Brazoria_County_Commissioner_Precincts	Polygon
Brazos_Transit_District_Bus_Routes	Polyline
Brazos_Transit_District_Park_and_Rides	Point
Buildings	Point
Cedar_Bayou_Watershed_Project_Monitoring_Sites	Point
CensusTracts_MB	Polygon
Chambers_County_Commissioner_Precincts	Polygon
City_of_Conroe_ETJ	Polygon
City_of_Huntsville_ETJ	Polygon
City_of_Missouri_City_ETJ	Polygon
City_of_Pearland_ETJ	Polygon
City_of_Texas_City_ETJ	Polygon
Clean_Rivers_Public_Feedback	Point
Clean_Rivers_Public_Feedback__ATTACH	Table
COH_Boundaries	Polygon
COH_Boundaries_census	Polygon
COH_Boundaries_census_new	Polygon
CoH_Council_Districts	Polygon
CoH_ETJ	Polygon
CoH_Historical_Districts	Polygon
CoH_Police_Districts	Polygon
CoH_Street_Pavement_Edges	Polyline
CoH_Traffic_Signals	Point
CoH_Traffic_Signs	Point
Colorado_County_Commissioner_Precincts	Polygon
Colorado_Valley_Transit_Bus_Routes	Polyline
Connect_Transit_Bus_Routes	Polyline
Conroe_Transit_Bus_Routes	Polyline

Critical_Facilities_2017	Point
CRP_HUC12_RPS_updated	Polygon
CRP_MonitoringStations_Subwatersheds	Polygon
CRP_Project_Areas	Polygon
EPA_Eco_Regions	Polygon
FEMA_Floodplains_DFIRM_Q3_2010	Polygon
FEMA_Floodplains_NFHL_2015	Polygon
Fort_Bend_County_Commissioner_Precincts	Polygon
Fort_Bend_Transit_Bus_Routes	Polyline
Galveston_Bay_Estuary_Program_Watersheds	Polygon
Galveston_County_Commissioner_Precincts	Polygon
Gulf_Of_Mexico	Polygon
Harris_County_Commissioner_Precincts	Polygon
Harris_County_Constable_Precincts	Polygon
Harris_County_FCD_Sub_Watersheds	Polygon
Harris_County_FCD_Watersheds	Polygon
Harris_County_Sheriff_Districts	Polygon
Harris_County_Transit_Bus_Routes	Polyline
Harris_County_Zones_58	Polygon
HGAC_13_County_ACS_2014\BGs_2014	Polygon
HGAC_13_County_ACS_2014\Census_Places_2014	Point
HGAC_13_County_ACS_2014\Census_Tracts_2014	Polygon
HGAC_13_County_ACS_2014\Counties_2014	Polygon
HGAC_13_County_ACS_2014\Zips_2014	Polygon
HGAC_13_County_ACS_2015\BGs_2015	Polygon
HGAC_13_County_ACS_2015\BGs_Vulnerable_2015	Polygon
HGAC_13_County_ACS_2015\Census_Places_2015	Polygon
HGAC_13_County_ACS_2015\Census_Places_pt_2015	Point
HGAC_13_County_ACS_2015\CEnsus_Tracts_2015	Polygon
HGAC_13_County_ACS_2015\Counties_2015	Polygon
HGAC_13_County_ACS_2015\Places_poly_2015	Polygon
HGAC_13_County_ACS_2015\Zips_2015	Polygon
HGAC_13_County_ACS_2015_Blockgroup_summary	Polygon
HGAC_13_County_ACS_2016\BGs_2016	Polygon
HGAC_13_County_ACS_2016\BGs_Veterans_2016	Polygon
HGAC_13_County_ACS_2016\BGs_Vulnerable_2016	Polygon
HGAC_13_County_ACS_2016\Counties_2016	Polygon
HGAC_13_County_ACS_2016\Counties_TX_Veterans_2016	Polygon
HGAC_13_County_ACS_2016\ISDs_2016	Polygon
HGAC_13_County_ACS_2016\Places_poly_2016	Polygon
HGAC_13_County_ACS_2016\Places_pt_2016	Point
HGAC_13_County_ACS_2016\Tracts_2016	Polygon

HGAC_13_County_ACS_2016\Zips_2016	Polygon
HGAC_13_County_ACS_2016_Blockgroup_summary	Polygon
HGAC_13_County_ACS_2017\BGs_2017	Polygon
HGAC_13_County_ACS_2017\BGs_Vulnerable_2017	Polygon
HGAC_13_County_ACS_2017\Counties_2017	Polygon
HGAC_13_County_ACS_2017\ISDs_2017	Polygon
HGAC_13_County_ACS_2017\Places_poly_2017	Polygon
HGAC_13_County_ACS_2017\Places_pt_2017	Point
HGAC_13_County_ACS_2017\Tracts_2017	Polygon
HGAC_13_County_ACS_2017\Zips_2017	Polygon
HGAC_13_County_ACS_2017_Housing\ACS_Housing_Counties_2017	Polygon
HGAC_13_County_ACS_2017_Housing\ACS_Housing_Places_2017	Polygon
HGAC_13_County_ACS_2017_Housing\ACS_Housing_Tracts_2017	Polygon
HGAC_13_County_Airports	Point
HGAC_13_County_Airports_ParcelIDs	Table
HGAC_13_County_Brownfield_Sites	Point
HGAC_13_County_Closed_Landfill_Inventory	Point
HGAC_13_County_CRP_DO_Stations	Point
HGAC_13_County_CRP_Monitoring_Stations_2008	Point
HGAC_13_County_CRP_Monitoring_Stations_2010	Point
HGAC_13_County_CRP_Monitoring_Stations_2011	Point
HGAC_13_County_CRP_Monitoring_Stations_2012	Point
HGAC_13_County_CRP_Monitoring_Stations_2013	Point
HGAC_13_County_CRP_Monitoring_Stations_2014	Point
HGAC_13_County_CRP_Monitoring_Stations_2015	Point
HGAC_13_County_CRP_Monitoring_Stations_2016	Point
HGAC_13_County_CRP_Monitoring_Stations_2017	Point
HGAC_13_County_CRP_Monitoring_Stations_Historical	Point
HGAC_13_County_Districts	Polygon
HGAC_13_County_Ecological_Mapping_System_TPWD_2015	Polygon
HGAC_13_County_Farmland	Polygon
HGAC_13_County_Federal_Aid_Roads	Polyline
HGAC_13_County_FoodWaste_Composters	Point
HGAC_13_County_G1M	Polygon
HGAC_13_County_G3M	Polygon
HGAC_13_County_G5M	Polygon
HGAC_13_County_Grocery_Stores	Point
HGAC_13_County_Landfill_Areas	Polygon
HGAC_13_County_Landfill_Areas_Historical	Polygon
HGAC_13_County_Landfills	Point
HGAC_13_County_Landfills_Historical	Point
HGAC_13_County_Libraries	Point

HGAC_13_County_Libraries_Parcel_Xref	Table
HGAC_13_County_MPC	Polygon
HGAC_13_County_OSSF_Permits	Point
HGAC_13_County_OSSF_Permits_2017	Point
HGAC_13_County_OSSF_Permits_2018	Point
HGAC_13_County_Parks	Point
HGAC_13_County_Parks_Awards	Table
HGAC_13_County_Parks_Features	Table
HGAC_13_County_Parks_Parcels	Table
HGAC_13_County_Plats	Polygon
HGAC_13_County_Recycle_Centers	Point
HGAC_13_County_Service_Area_Boundaries	Polygon
HGAC_13_County_Service_Area_Boundaries_2013	Polygon
HGAC_13_County_Service_Area_Boundaries_2014	Polygon
HGAC_13_County_Service_Area_Boundaries_2015	Polygon
HGAC_13_County_Service_Area_Boundaries_2017	Polygon
HGAC_13_County_Service_Area_Boundaries_Domestic_2018	Polygon
HGAC_13_County_Soils	Polygon
HGAC_13_County_Superfund_NPL_Sites	Polygon
HGAC_13_County_Superfund_NPL_Sites_Pts	Point
HGAC_13_County_Wastewater_Outfall_Domestic_2018	Point
HGAC_15_County_Aquifer_Recharge_Zones	Polygon
HGAC_15_County_Basins	Polygon
HGAC_15_County_Bio_Monitoring_Sites	Point
HGAC_15_County_CRP_Impairments	Table
HGAC_15_County_CRP_Lakes	Polygon
HGAC_15_County_CRP_Stream_End_Points	Point
HGAC_15_County_CRP_Streams	Polyline
HGAC_15_COUNTY_LAND_COVER_2015_10_CLASS	Raster
HGAC_15_COUNTY_LAND_COVER_2018_10_CLASS	Raster
HGAC_15_County_NHDPlusV2_Catchment_Boundary	Polygon
HGAC_15_County_Soils_2012	Polygon
HGAC_15_County_Soils_2012_w_taxonomy	Polygon
HGAC_15_County_Wastewater_Outfalls	Point
HGAC_15_County_Wastewater_Outfalls_2017	Point
HGAC_15_County_Wastewater_Outfalls_Historical	Point
HGAC_15_County_Wastewater_Outfalls_Info	Table
HGAC_15_County_Water_Detailed_2018	Polygon
HGAC_15_County_Watershed_Insets	Polygon
HGAC_15_County_Watershed_Signs	Point
HGAC_15_County_Watersheds	Polygon

HGAC_8_County_Bikeway_Needs	Polyline
HGAC_8_County_Bikeways	Polyline
HGAC_8_County_Comprehensive_Plan_2010_pts	Point
HGAC_8_County_Eco_Types	Polygon
HGAC_8_County_Forecast_Cities_h	Table
HGAC_8_County_Forecast_Cities_v	Table
HGAC_8_County_Forecast_Counties_h	Table
HGAC_8_County_Forecast_Counties_v	Table
HGAC_8_County_Forecast_G025M_h	Table
HGAC_8_County_Forecast_G1_h	Table
HGAC_8_County_Forecast_G10K_h	Table
HGAC_8_County_Forecast_G10K_v	Table
HGAC_8_County_Forecast_G1M_h	Table
HGAC_8_County_Forecast_G1M_v	Table
HGAC_8_COUNTY_FORECAST_LU_G1_H	Table
HGAC_8_County_Forecast_RAZ_h	Table
HGAC_8_County_Forecast_RAZ_v	Table
HGAC_8_County_Forecast_Region_v	Table
HGAC_8_County_Forecast_TAZ_h_2003	Table
HGAC_8_County_Forecast_TAZ_v_2003	Table
HGAC_8_County_Forecast_Tracts_h	Table
HGAC_8_County_Forecast_Tracts_v	Table
HGAC_8_County_Forecast_Zip_Codes_h	Table
HGAC_8_County_Forecast_Zip_Codes_v	Table
HGAC_8_County_G025M	Polygon
HGAC_8_County_G1	Polygon
HGAC_8_County_G10	Polygon
HGAC_8_County_G1M	Polygon
HGAC_8_County_PedBike_Improvement_Areas	Polygon
HGAC_8_County_PedBike_Improvement_Locations	Point
HGAC_8_County_Pedestrian_Pathways	Polyline
HGAC_8_County_Sector_25	Polygon
HGAC_8_County_Soils	Polygon
HGAC_8_County_Water	Polygon
HGAC_Airport_Runways	Polygon
HGAC_Airport_System	Point
HGAC_Art_of_Transportation	Point
HGAC_Bastrop_Bayou_Sub_Watersheds	Polygon
HGAC_Buy_Active_EndUsers	Point
HGAC_Buy_PO_EndUsers	Point
HGAC_City_Boundaries	Polygon

HGAC_City_Ordinance_Areas	Polygon
HGAC_COASTAL_VIGNETTE_RASTER	Raster
HGAC_Commissioner_Precincts	Polygon
HGAC_Contours_2_Feet	Polyline
HGAC_Contours_5_Feet	Polyline
HGAC_Counties_Coastline	Polygon
HGAC_Counties_Coastline_15C	Polygon
HGAC_Counties_Coastline_Boundary	Polygon
HGAC_Counties_Coastline_Boundary_15C	Polygon
HGAC_Counties_Political	Polygon
HGAC_Counties_Political_15C	Polygon
HGAC_Counties_Political_Boundary	Polygon
HGAC_Counties_Political_Boundary_15C	Polygon
HGAC_CRP_Watersheds	Polygon
HGAC_Dams	Point
HGAC_Election_Precincts_2010	Polygon
HGAC_FM_Roads	Polyline
HGAC_HILLSHADE	Raster
HGAC_Hurricane_Dolly_Observations	Point
HGAC_Hurricane_Dolly_Track	Polyline
HGAC_Hurricane_Evacuation_Routes	Polyline
HGAC_Hurricane_Evacuation_Zip_Codes	Polygon
HGAC_Hurricane_Ike_High_Water_Measurements	Point
HGAC_Hurricane_Ike_Observations	Point
HGAC_HURRICANE_IKE_SALT_BURN_GULF_COAST	Raster
HGAC_Hurricane_Ike_Storm_Surge_Model	Polygon
HGAC_HURRICANE_IKE_STORM_SURGE_MODEL_RASTER	Raster
HGAC_Hurricane_Ike_Track	Polyline
HGAC_Lakes_AUs_2016	Polygon
HGAC_Lakes_Segments_2016	Polygon
HGAC_LAND_COVER_10_CLASS_2008	Raster
HGAC_LAND_COVER_10_CLASS_ROADS_2008	Raster
HGAC_LAND_COVER_3X3_MODE_FILTERED_2008	Raster
HGAC_LAND_COVER_MERGED_6_CLASS_2008	Raster
HGAC_Learning_Centers	Point
HGAC_LiDAR_Breakline	Polyline
HGAC_LiDAR_Contours_1_Foot	Polyline
HGAC_LiDAR_Spot_Elevation	Point
HGAC_Main_Railroads	Polyline
HGAC_Major_Lakes_and_Reserviors	Polygon
HGAC_Major_Rivers	Polyline

HGAC_Major_Rivers_15C	Polyline
HGAC_Major_Roads	Polyline
HGAC_Major_Roads_15C	Polyline
HGAC_MSWF_Managed_Lanes	Polyline
HGAC_MSWF_Traffic_Management_Strategies	Point
HGAC_NWR_Areas	Polygon
HGAC_Other_CRP_Monitoring_Stations	Point
HGAC_Pipelines	Polyline
HGAC_Raster_Extext	Polygon
HGAC_RAZ	Polygon
HGAC_Region_WWTF_Outfalls_FY17	Point
HGAC_Sea_Level_Rise	Polygon
HGAC_Seaports	Point
HGAC_Sidewalks_Preliminary	Polyline
HGAC_State_Highways	Polyline
HGAC_State_Parks	Polygon
HGAC_Streams_AUs_2016	Polyline
HGAC_Streams_Segments_2016	Polyline
HGAC_TAZ_2954	Polygon
HGAC_TAZ_5217	Polygon
HGAC_TIRZ	Polygon
HGAC_Water	Polygon
HGAC_Water_15C	Polygon
HGAC_Water_Detailed	Polygon
HGAC_Workforce_DARS	Point
HGAC_Workforce_Offices	Point
HGAC_Workforce_Solutions\HGAC_Career_Offices	Point
HGAC_Workforce_Solutions\HGAC_Parole_Offices	Point
HGAC_Workforce_Solutions\HGAC_Re_Entry_Resources	Point
HGAC_Workforce_Solutions\HGAC_Workforce_Centers	Point
HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_Offices	Point
HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_Offices_10mi_Demographics	Polygon
HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_Offices_5mi_Demographics	Polygon
HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_VR_Offices	Point
HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_VR_Offices_10mi_Demographics	Polygon
HGAC_Workforce_Solutions\HGAC_Workforce_Solutions_VR_Offices_5mi_Demographics	Polygon
HGAC_Zip_Codes_2000	Polygon
HGAC_Zip_Codes_2002	Polygon
HGAC_Zip_Codes_2005	Polygon
HGAC13_CountyTest	Polygon
Houston_Bcycle_Stations_2018	Point

HR_Buildings_2013	Table
HR_Parcels_2014	Polygon
InfoGroup_Businesses_2014	Point
InfoGroup_Businesses_2015	Point
InfoGroup_Businesses_2016	Point
InfoGroup_Businesses_2017	Point
InfoGroup_Businesses_2018	Point
InfoGroup_Businesses_Nix_2015	Point
InfoGroup_Businesses_Nix_2016	Point
InfoGroup_Businesses_Nix_2017	Point
InfoGroup_Businesses_Nix_2018	Point
InfoGroup_Businesses_Pre_2018	Point
InfoGroup_Businesses_Suspect_2014	Point
InfoGroup_Businesses_Suspect_2015	Point
InfoGroup_Businesses_Suspect_2016	Point
InfoGroup_Businesses_Suspect_2017	Point
InfoGroup_Businesses_Suspect_2018	Point
InfoGroup_Consumers_2014	Point
InfoGroup_Consumers_2015	Point
InfoGroup_Consumers_2016	Point
InfoGroup_Consumers_2017	Point
InfoGroup_Consumers_2018	Point
Island_Transit_Bus_Routes	Polyline
Lambert_Grid	Polygon
LEHD\County_LEHD_09_15	Polygon
LEHD\HEX_H1M_09_15	Polygon
LEHD\HEX_LEHD_09_15	Polygon
LEHD\Place_LEHD_09_15	Polygon
LEHD\Tract_LEHD_09_15	Polygon
Liberty_County_Commissioner_Precincts	Polygon
LID_Projects	Point
LiDAR_Grid_2008	Polygon
LivableCenters	Polygon
Master_Parcels_Address_2014	Point
Matagorda_County_Commissioner_Precincts	Polygon
Metro_Bus_Routes	Polyline
Metro_Bus_Stops	Point
Metro_LRT_Lines	Polyline
Metro_LRT_Stations	Point
Metro_MTA_Tax_Area	Polygon
Metro_Park_and_Rides	Point

METRO_Transit\METRO_Bus_Routes	Polyline
METRO_Transit\METRO_Bus_Routes_2018	Polyline
METRO_Transit\METRO_LRT_Rail_Lines	Polyline
METRO_Transit\METRO_LRT_Rail_Lines_2018	Polyline
METRO_Transit\METRO_Service_Area	Polygon
METRO_Transit\METRO_Service_Area_2018	Polygon
METRO_Transit\METRO_Transit_Facilities	Point
METRO_Transit\METRO_Transit_Facilities_2018	Point
Metro_Transit_Centers	Point
Model_Buildings	Point
Model_Buildings_2014	Point
Model_Buildings_2017	Point
Model_Buildings_2017_2	Point
Model_Buildings_Rural	Point
Model_Buildings_Uses	Table
Model_Buildings_Uses_Rural	Table
Model_Parcels	Polygon
Model_Parcels_2014	Polygon
Model_Parcels_2017	Polygon
Model_Parcels_AcctNums	Table
Model_Parcels_AcctNums_Rural	Table
Model_Parcels_Addresses	Table
Model_Parcels_Addresses_Rural	Table
Model_Parcels_Features	Table
Model_Parcels_Features_Rural	Table
Model_Parcels_Forecast	Table
Model_Parcels_Forecast2020	Table
Model_Parcels_Pts	Point
Model_Parcels_Removed_Merged	Polygon
Model_Parcels_Rural	Polygon
Model_Predictions_2018	Polygon
Model_Predictions_v2018\BZ_Model_Predictions_v2018	Polygon
Model_Predictions_v2018\CH_Model_Predictions_v2018	Polygon
Model_Predictions_v2018\FB_Model_Predictions_v2018	Polygon
Model_Predictions_v2018\GV_Model_Predictions_v2018	Polygon
Model_Predictions_v2018\HR_Model_Predictions_v2018	Polygon
Model_Predictions_v2018\HR_Model_Predictions_v2018_p1	Polygon
Model_Predictions_v2018\HR_Model_Predictions_v2018_p2	Polygon
Model_Predictions_v2018\HR_Model_Predictions_v2018_p3	Polygon
Model_Predictions_v2018\LB_Model_Predictions_v2018	Polygon
Model_Predictions_v2018\MG_Model_Predictions_v2018	Polygon

Model_Predictions_v2018\WA_Model_Predictions_v2018	Polygon
Montgomery_County_Commissioner_Precincts	Polygon
Montgomery_County_Zones_4	Polygon
ND\BZ_Parcels_2013	Polygon
ND\CH_Parcels_2013	Polygon
ND\FB_Parcels_2013	Polygon
ND\GV_Parcels_2013	Polygon
ND\HR_Parcels_2013	Polygon
ND\LB_Parcels_2013	Polygon
ND\MG_Parcels_2013	Polygon
ND\WA_Parcels_2013	Polygon
NGS_Control_Stations	Point
NLCD_IMPERVIOUSNESS_2001	Raster
NLCD_IMPERVIOUSNESS_2006	Raster
NLCD_IMPERVIOUSNESS_2011	Raster
NLCD_IMPERVIOUSNESS_CHANGE_2001_TO_2006	Raster
NLCD_IMPERVIOUSNESS_CHANGE_2006_TO_2011	Raster
NLCD_LAND_COVER_1992_19_CLASS	Raster
NLCD_LAND_COVER_1992_19_CLASS_CORRECTED	Raster
NLCD_LAND_COVER_2001_15_CLASS	Raster
NLCD_LAND_COVER_2006_15_CLASS	Raster
NLCD_LAND_COVER_2011_15_CLASS	Raster
NLCD_LAND_COVER_CHANGE_1992_TO_2011_9_CLASS	Raster
NLCD_TREE_CANOPY_2001	Raster
NOAA_LAND_COVER_1996_22_CLASS	Raster
NOAA_LAND_COVER_2001_22_CLASS	Raster
NOAA_LAND_COVER_2006_22_CLASS	Raster
NOAA_LAND_COVER_2011_15_CLASS	Raster
NOAA_LAND_COVER_2011_22_CLASS	Raster
NOAA_LAND_COVER_CHANGE_1996_TO_2010	Raster
NOAA_Surge_MOM_Galveston_Bay	Polygon
NOAA_Surge_MOM_Matagorda_Bay	Polygon
NTAD_Raillines	Polyline
Occupational_Analysis\BlockGroups_OccupationAnalysis	Polygon
Occupational_Analysis\Counties_OccupationAnalysis	Polygon
Occupational_Analysis\Tracts_OccupationAnalysis	Polygon
Parcels	Polygon
Parcels_2014	Polygon
Ped_Bike_Destinations_2010	Point
Ped_Bike_Destinations_2014	Point
Ped_Bike_Destinations_2017	Point

POHA_Ship_Channel	Polygon
RGF_2014_Q3\Census_Tracts	Polygon
RGF_2014_Q3\Nine_SQM_Grid	Polygon
RGF_2014_Q3\One_SQM_Grid	Polygon
RGF_2014_Q3\Transportation_Analysis_Zones_2954	Polygon
RGF_2014_Q3\Transportation_Analysis_Zones_5217	Polygon
RGF_2014_Q4\Census_Tracts_1	Polygon
RGF_2014_Q4\Nine_SQM_Grid_1	Polygon
RGF_2014_Q4\One_SQM_Grid_1	Polygon
RGF_2014_Q4\Transportation_Analysis_Zones_2954_1	Polygon
RGF_2014_Q4\Transportation_Analysis_Zones_5217_1	Polygon
RGF_2016\Forecast_Census_Tracts	Polygon
RGF_2016\Forecast_H3M	Polygon
RGF_2016\Forecast_TAZ2954	Polygon
RGF_2016\Forecast_TAZ5217	Polygon
RGF_2017\Current_Future_Land_Use	Polygon
RGF_2017\Forecast_Census_Tracts_2017	Polygon
RGF_2017\Forecast_H3M_2017	Polygon
RGF_2017\Forecast_TAZ5217_2017	Polygon
RGF_2018\Announced_Changes_v2018	Polygon
RGF_2018\Forecast_Census_Tracts_v2018	Polygon
RGF_2018\Forecast_H3M_v2018	Polygon
RGF_2018\Forecast_TAZ5217_v2018	Polygon
RGF_2018\Model_Predictions_v2018	Polygon
RGF_2018\Parcel_Land_Use_2045_v2018	Polygon
RGF_2018\Parcel_Land_Use_current_v2018	Polygon
SEM_User_Input_Point	Point
SEM_User_Input_Polygon	Polygon
SEM_User_Input_Polyline	Polyline
Solid_Waste\Closed_Landfill_Inventory	Point
Solid_Waste\HHW_Centers	Point
Solid_Waste\Landfill_Areas	Polygon
Solid_Waste\Landfills	Point
Solid_Waste\Recycling_and_HHW_Centers	Point
Solid_Waste\Recycling_Centers	Point
STARMap\HGAC_StarMap_Addresses	Point
STARMap\HGAC_StarMap_Centerlines	Polyline
STARMap\HGAC_StarMap_ZipCodes	Polygon
Strava_Bike_Usage	Polyline
TCEQ_Regions	Polygon
TEA_Education_Service_Regions	Polygon
TEA_School_Districts_2015	Polygon

TEA_Schools_2015	Point
Texas_Area_Codes	Polygon
Texas_Coastal_Bathymetry	Point
Texas_Coastal_Vignette	Polygon
Texas_Coastal_Zone_Boundary	Polygon
Texas_Coastline_Boundary	Polygon
Texas_COG_Boundaries	Polygon
Texas_Counties_Coastline	Polygon
Texas_Counties_Political	Polygon
Texas_Groundwater_Conservation_Districts	Polygon
Texas_Highways	Polyline
Texas_Hurricane_Evacuation_Routes	Polyline
Texas_Impairment_Streams_2008	Polyline
Texas_Impairment_Waterbodies_2008	Polygon
Texas_Major_Aquifers	Polygon
Texas_Major_Rivers	Polyline
Texas_Map_Extent	Polygon
Texas_Minor_Aquifers	Polygon
Texas_National_Forests	Polygon
Texas_National_Parks	Polygon
Texas_Natural_Regions	Polygon
Texas_Political_Boundary	Polygon
Texas_Senate_Board_of_Education_Districts	Polygon
Texas_Stream_Team_Monitoring_Sites_2016	Point
Texas_Stream_Team_Monitoring_Sites_2018	Point
Texas_Surface_Water_Rights_Diversion	Point
TEXAS_TERRAIN_COLOR_MAP	Raster
Texas_Zip_Codes_2005	Polygon
The_Woodlands_Pathways	Polyline
TMDL_Watersheds	Polygon
TPW_State_Parks	Polygon
TPWD_13_County_LWRCRP_conservation_and_recreation_lands	Polygon
TxDOT_Highway_Milemarkers	Point
TxDOT_State_House_Districts_2018	Polygon
TxDOT_State_Senate_Districts_2018	Polygon
TxDOT_US_House_Districts_2018	Polygon
US_State_Boundaries	Polygon
USCB_ACS_2016_5Yr_Block_Groups	Polygon
USCB_ACS_2016_5Yr_Counties	Polygon
USCB_ACS_2016_5Yr_Places	Polygon
USCB_ACS_2016_5Yr_Tracts	Polygon
USCB_ACS_2016_5Yr_Zip_Codes	Polygon

USCB_BlockGroups_1990	Polygon
USCB_BlockGroups_2000	Polygon
USCB_BlockGroups_2010	Polygon
USCB_Blocks_2000	Polygon
USCB_Blocks_2010	Polygon
USCB_Metropolitan_Statistical_Area	Polygon
USCB_Places_2000	Polygon
USCB_Places_2000_Pts	Point
USCB_Places_2010	Polygon
USCB_Places_2010_Pts	Point
USCB_PSAP_Prep_CDPs_and_Cities	Polygon
USCB_PSAP_Prep_Tracts	Polygon
USCB_School_Districts_2010	Polygon
USCB_Texas_113th_Congressional_Districts	Polygon
USCB_Texas_Census_BlockGroups_1990	Polygon
USCB_Texas_Census_BlockGroups_2000	Polygon
USCB_Texas_Census_BlockGroups_2010	Polygon
USCB_Texas_Census_Blocks_2000	Polygon
USCB_Texas_Census_Blocks_2010	Polygon
USCB_Texas_Census_School_Districts_2010	Polygon
USCB_Texas_Census_Tracts_1990	Polygon
USCB_Texas_Census_Tracts_2000	Polygon
USCB_Texas_Census_Tracts_2010	Polygon
USCB_Texas_Census_Urban_Areas_2009	Polygon
USCB_Texas_State_House_Districts_2012	Polygon
USCB_Texas_State_Senate_Districts_2012	Polygon
USCB_Tracts_1970	Polygon
USCB_Tracts_1980	Polygon
USCB_Tracts_1990	Polygon
USCB_Tracts_2000	Polygon
USCB_Tracts_2010	Polygon
USCB_Urban_Areas_1990	Polygon
USCB_Urban_Areas_2000	Polygon
USCB_Urban_Areas_2009	Polygon
USCB_Urban_Areas_2010	Polygon
USCB_Zip_Codes_2010	Polygon
USFWS_15_County_Wetlands_2018	Polygon
USFWS_Wetlands_2009	Polygon
USFWS_Wetlands_2010	Polygon
USFWS_Wetlands_2011	Polygon
USFWS_Wetlands_2012	Polygon
USGS_15_Minute_Quad	Polygon
USGS_24K_Quad	Polygon

USGS_DEM_10M	Raster
USGS_DOQQ_Grid	Polygon
USGS_HUC_10_Watersheds	Polygon
USGS_HUC_12_Sub_Watersheds	Polygon
USGS_HUC_6_Basins	Polygon
USGS_HUC_8_Sub_Basins	Polygon
USGS_River_Basins	Polygon
USGS_Stream_Gauges_2009	Point
USGS_Stream_Gauges_2010	Point
USGS_Stream_Gauges_2012	Point
USGS_Stream_Gauges_2017	Point
Walker_County_Commissioner_Precincts	Polygon
Waller_County_Commissioner_Precincts	Polygon
Wharton_County_Commissioner_Precincts	Polygon
World_Country_Boundaries	Polygon

C&E NON-SPATIAL DATA

Ambient Surface Water Quality Monitoring
Wastewater Self-reporting Data
Parcel-Based Land Use, Attributes, and Valuation (9 counties)
Census Data

APPENDIX E.6 DATA DICTIONARY

Data Dictionary
Houston-Galveston Area Council
Community and Environmental Planning Department

General Information		
Thematic Layer Name		
Feature Class		
Topology		
Table Name		
Data Source		
Report Prepared by		
Phone	Fax	E-Mail

Attribute Table				
Variable	Begin Column	Item Name	Alternate Name	Item Definition

Data History
Source Agency
Originating Date
Originating Scale

Status Information
Percentage Complete
Planned Completion Date
Geographic Extent
Planned Enhancements
Known problems or limitations

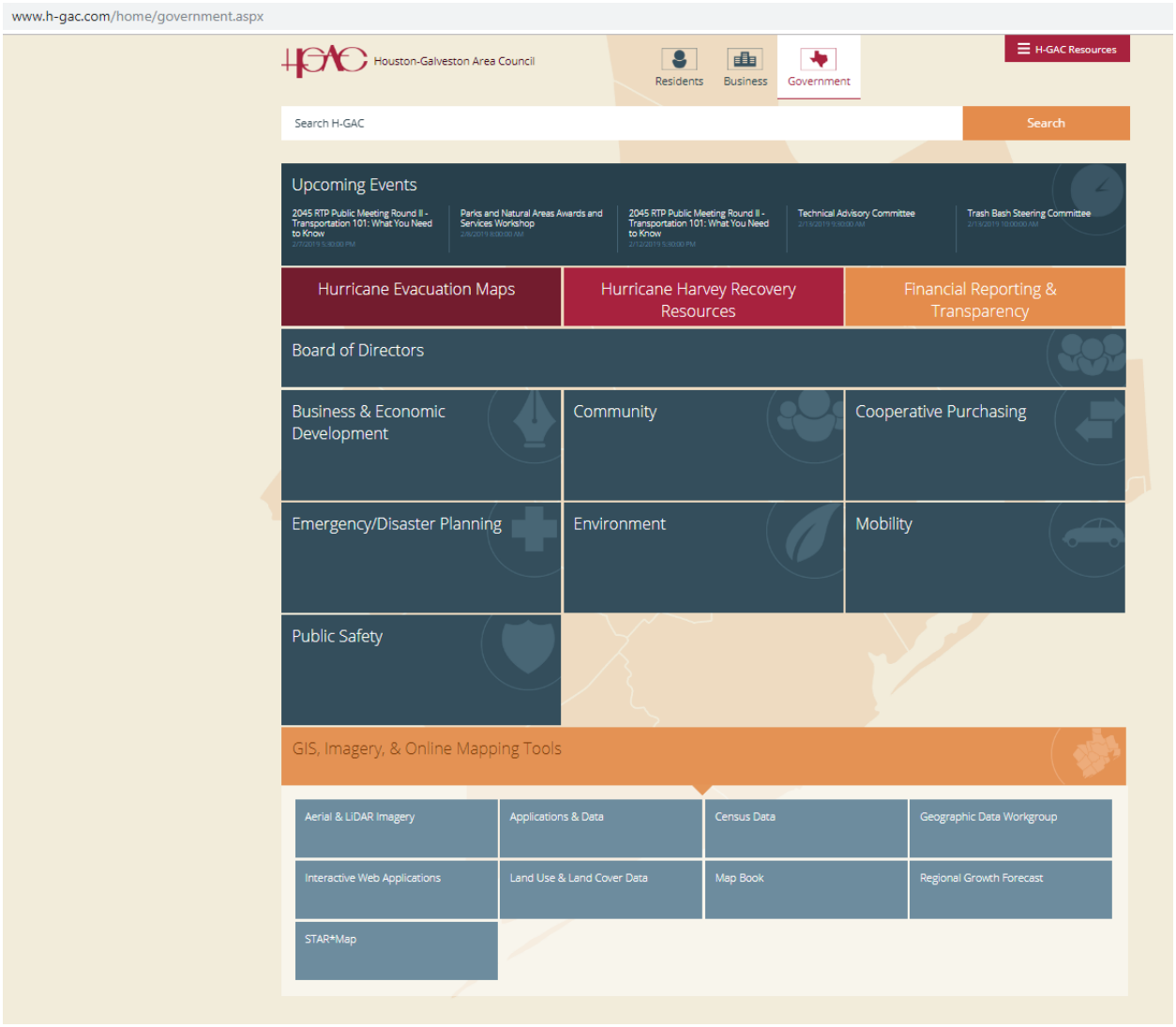
Maintenance Information
Maintaining Office/Division/Section
Contact Name
Contact Telephone Number
Type of updates performed
Frequency of Updates

Data Format Information
Data Format
Software/Version
Number of features/records
Total File Size

Projection
Geographic Projection:
Spheroid:
Zone:
Datum:
Units:
Fips Zone:
Quadrant:
X Shift:
Y Shift:
1st Standard Parallel:
2nd Standard Parallel:
Central Meridian:
Lat. of Projection Origin:
False Easting:
False Northing:

Additional Documentation
Quality Assurance Quality Control
Attribute Reports Available
Additional Documentation Available

APPENDIX E.7 H-GAC GIS DATA AND MAPPING APPLICATIONS



APPENDIX F.
METHODOLOGY FOR MODIFIED LDC

Appendix F. Methodology for Modified LDC

Modified LDC Development

The difference in the modified LDC from the traditional approach is the application of salinity in development of the flow duration curves to account for tidal flux in the tidal segment (1101). In addition to salinity, the fecal indicator bacteria are now enterococci, used to indicate the potential for pathogens in tidal waters. The modified approach is applied to all stations based on an analysis of salinity levels, indicating tidal action.

To develop the modified LDCs, quarterly CRP enterococci and salinity measurements are acquired. Due to the tidal nature of segments using the modified approach, there are no daily flow records to estimate the daily loads of bacteria. As a surrogate, derived daily flow measurements at each station are used. Daily flow records are generated in LOADEST and related to the salinity of the stream in the next step.

Salinity vs. Flow Regression Analysis

The next step is to combine salinity observations (from CRP monitoring) taken at each station with adjusted daily freshwater flow values based on the date of the observation. The top and bottom 5% are considered outliers and eliminated from further calculations. The salinity records are then plotted against the base 10 LOG flow values in a scattered plot (an example is shown in Figure F1).

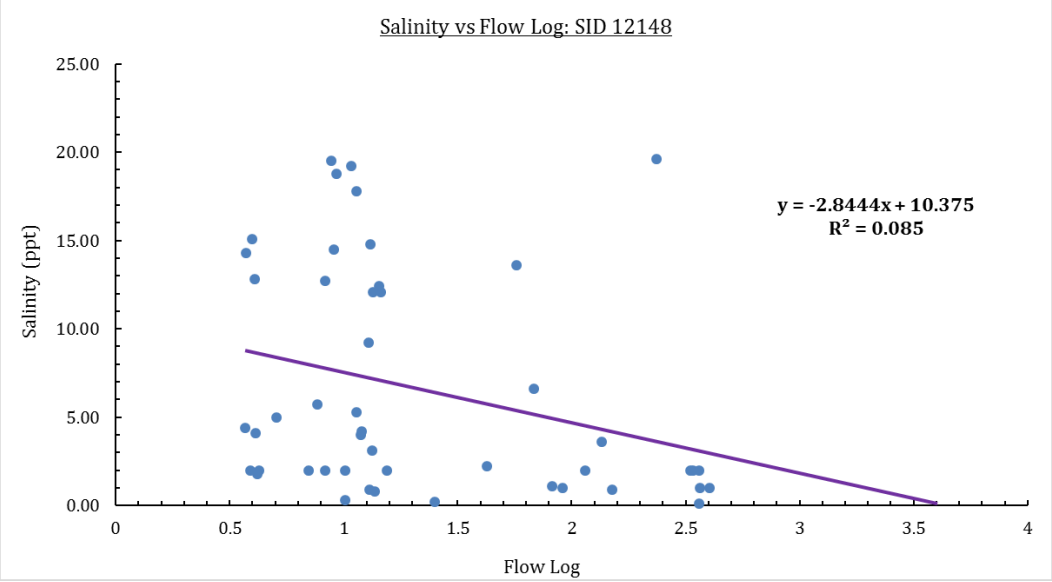


Figure F1 – Example of Salinity vs. flow regression

A linear regression curve and the curve-fitting equation are estimated to develop a daily freshwater flow-measured salinity relation. Using the linear regression equation in each station, daily salinity time series are generated with respect to the derived daily flow values.

For example: the equation for the example station 12148:

Salinity (ppm) = (-2.8444*derived flow at 12148) + 10.375 (Equation 1)

The resulting equation developed for each station was then used to calculate the volume of seawater flowing through the station cross section over the period of a day.

Total Water Volume Estimation at The Station

The regression equations are then used to compute the total daily flow volume including both fresh and saline water. Sea water volume is estimated based on the measured salinity values using the following mass balance formula:

$$(V_s = V_r / (S_s/S_t - 1)) \quad \text{(Equation 2)}$$

Where,

Vs = Seawater Flow,
Vr = Daily Freshwater Flow,
Ss = Salinity of Seawater = 35 ppt,
St = Estimated Salinity in Stream

The total flow at the station (i.e. sea water and freshwater) was estimated using formula;

$$Vt = Vr + Vs \quad \text{(Equation 3)}$$

Where,

Vt = Total flow
Vr = Daily freshwater flow
Vs = Seawater flow

Modified Flow Duration Curve Development

The modified FDC is then developed following similar procedures for creating an FDC in an above tidal segment. Daily flows (Vt) are ranked from highest to lowest. Then the percent of days each flow is exceeded (exceedance value) is calculated, (rank ÷ (number of data points + 1) * 100). The resulting exceedance value is plotted against the flow value.

Completed Modified LDC

Using statistical analysis software (SAS), enterococci observation, and total river flow values are combined based on the observation date. Like the approach used in and above tidal segment for *E. coli*, the load regression curves are developed for enterococci at the tidal stations using the LOADEST tool and approach. All the FDCs, load regression curves, observed data points, and standard curves are plotted in a semi-log plot to complete the LDC.

The data quality objectives and acceptability of results, the review by H-GAC staff, and the reliance on quality-assured data sources is the same for both LDC approaches. The data quality criteria for the modified approach are primarily that the competed LDC represents the best estimation of the desired flow regimes, accounting for tidal action.