TEXAS COMMISSION ON ENVIRONMENTAL QUALITY
TASK 5 - Rio Grande River
CONTINUOUS WATER QUALITY and STREAMFLOW MONITORING PROJECT PLAN

USGS Project No. 8653D2R

A1 APPROVAL PAGE

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Tables:

A3 LIST OF ACRONYMS

AQI	**Ambient Quality Invalid**
CFS	**Cubic Feet per Second**
CVS	**Calibration Verification Sample**
CWQM	**Continuous Water Quality Monitoring**
CWQMN	**Continuous Water Quality Monitoring Network**
DO	**Dissolved Oxygen**
DM&QA	**Data Management and Quality Assurance**
DQO	**Data Quality Objective**
EC	**Electrical Conductance (Reported as Specific Conductance)**
GOES	**Geostationary Operational Environmental Satellite**
LEADS	**Leading Environmental Analysis and Display System**
MOPs	**TCEQ Monitoring Operation Division**
MOQs	**Measurement Quality Objectives**
NA	**Not Applicable**
NIST	**National Institute of Standards and Technology**
QA	**Quality Assurance**
QAO	**Quality Assurance Officer**
QAPP	**Quality Assurance Project Plan**
QC	**Quality Control**
RPD	**Relative Percent Difference**
ROX™	**Reliable Optical Dissolved Oxygen Sensor**
SC	**Specific Conductance**
SOP	**Standard Operating Procedure**
SWQM	**Surface Water Quality Monitoring Team**
SWQMIS	**Surface Water Quality Information System**
TBD	**To Be Determined**
TCEQ	**Texas Commission on Environmental Quality**
TDS	**Total Dissolved Solids**
TRACS	**TCEQ Regulatory Activities and Compliance System**
RPE	**Relative Percent Error**
µS/cm	**micro Siemens per centimeter**
USGS	**U. S. Geological Survey**
WQM&A	**Water Quality Monitoring & Assessment Section**
YSI	**Yellow Springs Instrument**
°C	**Degrees Centigrade**

A3 DISTRIBUTION LIST

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY (TCEQ)

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Mr. Wade Kress, San Angelo Hydrologic Surveillance & Analysis Unit, USGS Texas Water Science Center

A4 PROJECT/TASK ORGANIZATION

This section is intended to identify individuals and organizations that will be responsible for developing and/or supporting new CWQMN projects. This Project Plan describes policies, procedures, and protocols for the measurement of water quality and water flow (discharge) by USGS at the sites listed in Table A.4.3 of this project plan. For a list of additional project/task and responsibilities please refer to section A4 of the CWQMN QAPP.

A4.1 TCEQ CWQMN Network Coordinator: (Charles Dvorsky)

- Responsible for establishing new monitoring stations and integrating stations into the existing monitoring network.
- Coordinates development of the Project Plan.
- Provides overall support for the ingestion of USGS data into LEADS and SWQMIS.

A4.2 TCEQ Project Lead: (Christine Kolbe)

- Determined project objectives.
- Approves monitoring locations
- Responsible for obtaining, managing, and analyzing project data.

A4.3 TCEQ Contract Manager: (Ed Bridgman)

- Manage TCEQ/USGS contract amendment.

A4.4 CWQM Site Operator USGS San Angelo Program Office (325) 944-4600

Table A4.3 – Site Operators CWQMN and Streamflow

TCEQ Region	Basin	CAMS Number	TCEQ Station ID	USGS/USIBWC Station ID	Operator/ Proj. Element	Site Location
6	Rio Grande	757	13230	08371500	USGS/ CWQM	Above Rio Conchos near Presidio, TX
6	Rio Grande	758	13229	08374200	USGS/ CWQM	Below Rio Conchos near Presidio, TX
16	Rio Grande	759	13223	08377200	USGS/ CWQM	At Foster Ranch near Del Rio, TX
6	Rio Grande	720	18482	08374550	USGS/ STREAMFLOW	Big Bend National Park at Castolon, TX
6	Rio Grande	721	18483	08375300	USGS/ STREAMFLOW	Big Bend National Park at Rio Grande Village, TX

Site Operation

USGS will conduct operation of the instruments and site consistent with Standard Operating

Procedure (SOP) AMPM-011, Analysis of Dissolved Oxygen (DO), Specific Conductance (SC), pH, Temperature, and Sample Depth in Ambient Surface Water Using Yellow Springs Instrument (YSI) 600 XLM and 6600 Extended Deployment System (EDS) Sonde (Attachment A) except for:

Method Summary 3.2

- The DO sensor is a Reliable optical dissolved Oxygen sensor (ROX™) using luminescence technology and should follow manufacture calibration and maintenance requirements.

Method Summary 3.3

- The specific conductance sensor is a flow cell with four pure nickel electrodes for the measurement of solution conductance. Two of the electrodes are current driven and two are used to measure the voltage drop. The measured voltage drop is then converted into a conductance value. Specific conductance uses the temperature and raw conductivity values associated with each determination to generate a specific conductance value compensated to 25°C.

Method Summary 3.6

- The selected YSI sondes include a built in depth sensor with a vented cable. A calculated measurement in open-channel requires a vented cable. Range: 0-30 feet, resolution: 0.001 feet. Accuracy: at 0-10 feet ±0.01 feet, at 10-30 feet ±0.016 feet.

Procedure 7.4.3 addresses DO membrane calibration.
Procedure 7.4.4 addresses depth sensor calibration.

USGS will conduct operation and maintenance of the instruments and site consistent with the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge. (http://pubs.usgs.gov/wsp/wsp2175); United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods.

A4.4. CWQMN Data Validation: USGS San Angelo Program Office (325) 944-4600

- Daily examination of data record to ensure completeness and accuracy of reporting.
- Maintenance of a hard copy validator log with notes sufficient to reconstruct a validation event at a later time.
- Investigation of loss data.
- Review of operator logs for post-calibration records and general site information.
- Weekly validation of data record using Manual Validation.
- Monthly validation of hourly data.

USGS will conduct operation and maintenance of the instruments and site consistent with the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge (http://pubs.usgs.gov/wsp/wsp2175); and United States Geological Survey Water-

Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf). USGS will host the data from these sites on their continuous surface water monitoring web pages.

A4.5 Project Participant

CWQMN Project Technical Lead.

Cary Carman - San Angelo Program Office (325) 944-4600 x12

CWQMN Project Technical Personnel

Brian Petri - San Antonio Program Office (210) 691-9229
Henry Jacques - San Angelo Field Office (325) 280-1281
Milton Sunvison - Austin Field Office (512) 927-3533

Streamflow Project Technical Lead

Cary Carman - USGS San Angelo Program Office (325) 944-4600 x12

Streamflow Project Technical Personnel

Andy Teeple - San Angelo Field Office (325) 944-4600 x20
Henry Jacques - San Angelo Field Office (325) 944-4600 x15
Jason Payne - San Angelo Field Office (325) 944-4600 x21
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A5 PROBLEM DEFINITION/BACKGROUND

The upper Rio Grande Basin has been affected by drastic hydrological modifications developed to divert water for irrigation and drinking water. In the recent past, little water remains after irrigation withdrawal in the upper part of the Rio Grande Basin. Long-term drought throughout northern Mexico, the desert southwest, and the southern Rockies in the U.S. has put pressure on an already over-appropriated basin. The end result is increasing dissolved solids and salinity. The lack of consistent flow and the subsequent impact on water quality in the Rio Grande is of international, national, and regional concern.

The Rio Grande in the Big Bend area has increased and variable salinity (measured as specific conductance) and there are concerns about the current water quality criterion for total dissolved solids (TDS). The upper portion of 2306 is affected by high salinity from Segment 2307 and possibly the Rio Conchos. The lower half receives input from freshwater springs down to Amistad Reservoir.

By averaging the chloride, sulfate, and TDS values across the entire segment, the problems in the upper portion are masked. Current water quality standards (TDS, chloride, and sulfate) are not protective of the upper portion of Segment 2306 which flows through Big Bend National Park and the protected areas in Chihuahua and Coahuila, important national resources for both the U.S. and Mexico.
This project would provide data to support revision of the segment boundary to be more protective of water quality.

A6 PROJECT/TASK DESCRIPTION

Continuous monitoring of water temperature, pH, dissolved oxygen, specific conductance, and water depth (by multi-probe sonde) at the sites listed in Table A4.3 beginning August 1, 2007 through August 31, 2008.

USGS will host monitoring data from Table A4.3 locations on their continuous surface water monitoring web pages. TCEQ will decode the data from the NOAAPort and will ingest the data to LEADS. TCEQ will download the daily discharge look-up table for USGS and report the associated discharge for the site in LEADS.

A7 QUALITY OBJECTIVES AND CRITERIA

A7.1 CWQM Element

The measurement performance specifications to support the project objectives are specified in Table A7.1. Methods used are based on Standard Methods for the Examination of Water and Wastewater, 20th Edition, 1998 unless otherwise noted.

Table A7.1 – YSI 6600 EDS Sonde Performance Specifications

Parameter	Parameter Code TCEQ/USGS	Units	Method	Calibration Verification Sample (CVS) *
pH	00400/00400	pH / units	Glass electrode, Standard Method 4500-H+B	± 0.50 pH unit

DO	00300/00300	mg/L	ASTM D888-05	% Saturation ≤6.0% ± 0.50 mg/L
SC	00094/00095	μS/cm	Standard Method 2510	≤5.0% RPE
TDS	**00294**	mg/l	Calculated by LEADS. Sonde SC measurements are multiplied by 0.65.	≤5.0% RPE (SC CVS)
Temperature	00010/00010	C	Standard Method 2550 B	±1.5°C
Depth	NA/00003	meters or feet	Pressure Transducer	NA

* CVS criteria. SWQM DQOs.
NA = Not Applicable

Total Dissolved Solids

Estimates for TDS concentrations are calculated from sonde SC measurements using TCEQ's factor of 0.65

Ambient Water Reporting Limits (AWRLs)

Ambient Water Reporting Limits do not apply to this project.

CWQM Precision

Currently, sonde measurement precision is not being determined.

CWQM Bias

As described in section B5 of the CWQMN QAPP.

CWQM Representativeness

As described in section B5 of the CWQMN QAPP.

CWQM Comparability

As described in section B5 of the CWQMN QAPP.

CWQM Completeness

The minimum data completeness requirement for water quality is 75 percent valid data for each parameter (DO, SC, pH and Temperature). USGS validation requirements are outlined in Section D2 of this project plan. Periods of no flow or dry conditions necessitate shutdown of some instrumentation and these times are not considered in the goal for data completeness.

Data completeness is calculated as follows for stream sites:

$$\% \text{ Completeness} = \frac{\text{Number of valid measurements during Streamflow}}{\text{Total possible measurements} - \text{Total possible measurements during no Streamflow}} \times 100$$

A7.2 Streamflow Element

The measurement performance specifications to support the project objectives are specified in Table A7.2. Methods used are discussed in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge. (http://pubs.usgs.gov/wsp/wsp2175/)

Table A7.2 – Surface Water Performance Specifications

Parameter	Parameter Code	Units	Method	Accuracy
Discharge	00061	ft3/sec	Mid-section method as described in United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge. (http://pubs.usgs.gov/wsp/wsp2175)	Computed to 3 significant figures
Stage	00065	ft	See United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge. (http://pubs.usgs.gov/wsp/wsp2175)	+/- 0.02ft

Streamflow Precision

As described in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge (http://pubs.usgs.gov/wsp/wsp2175); and United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf), surface-water stage readings are accurate to 0.01ft and discharge measurements are accurate to three significant figures.

Streamflow Bias

Gage height corrections will be applied when the difference between actual and recorded gage height exceeds 0.02ft. Gage height corrections will be prorated by time or stage as discussed in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge. (http://pubs.usgs.gov/wsp/wsp2175); United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf).

Streamflow Representativeness

Not applicable to this project.

Streamflow Comparability

As described in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge. (http://pubs.usgs.gov/wsp/wsp2175); United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf).

Streamflow Completeness

The minimum data completeness requirement for discharge is 75 percent valid data. USGS validation requirements are outlined in Section D2 of this project plan.

A8 SPECIAL TRAINING/CERTIFICATION

A8.1 CWQM Element

According to the TCEQ *Quality Management Plan*, training requirements for contract staff shall be stated in contract specifications if contracted work is part of the project. In accordance with TCEQ agreement number 582-5-72628:

- Field operator training will be provided by designated TCEQ personnel to USGS personnel within 60 days of the final approval of the Project Plan.
- Manual data validation training will be provided by designated TCEQ personnel to USGS personnel. Manual data validation training occurred on May 23, 2007, for the following USGS personnel:
    - Michael Lee (USGS Houston Office (713 560-9614)
    - Milton Sunvison (USGS Austin Field Office (512) 940-9393)
    - Michael Canova (USGS Austin Field Office (512) 413-5537)
    - Jon Snatic (USGS Austin Field Office (512) 423-2517)
    - Cary Carman (USGS San Angelo Field Office (325) 280-1352)
    - Amy Clark (USGS San Antonio Office (210) 827-0585)
    - Chiquita Lopez (USGS San Antonio Office (210) 827-7122)

- Brian Petri ((USGS San Antonio Office (210) 414-1285)
- Mick Baldys (USGS Fort Worth Office (817) 253-3470)

A8.2 Streamflow Element

No special training will be provided by TCEQ.

In addition to on the job training provided by senior USGS technical staff, USGS field personnel have attended some or all of the following USGS National Training Center Courses:

Basic Hydraulic Principles
Surface-Water Rating Curve Analysis
Surface-Water Records Computation
Streamflow Measurements Using ADCP's (Son Tek/RDI)
Overview of Surface-Water Field Methods
Computing Streamflow Records
Rating Curve Analysis for Records Computation
ADCP Refresher and StreamPro Data Collection and Review

A9 DOCUMENTS AND RECORDS

A9.1 CWQM Element

As described in section A9 of the CWQMN QAPP.

A9.2 Streamflow Element

Each project participant is expected to maintain records that include sufficient information to reconstruct each final reported measurement from the variables originally gathered in the measurement process. This includes, but is not limited to, information (raw data, electronic files, and/or hard copy printouts) related to gage height readings, discharge measurements, measurement instrument calibration, quality control (QC) checks, an audit trail for any modifications made to the "as collected" measurement values and traceability documentation. Annual reviews of these records are performed during Technical System Audits (TSA).

Difficulties encountered during sampling or analysis is documented in operator logs to clearly indicate the affected measurements.

A9.3 Streamflow Record Keeping

USGS written records will be kept for five years. Electronic records will be kept indefinitely or for a life of a project. Please see Table A10.2 for type of record and location.

Table A10.2 – List of Records to be Maintained

Record	Location
Field Gage Height Readings (USGS form 9-275)	ADAPS/USGS Texas Water Science Files
Field Discharge Measurements (USGS form 9-275)	USGS Texas Water Science Files
Electronic Field Discharge Measurements	ADAPS
Electronic Gage Height Unit Values	ADAPS
Electronic data files for transmission to LEADS	USGS Texas Water Science Center
Validators notes	USGS Texas Water Science Center
Field Station Folder (field measurements, list of visits, station description, traffic control plan, emergency contact info)	USGS Texas Water Science Center
Gage Shelter Folder (field measurements, list of visits, station description, traffic control plan, emergency contact info)	Gage shelter
Electronic Operator Log	TCEQ LEADS database

B1 SAMPLING PROCESS DESIGN

Site Selection Criteria

The TCEQ project lead chose monitoring locations that will provide the needed information for the project objectives in section A5 of this project plan.

- The USGS has published a method for the operation of continuous water quality stations (USGS Techniques and Methods 1-D3, 2006). (http://pubs.usgs.gov/tm/2006/tm1D3). The USGS guidance document describes the site selection process and was followed to develop the procedures included in the above named SOP.

Monitoring Station Design

Monitoring and/or support equipment are installed in weather-tight aluminum enclosures or climate controlled trailers containing a data logger, modem, telemetry equipment, and various other support equipment.

CWQM sites:
YSI 6600EDS
Sutron Satlink with display, 300 baud (HDR) radio.
Yagi antenna
20 watt arrays with charging regulator solar panel.

Streamflow sites:
Hoffman enclosure 24x36x72
Sutron Satlink with display, 300 baud (HDR) radio.

Yagi antenna
20 watt arrays with charging regulator solar panel.

Site operation and maintenance will be provided by the site operator listed in Table A4.1

B2 SAMPLING METHODS

B2.1 CWQM Element

In-situ water quality and sample depth water level measurements are logged once every 15 minutes by the data logger.

Table B2.1 – CWQMN - Monitoring Methods and Equipment

River Basin	Station Location	MeteoStar/ LEADS Data Averaging Time	Sampling Method	Measurement Equipment	Telemetry	Station Parameters
Rio Grande	Above Rio Conchos near Presidio, TX	Measurement every 15 minutes averaged into one-hour averages	YSI 6600 EDS	YSI 6600 EDS	GOES	Surface Temperature Surface SC Surface DO Surface pH Sample Depth
	Below Rio Conchos near Presidio, TX					
	At Foster Ranch near Del Rio, TX					

Sampling/Measurement System Corrective Action

CWQM Element

USGS is responsible for Sampling/Measurement system corrective action. Corrective action measures in the CWQMN will be taken to ensure the DQOs and Measurement Quality Objectives (MQOs) are attained. The site operator is responsible for monitoring the performance of the measurement and support equipment and identifying problems or potential problems. The site operator is responsible for documenting problems and corrective actions in the appropriate instrument logbook(s).

B2.2 Streamflow Element

As described in the **United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge** (http://pubs.usgs.gov/wsp/wsp2175); and United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf).

Table B2.2 – Streamflow Monitoring Methods and Equipment

River Basin	Station Location	MeteoStar/ LEADS Data Averaging Time	Sampling Method	Telemetry	Station Parameters
Rio Grande	Big Bend National Park at Castolon, TX	Measurement every 15 minutes averaged into one-hour averages	States Geological Survey Water-Supply Paper 2175	GOES	Gage Height Discharge
	Big Bend National Park at Rio Grande Village, TX				

Sampling/Measurement System Corrective Action

Streamflow Element

As described in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge (http://pubs.usgs.gov/wsp/wsp2175; and United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf).

B3 SAMPLING HANDLING AND CUSTODY

B3.1 CWQM Element

See Section B10 of this project plan for electronic data management.

B3.2 Streamflow Element

Not applicable to this project element.

B4 ANALYTICAL METHODS

B4.1 CWQM Element

Analytical methods are listed in Table A.7.1 of this project plan

B4.2 Streamflow Element

As described in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge (http://pubs.usgs.gov/wsp/wsp2175}; and United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of

Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf).

B5 QUALITY CONTROL

B5.1 CWQM Element

As described in Section B5 of the CWQMN QAPP. Please see Table A7.1 for QC criteria. USGS will follow procedures and criteria in TCEQ SOP AMPM-011, Analysis of Dissolved Oxygen (DO), Specific Conductance (SC), pH, Temperature, and Sample Depth in Ambient Surface Water Using Yellow Springs Instrument (YSI) 600 XLM and 6600 Extended Deployment System (EDS) Sonde (Attachment A). See exceptions listed in section A4.3 of this project plan.

B5.2 Streamflow Element

As described in the Texas Water Science Center Surface-Water Quality-Assurance Plan. (Attachment B)

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

USGS maintenance documents are based on manufacturers' recommendations. Instrument maintenance activities are documented in equipment dedicated logbooks. Preventative maintenance records contain information on periodic routine maintenance, symptoms, troubleshooting effort descriptions, results and follow-up observations. Records should include the date, time, and the name or initials of the site operator performing the maintenance.

B6.1 CWQM Element

YSI Series 6 operational, maintenance and inspection manuals are being used as guidance for maintenance activities.

TCEQ AMPM-011 is the SOP being used for instrument testing by CVS requirements.

B6.2 Streamflow Instruments

Every eight weeks the following equipment will be visually inspected and maintenance conducted by USGS field personnel if required.

Design Analysis H-360 Radar Distance Measurement System (http://www.waterlog.com/downloads/manuals/Entire%20H-360%20Manual.pdf)

Sutron 8210 Datalogger (http://www.sutron.com/pdfs/8210_RevD_Manual.pdf)

Son Tek Flow Tracker (http://hydroacoustics.usgs.gov/policy/OSW2007-01.pdf)

Price Type AA Current Meter (http://pubs.usgs.gov/twri/twri8b2/html/toc.html)

RDI Acoustic Doppler Current Profiler (http://hydroacoustics.usgs.gov/policy/OSW2006-02.pdf and http://pubs.usgs.gov/sir/2005/5183/)

B7 INSTRUMENT CALIBRATION AND FREQUENCY

B7.1 CWQM Element

As described in TCEQ YSI SOP AMPM-011. See USGS exceptions listed in A4.3.

B7.2 Streamflow Instruments

Instrumentation calibration and frequency for the following equipment is performed according to manufactures specifications and USGS policy: (http://hydroacoustics.usgs.gov/policy/index.html) (See section A6.2 for list of instruments)

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Standards, reagents and parts are purchased using USGS procurement guidelines.

B8.1 CWQM Element

B8.1.1 Standards and Reagents

Standards and reagents are traceable to NIST standards. Certification of traceability is available upon request.

B8.1.2 Spare Parts

Site operators are required to keep replacement probes and instrument parts on hand at all times for field equipment.

B8.2 Streamflow Element

B8.2.1 Standards and Reagents.

Not applicable to this project element.

B8.2.2 Spare Parts

Spare parts are maintained at USGS Texas Water Science Center offices as part of routine data collection activities. Additional inventory maintained at USGS Hydrologic Instrumentation Facility (HIF).

B9 NON-DIRECT MEASUREMENTS

B9.1 CWQM Element

There are no non-direct measurements used for continuous water quality monitors.

B9.2 Streamflow

There are no non-direct measurements used in this project.

B10 DATA MANAGEMENT

TCEQ Project Lead will be responsible for analyzing project data.

B10.1 Streamflow and CWQM Element

As described in section B10 of the CWQMN QAPP for the CWQM element.

Monitoring site data are stored in a Sutron Satlink data logger and transmitted via GOES satellite to TCEQ (Austin, Texas) Comms Front-End Processor (CFEP) computer once every hour.

TCEQ will decode and ingest data from the NOAAPort and ingest the data to LEADS. TCEQ will download the daily discharge look-up table from USGS and display discharge based on the table. USGS will submit gage height and discharge data in SWQMIS format semi-annually.

The USGS will be responsible for water quality and Streamflow data through the point of data validation

USGS will be responsible for detecting and resolving any communications issues with the monitoring sites up to and including the GOES transmission.

The site operator should check the operational status of the station every business day via the USGS website. If communication problems are detected, the site operator needs to initiate corrective action in a timely manner.

B10.2 USGS – Streamflow

Project data will be managed by Project Lead and Technical Personnel. Data management includes:

- Daily review of WEB data
- Computation of record
- Checking of computed record
- Final review and approval of computed record
- Retrieval and reformatting of data into LEADS format
- Semi-annual submittal to TCEQ of computed unit values for gage height (**SWQM IS** format)
- Semi-annual submittal to TCEQ of computed unit values for discharge (**SWQM IS** format)
- Semi-annual submittal to TCEQ of daily mean values for discharge (**SWQM IS** format)

C1 ASSESSMENTS AND RESPONSE ACTIONS

C1.1 CWQM Element

As described in the United States Geological Survey Techniques and Methods 1-D3, Guidelines and Standard Procedures for Continuous Water-Quality Monitors.

C1.2 Streamflow Element

As described in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge (http://pubs.usgs.gov/wsp/wsp2175; and United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf).

C2 REPORTS TO MANAGEMENT TCEQ

CWQMN and Streamflow Element

The TCEQ CWQMN Network Coordinator must be notified in writing of any USGS collected data (only USGS validated data that has been provided to TCEQ) that has been identified by USGS and/or TCEQ as not meeting USGS/TCEQ quality objectives or criteria.

Reports to TCEQ Project Management

USGS will provide TCEQ with a report providing the following information when any USGS validated data does not meet quality objectives or criteria:

- Specific data not meeting quality objectives or criteria.
- The quality objective or criteria not met.
- An explanation of impact to data.
- Corrective action.

D1 DATA REVIEW, VERIFICATION, AND VALIDATION

D1.1 CWQM Element, Data Verification

As described in section D1 of the CWQMN QAPP.

D1.2 Streamflow Element, Data Verification

USGS project lead and project technical personnel will be responsible for validating station data as described in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge (http://pubs.usgs.gov/wsp/wsp2175; and United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf).

D2 VERIFICATION AND VALIDATION METHODS

USGS is responsible for the validation of water quality and discharge data.

D2.1 CWQM Element, Data Validation

As described is section D1 of the CWQMN QAPP. USGS will validate (behind TCEQ's firewall) water quality data using LEADS manual validation tool. USGS will follow: TCEQ SOP DQRP-015 Validation of Continuous Water Quality Monitoring Data Collected by Multiparameter Sonde. (Attachment C)

When CVS criteria ($\leq$5.0% RPE) for SC are not met the corresponding calculated TDS values back to the last SC calibration should be invalidated using the AQI data flag (AQI Ambient Quality Invalidated).

Table D2.1 - CWQMN Data Validators

Basin	CAMS Number	TCEQ Station ID	USGS/USIBWC Station ID	Data Validator	Site Operator	Site Location
Rio Grande	757	13230	08371500	USGS	USGS	Above Rio Conchos near Presidio, TX
Rio Grande	758	13229	08374200	USGS	USGS	Below Rio Conchos near Presidio, TX

Rio Grande	759	13223	08377200	USGS	USGS	At Foster Ranch near Del Rio, TX

D2.2 Streamflow Element, Data Validation

As described in the United States Geological Survey Water-Supply Paper 2175, Measurement and Computation of Streamflow: Volume 1. Measurement of Stage and Discharge; Volume 2. Computation of Discharge (http://pubs.usgs.gov/wsp/wsp2175); and United States Geological Survey Water-Resources Investigations Report 01-4044, Standards for the Analysis and Processing of Surface-Water Data and Information Using Electronic Methods (http://wwwnwis.er.usgs.gov/nwisdocs4_3/WRIR01-4044.pdf).

D3 RECONCILIATION WITH USER REQUIRMENTS

D3.1 CWQM and Streamflow Element

TCEQ Project Lead will make the determination if the data in question are useable.

Attachment A: TCEQ AMPM – 011 Analysis of Dissolved Oxygen (DO), Specific Conductance (SC), pH, Temperature, and Sample Depth in Ambient Surface Water Using Yellow Springs Instrument (YSI) 600 XLM and 6600 Extended Deployment System (EDS) Sondes

STANDARD OPERATING PROCEDURE (SOP)	
Title: Analysis of Dissolved Oxygen (DO), Specific Conductance (SC), pH, Temperature, and Sample Depth in Ambient Surface Water Using Yellow Springs Instrument (YSI) 600 XLM and 6600 Extended Deployment System (EDS) Sondes	
Team Leader: ____________________	Date: ____________
Quality Control Review: ____________________	Date: ____________
Section Manager: ____________________	Date: ____________
Effective Date: 06/22/06	

1.0 PURPOSE

This describes the analytical procedures for continuous automated analysis of DO, SC, pH, Temperature, and Sample Depth in ambient surface water using the YSI 600 XLM and 6600 EDS Sonde (Multi-probes).

2.0 SCOPE AND APPLICABILITY

2.1 This procedure is intended for use in the Continuous Water Quality Monitoring Network (CWQMN).

2.2 Due to the extended length of time Sondes are deployed the data can be used to establish baseline conditions, identify trends, characterize pollution events, and seasonal variations in water quality.

2.3 SC, DO, pH, and Temperature data meeting Surface Water Quality Monitoring Data (SWQM) Quality Objectives Criteria (DQOs) may be used for the Federal Clean Water Act Sections 305(b) Report and 303(d) Lists.

2.4 Sonde sample depth measurements can be used for data validation purposes. The working range of the sensors is listed below.

Parameter	Working Range
DO	0 - 50 milligrams/Liter (mg/L)
SC	0 - 100,000 micro siemens/cubic centimeter (μS/cm)
pH	0 - 14 pH Units
Temperature	5° to 45° Degrees Centigrade ($^{\circ}$C)
Sample Depth	0 - 61 meters

3.0 METHOD SUMMARY

3.1 The Sonde is deployed in the water body of interest and ambient surface water DO, SC, pH and temperature is measured in situ. Membrane electrodes for DO analysis can be used in polluted waters, highly colored waters and strong waste effluents due to the oxygen-permeable plastic membrane that serves as a diffuse barrier against impurities.

3.2 The DO sensor is a polargraphic membrane electrode, which has solid metal anode and cathode in contact with a supporting electrolyte separated from the test solution by a semi-permeable membrane. The membrane electrode is continuously polarized at a voltage to cause oxygen to be reduced to hydroxide ion at the cathode and silver metal to be oxidized to silver chloride at the anode. The oxygen diffuses through the membrane. The temperature compensated current associated with this process is proportional to the oxygen concentration in the test solution outside the membrane. The YSI electrode is polarized and depolarized during a measurement sequence resulting in a measured net charge that reduces oxygen consumption in the test solution.

3.3 The Electrical Conductivity (EC) sensor is a flow cell with four electrodes. Conductivity/specific resistance is measured through an approximately 5.0 centimeter^{-1} cell using alternating current.

3.4 The pH sensor utilizes a glass sensing electrode with a combined double junction half cell silver chloride reference electrode. The reference electrode provides a constant electrode potential and makes an electrical circuit with the sensing electrode. The sensing electrode contains a glass bulb of a fixed concentration of potassium chloride solution in contact with the reference electrode. Sodium ions are exchanged for hydrogen ions and a potential develops across the sensing membrane; the resulting membrane potential varies with pH. The reference electrode quantitatively compares the changes of the sensing membrane.

3.5 Surface water temperature is measured by a resistance thermistor.

3.6 Sample depth is measured by a non-vented pressure transducer. The transducer measures the pressure of the water column plus the atmospheric pressure above the water with a differential strain gauge.

4.0 LIMITATIONS

4.1 DO, EC, and pH sensors can become fouled due to bacteria, algae, and chemical deposits. In some water bodies (or due to seasonal variations in water quality) sensor fouling can occur rapidly, decreasing deployment periods. YSI 6600 EDS sondes are equipped with a brush that mechanically cleans the DO and pH sensor tips. This capability can increase deployment periods. Prolonged use of membrane electrodes in waters containing such gases as hydrogen sulfide tends to lower cell sensitivity.

4.2 DO membrane electrode sensitivity varies with dissolved salt concentration. Plastic film membranes are permeable to a variety of gases besides oxygen. The acid electrolyte in the galvanic cell must be replaced periodically after its capacity to reduce oxygen is depleted. Ambient DO concentration measurements are not corrected for changes in local barometric pressure after calibration.

4.3 In rivers that have high sediment loading, sensors can periodically become covered with sediment.

4.4 Electrolytic conductivity increases with temperature. Significant errors can result from inaccurate temperature measurements.

4.5 The glass pH electrode is relatively free from interference from color, turbidity, colloidal matter, oxidants, reductants, or high salinity, except for sodium error at pH > 10. pH measurements are affected by temperature and can cause long term drift.

4.6 The depth sensor is non-vented. The software uses the atmospheric pressure at the time of calibration, changes in atmospheric pressure between calibrations appears as changes in depth. The error is equal to 0.045 feet for every 1 millimeter mercury (Hg) change in atmospheric pressure.

4.7 Expired standards should not be used.

5.0 SAFETY

This procedure includes processes that can be hazardous. Therefore, before attempting this process, review the TCEQ Chemical Hygiene Plan for proper equipment and procedures necessary for the safe completion of this procedure. Operators must read and be familiar with the Material Safety Data Sheets for potassium chloride. Lab coats, safety glasses with side shields and/or splash goggles and chemical resistant gloves should be worn when handling these chemicals. These chemicals have the potential to be skin and eye irritants.

6.0 EQUIPMENT AND REAGENTS

6.1 Equipment

- YSI 600 XLM or 6600 EDS, with EC, DO, pH, Temperature, and Depth Sensors
- YSI Multi-Parameter Display System (MDS)
- YSI Field cable
- Calibration forms
- Instrument logbook
- Calibration Cup
- Ring stand and clamp
- Plastic bucket large enough to immerse sonde sensors completely in water
- Thermistor or Thermometer traceable to National Institute of Standards and Technology (NIST) with a 0.1°C

6.2 Standards and Reagents (All reagents/chemicals must be AR grade)

- EC Potassium chloride (KCL) solution calibration standards traceable to NIST
- KCL solutions traceable to NIST with approximate pH values of 7.00 and 10.0 pH units in neutral-to-basic water bodies. In neutral to acidic waters approximate pH values of 4.00 and 7.00 pH units should be used
- De-ionized (DI) Type1 water

7.0 PROCEDURE

Before water quality is monitored, the sensors are calibrated and quality control (QC) samples are analyzed at a minimum of once a month. The station's water quality parameters are monitored by the site operator remotely to evaluate operational status of the station.

7.1 Monitoring

The Sonde measures ambient surface water while in situ. The Sondes can be deployed in poly vinyl chloride (PVC) tubing that is attached to a support structure.

7.1.1 The sonde should be deployed in a representative section of the water body. When monitoring rivers and streams, the sonde should be located as close as possible to the centroid of flow. Centroid is defined as the midpoint of that portion of stream or river width which contains 50 percent of the total flow.

7.1.2 Sensors should be at approximately one foot of water depth. Areas of excessive vegetation, turbulence, or silt should be avoided.

7.1.3 Drill holes in the PVC to allow for an exchange of water into the tubing.

7.1.4 Adjust the sonde periodically due to fluctuations in water levels of the water body.

7.2 Station Monitoring

The site operator should monitor water quality and other parameters daily to ensure the station is operational.

7.2.1 Every business day the site operator will monitor (via TCEQ website http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wqm/swqm_realtime_alt.html/data) and screen EC, DO, pH, temperature, and sample depth measurements for anomalies. If problems are identified, a site visit may be needed to correct any problems.

7.2.2 Sample depth measurements can be used as an indicator to whether the sonde sensors are still submerged in the water body or that the sonde may need to be adjusted to the correct depth.

7.3 DO, EC, and pH Sensor Calibration Verification Samples (CVS) and Temperature QC.

EC, DO, and pH CVSs are analyzed and the sensors are re-calibrated at a minimum of once every month. More frequent sensor re-calibrations may be needed in high fouling environments. The site operator will need to determine sensor re-calibration frequency for their water body. Temperature and sample depth sensors are checked monthly. Note: The TCEQ Surface Water Quality Monitoring program has used the phrase "Post-Calibration" to describe QC samples used to assess analytical drift from previous sensor calibrations. For the purposes of this document, CVS is used in place of "Post-Calibration"

7.3.1 EC, DO, and, pH CVSs are analyzed at a minimum of once every month (or more frequently) immediately before the sonde EC, DO, and pH sensors are re-calibrated. If a EC, DO, or pH temperature does meet acceptance criteria in Table 9-1, the data for failing parameter(s) must be invalidated back to the last sensor CVS or calibration. For further details, see Section 9.0.

7.3.2 The temperature sensor should be checked once every month. If the sensor does meet acceptance criteria in Table 9-1, the temperature data must be invalidated back to the last temperature check. For further details, see Section 9.0.

7.3.3 The depth sensor should be calibrated once every month.

7.3.4 If barometric pressure for DO calibrations is determined using the barometer in the YSI Multi-Parameter Display System (MDS) the accuracy of the barometer will need to be checked once a year.

7.4 EC, DO, pH, and Depth Sensor Calibration

EC, DO, pH and Depth Sensor calibrations are performed once a month at a minimum and are performed immediately after the monthly EC, DO, and pH CVSs are analyzed. After EC, DO, pH, and depth sensor calibration(s), calibration parameters/constants are recorded in the instrument logbook. When using the YSI MDS to obtain barometric pressure for DO calibrations the MDS barometric pressure sensor is checked once a year.

- Note: Perform calibrations and analyze DO, EC, and pH CVSs as close to 25.0 °C, as possible.
- Note: perform the EC calibration before calibration of the pH sensor.
- Barometric pressure measurements for DO calibrations can be obtained at the National Weather Service.
- Allow the sonde and calibration standards time to equilibrate before calibration(s) or initial readings.
- Use a ring stand and clamp to secure the sonde body.
- Before calibration, make sure plugs are installed in empty sensor ports.
- Insure all sensors are immersed in KCL calibration solutions.
- Use a small amount of calibration solution to pre-rinse the sensors. Old calibration solutions may be used for this.
- Have several clean absorbent paper towels. Shake the excess rinse water off the sondes. This will reduce carry-over contamination of calibrator solutions.

7.4.1 Single-Point EC Calibration

The calibration of the EC sensor consists of a single-point calibration with a KCL solution. Choose the calibration conductivity that is closest to the expected conductivity of the water body. During the calibration, the YSI sonde will measure the temperature of the standard and automatically calculate the (non-normalized) conductivity of the standard.

- Rinse the sensor twice with conductivity standard.
- Fill the calibration cup with conductivity standard. Place the sensors into the conductivity standard and make sure the sensors are completely immersed passed the vent hole. Allow at least 60 seconds for the temperature to equilibrate. After EC readings have stabilized record temperature and initial specific conductance measurement of the standard before calibration on the calibration worksheet.
- Gently tap the side of the calibration cup to dislodge any air bubbles from the cell.
- Allow at least one minute for temperature equilibration to occur before proceeding with the calibration.
- From the Calibration Menu select 1-Conductivity and a second menu will offer you options of calibrating in specific conductance, conductivity, or salinity. Calibrating any one option automatically calibrates the other two.
- Select Specific Conductance and then you will be prompted to enter the value of the EC standard (µS/cm or ms/cm at 25.0° C). Then select Enter
- Observe readings under Specific Conductance or Conductivity, and when they show no significant change for approximately 30 seconds, press Enter. The screen will indicate that the calibration has been accepted; press Enter again and return to the Calibrate menu.
- Record EC calibration constant on the Calibration Worksheet. The EC Cell Constant should be between 4.5 and 5.5. Values outside the recommended range may indicate the EC sensor needs maintenance or replacement.

7.4.2 Two-Point pH Calibration

The pH calibration requires two KCL solutions (pH 4.00 and 7.00 or pH 7.00 and 10.00). Choose solutions that bracket the expected pH range of the water body.

- Place enough pH 7.00 buffer into a clean, dry, or pre-rinsed calibration cup to immerse the pH probe reference junction, and thermistor. Allow one minute for the temperature to equilibrate.
- From the Calibrate menu, select 4-ISE1 pH to access the pH calibration choices; then select 2 point. Press "Enter" and input the value of the buffer at the prompt. Press Enter and the current values of the enabled sensors will appear on the screen. Observe the pH millivolt (mV) readings. This value should be between -40 and 40. Record the mV on the calibration worksheet.

- Observe the pH reading and when it shows no significant change for approximately 30 seconds press Enter. The display will indicate that the calibration is accepted.
- After the pH 7.00 calibration is complete, press Enter to continue. Rinse the sonde with water before proceeding.
- Place enough pH 4.00 or 10.00 buffer solution into a clean, dry, or pre-rinsed calibration cup to immerse the pH probe reference junction, and thermistor. Allow one minute for the temperature to equilibrate.
- Observe the pH mV reading. This value should be between 120 and 200 mV in pH buffer 4.00 and should be between -120 and -200 mV in pH buffer 10.00. Record the mV on the Calibration Worksheet. Values outside the range may indicate the pH sensor needs maintenance or replacement.

- Press Enter and input the value of the second pH buffer at the prompt. Select Enter and the current values of all enabled sensors will appear on the screen.
- Observe the pH reading and when it shows no significant change for approximately 30 seconds press Enter. The display will indicate that the calibration is accepted. After the second calibration is completed, press Enter again. If you are performing a 2-point Calibration, the display will return to the Calibrate Menu.
- After the calibration is complete, rinse the sonde with DI water before proceeding. Rinse the calibration cup.

7.4.3 DO Calibration

The DO sensor is calibrated using percent saturation in water-saturated air. When using YSI sondes in the CWQMN the Autosleep RS232 function should be enabled.

- From the Main Menu, Select 8-Advanced and then 2-Setup. Ensure that 5-Autosleep RS232 and 6-autoSleep SDI12 are enabled. If the Autosleep functions are not enabled, Select 5-Autosleep RS232 and 6-autoSleep SDI12 and press "Enter."
- Place about 1/8 inch water in the bottom of the calibration cup. Place the probe in the cup. Make certain that the DO and temperature probes are not immersed in the water. Engage only one thread of the calibration cup to ensure the DO probe is vented to atmospheric pressure. Wait at least 10 minutes for the air in the calibration cup to become water saturated and for the temperature to equilibrate.
- From the Calibrate Menu, Select 2-Dissolved Oxygen, then 1-DO% to access the DO% saturation calibration procedure.
- Follow the screen prompt and enter <u>actual</u> barometric pressure in mm of Hg, press "Enter," and the calibration will automatically occur after

the warm-up time. Then, press "Enter" to return to the Calibrate Menu. Note: When using National Weather Service barometric pressure measurements, the reading will need to be uncorrected from sea level to actual barometric pressure. See equation in Section 8.1. YSI MDS barometric pressure sensor displays actual barometric pressure.

- Record the DO Charge on the Calibration Worksheet. This value should be between 25 – 75. Values outside the recommended range may indicate the DO sensor needs maintenance or replacement.
- Record the DO gain on the Calibration Worksheet. This value should be between 0.7- 1.7. If values are outside this range there could be calibration process errors(s) or calibration standard problems.
- Press "Enter" to return to the Calibrate Menu.

7.4.4 Depth Sensor Calibration

The depth sensor is non-vented. The depth sensor is factory calibrated, but it is always necessary to zero the absolute sensor relative to the local barometric pressure. Note: When performing a depth sensor calibration the sondes orientation should remain constant while taking readings.

- From the Calibration Menu, Select 3-Pressure Abs (non-vented) to zero the depth sensor.
- The zeroing procedure should be performed in ambient air. Select "depth option."
- After the depth option is selected, enter 0.00 at the prompt, press "Enter" and monitor the stabilization of the depth readings. After no changes occur for approximately 30 seconds, press "Enter" to confirm the calibration.
- As instructed, press "Enter" again to return to the Calibration Menu.

8.0 CALCULATIONS

8.1 Sea Level Corrected Barometric Pressure Uncorrected to Actual Barometric Pressure

This equation is used to uncorrected sea level corrected barometric to actual barometric pressure. Local barometric pressure obtained from the National Weather Service is corrected to sea level and is usually reported in inches of Hg (inches Hg x 25.4 = mm Hg).

$$ABP = CBP - (2.5mmHg)\left(\frac{A}{100}\right)$$

Where:

ABP = Actual Barometric Pressure in mm Hg.
CBP = Barometric Pressure corrected to see level in mm Hg.
A = is local altitude in feet above mean sea level.
2.5 mm Hg = constant.

8.2 Sample Conductivity

Electrical Conductivity is reported as SC using Equation 8.2.1.

8.2.1 SC is actual conductivity corrected to 25 □C:

$$SC = \frac{AC}{1 + 0.0191 \times (t - 25.0)}$$

Where:

AC = is non standardized conductivity in □S/cm.
t = is the solution temperature in degrees C.

8.2.2 To determine un-normalized (raw) potassium chloride EC concentration from normalized

Raw EC = normalized EC in µS/cm (1+0.0191(temp measured - 25)).

8.3 QC Calculations

8.3.1 The mean $(\overline{X})$ is the average of a given set of related data:

$$\overline{X} = \frac{\sum_{y=1}^{n} X_y}{n}$$

Where:

X = individual measurements; and
n = total number of measurements.

8.3.2 Relative Percent Error (RPE) can also be used to determine the relative accuracy of a measurement to a known value:

$$RPE = \frac{|Y - X|}{X} X100$$

Where:
Y = measured value; and
X = known value.

9.0 QC

9.1 QC Samples

Note: Analyze EC, DO, and pH CVSs as close to 25.0° C as possible.

QC samples are used to ensure that acceptable data quality is maintained throughout the process and to help assess data validation. The QC samples analyzed for this method are performed on a monthly basis, or more frequently as determined by the site operator.

Any deviation from the procedures documented in the SOP, including any QC samples which do not meet the frequency requirement or acceptance criteria, need to be documented in the operators log. The log entry should contain a description of the exception, the cause (if possible), the affected data, and the impact on data. Any affected data should be qualified accordingly. Note: A failing CVS can be followed by a single replicate analysis to determine if there is a systematic problem. If the reanalysis meets all acceptance criteria, then the system may be deemed as providing acceptable data. Conducting multiple analyses to obtain a single passing QC sample when no corrective action as a result of an assignable cause or instrument maintenance is performed is not acceptable. In other words, if the original QC sample or its rerun passes, then the failing QC analysis is considered to be an anomaly, its results are not used for data assessment.

<u>EC QC Samples</u>

9.1.1 An EC CVS is analyzed at a minimum of once monthly (before calibration of the EC sensor) to assess analytical drift from the previous calibration. The CVS should be the same standard used to generate the initial single-point calibration.

9.1.2 The CVS KCL solution is introduced using the Cal Cup. Rinse the sensor with DI water and shake off DI water before introducing the CVS. The

Relative Percent Error (RPE) of the CVS should be 5.0 %. If the CVS does not meet acceptance criteria, the previous month's EC (back to the last EC calibration) data should be invalidated. Note: a failing CVS could be the result of an aged EC CVS standard. If CVS has failed, re-analyze the CVS using a fresh EC standard. CVS results should be entered into the operator log and Instrument Logbook.

<u>DO QC Samples</u>

The amount of DO in a sample is pressure and temperature dependent.

9.1.3 A DO CVS is analyzed a minimum of once monthly (before calibration of the DO sensor) to assess analytical drift from the previous calibration. The CVS consists of water percent saturation in water-saturated air using procedures in Section 7.4.3. Note: when using Section 7.4.3 the unit calibration step is not performed.

9.1.4 This reading (CVS) should be within 6.0% saturation.

9.1.5 If the CVS does not meet acceptance criteria the previous month's DO (back to the last passing CVS or DO calibration) data should be invalidated. CVS results should be entered into the operator log. The results should also be logged in the Instrument Logbook and/or recorded in the Calibration Worksheet.

<u>pH QC samples</u>

9.1.6 A pH CVS is analyzed a minimum of once monthly (before calibration of the pH sensor) to assess analytical drift from the previous calibration. The CVS consists of KCL solution of 4.00 or 10.00 pH units. The KCL solution is introduced using the Calibration cup. Note: Rinse the sensor with DI water and shake off DI water before introducing the CVS. The CVS is prepared from the same standard used to generate the initial calibration curve. The CVS should be within 0.50 pH units. Note: a failing CVS could be the result of an aged pH CVS standard. If CVS has failed re-analyze the CVS using a fresh EC standard. If the CVS does not meet acceptance criteria, the previous month's pH (back to the last pH calibration) data should be invalidated. CVS results should be entered into the operator log. The results should also be logged in the instrument logbook and/or recorded in the Calibration Worksheet.

<u>Temperature</u>

9.1.7 Once a month check the accuracy of sonde temperature sensor with a NIST traceable thermometer or thermistor. Fill a plastic bucket with water from the water body and immerse Sonde sensors into water. Place the thermometer or thermistor thermocouple next to the sonde temperature sensor and allow both temperature measuring devices time to stabilize. The Sonde temperature measurement should be within 1.5 °C of the NIST traceable thermometer or thermistor. If sonde temperature accuracy is not within acceptance criteria confirm with second NIST traceable thermometer or thermistor. If the sonde temperature is not within acceptance criteria with second NIST traceable thermometer or thermistor the previous (back to last temperature check) month's temperature data should be invalidated. If it is determined that the sonde's temperature sensor does not meet acceptance criteria, the sensor needs to be sent back

to the factory for repairs/calibration. The temperature check results should be entered into the operator log. The results should also be logged in the instrument logbook and/or recorded in the Calibration Worksheet.

<u>YSI MDS Barometer</u>

9.1.8 Once a year check the accuracy of the YSI MDS barometer using National Weather Service barometric pressure readings or use readings from a high quality laboratory barometer. The YSI MDS should be within 20 millimeters of Hg from the National Weather Service reading or a high quality laboratory barometer reading. See the equation in Section 8.1 to calculate National Weather Service sea level corrected barometric pressure to actual barometric pressure. YSI MDS and laboratory barometers measure actual barometric pressure. The barometer check results should be logged in the instrument logbook and/or recorded on the Calibration Worksheet.

Table 9-1
QC Checks

QC Check	Purpose	Frequency	Acceptance Criteria	Response Action
Single-Point EC Calibration	To establish slope used for quantitation	A minimum of once monthly or after failing CVS	Concentration level is detected	1) Analyze standard again 2) Perform corrective action as necessary 3) Re-calibrate
Single-Point DO Calibration	To establish slope used for quantitation	A minimum of once monthly or after failing CVS	Concentration level is detected	1) Analyze standard again 2) Perform corrective action as necessary 3) Re-calibrate
Two-Point pH Calibration	To establish slope used for quantitation	A minimum of once monthly or after failing CVS	Concentration level is detected	1) Analyze standard again 2) Perform corrective action as necessary 3) Re-calibrate
DO CVS (percent saturation in water-saturated air)	To assess sensor drift	Before sensor re-calibration. A minimum of once a month	± 6.0% saturation	1) Reanalyze CVS 2) If still failing perform corrective action and/or re-calibrate 3) Invalidate data accordingly
EC CVS	To assess sensor drift	Before sensor re-calibration. A minimum of once a month	≤ 5.0% RPE	1) Reanalyze CVS with fresh standard 2) Perform corrective action as necessary 3) Invalidate data accordingly
YSI MDS Barometric Pressure sensor	To assess sensor accuracy	Once a year and after sensor replacement	± 20 mmHg	Re-calibrate sensor

10.0 DEFINITIONS

See Appendix A of the Laboratory and Mobile Monitoring Quality Manual
Surface Water Quality Monitoring Quality Assurance Project Plan

11.0 REFERENCES

U.S. EPA equivalent method EQSA-0193-092
U.S. Geological Survey TWRI Book 9
Yellow Springs Instrument 6-series Operator's Manual
TCEQ Operating Policies and Procedures, Chapter 6.13
Laboratory and Mobile Monitoring Quality Manual
Surface Water Quality Monitoring procedures Manual, Volume I
Continuous Water Quality Monitoring Network Quality Assurance Project Plan
Monitoring Operations Hazardous Waste Disposal Plan
TCEQ Chemical Hygiene Plan

12.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Supervisors, sampling personnel, and laboratory analysts should identify and implement innovative and cost-saving waste reduction procedures as part of the method development, review, and revision of standard operating procedures. Wastes that do result from these procedures are managed and disposed of in accordance with appropriate state and federal regulations.

Refer to Chapter 6.13 of the TCEQ Operating Policies and Procedures for guidelines on general recycling, waste reduction, and water and energy conservation. Review these procedures for specific employee responsibilities and mechanisms for office-related waste prevention and management. Consult the Monitoring Operations Hazardous Waste Disposal Plan for laboratory-specific waste minimization recommendations and requirements for proper handling of hazardous waste that result from laboratory procedures.

The reagents, washes, standards, and waste associated with this procedure do not require special disposal. Before disposing waste into a municipal sewer system check with respective municipal sewer system on what concentration levels are allowed to be put into their system.

13.0 SHORTHAND PROCEDURE

- Set-up Procedures (Section 7.1 and, 7.3).
- Calibrate EC, DO, pH, and Depth Sensors once a month at a minimum.
- Deploy sonde.
- Monitoring and Sensor Verification (Section 7.2 and 7.4).
- Monitor sonde every business day via the internet.
- Analyze EC, DO, and pH CVSs once a month.

- Check sonde temperature and depth sensors monthly.
- Check YSI MDS barometric pressure sensor yearly.

YSI SERIES 6 SONDE (MULTI-PROBE) CALIBRATION WORKSHEET
FOR USE IN CONTINUOUS WATER QUALITY MONITORING NETWORK

Calibration

Date:	Time:	Analyst:	YSI MDS serial number:
Battery Voltage:		Sonde Type and Serial No.	
CAMS Station: Date Deployed:		Location: Date Retrieved:	

Parameter	Temp. of Standard	Concentration or pH of Calibration Standard	Initial Reading	Calibrated to	Comments
Specific conductance (high) 1,000 µmhos/cm					
Conductivity cell constant					Range 4.5 to 5.5
pH calibrated (~7)					
pH mV for pH 7 solution					Range 0 40 mV
pH slope (~ 4/10)					
pH mV for pH 10 pH mV for pH 4					Range: -160 40 mV Range: +160 40 mV
Dissolved oxygen (%sat)					
Dissolved oxygen charge					Range 25 to 75
Dissolved oxygen gain					Range 0.7 to 1.7

Barometric pressure (actual) used for DO calibration _________mm Hg

Barometric Pressure (BP) Options	Barometric Pressure Formulas
Altitude (A) =______________feet above mean sea level	
National Weather Service Barometric Pressure corrected to sea level in inches of Hg.	Barometric pressure (inches) ________ x 25.4 = BP ________mm Hg
	Actual BP = corrected BP _______mm - 2.5 (altitude ____/100)

Deployment Checklist	
Logging interval: Yes No	SDI-12 Autosleep enabled: Yes No
DO warm-up time:	Battery volts in Sonde (days):
RS 232 autosleep enabled: Yes No	Available memory in Sonde (days):

Calibration Verification Sample (CVS), Post-Calibration		
Date:	Time:	Analyst: Fluke Thermometer Serial No.
Battery Voltage:		Sonde Type and Serial No.

Parameter	Temp. of Standard	CVS Concentration or pH	CVS or temp results	Criteria
Specific conductance				5.0% RPE
pH calibrated (~7)				0.50 pH unit
YSI SERIES 6 SONDE (MULTI-PROBE) CALIBRATION WORKSHEET FOR USE IN CONTINUOUS WATER QUALITY MONITORING NETWORK				
pH slope (~ 4/10)				0.50 pH unit
Dissolved oxygen				6.0% saturation
Temperature	NA	NA		1.5 degrees C

Comments:

YSI Multi-Parameter Display System (MDS) Barometer Worksheet

Date:

Analyst:

YSI MDS serial number:

Reference standard: National Weather Service or Laboratory Barometer

Parameter	MDS Barometric Pressure (mm Hg)	Reference Standard Barometer Pressure (mm Hg)	Criteria
YSI MDS Barometer			20 mmHg

Comments:

Attachment B Texas Water Science Center Surface-Water Quality-Assurance Plan

Abstract
It is the policy of the Water Resources Discipline of the USGS that each Water Science Center will develop and maintain a Surface-Water Quality-Assurance Plan. This Surface-Water Quality-Assurance Plan documents the standards, policies, and procedures used by the Texas Water Science Center for activities related to the collection, processing, storage, analysis, presentation, and publication of surface-water data. The Plan is available to all Texas Water Science Center employees and located at the Water Science Center internal home page at http://tx.cr.usgs.gov/

INTRODUCTION

The U.S. Geological Survey (USGS) was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to perform the systematic and scientific "classification of the public lands, and examination of the geologic structure, mineral resources, and products of the national domain." Surface-water activities in the Texas Water Science Center (WSC) are part of the Water Resources Discipline's (WRD) overall mission of appraising the Nation's water resources. Surface-water information for streams and reservoirs are used at the Federal, State, and local levels for resources planning and management.

The purpose of this WSC Surface-Water Quality-Assurance Plan (QA Plan) is to document the standards, policies, and procedures used by the Texas WSC for activities related to the collection, processing, storage, analysis, presentation, and publication of surface-water data.

This plan identifies responsibilities for ensuring that stated policies and procedures are carried out. The plan also serves as a guide for all WSC personnel involved in surface-water activities and as a resource for identifying memoranda, publications, and other literature that describe in more detail associated techniques and requirements.

The scope of this report includes discussions of the policies and procedures followed by this WSC for the collection, processing, analysis, storage, presentation, and publication of surface-water data. Specific types of surface-water data include stream stage, streamflow, reservoir stage, reservoir storage, and basin characteristics. In addition, issues related to the management of the computer data base and employee safety and training are presented. Although procedures and products of interpretive projects are subject to the criteria presented in this report, specific interpretive projects are required to have a separate and complete quality-assurance plan.

This QA Plan is reviewed and revised at least once every 3 years in order that responsibilities and methodologies are kept current and in order that the ongoing procedural improvements can be effectively documented. This QA Plan is based on references provided within the Plan, OSW Technical Memoranda (http://water.usgs.gov/admin/memo/SW/auto.html), and WSC memoranda and policy statements referenced within.

RESPONSIBILITIES

Quality assurance (QA) is an active process. Achieving and maintaining high-quality standards for surface-water data are accomplished by specific actions carried out by specific persons. Errors and deficiencies can result when individuals fail to carry out their responsibilities. Clear and specific statements of responsibilities promote an understanding of each person's duties in the overall process of assuring surface-water data quality.

The following is a list of general responsibilities of WSC personnel involved with surface-water data. Specific responsibilities are identified later within the text.

The WSC Director is responsible for:

- Managing and directing the WSC program, including all surface-water activities.
- Ensuring that surface-water activities in the WSC meet the needs of the Federal Government, the Texas WSC, State and local agencies, other cooperating agencies, and the general public.
- Ensuring that all aspects of this QA Plan are understood and followed by WSC personnel. This is accomplished by the WSC Director's direct involvement or through clearly stated delegation of this responsibility to other personnel in the WSC.
- Providing final resolution of any conflicts or disputes related to surface-water activities within the WSC.
- Reviewing the funding, budgeting, cost accounting, and expenditures of the Data Program.

The WSC Deputy Director for Data is responsible for:

- Funding, cost accounting, budgeting, and expenditures under the Data Program.
- Assuring that all quality-control and quality-assurance procedures are implemented for the Data Program.
- Providing communication from Headquarters, Region, and TX WSC management regarding the Data Program to Program Office and Field office Data Chiefs or all personnel involved in the Data Program.
- Assuring that all procedures and policies for the Data Program are implemented.

The WSC Surface-Water Specialist is responsible for:

- Reviewing the techniques, procedures, and tools used to collect, transport, process, store, analyze, present, and publish SW data.
- Documenting the techniques, procedures, and tools, and documenting revisions or additions that need to be made.
- Communicating such documentation to the Program Office and Field office Data Chiefs, and in some cases, directly to all personnel involved.
- Training in field and office surface-water procedures.

The Program Office and Field Office Data Chiefs are responsible for:

- Reviewing the collection and processing of data for their office.

- Assuring that proper procedures and policies are implemented.
- Finalizing data values for their office.

The Program Office and Field Unit Chiefs are responsible for:

- Providing the manpower necessary to carry out the work under the Data Program.
- Resolving conflicts or disputes related to surface-water activities in their office.

COLLECTION OF STAGE AND STREAMFLOW DATA

Many of society's daily activities, including industry, agriculture, energy production, waste disposal, and recreation, are closely linked to streamflow and water availability; therefore, reliable surface-water data are necessary for planning and resource management. The collection of stage and streamflow data is a primary component in the ongoing operation of streamflow-gaging stations (referred to in the remainder of this report as gaging stations) and other water-resource studies performed by the USGS and the Texas WSC.

The objective of operating a gaging station is to obtain a continuous record of stage and discharge at the site (Carter and Davidian, 1968, p. 1). A continuous record of stage is obtained by installing instruments that sense and record water-surface elevation in the stream. Discharge measurements are made at periodic intervals to define or verify the stage-discharge relation and to define the time and magnitude of variations in that relation.

All stage and streamflow data are to be collected and processed in accordance to WRD and WSC policies.

Gage Installation and Maintenance

Proper installation and maintenance of gaging stations are critical activities for ensuring quality in streamflow-data collection and analysis. Effective site selection, correct design and construction, and regular maintenance of a gage can make the difference between efficient and accurate determination of drainage-basin discharge or time-consuming, poor estimations of flow.

Sites for installation of gaging stations are selected with the intent to meet the purpose of each specific station. Additionally, sites are selected with the intent of achieving, to the greatest extent possible, ideal hydraulic conditions. Criteria that describe the ideal gaging-station site are listed in Rantz and others (1982, p. 5). These criteria include unchanging natural or unnatural controls that promote a stable stage-discharge relation, a satisfactory reach for measuring discharge throughout the range of stage, and the means for efficient access to the gage and measuring location. Other aspects of controls considered by WSC personnel when planning gage-house installations include those discussed in Kennedy (1984, p. 2).

The individual responsible for selecting sites for new gaging stations is the Program Office or Field Office Data Chief. The Surface-Water Specialist will approve the selections. The process of site selection includes field reconnaissance by the Office Data Chief or his/her designee. The responsibility for ensuring proper documentation of agreements with property owners is held by the Office Data Chief. Approval of site design, the responsibility for construction of gages, and inspection and approval of the completed installation is the responsibility of the Office Data Chief or Office Chief.

A program of careful inspection and maintenance of gages and gage houses promotes the collection of reliable and accurate data. Allowing the equipment and structures to fall into disrepair can result in unreliable data and safety problems. It is WSC policy that a visual inspection is performed at sites by field personnel during each site visit. Other maintenance activities performed on a regular basis include maintenance of station markers on bridges, maintenance of cross sections, cleanliness and maintenance of equipment.

It is the responsibility of each Office Data Chief to ensure that gages and gage houses are kept in good repair. To ensure these responsibilities are carried out, periodic inspections will be conducted by the Office Data Chief.

Measurement of Stage

Many types of instruments are available for measuring the water level, or stage, at gaging stations. There are nonrecording gages (Rantz and others, 1982, p. 24) and recording gages (Rantz and others, 1982, p. 32). Because the uses to which stage data may be used cannot be predicted, it is OSW policy that surface-water stage records at stream sites be collected with instruments and procedures that provide sufficient accuracy to support computation of discharge from a stage-discharge relation, unless greater accuracy is required (Office of Surface Water memorandum 93.07).

In general, operation of gaging stations for the purpose of determining daily discharge includes the goal of collecting stage data at the accuracy of + or - 0.01 foot (Office of Surface Water memorandum 89.08). An explanation of WRD policy on stage-measurement accuracy as it relates to instrumentation is provided in Office of Surface Water memorandum 93.07.

The types of instrumentation installed at any specific gage house operated by the Texas WSC are dependent on safety, security, the type of data being collected, the availability of utility lines, and available funding. Types of water-level recorders operated by personnel in this WSC include data loggers, digital, and analog equipment.

The responsibility for determining what type of water-level recorders are operated at each gaging station is held by the Office Data Chief. Ensuring that equipment has been installed correctly is the responsibility of the Office Data Chief or Surface-Water Specialist. Proper maintenance of gage instrumentation or replacement, if appropriate, of equipment is the responsibility of the Office Data Chief or WSC Data Chief.

Accurate stage measurement requires not only accurate instrumentation but also proper installation and continual monitoring of all system components to ensure the accuracy does not deteriorate with time (Office of Surface Water memorandum 93.07). To ensure that instruments located within the gage house record water levels that accurately represent the water levels of the body of water being investigated, "base" gage (wire-weight or staff) readings are made. Also, crest-stage gages are to be installed and maintained at every streamflow station in order to verify peak stages. Where crest-stage gages are destroyed or overtopped, personnel will locate and stake or mark peak flood marks, so that the gage height for the peak can be determined by levels. This policy will be especially enforced if the peak might represent the annual peak. The recorded gage readings do not necessarily always equal base gage readings, especially if the gages are not in the same pool at all ranges of stage.

Personnel servicing the gage are responsible for comparing recorded and base readings during each site visit to determine if the outside water level is being represented correctly by the gages. If a deficiency is identified, the personnel servicing the gage are responsible for thoroughly documenting the problem on the field note sheet and either correcting the problem immediately or contacting the Office Data Chief so that corrective actions can be taken at the earliest opportunity. Wire-weight check bar readings are to be recorded to verify the calibration of the wire-weight dial.

Ensuring that instrumentation installed at gaging stations is properly serviced and calibrated is the responsibility of the Office Data Chief. This responsibility is accomplished by field visits to stations by the Office Data Chief and by having personnel rotate field trips. Individuals who have questions related to the calibration and maintenance of water-level recorders should contact the Office Data Chief or the Surface-Water Specialist.

Gage-height readings for base gages can contain errors, especially during high wind or flood, when the water surface is not tranquil. Therefore, the potential error will be documented with gage-height readings. For example, a reading could be documented as 15.05+/- .10 feet. Such documentation can prevent the use of unnecessary gage-height corrections.

Gage Documents

It is WSC policy that certain documents are placed in each gage house for the purpose of keeping an on-site record of observations, equipment maintenance, structural maintenance, and other information helpful to field personnel. Documents maintained at each gage house include:

- Stage-discharge or stage-capacity rating table and rating curve
- Up-to-date station description
- Plot of cross section
- Bridge safety plan
- DCP program sheet
- Gage calendar

It is the responsibility of the individual operating the station to exchange outdated material with updated gage documents as needed. When field personnel visit a gage house and identify a need to update one or more of the documents, such need shall be documented on a Field Visit Sheet and replaced on the next visit to the station. Individuals having questions related to what documents should be kept in a gage house, when the documents should be replaced with newer documents, or appropriate methods of appending logs or plotting measurements should contact the Office Data Chief.

Levels

The various gages at a gaging station are set to register the elevation of a water surface above a selected level reference surface called the gage datum. The gage's supporting structures--stilling wells, backings, shelters, bridges, and other structures--tend to settle or rise as a result of earth movement, static or dynamic loads, vibration, or battering by floodwaters and flood-borne debris. Vertical movement of a structure makes the attached gages read too high or too low and, if the errors go undetected, may lead to increased uncertainties in streamflow records. Leveling, a procedure by which surveying instruments are used to determine the differences in altitude between points, is used to set the gages and to check them from time to time for vertical movement (Kennedy, 1990, p. 1). Levels are run periodically to all bench marks, reference marks, reference points, and gages at each station for the purpose of determining if any datum changes have occurred (Rantz and others, 1982, p. 545).

It is WSC policy that levels are run at newly installed gaging stations within 2 months of when record-collection begins. Levels are run to established gaging stations in accordance to methods documented by Kennedy (1990) and Office of Surface Water memorandum 90.10. Gages are reset to agree with levels when exceeding 0.015 foot in error. When gages are reset, field personnel document the reset by running levels to the re-set gage. The time the gage was reset shall be documented on the Level Notes, along with the identity of the gages reset and the amount they were reset, as outlined in Attachment no. 1 in Appendix 3.

Level procedures followed by WSC personnel pertaining to circuit closure, instrument reset, and repeated use of turning points are described in Kennedy (1990) and in Office of Surface Water memorandum 93.12. The level instruments are kept in proper adjustment by running a Peg test prior to each trip when levels will be run. Peg tests shall be documented and a copy of the notes kept in the instrument box or in the office.

It is the responsibility of the Office Data Chief to ensure that field level notes are checked. The level information is entered in the level-summary form by the Office Data Chief or his/her designee. Ensuring that levels are run correctly and that all level notes are completed correctly is the responsibility of the Office Data Chief. Ensuring that levels are run at the appropriate frequency is the responsibility of the Office Data Chief. Levels shall be run the next year after a gage is established, then every 3 years. Levels are also to be run every three years for stations where gages have been reset. Levels may be run every 5 years for stations with at least two sets of levels for which gages did not have to be reset, and no reference marks or base gages exhibit elevation changes greater than 0.015 ft. If the change in base gage elevation exceeds 0.015 ft, the base gage will be surveyed again after being reset.

Levels will be run if base gages or reference marks are damaged or replaced, or if CSG is installed or moved. When a gage is discontinued, a complete set of levels will be run.

If datum corrections are found by levels, the Office Data Chief and Surface-Water Specialist will determine the need to revise streamflow records. If datum corrections exceed 0.10 feet, gage heights, especially peak gage heights in the Peak Values File, will be revised.

At least 3 reference marks will be maintained at each gage, including at least 2 reference marks located away from the bridge structure (to ensure datum preservation if the bridge is replaced or destroyed). At least one of the reference marks will be a USGS brass tablet. If a reference mark is missing or damaged, a new reference mark will be established.

Offices should maintain a spreadsheet containing for each station the date of last levels, date of next levels, and significant findings.

Site Documentation

Thorough documentation of qualitative and quantitative information describing each gaging station is required. This documentation, in the form of a station description and photographs, provides a permanent record of site characteristics, structures, equipment, instrumentation, altitudes, location, and changes in conditions at each site. Cameras shall be carried by all field personnel and photographs of the stage controls at stations shall be taken at least twice per year. Such photos can be used to verify ratings or shifts at high stages. Information pertaining to where these forms of documentation are maintained is discussed in the section of this report entitled "Office Setting."

Station Descriptions

A station description is prepared for each gaging station and becomes part of the permanent record for each station. It is WSC policy that the station description is written within 2 months after the beginning of data collection. The responsibility for ensuring that station descriptions are prepared correctly and in a timely manner is held by the Office Data Chief. Station descriptions are updated as needed, particularly following instrument changes or station levels. It is the responsibility of the Office Data chief to ensure that station descriptions are updated as described. Revisions to station descriptions shall be made within 1 month after changes are made.

Station descriptions are written to include specific types of information in a consistent format (Kennedy, 1983, p. 2). Maps presenting precise and exact locations of stations will be included for all stations not easily located by written locations.

For all new stations, efforts will be made to collect flood history information from nearby residents. Such information will include the date of the highest known flood; the gage height (from levels run to a high-water mark indicated by a resident); the period of record for the peak (highest since or since at least----); and contact information for the person documenting the historic peak. This information will be included in the station description.

Photographs

Photographs of the water-level controls, shelters, base gage, orifice line, reference marks, bridges, and floods are made by field personnel for the purpose of documenting gage-house construction, changes in control conditions, or to supplement various forms of written descriptions. All field personnel shall carry cameras. Each photograph then becomes part of the station record. Photographs for the current year are placed in the current record file.

Direct Measurements

Direct measurements of discharge are made with any one of a number of methods approved by WRD. The most common is the current-meter method.

A current-meter measurement is the summation of the products of the subsection areas of the stream cross section and their respective average velocities (Rantz and others, 1982, p. 80). Procedures used for current-meter measurements are described in Rantz and others, 1982, p. 139; Carter and Davidian, 1968, p. 7, and Buchanan and Somers, 1969, p. 1.

When feasible, sufficient discharge measurements will be made each year to cover the range in stage experienced for each full-range discharge station. Where artificial controls exist and ratings are stable, four measurements will be made per year. For other stations, at least eight measurements will be made per year, including six measurements made during routine field trips, and two (e.g., high flow) scheduled at the discretion of the Office Data Chief. It is the responsibility of the Office Data Chief to assure that this policy is accomplished. Office review of real-time data will be conducted by the Office Data Chief and field personnel in order to identify flow conditions when measurements are needed.

It is WSC policy that the Office Data Chief will periodically meet with each field person and review the stage-discharge rating for each station that person operates. The Office Data Chief will prepare a written document that contains the range of stage for which measurements are needed for each station. When that stage is experienced, the field person will notify the Data Chief who will determine if a trip will be made to obtain a flow measurement. This policy is further identified in Attachment no. 2.

When personnel make measurements of stream discharge, attempts are made to minimize errors. Sources of errors are identified in Sauer and Meyer, 1992. These include random errors such as depth errors associated with soft, uneven, or mobile streambeds, or uncertainties in mean velocity associated with vertical-velocity distribution errors and pulsation errors. These errors also include systematic errors, or bias, associated with improperly calibrated equipment or the improper use of such equipment. In order to identify and minimize errors, Office Data Chiefs will periodically make discharge measurements at selected stations, and rotate field trips.

WSC policies related to the measurement of discharge by use of the current-meter method, in accordance with WRD policies, include:

Depth criteria for meter selection.--WSC personnel select the type of current meter to be used for each discharge measurement on the basis of criteria provided by the OSW (written commun., 1995), Meters are used with caution when a measurement must be made in conditions outside of the ranges of the method provided by OSW. Any deviation from those criteria are noted and the measurement accuracy is downgraded accordingly.

It is recommended that a change of meters is not made during a measurement in response to the occurrence of two or more subsections in a single measurement cross section that exceed the stated ranges of depth and velocity.

Number of measurement subsections.--The spacing of observation verticals in the measurement section can affect the accuracy of the measurement (Rantz and others, 1982, p. 179). The WRD criteria are that observations of depth and velocity be made at a minimum of about 25-30 verticals, which are normally necessary so that no more than 5 percent of the total flow is measured in any one vertical. Even under the worst conditions the discharge computed for each vertical should not exceed 10 percent of the total discharge and ideally not exceed more than 5 percent (Rantz and others, 1982, p. 140). Exceptions to this policy are allowed in circumstances where accuracy would be sacrificed if this number of verticals were maintained, such as for measurements during rapidly changing stage (Rantz and others, 1982, p. 174). For these conditions, one velocity reading (6/10-depth) per section may be taken, 20-second observations (half counts) may be used, or fewer sections (15-18) may be taken. Measurement accuracy decreases markedly when the number of samples is less than about 25.

Other direct methods of measuring discharge.--It is WSC policy that WRD and OSW techniques and guidelines are followed when discharge measurements are made with any selected method of measurement. Guidelines for the use of Acoustic Doppler Current Profilers (ADCP) are included in Appendix 1.

Computation of mean gage height.--WSC personnel shall use a time-weighted method to compute the mean gage height of a discharge measurement--discharge-weighted gage heights will not be used.

Check measurements.--A second discharge measurement is made for the purpose of checking a first discharge measurement when the discharge plots more than its rated accuracy from the rating table, or when the shift is not expected by previous measurements.

Corrections for storage.--Corrections for storage applied to measured discharges for the purpose of defining stage-discharge relations are those discussed in Rantz and others, 1982, p. 177 and in Office of Surface Water memorandum 92.09.

Corrections for non-steady flow.--For sites that indicate a loop rating at high stage (rising-stage measurements generally plot right of the rating, and falling-stage measurements plot left), the Wiggins method (Rantz and others, 1982, p. 418) shall be used to adjust measured discharge. Measurements shall not be adjusted where there is no evidence of a loop rating.

Questions.--Personnel who have questions concerning the appropriate procedures for making stage and discharge measurements should address their questions to the Office Data Chief or WSC Surface-Water Specialist.

Field Notes

Thorough documentation of field observations and data-collection activities performed by field personnel is a necessary component of surface-water data collection and analysis. To ensure that clear, thorough, and systematic notations are made during field observations, discharge measurements are recorded by field personnel on form 9-275F or its equivalent. Original observations, once written on the note sheet, are not erased. Original data are corrected by crossing the value out then writing the correct value. Some examples of original data on a discharge-measurement note sheet include gage readings, depth, stations, flow angles and the time and revolutions for velocity determination. Only derived data can be erased for the purpose of correction.

It is WSC policy that all discharge measurements be computed and front sheets completed at the station, unless the Office Data Chief states otherwise or unless emergency evacuation is required for reasons of safety. Information required to be included by field personnel on the measurement note sheet includes, at minimum, the station number and name, the initials and last name of all field-party members, date, times associated with gage readings and other observations, spin test data, control conditions, point of zero flow, meter number, location of measurement, potential error for measurement, and peaks from the crest-stage gage, or if a crest-stage gage is not present, information about peak marks being staked.

Notations associated with miscellaneous surface-water data-collection activities are to be documented on the basis of information provided by other personnel. All miscellaneous notes are required to include, at minimum, initials and last name of field-party members, date, time associated with observations, purpose of the site visit and other needed information.

A review of field note sheets is required after each trip by the Office Data Chief. Deficiencies found in the content, accuracy, clarity, or thoroughness of field notes are identified and communicated to the field person by the Office Data Chief in a timely manner. The deficiencies are remedied by providing specific instructions to individuals who fail to record notations that meet USGS and WSC standards.

Acceptable Equipment

Equipment used by the Texas WSC for the measurement of surface-water discharge has been found acceptable by the WRD through use and testing. An array of acceptable equipment for measuring discharge includes current meters, timers, wading rods, bridge cranes, tag lines, and others (Rantz and others, 1982, p. 82; and Smoot and Novak, 1968). Acceptable acoustic instruments include ADCPs and Acoustic Doppler Velocimeters (ADV). Although an official list of acceptable equipment is not available, Buchanan and Somers (1969), Carter and Davidian (1968), and Edwards and Glysson (1988) discuss the equipment used by the U.S. Geological Survey.

Price AA and pygmy current meters are commonly used by WSC personnel for measuring surface-water discharge. Methods followed by WSC personnel for inspecting, repairing, and cleaning these meters are described in Smoot and Novak (1968, p. 9), Rantz and others (1982, p. 93), and Buchanan and Somers (1969, p. 7).

The ultimate responsibility for the good condition and accuracy of a current meter rests with field personnel who use it (Office of Surface Water memorandum 89.07). A timed spin test made a few minutes before a measurement does not ensure that the meter will not become damaged or fouled during the measurement. Field personnel must assess apparent changes in velocity or visually inspect the meter periodically during the measurement to ensure that the meter continues to remain in proper operating condition.

Spin tests.--It is WSC policy that spin tests are performed and logged prior to each field trip. Repairs are made to meters when deficiencies are identified through the spin test or inspection. Spin tests and repairs are to be logged in a book for maintained for each meter.

In addition to the timed spin tests performed and logged prior to field trips, field personnel are required to inspect the meter before and after each measurement to see that the meter is in good condition, that the cups spin freely, and the cups do not come to an abrupt stop. Descriptive notations are made at the appropriate location on the field-note sheet concerning the meter condition, such as "OK" or "free" or other such comments. To ensure that field personnel carry out their responsibilities in maintaining the equipment they use, the equipment is inspected by Office Data Chiefs.

Alternative Equipment

New conditions and the development of new technology sometimes involve the collection of surface-water data with alternative equipment that has not been fully accepted by WRD. To demonstrate the quality of surface-water data collected with alternative equipment, thorough documentation of procedures and observations must be maintained. Alternative equipment used by this WSC must be approved by the Surface-Water Specialist.

The responsibility for ensuring that alternative equipment is utilized correctly and for ensuring that documentation is comprehensive and is stored correctly is held by the Office Data Chief or Surface-Water Specialist.

Indirect Measurements

In many situations, especially during floods, it is impossible or impractical to directly measure peak discharges. There may not be sufficient warning for personnel to reach the site to make a direct measurement, or physical access to the site during the event may not be feasible. A peak discharge determined by indirect methods is in many situations the best available means of defining the upper portions of the stage-discharge relation. Because extrapolation of a stage-discharge rating, beyond about twice the highest measured discharge at a gaging station is undesirable and may be unreliable, discharge measurements made by indirect methods during periods of high flows are important forms of data (Rantz and others, 1982, p. 334).

The WSC follows data-collection and computation procedures presented in Benson and Dalrymple (1967). That report includes policies and procedures related to site selection, field survey, identification of high-water marks, the selection of roughness coefficients, computations, and the written summary. The WSC also follows procedures for measurement of peak discharge by indirect methods presented in Rantz and others (1982, p. 273).

The procedures for approving that an indirect measurement will be done are provided in Texas WSC Memo 97.04 (Attachment no. 3 in Appendix 3).

In addition to the general procedures presented in Benson and Dalrymple (1967), the WSC follows guidelines presented in other reports that describe specific types of indirect measurements suited to specific types of flow conditions. The slope-area method is described in Dalrymple and Benson (1967). The USGS applies the Manning equation in application of the slope-area method. Procedures for selecting the roughness coefficient are described in Barnes (1967) and Arcement and Schneider (1989). A computer program, SAC, is available to assist in computations of peak discharge with the slope-area method, and is described in Fulford (1994). Procedures for the determination of peak discharge through culverts, based on the classification of flow type, are described in Bodhaine (1982). A computer program, CAP, is available to assist in computations of peak discharge at culverts, and is described in Fulford (1998). At sites where open-channel width contractions occur, such as flow through a bridge structure, peak discharge can be measured with methods described in Matthai (1967) and with the Water-Surface PROfile computation model (WSPRO) (Shearman, 1990). Debris-flow conditions, which are most common in small mountainous basins, are discussed in Office of Surface Water memorandum 92.11. Computations for broad-crested weirs are presented in Hulsing (1967). WSC policy regarding such computations also is presented in Attachment no. 4 in Appendix 3.

Determinations of water-surface profiles along a stream channel in association with selected discharges are made when studies are performed that involve delineations of flood plains or when extensions are made to stage-discharge relations at streamflow sites. WSC personnel are required to follow the procedures associated with step-backwater methods described in Davidian (1984). The computer program used for assisting in the computations of water-surface profiles with step-backwater methods, WSPRO, is discussed in Office of Surface Water memorandum 87.05.

General guidelines that are followed by the WSC when making indirect measurements include those discussed in Office of Surface Water memorandum 92.10 and in Shearman (1990). Violation of any one of the general guidelines does not necessarily invalidate an indirect measurement (Office of Surface Water memorandum 92.10).

It is the policy of the WSC that slope-area measurements shall include three to four cross sections. Any computation based on two sections shall be considered only an estimate of peak flow. Also, slope-area surveys should be of sufficient reach length to obtain at least one foot of fall.

The responsibility for ensuring that indirect measurements are performed correctly is held by the WSC Surface-Water Specialist. It is required that a review of procedures and documentation be performed by the Surface-Water Specialist. If deficiencies are found during the review, actions will be taken to remedy the situations. Measurements that are questionable and difficult to assess are reviewed by specialists outside the WSC, and the Regional Surface-Water Specialist is responsible for ensuring that deficiencies identified by the outside party are corrected.

It is the responsibility of all field personnel to identify, flag, and qualify high-water marks. Because the location, quality, and clarity of high-water marks are best soon after a flood, personnel traveling in the field are required to have available in their field vehicles a camera, stakes, flagging, nails, hand level, hammer, spray paint, and string line with string level. Selection of a suitable reach of channel is an extremely important element in making an indirect measurement, thus the stream reach for indirect measurements at specified ranges of stage has been preselected, and that information has been included in the station description for some streamflow-gaging-stations.

After each indirect measurement is computed, the graphs, field notes and data, plotted profiles, maps, calculations or computer output, and written analysis associated with the measurement are checked by the Office Data Chief or his/her designee. The information is organized as customarily done in this WSC and is then sent to the WSC Surface-Water Specialist for review and return. Storage of each indirect-measurement package includes the field notes, photographs of cross sections and peak marks, all computations and plots, a summary, and review comments by the Surface-Water Specialist.

The responsibility of maintaining the accuracy of the peak-flow data files, including computer database files, lies within the WSC (Office of Surface Water memorandum 92.10). It is the responsibility of the WSC Data Chief to ensure that indirect-measurement results are entered into the peak-flow files. It is the responsibility of the Surface-Water Specialist to assist the WSC Data Chief by periodic reviews of the peak-flow file to ensure accuracy and completeness. For further discussion on the update and review of the peak-flow files, refer to the "Database Management" section in this QA Plan.

Crest-Stage Gages

Crest-stage gages are used as tools throughout the WRD for determining peak stages at otherwise ungaged sites, confirming peak stages at sites where recording gages are located, confirming peak stages where pressure transducers are used, and determining peak stages along selected stream reaches or other locations, such as upstream and downstream from bridges and culverts. The OSW requires quality-assurance procedures comparable to those used at continuous-record stations for the operation of crest-stage gages and for the computation of annual peaks at crest-stage gages (Office of Surface Water memorandum 88.07).

The operation of crest-stage gages is part of this WSC's surface-water program. Procedures followed by this WSC in the operation of crest-stage gages are presented in Rantz and others (1982, p. 9, 77, 78). One or more gages are maintained at each selected site where peak water-surface elevations are required on a stream. Upstream and downstream gages are maintained at culverts or other structures where water-surface elevations are required to compute flow through the structure and to establish the resulting type of flow.

Except at sites where crest-stage gages are used only to confirm or determine peak stages, stage-discharge relations are developed in association with the gage based on direct or indirect high-water measurements. Direct or indirect measurements are obtained to verify or adjust the rating. Levels are run to the gage or as soon as possible after significant changes in the gage because of damage to the gage, reconstruction, or other such situation. When extremely high peaks occur, an outside high-water mark to confirm the gage reading is found when possible, is described on the note sheet, and is flagged by a durable indicator so that the elevation of the high-water mark can be determined the next time levels are run.

Field observations of peak marks are written on the field visit form 9-275-F or its equivalent. All field notes are required to include, at minimum, station number and name, initials and last name of field personnel, date, and time of observation.

The responsibility for ensuring that correct data-collection procedures are used by personnel is held by the Office Data Chief. This responsibility is carried out by timely review of all field trips and field notes by the Office Data Chief. When a deficiency in data-collection activities is identified, the problem is remedied by oral or written correction procedures from the Office Data Chief or Office Chief.
Policies and procedures for computation of peak discharges at crest-stage gages and associated documentation are presented in this report in the section entitled "Processing and Analysis of Stage and Streamflow Data."

Artificial Controls
Artificial controls, including broad-crested weirs, thin-plate weirs, and flumes, are built in stream channels for the purpose of simplifying the procedure of obtaining accurate records of discharge (Rantz and others, 1982, p. 12). Such structures serve to stabilize and constrict the channel at a section, reducing the variability of the stage-discharge relation.

Artificial controls are used at some gaging stations maintained by this WSC. In situations where artificial controls are installed as permanent structures, it is WSC policy that stage-discharge relations can be determined by theoretical ratings as outlined in Attachment no. 5 of Appendix 3, but will be verified by direct or indirect measurements. Such ratings may be extended to cover extreme high flows as outlined in Attachment 6 of Appendix 3. Portable weir plates and flumes are used by WSC personnel in situations approved by the Surface-Water Specialist. These portable devices are applied according to methods described in Buchanan and Somers (1969, p. 57) and Rantz and others (1982, p. 263).

Ensuring the correct design and installation of artificial controls for this WSC is the responsibility of the Surface-Water Specialist. When installing an artificial control, the WSC personnel take into account the criteria for selecting the various types of controls, principles governing their design, and the attributes considered to be desirable in such structures (Carter and Davidian, 1968, p. 3; Rantz and others, 1982, p. 15 and 348; and Kilpatrick and Schneider, 1983, p. 2 and 44).

When field inspections of artificial controls are performed, specific information pertaining to control conditions are written on the field note sheets for the purpose of assisting in analysis of the surface-water data. These notes include the condition of the control and conditions regarding the approach to the control and cross section immediately downstream from the control. Regular maintenance at artificial controls include reading and recording all base and recorder readings; cleaning the control if needed, and reading and recording all gages again. When problems pertaining to artificial controls are encountered by field personnel the Surface-Water Specialist will be notified.

Flood Conditions

Flood conditions present problems that otherwise do not occur on a regular basis. These problems can include difficulties in gaining access to a streamflow gage or measuring site because roads and bridges are flooded, closed, or destroyed. Debris in the streamflow can damage equipment and present dangers to personnel collecting the data. Rapidly changing stage or conditions requiring measurements to be made at locations some distance away from the gage can create problems in associating a gage height to a measured discharge.

The WSC maintains a Flood Plan so that high-priority surface-water data associated with flood conditions are collected correctly and in a timely manner. The Flood Plan describes responsibilities before, during, and after a flood, informational-reporting procedures, and field-activity priorities. The Flood Plan serves as a central reference for priority procedures and stations for flood measurements, emergency communications, telephone numbers for key WSC personnel, and codes for accessing streamflow gages equipped with telemetry.

It is the responsibility of the WSC Data Chief for ensuring that the Flood Plan includes all appropriate information, including updated information. The Flood Plan is reviewed every 2 years by each Office Data Chief, the Surface-Water Specialist, and the WSC Data Chief. A copy of the Flood Plan should be kept in each field vehicle. The Flood Plan is maintained on the Internet at: http://tx.cr.usgs.gov/field/plans/TX-Flood-Plan2005.doc

During a flood, coordination of flood activities is performed (in order) by the Data Chief, the Surface-Water Specialist, or the WSC Director. If flooding is confined to one offices area, flood coordination may be designated to the Office Data Chief or Office Chief. For personnel that are not already in the field, their first responsibility during flood conditions is to contact the Office Data Chief or Office Chief for instructions. For personnel that are already in the field, their first responsibility during flood conditions is to contact the Office Data Chief or Office Chief. Personnel who arrive at a gaging station to find that a flood has occurred are responsible for immediately contacting (in order) the Office Data Chief, Office Chief, Surface-Water Specialist, or Data Chief for instructions. The WSC personnel apply methods discussed in Rantz and others (1982, p. 60) for determining peak stage at gaging stations.

WSC personnel follow policies and procedures stated in a number of publications and memoranda when collecting surface-water data during floods. Techniques for current-meter measurements of flood flow are presented in Rantz and others (1982, p. 159 to 170). Procedures for identifying high-water marks for indirect discharge measurements are presented in Benson and Dalrymple (1967, p. 11). Adjustments applied to make measured flow hydraulically comparable with recorded gage height when discharge measurements are made a distance from

the gaging station are presented in Office of Surface Water memorandum 92.09 and in Buchanan and Somers (1969, p. 54). It is the responsibility of all personnel with questions about particular policies or procedures related to flood activities, or who recognize their need for further training in any aspect of flood-data collection, to address their questions to the Office Data Chief and subsequently to the WSC Data Chief and Surface-Water Specialist.
Review of WSC activities related to floods is the responsibility of the WSC Data Chief. This review includes seeing that guidelines and priorities spelled out in the Flood Plan are followed and that the guidelines appropriately address WSC requirements for obtaining flood data in a safe and thorough manner. When deficiencies are identified by the reviewer, deficiencies are remedied by oral or written communication to the Office Data Chief.

Low-Flow Conditions
Streamflow conditions encountered by WSC personnel during periods of low flow are typically quite different from those encountered during periods of medium and high flow. Low-flow discharge measurements are made to define or confirm the lower portions of stage-discharge relations for gaging stations, as part of seepage runs to identify channel gains or losses, and to help in the interpretation of other associated data. Additionally, low-flow measurements are made to define the relation between low-flow characteristics in one basin and those of a nearby basin for which more data are available (Office of Surface Water memorandum 85.17).

In many situations, low flows are associated with factors that reduce the accuracy of discharge measurements. These factors include algae growth that impedes the free movement of current-meter buckets and larger percentages of the flow moving in the narrow spaces between cobbles. When natural conditions are in the range considered by the field personnel to be undependable, the cross section is physically improved for measurement by removal of debris or large cobbles, construction of dikes to increase flow velocities, or other such efforts (Buchanan and Somers, 1969, p. 39). After modification of the cross section, the flow is allowed to stabilize before the discharge measurement is initiated.

WSC policy requires that point-of-zero-flow measurements be made by field personnel whenever they can be reasonably determined.

The individual responsible for ensuring that WSC personnel use appropriate equipment and procedures during periods of low flow is the Office Data Chief. Determination that appropriate procedures are used for data-collection activities during low-flow conditions is accomplished by review of the Office Data Chief or Surface-Water Specialist. The Office Data Chief is responsible for providing answers to questions from WSC personnel pertaining to data collection during periods of low flow.

Cold-Weather Conditions
Surface-water activities in this WSC include making streamflow-discharge measurements during cold weather conditions. Cold temperatures, wind, snow, and ice can create difficulties in collecting data. These factors also can create dangers to field personnel. The highest priority in collecting streamflow data during winter periods is employee safety.

For gaging stations where the stream is subject to freezing during the winter, discharge measurements under ice cover and during periods of partial ice cover are useful for analysis and determination of flow throughout winter periods. While ice cover is rare in Texas, WSC personnel are required to follow procedures for discharge measurements under ice cover presented in Buchanan and Somers (1969, p. 42). This same publication includes procedures for discharge measurements made by wading or discharge measurements from cableways and bridges when debris and ice are in the streamflow. WSC personnel also follow procedures to collect winter streamflow data as presented in Rantz and others (1982, p. 124). Additionally, guidelines on equipment for measurement of flow under ice are provided in Office of Surface Water memorandum 84.05.

The responsibility for ensuring the correct use of equipment and procedures for surface-water data-collection activities during periods of winter conditions is held by the Office Data Chief. This is accomplished by review by the Office Data chief and oral or written instructions to personnel.

PROCESSING AND ANALYSIS OF STAGE AND STREAMFLOW DATA

The computation of streamflow records involves the analysis of field observations and field measurements, the determination of stage-discharge relations, adjustment and application of those relations, and systematic documentation of the methods and decisions that were applied. Streamflow records are computed and checked following each field trip, reviewed at least quarterly, and published for each gaging station annually (Rantz and others, 1982, p. 544 and Kennedy 1983).

This section of the QA Plan includes descriptions of procedures and policies pertaining to the processing and analysis of data associated with the computation of streamflow records. The procedures followed by the Texas WSC coincide with those described in Rantz and others (1982) and in Kennedy (1983).

Measurements and Field Notes

The gage-height information, discharge information, control conditions, and other field observations written by personnel onto the measurement note sheets and other field note sheets form the basis for records computation for each gaging station. Measurements and field notes that contain original data are required to be stored indefinitely (Hubbard, 1992).

Measurements and other field notes for the water year that is currently being computed are filed in each office. Measurements and notes for previous water years are filed in each office or archived in a Federally approved facility.

It is WSC policy that all measurements are checked prior to entry into ADAPS. The measurements are checked by reviewing the mathematics and other items listed in Kennedy (1983, p. 7).

Measurement data are entered into ADAPS by each office. To facilitate the timely computation of streamflow records, measurement data are to be entered into ADAPS within two weeks from the date of the measurement. The Office Data Chief is responsible for ensuring that all measurement data are entered in a correct and timely manner.

Continuous Records

Surface-water gage-height data are collected as continuous record (hourly, 15-minute, or 5-minute values, mostly) in the form of electronic transmissions. Streamflow records are computed by converting gage-height record to discharge record through application of stage-discharge relations. Ensuring the accuracy of gage-height record is, therefore, a necessary component of ensuring the accuracy of computed discharges.

Gage-height record is assembled for the period of analysis in as complete a manner as possible. Periods of inaccurate gage-height data are identified then corrected (see the section "Datum corrections, gage-height corrections, and shifts") or deleted as appropriate. Unit gage-height data are deleted only if no fragmented record can be salvaged. If fragmented gage-height records are available, the gage heights will be corrected and used to compute streamflow. If fragmented gage-height record is not available, or cannot readily be corrected, daily-mean discharges will be estimated directly from other streamflow data, rainfall data, or other data. Items included in the assembly of gage-height record and procedures for processing the data are discussed in Kennedy (1983, p. 6), and Rantz and others (1982, p. 560 and p. 587).

Records and Computation

Computations of records will be completed within two weeks after the field trip is completed. The Office Data Chief and WSC Data Chief may adjust work assignments to meet this goal. Unless designated otherwise by the Office Data Chief, each field person is responsible for the initial computations of their stations. Scheduling of responsibilities for final record completion is done by the Office Data Chief. The Office Data Chief is responsible for assuring that all records are checked and for the review of all records. The Office Data Chief is responsible for the timeliness and quality of completed records in their office. The Office Data chief also is responsible for reporting to the WSC Data chief the progress of record completion so that the WSC Data Chief may redirect resources (if deemed needed) for the timely completion of all records. Record periods preceding each discharge measurement are to be checked within two months of the date of the measurement.

Procedures for Working and Checking Records

Procedures for ensuring the thoroughness, consistency, and accuracy of streamflow records are described in this section of the QA Plan. The goals, procedures, and policies presented in this section are grouped in association with the separate components that are included in the records-computation process.

Gage Height

The accuracy of surface-water discharge records depends on the accuracy of discharge measurement, the accuracy of rating definition, and the completeness and accuracy of the gage-height record (Office of Surface Water memorandum 93.07). Computation of streamflow records includes ensuring the accuracy of gage-height record by comparisons of gage-height readings made by use of independent reference gages, comparison of base gage and recording gages, examination of high-water marks, comparisons of the redundant recordings of peaks and troughs, examination of data obtained at crest-stage gages, and confirmation or updating of gage datums by levels.

Records computation includes examination of gage-height record to determine if the record accurately represents the water level of the body of water being monitored. Additionally, it includes identifying periods of time during which inaccuracies have occurred and determining the cause for those inaccuracies. When possible and appropriate, inaccurate gage-height record is corrected. When corrections are not possible, the erroneous gage-height data are removed from ADAPS and not used for streamflow records computation.

Levels

Errors in gage-height data caused by vertical changes in the gage or gage-supporting structure can be measured by running levels. Gages can be reset or gage readings can be adjusted by applying corrections based on levels (Kennedy, 1983, p. 6).

Procedures for revising records based on errors discovered by levels are explained in the "Levels" section under the heading "Collection of stage and streamflow data." The individual computing the record or the Office Data Chief are required to check field notes for indications that the gages were reset correctly by field personnel. The individual computing the records makes appropriate adjustments to the gage-height record by applying datum corrections, as identified in the previous "Levels" section of this plan.

Ratings

The development of the stage-discharge relation, also called the rating, is one of the principal tasks in computing discharge record. The rating is usually the relation between gage height and discharge (simple rating). Ratings for some special sites involve additional factors such as rate of change in stage or fall in slope reach (complex ratings) (Kennedy, 1983, p. 14). WSC personnel follow procedures for the development, modification, and application of ratings that are described in Kennedy (1984). WSC personnel also follow guidelines pertaining to rating and records computation that are presented in Kennedy (1983, p. 14) and in Rantz and others (1982, Chap. 10--14 and p. 549). All ratings will be approved by the Office Data Chief. New rating tables and curves will be checked after entry into ADAPS. New ratings will be developed when discharge measurements continually plot off the rating or when the measurements indicate that the rating slope is incorrect. All old high measurements will be plotted on new ratings. For each gaging station, the most recent digital rating table or plotted rating curve can be obtained from ADAPS.

Ratings occasionally need to be extended to cover the range in experienced stage. There are many factors involved in the decision to extend a rating and in how much a rating should be extended. The factors include: the stability of the rating, potential error in direct and indirect measurements, and the ability to obtain high discharge measurements. Because of the complexities of these factors, WSC criteria are not established regarding extension of ratings, except that the Surface-Water Specialist shall approve the approach to be used for the extension. General procedures for extending ratings are presented in Attachment 6 of Appendix 3.

It is WSC policy that theoretical ratings not be used except where direct or indirect measurements cannot reasonably made. The decision to use a theoretical rating will be approved by the Surface-Water Specialist--who also will approve the approach for such ratings. WSC policy regarding the approach to be used for developing theoretical ratings is summarized in Attachment 5 of Appendix 3.

Datum corrections, gage-height corrections, and shifts

A correction applied to gage-height readings to compensate for the effect of settlement or uplift of the gage is usually measured by levels and is called a "datum correction" (Kennedy, 1983, p. 9). Datum corrections are applied to gage-height record in terms of magnitude (in feet) and in terms of when the datum change occurred. In the absence of any evidence indicating exactly when the change occurred, the change is assumed to have occurred gradually from the time the previous levels were run, and the correction is prorated with time (Rantz and others, 1982, p. 545) Datum corrections are applied when the magnitude of the vertical change is 0.10 foot or greater.

A correction applied to gage-height readings to compensate for differences between the recording gage and the base gage is called a "gage-height correction" (Rantz and others, 1982, p. 563). These corrections are applied in the same manner as datum corrections by use of the same computer software. Gage-height corrections are applied so the recorded data are made to agree with base-gage data. These corrections are applied when the difference between the recording gage and the base gage is equal to or greater than 0.02 foot or when the correction exceeds the potential error identified for the base gage reading.

A correction applied to the stage-discharge relation, or rating, to compensate for variations in the rating is called a shift. Shifts reflect the fact that stage-discharge relations are not permanent but vary from time to time, either gradually or abruptly, because of changes in the physical features that form the control at the gaging station (Rantz and others, 1982, p. 344). Shifts can be applied to vary in magnitude with time and with stage (Kennedy, 1983, p. 35). The interpretation and application of shifts are too complex for the establishment of WSC criteria. Office Data Chiefs are responsible for the application of shifts and have the authority to approve shift applications for their office.

Datum corrections, gage-height corrections, and a summary of shift applications will be documented on a "Station Analysis" prepared every year for each station. The person preparing the records will prepare and sign the analysis, and it will be reviewed and signed by the Office Data Chief.

Hydrographs

A discharge hydrograph is a plot of daily mean discharges versus time. The date is aligned with the horizontal axis and the discharge is aligned with the logarithmic vertical axis. In the process of computing station records, this hydrograph is a useful tool in identifying periods of erroneous information, such as incorrect shifts or datum corrections. Additionally, hydrographs are helpful when estimating discharges for periods of undefined stage-discharge relation, such as during backwater or ice conditions, and in estimating discharges for periods of missing record.

Information placed on the hydrograph for each station includes station name, station number, water year, date the hydrograph was plotted, plot of daily mean discharge data, and plots of measurements. Missing record will be indicated on the hydrograph along with estimated discharges.

Hydrographic comparison with nearby stations is strongly encouraged. This approach is not only useful in estimating missing record, but serves as a quality check of computed daily discharges. File the plotted comparison hydrographs in the analysis folder for each water year.

Station Analysis

A complete analysis of data collected, procedures used in processing the data, and the logic upon which the computations were based is documented for each year of record for each station to provide a basis for review and to serve as a reference in case questions arise about the records at some future date (Rantz and others, 1982, p. 580). Topics discussed in detail in the station analysis include gage-height record, datum corrections, rating, shifts, discharge, special computations, and remarks. The station analysis is written by the person who worked the record and reviewed by the Office Data Chief. Station analyses are updated in SIMS (Station Information Management System) after records are processed following each field trip.

Furnished records

Surface-water data collected under the supervision of other agencies, organizations, or institutions are received by the WSC office. These data are published in our annual data report and stored in ADAPS. However, the agency providing the data are referenced in the Data report and the providing agency is referenced in ADAPS. It is WSC policy that all non-USGS data will be clearly and consistently referenced as such.

Daily values tables

With few exceptions, for each continuous-record streamflow gaging station operated by the WRD a daily-mean discharge value is determined and stored for each day. The daily values table generated by ADAPS represents what discharge values are stored for each day of the water year.

Daily-mean discharges will be estimated for all days with missing record. The approach to estimate missing record will be approved by the Office Data Chief. Nonstandard or complex approaches will be approved by the WSC Surface-Water Specialist. All estimated daily discharges should be flagged in the database.

Manuscript and annual report

When records computation for the water year has been completed and the data collected and analyzed by WSC personnel have been determined to be correct and finalized, the surface-water data for that water year are published along with other data in the WSC's Annual Data Report. The annual data report is part of the series titled "U.S. Geological Survey Water-Data Reports." Information presented in the Annual Data Report includes daily discharge values during the year, extremes for the year and period of record, and various statistics. Additionally, manuscript station descriptions are presented in the Annual Data Report. Information contained in the manuscript includes physical descriptions of the gage and basin, history of the station and data, and statements of cooperation. Manuscript information is maintained in the NWIS database and in SIMS.

In preparing the annual data report for publication, the WSC follows the guidelines presented in the report, "WRD Data Reports Preparation Guide," by Charles E. Novak, 1985 edition.

Under supervision of the WSC Data Chief, the WSC Records Team will coordinate the aggregation of surface-water data and manuscripts for inclusion in the Annual Data Report. The Data Team, along with selected personnel from the WSC and other offices, will form a committee to review the format for the data and manuscripts soon after all data are finalized. That committee is responsible for assuring that all stations are included in the Data Report, and responsible for the format of the data summaries and manuscripts.

Station Records Status

It is WSC policy that each office will maintain a list of all stations for which data will be published. The list will indicate the status of records analysis and checking for each station. The list will be readily accessible to WSC personnel.

Review of Records

After streamflow records for each station have been computed and checked, records for every station will be reviewed by each Office Data Chief. The Surface-Water Specialist will review a few stations for each office and prepare a written summary of his or her findings. The WSC Data Chief and Surface-Water Specialist will lead or conduct statistical reviews and summaries of data for each office. The reviews may include gage-height record, station levels, discharge measurements, annual peak discharges, and daily streamflow or reservoir contents. Written summaries of the reviews will be presented to the Office Data Chiefs and others including WSC management.

Partial-Record Stations

Records for crest-stage stations, flood-hydrographs stations, low-flow stations, and other partial-record stations are computed with goals and procedures similar to those for other gaging stations. The field notes are examined for correctness and accuracy. Peak stages recorded by crest-stage and flood-hydrograph stations are cross referenced with other available information; the dates of the peaks are determined by analyzing available precipitation data and peak data from recording gages within the same basin or from nearby basins.

A discussion on the policies and procedures used for field aspects of collecting data at partial-record stations is included in this report in the section "Collection of Stage and Streamflow Data." The discussion in this section describes the analysis and office documentation of crest-stage data. This section does not pertain to data collected at crest-stage gages installed solely for the purpose of confirming peak stages at sites where manometer or pressure-transducer gages are used.

At sites where crest-stage and flood-hydrograph stations are used to compute peak discharges, an initial stage-discharge relation, or rating, is developed for the site by direct or indirect high-water measurements. The rating is verified or adjusted on the basis of subsequent direct or indirect high-water measurements.

Discharge measurements for each station are stored in ADAPS. For each station, a graphical plot of the current rating along with each recent and each notably high stage-discharge measurement is made readily available to those who check and review the station record. The rating is maintained in ADAPS by the servicing office. Current station descriptions and a summary of levels are maintained in SIMS. A brief station analysis is written each year in SIMS describing computation of the annual peak, identifying which rating was used and the type of flow condition, describing how the dates of the peaks were determined.

Annual Peak Data

An Annual Peak Values File is maintained by the WSC Records Team. It contains the annual-peak gage height, discharge, date, and discharge and gage-height qualification codes for every station gaging such data. Annual peak stages will be included for these stations not gaging discharge.

Each Office Data Chief is responsible for assuring that the above data are computed and checked for every station. For stations with missing record for the annual peak, the Office Data chief is responsible for assuring that the peak is documented on a crest-stage gage or documented by levels. The Office Data Chiefs are responsible for aggregating annual peak data from manuscripts and the Annual Data Report, and assuring that it is stored in NWIS.

OFFICE SETTING

Maintaining surface-water data and related information in a systematic and organized manner increases the efficiency and effectiveness of data-analysis and data-dissemination efforts. Good procedures and organization of data and files reduces the likelihood of lost or reduced-quality data and misplaced information. Misplaced data and field notes can lead to analyses based on inadequate information, with a possible decrease in the quality of analytical results.

This section of the QA Plan includes review of real-time data and descriptions of how station folders, reference maps, levels documentation, and other information related to surface-water data are organized and maintained. Additionally, this section provides an overview of how work activities are designed to be carried out within the office setting.

Processing and Review of Real-Time Data

The installation of Data Collection Platforms at almost all stations has allowed for the presentation of near-real- time data on the WSC home page. This feature has greatly benefited many agencies and the public and has provided much recognition to the USGS. However, it also has provided much additional scrutiny to our data-collection efforts. We often receive email and telephone calls regarding station data from agencies and the public. Much of this communication involves notification that a station is not operating properly.

A station not reporting data can result in lost record but a station reporting wrong data can also cause problems for agencies and the public. This is especially true if the wrong data are not recognized as such, and management or water-use actions are based on the erroneous data.

WSC policy requires that malfunctioning stations will be repaired as soon as feasible after the malfunction is identified. As part of this effort, USGS personnel will make efforts to identify malfunctioning stations as soon as possible. WSC policy therefore states that all current data will be reviewed on a daily basis, as outlined in Attachment no. 2 of Appendix 3.

A necessary and critical element in maintaining accurate streamflow records on a real-time basis is the need for rating analysis and shift application as soon as practicable after a discharge measurement has been made. The Texas WSC's policy is that as soon as feasible after a discharge measurement is made, it will be reviewed and a current shift will be applied in ADAPS. This procedure minimizes the time that improper shifts would be used for the near-real-time data. The same procedure will be used for gage-height corrections discovered during visits to the station.

Review of Real-Time Streamflow Data

Real-time streamflow data that are disseminated on the public Web page must be reviewed frequently to ensure their quality and to prevent the distribution of erroneous information. The Texas WSC utilizes both automated and manual review procedures to meet this objective.

Automated procedures that have been implemented by the Texas WSC include the setting of minimum and maximum threshold values for stage and discharge and their rates of change. If exceeded, these settings will initiate warnings of potential errors that will be delivered to the Office Data Chief, who is responsible for correcting the problem.

In addition to the automated procedures, WRD Technical Memorandum 97.17 requires frequent and on-going screening and review of Web data, including the at least daily review of hydrographs during normal hours of operation. The Texas WSC also requires that all Web pages containing real-time streamflow data are reviewed daily for accuracy and/or missing data as identified in Attachment no. 2 of Appendix 3.

Error Handling

There are two general types of errors associated with streamflow data that are delivered by the real-time system and disseminated on the Internet. The first are persistent-type problems usually associated with some type of equipment failure whether in data collection or transmission, but could also be related to ice effects. Because of the nature of the problem they generally occur on a continuing basis for more than a single recording interval. The second are the intermittent-type problems, which are often the result of a data transmission error. These often show up as either a zero or an unreasonably large value. Data will be reviewed for those errors and corrected. Some of the errors can be caused by the transmission and processing systems. Because of this, stage data from data loggers will be downloaded after each field visit and stored in each office--these data could be later used if the transmitted data cannot be corrected.

Data Qualification Statements

WRD Technical Memorandum 95.19 requires that streamflow data made available on the Web should be considered provisional until the formal review process has been completed. To ensure that everyone who accesses data from the Web are aware of this, data qualification statements must be included at key locations with a clickable heading "Provisional Data Subject to Revision" on all real-time data pages.

Work Plan

The Texas WSC does not have a formal work plan for personnel. Along with their duties of maintaining stations and working records, many employees are involved in data collection for reservoirs, ground water, and water quality. They also are subject to be involved in special studies and data collection or analysis for project investigations.

Day-to-day task assignments and priorities are established by the Office Data Chief, but special tasks and assignments can be instigated by the WSC Director, WSC Data Chief, or Office Chief, through coordination with the Office Data Chief.

File Folders for Surface-Water Stations

This section of the QA Plan describes the location and makeup of hard-copy files associated with surface-water data. Information pertaining to files maintained in computer storage can be found in the "Database Management" section of this report.

For "current" files and "back files," information and data pertinent to the current year are kept in the current file which includes: primary printouts of current data, up-to-date Station Description, rating table, rating curve, up-to-date cross section, and the last Station Analysis. The latest discharge measurements, site visits, station levels, and levels summary are kept in the current files or in a nearby separate file, as are photos of the equipment and control.

The "back files" will include previous rating tables and curves, old Station Analyses, discharge measurement summaries (9-207), primary printouts of data, and Field Operation Plans, and any special analyses. Old discharge measurement notes, site visits, levels, and photos may be kept in separate files.

Field-Trip Folders

Field folders will be kept for every station. Each folder will contain all information that would be needed so that a field person totally unfamiliar with the site could fully service the station. As a minimum, the folder will contain up-to-date Station Description, Field Operation Plan, list of measurements and their location, cross section, and rating curve.

Discontinued Stations

Back files will be kept by the Field Offices for all discontinued stations and will contain all the items identified in the section "File Folder for Surface-Water Stations."

Map Files

Map files for the entire State will be maintained in the WSC. The files will contain: 1:100,000 planimetric topographic maps; 7 1/2-minute quadrangle maps; and Digital Elevation Model files of topography. These maps and files will be used to determine basin characteristics for stations, regulation status of basins, and land use and other characteristics.

Hard copies of the 7 1/2-minute quadrangle map will be kept in each office and will cover the basins being gaged by each office. Those maps are valuable for locating alternative flood measurement sites, alternative access routes, and reaches for indirect discharge measurements.

Archiving

All WRD personnel are directed to safeguard all original field records containing discharge measurements and observations. Selected material not maintained in field offices are placed in archival storage. Detailed information on what records have been removed to archival centers should be retained in the WSC or project office (Water Resources Division memorandum 77.83). The types of original data that should be archived include, but are not limited to, recorder charts and tapes, original data and edited data, observer's notes and readings, station descriptions, analyses, and other supporting information (Water Resources Division memorandum 92.59 and Hubbard, 1992, p. 12). At this time there is an agreement between WRD and the Federal Records Centers (FRC) of the National Archives and Records Administration to archive original-data records (memorandum from the Chief, Branch of Operational Support, May 7, 1993).

Surface-water information is sent to the FRC from the Texas WSC on periodic basis as determined by each office. The Office Data Chief is responsible for deciding what information is sent to the FRC, for ensuring that the information is properly packed and logged, and for ascertaining that the information is received by the FRC. Records of exactly what has been archived are maintained at each office. It is WSC policy that the following items will not be archived and will be maintained for each discontinued station in each office: latest rating curve, rating table, and Station Description. For active stations a list of discharge measurements (Form 9-207 or equivalent) and level notes and summaries will be maintained in each office.

Original electronic data from ADCPs, Flowtrackers, and Aquacalcs shall be downloaded within two weeks of the measurement, maintained by each office on a server, and backed up nightly. Archive directory structure and file naming convention shall be documented by each office.

Communication of New Methods and Current Procedures

WRD policies and procedures and WSC policies and procedures will be communicated to each Office Data Chief or directly to all involved individuals. Those policies and procedures also will be updated in this Plan. An up-to-date electronic copy of this Plan will be maintained by the

Surface-Water Specialist and be readily available to all personnel. This QA Plan is available on the Internet at:
http://tx.cr.usgs.gov/field/plans/TX-QA-plan2005.doc

COLLECTION OF RESERVOIR DATA

Water elevations and storage capacity data are collected, analyzed, published, and stored in ADAPS in this WSC. The procedures for collecting, computing, checking, reviewing, finalizing, and publishing this data are identical to those for streamflow data.

COLLECTION OF PRECIPITATION DATA

Precipitation data are collected at many gaging stations and remote sites in this WSC. Some of the data are used in project investigations and are sufficiently funded for analysis and publication. For these stations, the rain collectors will be calibrated and the data computed and checked prior to being published in reports other than the Annual Data Report. Most of the rainfall data, however, are not sufficiently funded to meet QA standards in order to be published. That data therefore will not be published or presented on the WSC home page. It will be represented as nonofficial USGS data for internal use only until that policy is revised by written official policy regarding this type of rain gage. Precipitation data are to be deleted from ADAPS at the end of the annual records review and publication.

COLLECTION OF SEDIMENT DATA

Surface-water activities in the WSC currently do not include the collection, analysis, and publication of daily sediment data.

DATABASE MANAGEMENT

Database management is the responsibility of the WSC Data Chief. That person is responsible for assuring that all data are properly entered and qualified in the WSC and the NWIS databases. Also, procedures and programs will be written and used to review databases in search of missing, incorrect, or improperly qualified data. The WSC Data Chief also is responsible for assuring that WSC-stored data are protected from unauthorized access and for assuring that all appropriate data are made available to the public through the WSC home page.

Daily and Annual Peak Values

These data will be maintained in NWIS and will be made available for internal and external data requests.

Unit Values

With the exception of some unit values and some precipitation data, all USGS data are reviewed and most are published. There have been increasing requests for unit values, especially streamflow values. Unit values typically are not published by the USGS in the Annual Data Report; however, recent unit-value are available on the Internet. Therefore, unit-value data should be thoroughly reviewed and erroneous data removed in a timely manner. Further details regarding procedures for reviewing and providing unit values are identified in Attachments 7 and 8 of Appendix 3.

Basin Characteristics

Selected basin characteristics are computed and maintained for streamflow stations in Texas. They are used for statistical and other analyses of streamflow data. A file of basin characteristics is maintained by the Surface-Water Specialist.

Flow Loss Studies

Flow loss studies (low-flow streamflow measurements made at many sites on selected stream reaches) have been made for many streams in Texas. The Surface-Water Specialist will maintain the data for those studies. These data are often needed by State agencies and others for use in permitting and managing streamflow diversions and return flow. Discharge measurements obtained for flow loss studies are stored in ADAPS.

Time of Travel Studies

The Texas WSC has conducted many time of travel studies for specific stream reaches in Texas. The studies represent recovery of dye at selected sampling points downstream from a point where the dye is injected. These studies produce flow characteristics including: time of travel for leading edge of dye; time of travel for peak concentration; time of travel for trailing edge of dye; and volume of dye recovered. These data are useful for contaminant spills. The data will be maintained by the Surface-Water Specialist.

Major Storms and Floods

The Texas WSC and other agencies have prepared many reports documenting major storms and floods. These reports often are needed by the USGS and others. The Surface-Water Specialist will aggregate and maintain these reports and make them available as needed.

Non-USGS Data

Data and information not collected by the USGS often are used by USGS personnel for record computations and for project investigations. Such data include daily and incremental precipitation, evaporation, wind speed and direction, and air temperature collected by the National Weather Service. These data will be aggregated and maintained in ADAPS with the appropriate agency code. Other data include land use, land cover, and Geographical Information System data such as stream channel coverages, Digital Elevation Models, roads, country boundaries, cities, and other meta data used by the WSC. These data are aggregated and maintained by the WSC GIS unit.

Data Requests

Requests for data and information have substantially increased since the WSC home page was created. Because of the increased requests, publication policy (discussed in the next section), and the public's "right to know," WSC policy regarding data requests are identified here.

Data and information requests are received by email (mostly by webmaster committee link to the WSC home page), and by telephone, post office mail, and during visits and meetings. Requests through the webmaster are reviewed by a Public Information Officer who responds to these inquiries that he or she is qualified to fully answer. The other requests are forwarded to the proper person for response. The person responding shall copy the webmaster committee with the response, so that they and the Public Information Officer can assure that all requests are fully answered in a timely manner.

Requests through means other than webmaster are processed in a similar manner. All requests involving published or online data can be processed by providing electronic or hard copy files directly to the requester. Requests for data not reviewed shall not be provided as dictated by policy in the next section.

Requests for interpretive surface-water information will be approved by the Surface-Water Specialist. Highly-interpretive information will not be provided, unless published in an approved USGS report. It is the responsibility of the Surface-Water Specialist to research interpretive inquiries and to provide appropriate, accurate, and full responses to such requests.

The USGS will be reimbursed for data requests requiring more than about 30 minutes to process. Currently a paper copy of the 'Data Request Agreement' shall be used to obtain information and the signature of the requester to proceed with data requests when costs will be incurred. Originals of these forms may be obtained from the Public Information Officer. Data requests where the costs to fulfill exceed $2500 require the prior approval of the WSC Director.

PUBLICATION OF SURFACE-WATER DATA

The act of Congress (Organic Act) that created the U.S. Geological Survey in 1879 established the Survey's obligation to make public the results of its investigations and research and to perform, on a continuing, systematic, and scientific basis, the investigation of the geologic structure, mineral resources and products of the National domain (U.S. Geological Survey, 1986, p. 4). Fulfilling this obligation includes the publication of surface-water data and the interpretive information derived from the analyses of surface-water data.

Publication Policy

The USGS and WRD have created specific policies pertaining to publication of data and interpretation of those data. All WRD personnel are required to abide by those policies. Current (2005) USGS publishing and related policies are summarized at:
http://internal.usgs.gov/gio/pubs/policies.html
Central Region report processing and policy guidelines can be found at:
http://wwwrcolka.cr.usgs.gov/uo/rpt/
Texas WSC report processing and policy guidelines can be found at:
http://tx.cr.usgs.gov/prj_dev/man_reports.050205.pdf

It is the policy of the USGS to conduct its activities and to make the results of its scientific investigations available in a manner that will best serve the whole public, rather than the interest or benefit of any special group, corporation, or individual. All data and information gathered through investigations and observations by the staff of the USGS and by its contractors must not be disclosed to others until the information is made available to all, impartially and simultaneously through bureau-approved publication or other approved means of public release, except to the extent that such release is mandated by law. However, the results of an investigation can be made available to Federal, State, and local governmental agencies and their staffs who, under joint funding agreement or other cooperative arrangements, contributed materially to the investigation. Hydrologic measurements resulting from observations and laboratory analyses, after they have been reviewed for accuracy by designated WRD personnel, have been excluded from the requirements to hold unpublished information confidential.

Types of Publications
Current (2005) USGS publication series and definitions/applicability of each are summarized at:
http://www.usgs.gov/usgs-manual/1100/1100-3appendixa.pdf
The publication series comprises Administrative Reports, Circulars, Data Series, Fact Sheets, General Information Products, Open-File Reports, Professional Papers, Scientific Investigations Maps, Scientific Investigations Reports, and Techniques and Methods. The publication series are intended to be broadly usable by all disciplines and are based content and audience. The four distinct audience types are core professional, non-core professional, the general public, and USGS employees. Scientific reports and maps generally are directed to core and non-core professional audiences. Circulars, Fact Sheets, and General Information Products are predominantly directed to a general audience and should not contain new scientific information or data; however, Circulars and Fact Sheets can be directed to core and non-core professionals.

In addition to the report series listed above, water data collected by the WSC are published each year in an Annual State Water-Data Report. Guidelines for annual data reports can be found at:
http://water.usgs.gov/usgs/publishing/datareports/index.html
Review Process
The current (2005) USGS report review process comprises four principal review steps—supervisor, colleague, WSC Publications Unit, and Central Region. Ideally, each of the four review steps has a slightly different focus, although in general the purpose of each review step is to ensure that a report is technically adequate, internally consistent, accurate, and conforms to USGS publication and editorial policies. The details of the review process can be found at:
http://tx.cr.usgs.gov/prj_dev/man_reports.050205.pdf

SAFETY

Performing work activities in a manner that ensures the safety of personnel and the public is of the highest priority for the USGS and the Texas WSC. Beyond the obvious negative impact, unsafe conditions can have on personnel, such as accidents and personal injuries, they also can have a direct effect on the quality of surface-water data and data analysis. For example, errors may be made when an individual's attention to detail is compromised when dangerous conditions create distractions.

To increase safety awareness, and to communicate established procedures and policies, the WSC and its employees will:

- Require that all employees complete, thru the DOIU, the USGS Occupational Safety and Health Curriculum. http://www.doiu.nbc.gov/safety/usgs.html
- Communicate information and directives related to safety to all personnel by email and memorandum from the WSC and WRD: http://water.usgs.gov/admin/memo/index.html
- Follow safety procedures identified in the *U.S. Geological Survey Manual, 445-2-H, Occupational Safety and Health Program Requirements* at:
  http://www.usgs.gov/usgs-manual/handbook/hb/445-2-h.html and,
- Develop and follow Job Hazard Analysis (JHA) for specific hazardous task and for each gaging station. The JHA will be kept current in each gaging station and field folder, and can also be found on line at WSC Station Information Management Site (SIMS) at: http://tx.cr.usgs.gov/field/sims/

Responsibilities

It is the responsibility of managers, supervisors and field team leaders to demonstrate a personal commitment and actively participate in providing for the safety and health of employees. Managers, supervisors, and field team leaders will:

- Establish a safety awareness program to reinforce safety concepts and goals thru open dialogue with employees thru formal or informal training, during staff meetings, and thru pre- and post-field trip meetings with individuals or groups.

- Provide required and supplemental safety and health training for personnel.

- Provide and ensure proper use of personal protective equipment necessary for prevention of injury, property damage, or occupational diseases.

- Investigate and report job-related accidents that result in or have the potential to cause injury, illness, or property damage and verify that incidents are reported using the Safety Management Information System (SMIS) at the web address: http://www.smis.doi.gov

- Monitor operations and activities and inspect work areas for hazardous acts and conditions and abate deficiencies as soon as possible.

- Hold employees accountable for safe work performance through their performance standards.

- Provide for employee participation in the safety program without employee fear of restraint, interference, coercion, discrimination, or reprisal.

It is the responsibility of each employee to follow safe work practices and job procedures at all times; applying knowledge gained from training and experience, and using safe judgment and common sense. Additionally, it is the responsibility of the employee to:

- Comply with applicable work rules/procedures including the use of safety equipment provided by the WSC.

- Report unsafe and/or unhealthful conditions. http://tx.cr.usgs.gov/adm/safety/hazardlog/default.asp

- Exercise rights and responsibilities as granted by the Safety Program without fear of restraint, interference, coercion, discrimination, or reprisal for reporting an unsafe or unhealthful condition, or otherwise participating in the Safety Program.

- Actively participate in safety and health education and training activities.

- Report every job-related accident/incident to their supervisors that results in, or has the potential to cause, injury, illness, or property damage and personal conditions (physical or mental) that adversely affect their ability to perform in a safe and healthful manner on the job. Such accidents or conditions should also be reported electronically into the Safety Management information System (SMIS) at: http://www.smis.doi.gov/SMISMAIN.htm

To assist with the implementation of the WSC Safety Program, an individual has been designated as the Collateral Duty Safety Program Coordinator for the Texas WSC. Each Program Office and Field Office is also assisted by an office safety representative. The Safety Program Coordinators duties include identifying and correcting safety problems, providing safety-related training, and keeping abreast of safety issues, equipment, and procedures. The collateral duty safety officers for the Texas WSC are:

Richard N. Slattery	Texas WSC & San Antonio Field Office Office (210) 691-9224 Mobile (210) 213-1728
Lynne S. Fahlquist	Austin WSC Headquarters Office (512) 927-3508
Michael L. Greenslate	Austin Field Office Office (512) 927-3530 Mobile (512) 565-6961
Glenn R. Harwell	Fort Worth Field Office Office (817) 263-9545 ext 213 Mobile (817) 253-3899
Tim D. Oden	Houston Subdistrict Office Office (936) 271-5325 Mobile (713) 591-1690
Henry Jacques	San Angelo Field Office Office (325) 944-4600 Mobile (325) 277-0994
Jackie D. Kelly	Wichita Falls Field Office Office (940) 692-4283

Mobile (940) 704-1506

Personnel who witness an unsafe act or condition, have questions or concerns pertaining to safety, or who have suggestions for improving some aspects of the safety program, can direct those questions, concerns, and suggestions to their supervisor, office safety representative, or to the WSC Safety Program Coordinator. Reports of unsafe or unhealthful conditions can also be made directly into the web based WSC Hazard Elimination Log, this can be found at: http://tx.cr.usgs.gov/adm/safety/hazardlog/default.asp

Temporary Traffic Control

A highway is one of the most hazardous workplaces that exist. Temporary traffic control zones present unique problems because they conflict with the driver's expectations and do not follow design consistency. Therefore it is imperative that the proper safeguards and adequate warnings of the work zone area be provided.

The policy of the Texas WSC for fieldwork conducted on bridges and in and around roadways is to adhere to the 2003 Texas Manual on Uniform Traffic Control Devices, Part VI, at: http://www.dot.state.tx.us/trf/mutcd.html

It is the responsibility of every employee performing work within the public right-of-way, or close enough to adversely affect someone within the right-of-way, to take proper precautions to insure his or her own safety as well as the safety of the motoring public. In addition, the WSC and its personnel can incur potential liability for failure to adequately protect the public safety. To help minimize risk and provide for adequate protection of employees, and to safe guard the public while traveling in or near the work zone, the WSC will provide the required traffic control devices, adequately designed Traffic Control Plans, and the necessary training for the proficient implementation of the Work Zone Traffic Control Plan.

The following general requirements of the Texas Department of Transportation (TxDoT), and which have been adopted by the WSC Director, must be followed:

1. Personnel conducting work in or near roadways must have Work Zone Safety Training following the curriculum established by the TxDoT and requirements of the TxMUTCD.

2. Personnel will be provided the necessary traffic control devices for the proper implementation of a Work Zone Traffic Control Plan. The traffic control devices shall meet the standards described in the TxMUTCD.

3. A Work Zone Traffic Control Plan will be developed and implemented for every site where work is within the public right-of-way or close enough to adversely affect someone within the right-of-way. Adherence to the Traffic Control Safety Plan will assure field personnel of full backing by the U.S. Geological Survey in the event of an accident.

4. For work occupying a lane of traffic or for work on the shoulder or near the roadway, an approved traffic control plan following guidelines established by TxDoT must be

implemented. No vehicle shall be parked on a highway bridge unless absolutely essential to work involved. Vehicles parked on the shoulder of the road before the work area must have an activated amber rotating beacon or strobe.

5. When a vehicle is necessary for making a measurement, it shall not be moved onto the roadway until the equipment is ready to begin the measurement. The vehicle shall be removed from the roadway as soon as the measurement is finished.

6. An activated rotating amber beacon or strobe light shall be used at all times on vehicles parked in or near the roadway. Vehicle flashers are not a substitute.

In addition to these general requirements a site-specific Traffic Control Plan (TCP) for each station shall be kept in the station field folder and station folder. Electronic versions of these plans can also be found on the web at the WSC Station Information Management Site (SIMS) at: http://tx.cr.usgs.gov/field/sims/

The TCP should be checked and updated in January of each year. The plan should also describe any exceptional circumstances, hazards, and deviations from the standards. These plans shall be followed closely to help ensure the safety of the motoring public and employees, as well as protect the employee and WSC from liability in case of an accident.

Additional guidance can be found in the WSC Traffic Control Safety Plan which is available on the WEB at: http://tx.cr.usgs.gov/adm/safety/documents/SAFETY%20POLICY.doc

To properly implement the TCP, each field vehicle should be equipped with the traffic control devices necessary for the implementation of any one of the five template Traffic Control Safety Plans. However, this inventory does not account for modifications to the plans that may be required for compensation of site-specific factors. In addition, each vehicle should be equipped with an amber rotating beacon or strobe.

Quantity	Description
2	Workers Ahead
2	One Lane Road Ahead (CW20-4)
2	Flagger (Symbol) (CW20-7)
2	Right Lane Closed Ahead (CW20-5)
2	Right Lane Closed (CW20-5)
4	"Left" Velcro attached overlay for "Right'
2	END ROAD WORK (G20-2a)
6	Portable Stands for 48"x48" warning signs.
2	Portable Stands for "END ROAD WORK" signs.
25 (approx)	Traffic cones, 28" minimum
2	Sign paddle, STOP / SLOW
3	Reflective vest, DOT type III

TRAINING

Ensuring that personnel obtain knowledge of correct methods and procedures is a vital aspect of maintaining the quality of surface-water data and data analysis. By providing appropriate training to personnel, the WSC increases the quality of work and eliminates the source of many potential errors.

Training needs are identified by all individuals, in consultation with their supervisor, and as identified by Office Data Chiefs, the Surface-Water Specialist, or the WSC Data Chief. Training will be conducted on the job, on the Internet, with self-paced books and CDs, or at formal classes, as appropriate, and approved by the WSC Director. Training will be documented and kept in each employee's personnel file.

SUMMARY

Information included in this WSC Surface-Water Quality-Assurance Plan documents the policies and procedures of the Texas WSC that ensure high quality in the collection, processing, storage, analysis, and publication of surface-water data. Specific types of surface-water data discussed in this report include stage, streamflow, reservoir, and precipitation. The roles and responsibilities of WSC personnel for carrying out these policies and procedures are presented, as are issues related to management of the computer database and issues related to employee safety and training.

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APPENDICES

Appendix 1. Hydroacoustic Instrumentation Standards, Policies, and Procedures

This addendum to the Texas WSC Surface Water Quality-Assurance Plan presents standards, policies, and procedures specifically related to hydroacoustic instrumentation. Many standards, policies, and procedures documented in the main body of the Surface Water Quality-Assurance Plan apply to the use of hydroacoustics. These include, for example, maintenance of gaging-station infrastructure, site documentation, and general records-working procedures. This addendum documents standards that are unique to the hydroacoustic instruments. It is expected that this addendum will be updated as the use of hydroacoustics increases and as new instruments, software, and firmware are introduced. This addendum is subdivided by instrument category:

1. Acoustic Doppler current profiler (ADCP)
2. Acoustic Doppler velocity meter (ADV)
3. Index-velocity meter

Acoustic Doppler Current Profiler

Acoustic Doppler current profilers are used to make medium- and high-water discharge measurements. The WSC has eleven RDI ADCPs (nine 1200 kHz and two 600 kHz) and one Sontek. Additionally, the WSC has seven tethered boats. A list of ADCPs in each Texas WSC office is contained in the WSC Flood Plan. The Flood Plan also contains lists of qualified ADCP and boat operators. All ADCP operators should read and become familiar with the information contained in the following policy memoranda and reports:

- Open-File Report 95-701, Quality Assurance Plan for Discharge Measurements Using Broadband Acoustic Doppler Current Profiles, Lipscomb
- Open-File Report 01-01, Discharge Measurements Using a Broad-Band Acoustic Doppler Current Profiler, Simpson
- OSW Technical memorandum 96.02, Interim Policy and Technical Guidance on Broadband ADCPs
- OSW Technical memorandum 2000.03, Software for Computing Streamflow from Acoustic Profiler Data
- OSW Technical memorandum 2000.07, National Coordination and Support for Hydroacoustic Activities
- OWS Technical memorandum 2002.01, Configuration of Acoustic Profilers (RD Instruments) for Measurement of Streamflow
- OSW Technical memorandum 2002.02, Policy and Technical Guidance on Discharge Measurements using Acoustic Doppler Current Profilers
- OSW Technical memorandum 2002.03, Release of WinRiver Software (version 10.03) for Computing Streamflow from Acoustic Profile Data
- OSW Technical memorandum 2003.01, Discharges computed using Sontek RiverSurveyor Acoustic Doppler Current Profiler

•OSW Technical memorandum 2005.04, Release of WinRiver Software version 10.06 for Computing Streamflow from Acoustic Profiler Data

•OSW Technical memorandum 2005.05, Guidance on the use of RD Instruments StreamPro Acoustic Doppler Profiler

Field Procedures

1. Prior to going into the field, the operators ensure that: the ADCP is in working order with the latest approved firmware; their laptop contains the latest approved software; they have sufficient space on the PCMCIA memory card, CD-R, or Zip disks for temporary backups; and they have a working laser range finder for measuring edge distances.

2. Each day the ADCP is used, a diagnostic test is performed and the results are recorded. The filename of the diagnostic test is included on notes of any measurement made with the ADCP that day.

3. Prior to each measurement, a moving-bottom check is performed by holding the position of the ADCP in the part of the river thought most likely to have the largest sediment load (usually near the zone of largest flow). The moving-bottom check is recorded and archived with the rest of the measurement-data files. The test should last at least 5 minutes. If the position of the ADCP cannot be held precisely, a moving-bottom check of 10 minutes or more might be needed to differentiate actual boat movement from apparent upstream movement caused by a moving-bottom condition.

4. The estimates used for edge distances shall always be measured. Distance may be measured, using a laser range finder, tag line, or rule.

5. When using an RD Instruments Rio Grande with WinRiver software, operators use the Configuration Wizard to set up the measurement. If any settings other than the Configuration Wizard settings are used, the reasons for the user settings are explained on the measurement note sheet.

6. The depth to the transducer below water surface shall always be verified before each measurement.

7. In accordance with OSW requirements, if all of the first four transects are not within 5 percent of the mean, at least four additional transects shall be made. Note: There are exceptions for unsteady flow.

8. After each measurement, or at least once a day, all measurement data and diagnostic tests are backed up temporarily on a removable medium such as a PCMCIA flash card (recommended), CD-R, or Zip disk.

Office Post-Field Procedures

ADCP measurements are processed, archived, and reviewed within two weeks after returning from the field. Data are archived in accordance with the Archiving section of the Texas WSC Surface-Water Quality-Assurance Plan.

The ADCP operator is responsible for archiving all ADCP measurement and diagnostic files, processing all measurements, entering the measurement data into the database, and finding a trained ADCP operator to review each measurement.

The reviewer of an ADCP measurement is responsible for ensuring that correct methods were used to collect and process the measurements, measurement notes are accurate, measurement data have been archived correctly, and that the measurement notes have been filed. If any changes are made during the review process, the changes should be discussed with the original ADCP operator, the database updated, and measurement notes filed.

Acoustic Doppler Velocity Meter

Acoustic Doppler velocity meters (ADVs) designed for use with a standard USGS top-setting wading rod are used to make wading discharge measurements. The make and model ADV used for this application is the SonTek Flowtracker. OSW Technical memorandum 2004.04 contains policies on the use of the FlowTracker. The following general guidelines are taken from that memo:

1. Under appropriate conditions and use as described below, the FlowTracker can be used in place of the mechanical Pygmy and Price AA meters for wading discharge measurements. The same procedures and polices for use of the mechanical meters apply to the use of the FlowTracker; these include:
   - Measurement site selection -- the measurement section should be within a straight reach, where streamlines are parallel. The streambed should be relatively uniform and free of numerous boulders, debris, and heavy aquatic growth. The flow should be relatively uniform and free of eddies, slack water, and excessive turbulence.
   - Velocity sample time – under normal measurement conditions, each point velocity measurement should be sampled for a minimum of 40 seconds. Under extreme flow conditions, such as rapidly changing stage, a shorter sample time may be used to lessen the time needed to complete the discharge measurement.
   - Location of velocity observations in each vertical – at depths below 1.5 feet, the 0.6-depth method should be used; at depths between 1.5 and 2.5 feet when a non-logarithmic velocity distribution may be present and the 0.8 depth sample location would be more than 2 inches from any boundary, the two-point method should be used; and at depths greater than 2.5 feet, the two-point method should be used. If a non-logarithmic velocity profile is discovered when using the two-point method, the three-point method should be used.
2. Prior to each field trip, or about once per week, perform a FlowTracker ADVCheck (FlowTracker Operation Manual Section 6.5.4). The ADVCheck should be logged to a file and archived. The name of the ADV check file should be written on the measurement note sheet. Perform FlowTracker field diagnostic procedures (FlowTracker Operation Manual Section 3.3.2) prior to starting every measurement.
3. Monitor the FlowTracker SNR readings during the measurement for SNR readings that are less than 4 dB. The FlowTracker will display a warning at the end of a velocity measurement if the SNR for any beam is less than 4 dB. If the SNR is below 4 dB, try moving to a different measurement section where backscatter may be higher. If a section with an acceptable SNR cannot be located, the FlowTracker should not be used to make a discharge measurement.
4. Avoid measurement sections with abrupt changes in bed topography. These changes can result because of such things as large rocks or cobbles in the measuring section. Abrupt changes in bed topography may cause boundary effects leading to inaccurate velocity measurements. During the measurement, velocities should be monitored for unrealistically low velocities, and also for unusually large SNR values (a solid boundary should cause an increase in the SNR). Be aware of the location of the FlowTracker sample volume when measuring. The sample volume typically is 10 centimeters (about 4 inches) from the center transmitting transducer

(figure 1). Avoid placing the sample volume within 2 inches from any solid boundary. Although this recommended placement does not mean that the FlowTracker cannot be used closer to boundaries, nevertheless, extra care should be taken in those situations.

5. Pay close attention to the flow angle reported by the FlowTracker. The wading rod (with FlowTracker attached) always should be held perpendicular to the tagline, so that the pulse generated by the transmitter (see figure 1) is parallel to the tagline. Ideally, the tagline should be set up in the cross section to be measured such that flow is perpendicular to the tagline. Flow angle, as calculated by the FlowTracker, is defined as the direction of flow relative to the x-direction of flow, so that

   $$FlowAngle = \arctan(Vy/Vx)$$

   where, Vy is the velocity in the y-direction (parallel to the tagline) and Vx is the velocity in the x-direction (perpendicular to the tagline) used to calculate discharge. The flow angle calculated by the FlowTracker can result from two sources: (1) the flow is not perpendicular to the tagline, and (2) the flow is perpendicular to the tagline but the wading rod is not being held correctly relative to the tagline, as described above. Regarding (1), some small angles and variation in the flow angle at a site is not unusual. However, if large fluctuations of flow angles are reported, measurements should be made at another section with more uniform flow. Regarding (2), holding the FlowTracker such that it is skewed at any angle relative to the tagline will result in a measurement of velocity that is biased low. Small angles do not result in significant biases, but because of these biases, users should be careful to minimize this error. If the FlowTracker is held such that it is skewed at an angle of approximately 8 degrees from the tagline, the measured velocity may be in error by as much as 1% (assuming that flow is perpendicular to the tagline).

   Large variations in flow angles may be indicative of poor or inconsistent alignment of the wading rod or poor site selection for the measurement.

6. Each FlowTracker measurement is stored in a binary file (.WAD extension) that a user can download to the computer and, using FlowTracker software, extract four files containing the measurement data. These files include a summary of the measurement (.DIS) with average subsection velocities and SNR readings, and a "raw" data file (.DAT) that lists 1-second velocities and SNR readings. The effect of unrealistic velocities may not be apparent in the average subsection velocities in the .DIS file. Thus, users should review the 1-second velocity and SNR data in the .DAT file if any of the following results are observed:
   - Average subsection SNR readings in the .DIS files are less than 10;
   - .DIS file average subsection velocities or SNR readings appear to be inconsistent across the measurement section or unrealistic for site conditions;
   - SNR readings are observed to fall below 4 dB any time during a discharge measurement;
   - The .DIS file shows unrealistic subsection velocity spikes;
   - The .DIS file shows subsection boundary variable values of 3 (poor);
   - The mean standard error of velocity for the measurement shown in a DIS file exceeds 5 percent of the mean velocity for the measurement; or,

• There is any reason to suspect data-quality problems (such as the presence of irregular bedforms or other solid boundaries that could interfere with the sample volume).

Measurement Quality Assurance

The following is a list of recommendations for using Flowtracker parameters to help assess the quality of discharge measurements. These parameters are not available with Price-type meters. Guidelines for using the parameters are:

•Velocity standard error—If the average standard error for the measurement exceeds 8 percent of the mean measurement velocity, the measurement should be rated no better than "fair." If the standard error exceeds 10 percent of the mean measurement velocity, the measurement should be rated no better than "poor."

•Boundary flag—There are four possible boundary flags assigned to each station: "best," "good," "fair," and "poor." A boundary flag of "best" does not guarantee a lack of boundary interference (see the Flowtracker Technical Documentation). If the ADV sample volume was striking a solid boundary, a "best" flag likely still would be displayed, but the measured velocity could be biased toward zero.

•Velocity spikes—An excessive number of velocity spikes (more than 10 spikes per measurement) could reduce the quality of the measurement.

•Flow angles—A good measurement section typically shows some flow-angle variations, but with angles less than 20 degrees.

Periodic Quality-Assurance Checks

Each Flowtracker must be checked for discharge-measurement accuracy at least annually and also after any hardware or firmware changes. The check consists of making a discharge measurement at a site where the Flowtracker-measured discharge can be compared with a known discharge derived from some other source. Appropriate sources of comparison discharge would be discharge obtained from a stable discharge rating, or discharge measured with a second Flowtracker or mechanical meter known to meet USGS calibration standards.

Index-Velocity Meter

The Texas WSC uses acoustic velocity meters (AVMs) and acoustic Doppler velocity meters (ADVMs) installed at gaging stations to index mean channel velocities for the computation of records of discharge.

Personnel who use index-velocity instruments for the production of discharge records obtain training by attending the Office of Surface Water class "Streamflow Records Computation using Hydroacoustic Current Meters and Index-Velocity Methods" that is offered periodically.

Installation

A thorough site reconnaissance is required prior to installation of an index-velocity meter at an existing gaging station or establishment of a new index-velocity-meter station. The site reconnaissance includes channel surveys and the collection of velocity and temperature profiles. The channel bed is characterized for stability. The site hydraulics are analyzed carefully for factors that potentially could cause rating instabilities. Other considerations include protection of the instrument, power/communications cable-length limitations, and adequate power supply. The data collected from the reconnaissance are used to ascertain the success of using an index-velocity meter. For ADVMs, aspect ratios (range/depth) and bridge-pier wake-turbulence zone can be computed to see if the ADVM sample volume will reach a zone of stable velocities. Gage-site-selection criteria documented in Rantz and others (1982, p. 5–9) remain applicable for index-velocity sites.

The index-velocity-meter deployment program is recorded and archived. If the index-velocity- meter deployment program can be saved, the deployment program is archived. Some index-velocity-meter programs cannot be saved directly. In these instances, a screen capture of the instrument deployment can be used to save the program parameters. A paper copy of the pertinent parameters is placed in the gage-house folder.

Field_Procedures

The following procedures are followed during visits to stations equipped with index-velocity meters:

1. A temperature reading from an independent source, such as a digital thermometer, is taken near the instrument. The temperature is recorded in the field notes along with the time of the reading.

2. For ADVMs, a beam-amplitude diagnostic test is run and logged in a file. All such files are archived according to the Hydrologic Data Section Surface-Water Electronic Archiving appendix. Beam-amplitude checks are an invaluable diagnostic and quality-assurance tool. The beam-amplitude checks must show that the ADVM sample cell is free of obstructions and is sized so that beam amplitudes at the end of the sample cell are a minimum of 5 counts above the instrument noise level. If these criteria are not met, the ADVM sample cell must be adjusted until the requirements are met. All sample-cell changes must be noted on the station log and in field notes and the new instrument deployment saved. If the sample-cell size changes significantly, a new index-velocity rating likely is needed.

3. If the gage does not have data telemetry or if all logged parameters are not transmitted, the data logger data are downloaded for each site visit and the data are input to NWIS at the office.

4. At least once annually, the standard cross section is checked to ensure that the channel geometry has not changed significantly. For channels with known scour or fill potential or for channels with the potential for dredging, the standard cross section may need to be checked more frequently. If possible, discharge measurements can be made at the standard cross-section location. The advantage of this approach is that for every measurement, the standard cross section is checked.

5.The frequency of discharge measurements is dictated by stability of the stage-area and index-velocity ratings and by the range of measurements used to define the ratings. Changes in index-velocity instrumentation or changes to existing instrument program parameters (for example, ADVM sample-cell-size changes) likely necessitate the need for a new index-velocity rating and, hence, more-frequent measurements to establish the new rating. It may be possible to reduce measurement frequency once stable ratings have been established for a wide range of flows. For stations that are subject to rapidly changing bidirectional flow, it is possible to measure discharge over a large percentage of the flow range during a single site visit. All sites, however, must be measured at least four times a year.

Data_Quality_Assurance
All data-quality parameters available are used to assess the quality of the velocity (and stage) record used to generate discharge records. For AVMs, these parameters include percent good signal and speed-of-sound. For ADVMs, these parameters can include cell end, velocity standard deviation, velocity y-component, water temperature, and signal strength (average backscatter amplitude). Unit-value plots are valuable for examining these quality-assurance parameters.

Discharge_Computation:
The same general USGS policies and recommendations that apply to stage-discharge methods used to produce discharge records apply to index-velocity methods. Thus, guidelines for the production of streamflow records presented in the section entitled Processing and Analysis of Stage and Streamflow Data outlined in the Texas WSC Surface-Water Quality-Assurance Plan apply to index-velocity methods. Polices and recommendations regarding stage data, such as the editing or deleting of unit values, apply to velocity unit values as well. Likewise, guidelines for records documentation, including the station analysis, daily-values tables, and other supporting materials, are applicable to index-velocity records.

Appendix 2. Water Resources Discipline Memoranda Cited

The following memoranda were cited in this report. The memoranda are provided in their entirety online at: http://water.usgs.gov/admin/memo/SW/auto.html

Office of Surface Water memorandum 2005.05

Office of Surface Water memorandum 2005.04

Office of Surface Water memorandum 2004.04

Office of Surface Water memorandum 2003.01

Office of Surface Water memorandum 93.12

Office of Surface Water memorandum 93.07

Office of Surface Water memorandum 92.11

Office of Surface Water memorandum 92.10

Office of Surface Water memorandum 92.09

Office of Surface Water memorandum 92.04

Office of Surface Water memorandum 90.10

Office of Surface Water memorandum 90.01

Office of Surface Water memorandum 89.08

Office of Surface Water memorandum 89.07

Office of Surface Water memorandum 88.18

Office of Surface Water memorandum 88.07

Office of Surface Water memorandum 87.05

Office of Surface Water memorandum 85.17

Office of Surface Water memorandum 84.05

Water Resources Division memorandum 92.59

Water Resources Division memorandum 77.83

Appendix 3. WSC Memoranda Cited

Attachment no. 1
Date: Thu, 17 Dec 1998 17:43:20 -0600 (CST)

From: Raymond Slade <rmslade@gisdtxast.cr.usgs.gov>

To: all@servdtxast.cr.usgs.gov

Subject: Station levels at gaging stations--setting staff gages

Recently, it was discovered that a staff gage was set in error (by 0.27 feet) at one of our streamflow stations. The error went undetected for 6 years thus wrong gage heights were published and computer stored for that duration. That error can easily happen and probably exists at other stations.

It can happen if the gage height of the turning point on the staff gage (or its backing or channel) is misread on the staff gage during levels. This problem is unlikely to happen where wire weights are used, because the bottom of the wire weight is shot--it's elevation is established from the gage height of the instrument.

If the staff gage exists prior to levels, it should be turned on (front and back site to the staff gage). If the levels shows it to read correctly, no further levels are needed at that gage. However, if a staff gage is being established or reset, the following procedure is recommended:

1. If the staff gage is in the water, run levels to the water surface and record the water surface as it reads on the staff gage--this gives a verification that the staff gage is set correctly. 2, If the staff gage is out of the water, shoot 2 different points on the backing. One or both readings can involve reading the staff gage directly through the level instrument. This provides a reading and a verification that the staff gage is set correctly.

Attachment no. 2
Date: Wed, 17 Sep 1997 13:42:33 -0500 (CDT)

From: Frank Wells <fcwells@gisdtxast.cr.usgs.gov>

To: all@servdtxast.cr.usgs.gov

Subject: DCP data review

The use and dependence on our real-time data on the Internet has been rapidly increasing by our cooperators, governing officials, consultants, and others. For example, the Texas Natural Resource Conservation Commission has been using our real-time data to manage surface-water withdrawals for many thousands of municipal, industrial, commercial, and farming water users throughout the State. Even one station transmitting incorrect data could cause allowed withdrawals to be affected for some water users. Our real-time data also are being used to manage and monitor surface-water quality conditions and discharge permits, as well a for reservoir operations and flood forecasting. Therefore we must do everything practical to verify that our real-time data are as complete and accurate as possible.

Because of the importance of our real-time data, I am requesting that current data for all stations with DCP's be reviewed on our home page on the Internet. The current data for all stations should be reviewed daily, but not less than every other day. The Data Chiefs will be responsible for overseeing this procedure, but the Data and Office Chiefs may assign review responsibility for individual stations, as they believe appropriate.

The review should emphasize the identification of stations that are not transmitting correct data, so that the problems can be remedied as soon as practical. The second reason for the review is to attempt to identify stages for which discharge measurements are needed, thereby allowing these sites to be incorporated into current field operations.

The data and office chiefs should work with Raymond Slade to establish training for real-time data review on the Net. Offices or individuals needing such training personnel from the district office are available to assist with the training as needed. Please implement these procedures as soon as possible and notify me or Raymond of any problems or suggestions associated with the procedures. We can revise these recommended procedures as the need exist.

Frank C. Wells (fcwells) Assistant District Chief.

Attachment no. 3
Date: Tue, 4 Mar 1997 11:03:14 -0600 (CST)

From: Raymond Slade <rmslade@gisdtxast.cr.usgs.gov>

To: all@servdtxast.cr.usgs.GOV Cc: "Kenneth L Wahl, Hydrologist, Denver, CO" <klwahl@gisdtxast.cr.usgs.gov>

Subject: District Policy Memorandum No. 97-04

MEMORANDUM

Texas District Memo 97.04

To: All Employees, Texas District

From: District Chief, Austin, TX

Subject: DISTRICT POLICY--Indirect Measurements and Flood Measurements

The Texas District Flood Plan (revised Feb. 1996) provides some guidance for conducting indirect measurements. The Flood Plan will be revised to include District policy as stated below.

1. Personnel will immediately notify the servicing Office Data Chief (if station within Data Program) or Project Chief (if station within Studies Program) of substantial peak stages at gaging stations.

2. The Office Data Chief or Project Chief will recommend if an indirect measurement is needed, based on the magnitude of the peak stage, the condition of the stream channel and control, and the magnitude and age of direct and indirect measurements on the rating curve.

3. The servicing office will contact the District Data Chief for approval to conduct the indirect measurement.

4. The servicing office will contact the District Surface-Water Specialist for technical advice concerning the measurement.

5. The Office Chief, Office Data Chief (or Project Chief), District Data Chief, and District Surface-Water Specialist will determine and approve personnel needs for documenting peak marks, conducting the survey, and processing the measurement.

6. The peak marks needed for the measurement will be documented (located, preserved, and qualified) as soon as possible, by personnel trained in this procedure, even if the surveying will be done later. Field personnel will be trained to locate, preserve, and qualify peak marks for indirect measurements. Field personnel will keep surveying stakes, flagging, nails, hammer, string line, string level, and hand level in their vehicle for such occasions.

7. At least one person in each subdistrict office will be trained to survey and process indirect measurements. Several people in the District office will be trained to conduct indirect measurements and be available to assist subdistrict and field offices as needed.

8. The indirect measurement will be sent to the District Surface-Water Specialist for review and approval. If the measurement needs further review, it will be forwarded to the Regional Surface Water Specialist.

Typical indirect measurements require from 3 to 6 man days of time and generally are less accurate than poor direct measurements. Therefore, the District encourages that non-standard direct measurement procedures be used when standard procedures cannot be followed.

Non-standard procedures include the following: Measurements made during rapidly-changing stages should be completed as quickly as possible, in order to minimize the change in stage during the measurement. Half-count or quarter-count velocity measurements can be made during these conditions or when the meter or line is in jeopardy of being damaged or frequently hung by debris. Counts and seconds should be recorded exactly as collected.

If depths cannot be sounded because of high velocities or debris, then the cross section can be used to measure velocities at 0.2 of depth. If this procedure cannot be used, then surface velocities will be sounded. Standard depth and velocity measurements, however, should be made at the sounding stations where possible. The standard soundings and other standard procedures will be used to adjust the measured discharge value.

Attachment no. 4
Date: Thu, 24 Dec 1998 14:54:28 -0600 (CST)

From: Raymond Slade <rmslade@gisdtxast.cr.usgs.gov>

To: David Brown <dsbrown@gisdtxast.cr.usgs.gov>, "Debra A. Sneck-Fahrer" <dsfahrer@gisdtxast.cr.usgs.gov>, Jeff East <jweast@gisdtxast.cr.usgs.gov>, "Kenneth C. Grimm" <kcgrimm@gisdtxast.cr.usgs.gov>, Robert Perez <rperez@gisdtxast.cr.usgs.gov>, Mick Baldys <sbaldys@gisdtxast.cr.usgs.gov>, Tim Raines <thraines@gisdtxast.cr.usgs.gov>, William Asquith <wasquith@gisdtxast.cr.usgs.gov>, Paul McKee <pwmckee@gisdtxast.cr.usgs.gov> Cc: Fred Liscum <fliscum@gisdtxast.cr.usgs.gov>, George Ozuna <gbozuna@gisdtxast.cr.usgs.gov>, Joseph Broadus <jbroadus@gisdtxast.cr.usgs.gov>, Jimmy Pond <jgpond@gisdtxast.cr.usgs.gov>, Mike Dorsey <medorsey@gisdtxast.cr.usgs.gov>, Rich Hawkinson DC <rohawkin@gisdtxast.cr.usgs.gov>, jmay@gisdtxast.cr.usgs.gov

Subject: INDIRECT MEASUREMENTS--computations over broad-crested weirs

Those who have computed indirect measurements for flow over broad-crested weirs realize that these discharge computations become complex and are sometimes not documented for non-standard dams or non-standard flow conditions. Such characteristics include non-level dams, dams without consistent dimensions, dams with unusual dimensions, and flows with backwater.

Flow adjustments for broad-crested weirs with submerged flows still are unknown. Therefore, indirect measurements should not be attempted at broad-crested weirs when the fall in water surface over the dam is less than 15% of the vertical distance from the dam crest to the water surface upstream from the dam.

Computations of flow over a broad-crested dam should be subdivided if: the elevation of the dam crest varies substantially along its width normal to flow; the water-surface depth over the dam varies substantially; or, the dimensions of the dam vary along its width. Therefore, the field survey for such conditions should include surveys of the break points on the dam and break points in the approach cross section. I developed a standard form that can be used to subdivide the flow computations for such conditions. The form contains the steps to be used in the computations, and explains and defines the steps. I'll be glad to send a copy of the form to anybody wanting it.

Attachment no. 5
Subject: THEORETICAL STAGE-DISCHARGE RATINGS

Frequently we need to develop theoretical stage-discharge ratings for USGS gaging stations, or extend ratings based on theoretical methods. Also. we have received several recent requests from some cooperators to develop theoretical ratings for sites where they collect data. The purpose of this EMAIL is to provide suggested procedures for developing theoretical ratings, and to document the criteria for the type of data needed to use each procedure.

There are several models that will provide estimates of water-surface elevations for specific discharges. For example WSPRO, HEC-RAS (US Army Corps of Engineers) and other routing-type models will perform such calculations. Typically these models require cross-sections, channel roughness values, and characteristics of hydraulic structures. However, these models were designed to estimate flood-plain elevations along stream reaches, and are not designed to provide exact elevations for discharges at specific sites on streams. We have attempted to use these models to provide stage-discharge ratings--these ratings often have proven to be unsatisfactory where discharge measurements later have been made to verify the ratings.

Also, USGS work is being highly scrutinized by the consulting-engineering industry. Use of these models to develop ratings for cooperators (at sites where USGS is not collecting data) might be construed as work that should be performed by private consultants.

However, we feel that the USGS has the authority to develop theoretical ratings for cooperators, especially if we use procedures for indirect-discharge measurements that we have developed and documented, and these ratings are at locations where the data would be valuable to us. Likewise, we should use these procedures where we need to develop theoretical ratings at USGS stations. Procedures for indirect-discharge measurements are documented in Techniques of Water Resources Investigations (TWRI), Book 3 Chapter A1 through A5--they should be used to develop theoretical ratings because the criteria for the sites, the information and data needed, and the potential error in their calculations are verified by laboratory and field data. Also, unlike the routing models, discharges from indirect measurements are based on actual water levels--therefore ratings based on indirects typically have less potential error than ratings based on routing models.

The following presents a general summary of the type of data needed to develop theoretical ratings using procedures for USGS indirect measurements:

Dam creating free fall of water surface:

If the dam is high enough so that there is free fall over it, the water surface would be going through critical flow over the dam. For this type of site, we don't need peak marks to develop the rating. Needed is an approach cross section upstream from the water-surface drawdown caused by the dam, a cross section on the dam, and measures of the characteristics of the dam. If there is uncertainty of free fall over the dam, peak marks from a large flood could be surveyed upstream and downstream from the dam to insure that free fall did occur. Reference--TWRI book 3, Chapter A5.

Dam, road, culvert, or bridge without free fall in water surface:

For these sites, free fall in the water surface would not be caused by the structure. The structure, however, must create some fall in the water surface before it can be involved in the theoretical rating computations. Because free fall isn't occurring, peak marks are needed upstream and downstream from the structure, along with characteristics of the structure, a cross section upstream from the structure, and channel roughness values representing the reach from the cross section to the structure. A crest-stage gage should be installed immediately upstream from the water-surface drawdown caused by the structure, and immediately downstream from the turbulence caused by the structure. Reference--TWRI book 3 Chapter A3, A4, and A5.

Open channel without hydraulic control

For theses sites, needed are 2 or 3 cross sections and peak marks at each section some distance apart (about 2 full channel widths) in a uniform or slightly converging reach where the cross sections would be stable (minimum scour or fill). Cross sections should be run, channel-roughness values determined, and crest-stage gages installed on the bank of each section. Reference--TWRI book 3 Chapter A2.

The general need for data and information at a gaging site where a theoretical rating is needed can be determined based on the information above. Cross sections can be run, structures measured, and crest-stage gages installed. Then the formulas to calculate peak discharges (from the TWRIs) can be identified. As floods occur, peak marks from the crest-stage gages can be recovered and used in the formulas to calculate the peak discharge for each flood. Using this procedure, peaks from about 6-10 floods (with varying stages) can be used to develop the rating curve.

Please contact me when a theoretical rating is needed--I'll be glad to discuss specific details regarding the data and information needed, and provide the method and formulas needed to calculate the peak discharges.

Attachment no. 6
Date: Mon, 19 Oct 1998 17:36:48 -0500 (CDT)

From: Raymond Slade <rmslade@gisdtxast.cr.usgs.gov>

To: Mike Dorsey <medorsey@gisdtxast.cr.usgs.gov>, Ed Ranzau <ceranzau@gisdtxast.cr.usgs.gov>, Robert Perez <rperez@gisdtxast.cr.usgs.gov>, Buddy Miller <ammiller@gisdtxast.cr.usgs.gov>, "Kenneth C. Grimm" <kcgrimm@gisdtxast.cr.usgs.gov>, John Tomlinson <jatomlin@gisdtxast.cr.usgs.gov>, Jon Gilhousen <jrgilhou@gisdtxast.cr.usgs.gov> Cc: George Ozuna <gbozuna@gisdtxast.cr.usgs.gov>, Rich Hawkinson DC <rohawkin@gisdtxast.cr.usgs.gov>

Subject: Extending stage-discharge ratings

Mike just asked me about any policy or suggestions for extending stage-discharge ratings. This might be a good time to present some summary ideas to the San Antonio and Austin offices.

You will be frequently answering 2 questions that were less frequent before the storm: 1. Do we need measurements to extend the rating, and, if not, 2. How should we extend the rating

Every year during our SW records workshop, we discuss a couple of effective methods to extend ratings. I suggest that the following procedure be used:

Part 1--determine area for extended GH

1. Identify the highest 4-6 discharge measurements (direct or indirect) that define or almost define the current rating. 2. Identify the GH needed for the rating extension (GH of extension). 3.

Plot on graph paper the GH against the cross sectional area for each measurement. 4. Determine, the cross sectional area for the GH of extension, by using the station cross section and the cross section from the latest high-flow measurement. 5. Plot the GH and area point (from no. 4 above) on the graph and draw a best-fit line through all points on the graph.

Part 2--estimate mean velocity for extended GH

6. Plot the GH against the mean velocity for the measurements. 7. Draw a line that best fits the data points. 8. Draw a line (along the GH scale) that represents the highest GH needed for the velocity extension. 9. Review the shape of the best fit line through the GH-velocity points. Is it almost a straight line? If so, it probably can be reasonably extended up to the extension GH.

The cross-sectional area for the extended GH can be taken from no. 5. the mean velocity for the extended GH can be taken from no. 8 above. The discharge for the extended GH represents the product of the mean velocity and the area. If the best fit line from no. 6 is not linear, chances are it should not be extended to estimate the mean velocity for the extended GH. In that case, a discharge measurement probably is needed to define the velocity for the extended GH.

Please write or call me if you have any questions, comments, or challenges to this procedure.

Attachment no. 7
Date: Thu, 11 Jun 1998 18:00:07 -0500 (CDT)

From: Raymond Slade <rmslade@gisdtxast.cr.usgs.gov>

To: data chiefs -- Buddy Miller <ammiller@gisdtxast.cr.usgs.gov>, Ed Ranzau <ceranzau@gisdtxast.cr.usgs.gov>, "Debra A. Sneck-Fahrer" <dsfahrer@gisdtxast.cr.usgs.gov>, Edna Paul <empaul@gisdtxast.cr.usgs.gov>, Dan McElhany <gdmcelha@gisdtxast.cr.usgs.gov>, John Tomlinson <jatomlin@gisdtxast.cr.usgs.gov>, Jimmy Pond <jgpond@gisdtxast.cr.usgs.gov>, "J.M. Taylor" <jmtaylor@gisdtxast.cr.usgs.gov>, James Hutchison <jshutchi@gisdtxast.cr.usgs.gov>, "Kenneth C. Grimm" <kcgrimm@gisdtxast.cr.usgs.gov>, Mike Dorsey <medorsey@gisdtxast.cr.usgs.gov>, Milton Miller <mmmiller@gisdtxast.cr.usgs.gov>, Robert Perez <rperez@gisdtxast.cr.usgs.gov>, Mick Baldys <sbaldys@gisdtxast.cr.usgs.gov>, Susan Gandara <sgandara@gisdtxast.cr.usgs.gov>, Ken VanZandt <vanzandt@gisdtxast.cr.usgs.gov>, William Damschen <wcdamsch@gisdtxast.cr.usgs.gov>, Willard Gibbons <wgibbons@gisdtxast.cr.usgs.gov> Cc: subchiefs -- George Ozuna <gbozuna@gisdtxast.cr.usgs.gov>, Harry McWreath <hcmcwrea@gisdtxast.cr.usgs.gov>, Joseph Broadus <jbroadus@gisdtxast.cr.usgs.gov>

Subject: Suggested procedure for reviewing historic unit values

A question has arisen concerning historic unit values being reviewed for data requests. What should be done for unit values that are deemed incorrect by the review?

This is another item for the next Data Chief's meeting and the new District Data Chief to tackle. In the meantime, Willard and I discussed this subject and agree upon an interim procedure.

We probably should not be using ADAPS to revise historic unit gage heights or discharges because most of our stored and published daily-mean discharges are based on the historic unit values. We suggest copying the unit discharges to a file to be delivered to the requester and reviewing the discharges in that file. If it is obvious that there are some "bad" unit values, it is suggested that they be changed if "better" discharges can be readily estimated. For example, corrupt discharges due to "spikes" can readily be estimated for base-flow conditions, and one or a few bad discharges can be estimated for falling or rising limbs of floods.

There might be days for which there are many bad unit values or revisions can't be made with confidence--we don't have to release unit values for those days. We can simply state that the unit values for those days are corrupted and won't be released. As part of the review, I suggest calculating a daily-mean discharge for the unit values about to be released, then compare that value with the daily value in ADAPS.

After the review is made and a determination is made of which days will be released, please document the station name, date of unit values requested and released, date reviewed, and reviewers name, and person, company, or agency receiving the values, along with a summary of the findings of the review (i.e. requested June 1-20, revised some unit values on June 3 & 7, didn't release June 10, other dates released as found. Keep a copy of the revised unit values.

These summaries later will be aggregated on NWIS or elsewhere so that we will know what was released and revised, when, and to whom. Also, this documentation will benefit the review for later releases of the same data.

If you have any suggestions for this interim policy, please advise.

Attachment no. 8
Date: Thu, 29 Jan 1998 14:26:40 -0600 (CST)

From: Raymond Slade <rmslade@gisdtxast.cr.usgs.gov>

To: all@servdtxast.cr.usgs.gov

Subject: Maintenance of unit values and rain gages

Recently, we had a request to provide precipitation unit values to be used in a flood-damage lawsuit. We discovered that: the rain gage wasn't officially identified in proposals or work plans; it wasn't funded; the recorded depths hadn't been verified by calibration; and the gage maintenance was minimal and undocumented.

This occurrence indicates that we need detailed guidelines for installation and maintenance of rain gages, and for maintenance and review of unit values. These subjects are extensive thus I'm requesting that they be addressed at the next Data Chiefs meeting. Until then, I'm suggesting some temporary guidelines.

Regarding rain gages--One item from a recent Data Chiefs meeting identified limited maintenance for rain gages, but recorder calibration wasn't addressed. There are reports that many of our rain gages are in need of calibration. Collector intakes should be checked for obstructions during each visit. The recorded depths for each rain should be verified at least once by pouring a predetermined amount of water into the collector and noting the recorded depth. Please do this for any rain gages where that hasn't been done and document the procedure on a field sheet. Corrections for recorded depths can be made at the instrument or applied as rating corrections in ADAPS. David Brown has a field sheet he uses for rain gage maintenance--we will discuss using it or a substitute at the next Data Chief's meeting.

Regarding unit values--We present unit values on our home page and, after each WY, write them onto compact disk for future use--therefore we must make every effort to assure they are correct or delete them. The Data Chief or project chief should be responsible for verifying unit values from their stations. Any rainfall, discharges, reservoir storage, water-quality constituent, or other published values that doesn't originate from the unit values should be identified (in station analysis or other form) and any incorrect unit values should be deleted if they can't be fixed by editing. However, we want to limit any deleted record to periods containing no useful data. For example, do not delete fragmented or partial record data--it could be used to estimate minimum or maximum values, partial-day values, or be used to estimate published values.

Attachment C Validation of Continuous Water Quality Monitoring Data Collected by Multiparameter Sonde

STANDARD OPERATING PROCEDURE (SOP)
Title: Validation of Continuous Water Quality Monitoring Data Collected by Multiparameter Sonde
Team Leader: ______________________ Date: __________ Quality Control Review: ______________________ Date: __________ Section Manager: ______________________ Date: __________ Effective Date: 4/14/06

1.0 PURPOSE

This SOP describes the procedure for Level I validation of ambient water quality data acquired from continuous water quality monitoring stations located within selected river basins of the State of Texas utilizing existing infrastructure and Leading Environmental Analysis and Display System (LEADS) data processing software.

2.0 SCOPE AND APPLICABILITY

Continuous water quality monitoring data for validation may include, but are not limited to: temperature, pH, dissolved oxygen, specific conductivity, turbidity, nitrate, ortho-phosphorus, and ammonia. The automated procedures are performed by the LEADS computer system, and the manual procedures are performed by the Water Data Validator.

3.0 METHOD OR PROCEDURAL SUMMARY

Data is examined for record completeness and reporting accuracy. Operator logs are reviewed for calibration and post-calibration records and unusual events. Data losses are investigated and data values exceeding established critical limits (Appendix A) are flagged or invalidated.

4.0 LIMITATIONS

4.1 Data validation is dependent upon the quality of field observations and reported calibration information in the Operator Log.

4.2 If data is reloaded or reprocessed after validation, previously flagged and/or recovered data defaults to the original status. Data must be validated again by referring to the Validator's Log and operator logs.

4.3 LEADS is a developing system. The software tools used to validate data may contain defects that may or may not be identified. This may necessitate checking one tool against another.

4.4 This procedure does not include Level II data validation with the SAS Program.

5.0 SAFETY

Usual office and computer safety practices apply. For additional information about the TCEQ safety program, see: http://home.tnrcc.state.tx.us/internal/admin/support/safety/index.html.

6.0 EQUIPMENT

Computer Hardware

- 486PC, 8MB RAM, 80 MB hard-drive or 68040 Macintosh, 8MB RAM 80 MB hard-drive
- Data logger, data communication hardware
- SCO UNIX computer system, 16 MB RAM, 500 MB hard-drive
- Modems (118)
- Central office HP Computer K460
- Ethernet Connection
- Seaspace Satellite System (images)

LEADS Hardware

Processor	Name	Type
Central Processor	tnrcc3	HP K460
Validation	tnrcc1	HP D380
Web Server/Validation	dsr	HP J280
Validation/Weather	tnrcc5	HP 715
Validation/Weather	tnrcc6	HP 715
Satellite	tnrcc4	HP 735
Satellite	tnrccs	HP D390
Comms Front End	cfep	HP C110
Test Bed	tnrcc9	HP 735
Sys Admin	tiros	HP 712
Weather	wx	HP 712
Amarillo Hub	reg1	HP 712
Arlington Hub	reg4	HP 712
Tyler Hub	reg5	HP 712
El Paso Hub	reg6	HP 712
Midland Hub	reg7	HP 712
Beaumont Hub	reg10	HP 712
Austin Hub	reg11	HP 712
Houston Hub	reg12	HP 712
San Antonio Hub	reg13	HP 712
Corpus Christi Hub	reg14	HP 712
Harlingen Hub	reg15	HP 712

Data logger, data communication hardware

- SCO UNIX computer system, 16 MB RAM, 500 MB hard-drive
- Modems (118)
- Central office HP Computer K460
- Ethernet Connection
- Seaspace Satellite System (images)

Computer Software (Validation Tools)

- HP UNIX
- SCO UNIX
- HP View Light, View, CDE (Common Desktop Environment)
- Exceed for PC
- Exodus for Macintosh
- LEADS pollution user interface
- LEADS user interface
- Microsoft Excel menu
- Microsoft Word
- Netscape
- Labview/Zeno datalogger application
- WXPlot
- AQPlot
- Power Point
- Fetch
- WXBase
- Fox Pro

7.0 PROCEDURE(S)

7.1 Daily procedure

7.1.1 Verify the operation of the *in-situ* multi-parameter data sonde, the ZENO data logger, and completed data transmission in the morning and at close of business, at a minimum.

- Using an internet browser, access the Texas Commission on Environmental Quality (TCEQ) internal server at **http://dsr/**. Within the **Data Reporting Pages** section, view the *CAMS Hourly Averages by Site* or *CAMS Data Printout*. Select the date, time format, CAMS number/location of the real-time water site, and generate a report. Confirm the data retrieval for all parameters.

- If data is missing, access *Comms Report* within **the Status Pages** section to confirm communication between the remote sites and the central computer site.

- Access the *Operator Logs* to check for unscheduled maintenance or unusual events.

- Contact the site operators and the project lead for possible site investigation/repairs, if necessary.

- Contact the LEADS administrator for possible data recovery and/or to resolve communications problems.

7.2 Weekly Procedure

7.2.1 Using an internet browser, access the TCEQ internal server at **http://dsr/**. Within the **Status Pages** Section, review the *Operator Logs* for each site to be validated. Confirm reporting of preventative maintenance information and calibration/post-calibration data for the previous seven days.

7.2.2 Access the LEADS Pollution Interface via an x-terminal emulation package (Exceed). Contact the LEADS Administrator for access rights, validation rights, and passwords.

7.2.3 Access the Manual Validation Retrieve window via Manual Validation Login.

- Select the "Start Time" button and indicate the beginning month, day, and time of the data validation interval.

- Select the "End Time" button and indicate the end month, day, and time of the data validation interval.

- Select the appropriate time label.

- Select the "Five-Minute" Database.

- Select sort by "CAMS."

- Select "Show Sites."

- Highlight the CAMS site for validation from the site list.

- Select "Show Available."

- Highlight the validation parameters. Hold down the CTRL key to select up to four validation parameters at one time.

- Select "OK."

- Compare the automatically generated LEADS data flags with the Operator Logs. Edit any data flagged incorrectly by selecting the data interval in the Manual Validation window and selecting the appropriate data flag from the EDIT drop-down menu. Document any changes in the Validator's Log. See Appendices A and B for data flags and flag priorities.

- If the Operator Log indicates that a parameter failed post calibration, flag the data associated with that parameter for the corresponding time period as invalid with an AQI flag. If PMA flags have been automatically generated, the data for the subsequent hour is flagged AQI.

- Investigate irregular data patterns by referring to the Operator Log, contacting the site operator for further information, using Best Professional Judgment (BPJ), and/or notifying the Surface Water Quality Monitoring (SWQM) staff.

- After all data flagging is complete, choose "Validate Data" from the FILE drop-down menu. Note any changes made to the data during manual validation in the Manual Validation Notes window. Include detailed explanation for any changes. Initial all entries. Ensure all changes are documented in the Validator's Log.

- Select the "Validate" button on the Manual Validation Notes Page to complete the validation procedure.

8.0 CALCULATIONS

Not Applicable

9.0 QUALITY CONTROL

9.1 Each experienced data validator is responsible for review, validation, and verification of data from assigned ambient stations.

9.2 Maintain detailed records in the form of a hardcopy Validator's Log that includes all activities and follow-up actions relating to ambient data. The records should be sufficient to reconstruct the data validation event.

9.3 The data validator reviews and questions any part of the measurement process and initiates data reviews and corrective actions to bring the process back into compliance.

9.4 The data validator uses a supplemental tool to examine water quality data. The data is reviewed using a SAS Program that can graph more of the data record than LEADS, and allows easy manipulation of scale. This Level II data validation ensures that data anomalies that are not apparent in LEADS are discovered and data is qualified accordingly.

10.0 DEFINITIONS

AQI – Ambient Quality Invalid
BPJ – Best Professional Judgment
CAMS - Continuous Ambient Monitoring Stations
EMS - Environmental Monitoring System
LEADS - Leading Environmental Analysis and Display System
PMA – Preventive Maintenance Action
SWQM - Surface Water Quality Monitoring
TCEQ – Texas Commission on Environmental Quality

11.0 REFERENCES

LEADS Web pages. Training Material: Manual Validation

LEADS Operator's Manual

TCEQ Operating Policies and Procedures, Chapter 6.13

Monitoring Operations Hazardous Waste Disposal Plan

12.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

Supervisors, sampling personnel, and laboratory analysts should identify and implement innovative and cost-saving waste reduction procedures as part of the method development, and review and revision of standard operating procedures. Wastes that do result from these procedures are managed and disposed in accordance with appropriate state and federal regulations.

Refer to Chapter 6.13 of the TCEQ Operating Policies and Procedures for guidelines on general recycling, waste reduction, and water and energy conservation. Review these procedures for specific employee responsibilities and mechanisms for office related waste prevention and management. Consult the *Monitoring Operations Hazardous Waste Disposal Plan* for laboratory specific waste minimization recommendations and requirements for proper handling of hazardous waste that results from laboratory procedures.

13.0 SHORTHAND PROCEDURE

13.1 Daily

- Confirm the collection and transmission of data.
- Contact the LEADS administrator for recovery of lost data, if necessary.
- Contact area operators and the project lead for site investigations, if necessary.

13.2 Weekly

- Investigate any irregular data patterns.
- Confirm all data flags.
- Edit any incorrect data flags.
- Document any data changes in the Validator's Log.
- Validate data.

Appendix A

Flags used by MeteoStar/LEADS

If there are less than nine valid five-minute samples within an hour, consult the priorities to determine which flag to assign to the hourly average. Flags with higher priorities overwrite flags of lower priority.

Flag	Description	Manually Set	Automatic	Priority
LST	Lost or missing data - indicates that data for this sample period is not stored in the MeteoStar database		X	1
LIM	Data failed one or more automatic quality checks		X	5
PMA	Instrument in preventative maintenance mode	X (set by field operators)		6
AQI	Data invalid	X		12
FEW	Not enough samples to create an hourly average		X	4
NEG	Data failed NEG test indicates data values are too negative; normally low negative values are set to zero by the MeteoStar software		X	3
VAL	Data valid	X	X	0

Appendix B

Validator Alert Limits

These limits are established to alert the water data validator to values exceeding the water quality standard and/or the expected normal range as determined by historical data for each site.

Green Creek at CR 266 and Resley Creek at CR 394		
Parameter	**Lower Limit**	**Upper Limit**
Temperature (°C)	< 1.00	> 33.00
pH	< 5.00	> 9.00
Dissolved Oxygen (mg/l)	0.00 to -0.50** < -0.51	> 16.00
Specific Conductivity (μmhos/cm)	< 163	> 1260
Turbidity (NTU)*	0	1000

North Bosque River on Riverside Road in Clifton and Leon River at Fauntleroy Park in Gatesville		
Parameter	**Lower Limit**	**Upper Limit**
Temperature (°C)	< 1.00	> 33.00
pH	< 5.00	> 9.00
Dissolved Oxygen (mg/l)	0.00 to -0.50** < -0.51	> 16.00
Specific Conductivity (μmhos/cm)	N. Bosque River < 146 Leon River < 181	> 938 > 1428
Turbidity (NTU)*	0	1000

* Limits based upon instrument range rather than actual historical data due to short term environmental effects.
**Generates an automatic NEG flag.
°C - degrees Centigrade
mg/l - milligrams per liter
μmhos/cm - micromho