3 OVERVIEW OF DATA PROCESSING

by Edward E. Fischer

This section provides a general description of how ADAPS is configured to receive, process, and store data from USGS data-collection stations and of the computational procedures that are available in ADAPS to process these data. Information also is provided on types of variables and ratings used, data corrections and shifts, and computation of daily mean values.

3.1 Levels of Database Access

Four levels of database access are available in ADAPS. The highest level (code SYST) has access to all NWIS databases and programs. The levels of access are listed in table 1.

Table 1: ADAPS Access Levels

Code	Description	Level of access
SYST	System Database Administrator (DBA)	All NWIS databases and programs
ADBA	ADAPS Database Administrator (ADBA)	ADAPS processing records
USER	User	Data processing capabilities
COOP	Cooperator	Read-only capabilities

3.2 Site and Data Type Records

At each site (station), the data types that will be collected, the data processing steps, and the data storage formats must be established in ADAPS before any data can be entered. This information is maintained within ADAPS with the following records.

3.2.1 Site (Station) Record

The site record is maintained in the NWIS Site File. It must be created before any data-specific information can be established in ADAPS. The site record is created and updated by the DBA. Information about creating and updating records in the Site File is provided in the GWSI manual.

3.2.2 Location Record

Sites where a single data type is measured at two or more points require a location record for each measuring point. For example, if temperature is measured at three depths in a single horizontal location in a lake, the station requires three location records. Other data types measured at the same locations (for example specific conductance) do not require additional location records. Location records are created and updated by the ADBA using program LOC_EDIT or program DD_EDIT.

3.2.3 Data Descriptor (DD) Record

Each data type that is collected requires a Data Descriptor (DD) record. The DD record contains information about processing and storing the data. It references other data that may be required for data processing such as data correction tables, shift tables, and rating tables. If the data are automatically collected, the DD record also references a processor record (next section). DD records are created and updated by the ADBA using program DD_EDIT. Only data types that are included in the NWIS parameter code dictionary, PARMFILE, can be stored in ADAPS.

3.2.4 Processor Record

A processor record corresponding to the DD record may be required depending on the type of data being collected. The processor record contains site-specific information on how to compute unit and daily values from the input data and, if required, how to compute data that serve as input for a different data type. Processor records are created and updated by the ADBA using program DD_EDIT.

3.2.5 Device Conversion and Delivery System (DECODES) Record

Data collected by Data Collection Platforms (DCP) and Electronic Data Loggers (EDL) require a Device Conversion and Delivery System (DECODES) record. The DECODES record defines the data types and their respective positions in the data stream. The record references the DD record that was created for the data type. The DECODES record is used by the DECODES program and by the Satellite Telemetry Input (SATIN) program. The record is created by the ADBA using the DECODES program.

3.2.6 Relation Between DD, Processor, and DECODES Records

A schematic of the relation between the DD, processor, and DECODES records is shown in figure 1. Stage/discharge data from a single-channel instrument are used as an example. The discharge processor record references the gage-height DD record. It also controls the daily values statistics computations of the gage-height data. For a multiple-channel instrument, the DECODES record references a separate DD record for each channel. Each DD record references its own processor record.

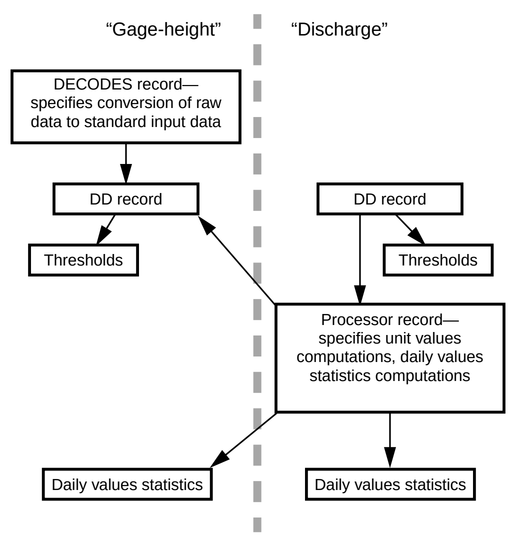


Figure 1. Relation between data descriptor, processor, and DECODES records.

3.3 Data Storage Formats

Data for a single data type are stored in several formats that correspond to the various processing steps. The values at each step are stored in case it is necessary to reprocess the data. There are also three special storage formats: discharge measurements, peak flow values, and summary statistics. Up to 2,880 values per unit-value-format type can be stored for a single day.

3.3.1 Measured Unit Values

Measured unit values are the “raw” values measured by the data collection instruments and entered into the ADAPS database. They can be entered using one of several entry programs. Measured unit values cannot be altered within the ADAPS system. When a mistake occurs, they must be deleted and the correct values entered.

During normal processing measured unit values are displayed after the conversion-of-input rating has been applied. Measured unit values can be viewed without the conversion-of-input rating applied by selecting the “view raw measured unit values” option available in programs that process them.

3.3.2 Edited Unit Values

Edited unit values are measured unit values that have been converted to the engineering units specified for the data type using a conversion-of-input rating. They are available for modification, deletion, or the addition of remark codes. For example, stage unit values may have spurious peaks or missing values that can be changed (edited) using the data editing program, HYDRA, and data from other sources. Any modifications to the edited unit values are saved back into the edited unit values.

3.3.3 Correction Unit Values

Correction unit values are added to edited unit values to correct systematic errors in the data such as datum corrections or instrument-bias corrections. For example, a 6-week period of stage unit values might require that a 10-foot datum correction be added to each value. Correction unit values are calculated from data correction curves.

3.3.4 Computed Unit Values

Computed unit values are edited unit values that have had correction unit values added to them.

3.3.5 Shift Unit Values

Shift unit values are added to stage computed unit values prior to computing discharge unit values. If the processing is a velocity-discharge computation, shift unit values are added to velocity computed unit values prior to computing discharge unit values. Shift unit values are calculated from shift curves.

3.3.6 Output-Computed Unit Values

Output-computed unit values are calculated by the primary computations program from other unit values. For example, discharge unit values are computed from stage unit values.

3.3.7 Computed Daily Values

Computed daily values are calculated by the primary computations program from unit values. For example, daily mean discharge is computed from discharge unit values.

3.3.8 Final Daily Values

Final daily values are computed daily values that have been reviewed and, if necessary, edited. For example, computed daily discharge values may be edited to account for an anomalous backwater situation. Final daily values can only be edited manually using HYDRA.

3.3.9 Discharge Measurements

Data from discharge measurements are stored in "Form 9-207" format in the Discharge Measurements File. They are entered into ADAPS manually.

3.3.10 Peak Discharges

Peak discharges are stored in a separate peak flow file. They are entered manually.

3.3.11 Summary Statistics

Summary statistics are stored as a distinct data format. They are stored automatically when they are computed.

3.4 Date and Time Conventions

Every piece of time-series data in ADAPS is tagged with a date and time. The tags conform to ISO (International Organization for Standardization) standards. **NOTE: The convention of designating midnight as 00:00:00 hours of a new day and of storing data with respect to UTC (see following) is different from that used in previous versions of ADAPS.**

3.4.1 Dates

Dates are stored in ADAPS according to the Gregorian calendar. Years are entered using four digits. Months are entered with numbers; "1" equals January. Leap years are automatically taken into account during data processing.

3.4.2 Times

The time of day runs from 00:00:00 (midnight, read as "zero hours, zero minutes, zero seconds") to 23:59:59 in 1-second intervals. If midnight is entered as 24:00:00, it is converted to 00:00:00 of the next day. Midnight 24:00:00 is used for certain purposes such as reporting the times of minimums and maximums on primary reports; 0000 is the beginning-of-day midnight and 2400 is the end-of-day midnight.

3.4.3 UTC, Local Time, Time Zones, Daylight Savings Time

All data in ADAPS are stored with respect to UTC (Universal Time Coordinate). Local time is calculated from time zone information stored in the site record. Whether local time is calculated as standard time or daylight savings time depends on how the site is configured to use daylight savings time.

3.4.4 Data Processing in Local Time

All data processing in ADAPS is done with respect to local time. Data corrections, shifts, ratings, etc., are entered using local time. Daily values are computed for data collected from midnight to midnight local time. When a site is configured to use daylight savings time, in most cases ADAPS automatically switches between standard time and daylight savings time as appropriate during data processing and printing of unit values tables.

3.5 Data Rounding Convention

The rounding of ADAPS numerical data for printing (the number of significant digits that are printed) is governed by codes stored in a rounding array that is part of the parameter code definition. The rounding array comprises 10 digits. The first nine digits specify the number of significant digits to which a value is rounded based on its magnitude, and the tenth digit specifies the maximum number of decimals that can be printed. The rounding array specifications are presented in table 2 along with four example arrays.

Table 2: Data Rounding Array

		Number of significant digits to print (first nine digits of rounding array) and maximum number of decimals that can be printed (tenth digit)			
Position in rounding array	Magnitude of data value, x	Water temperature, in degrees Celsius (00010) "0012333331"	Solar radiation, incidental, intensity, in cal./cm^2/day (00030) "3222234443"	Discharge, in ft^3/s (00060) "0222233332"	Stage, in feet (00065) "0223456782"
1st	$x < 0.01$	0	3	0	0
2nd	$0.01 \le x < 0.1$	0	2	2	2
3rd	$0.1 \le x < 1.0$	1	2	2	2
4th	$1.0 \le x < 10$	2	2	2	3
5th	$10 \le x < 100$	3	2	2	4
6th	$100 \le x < 1,000$	3	3	3	5
7th	$1,000 \le x < 10,000$	3	4	3	6
8th	$10,000 \le x < 100,000$	3	4	3	7
9th	$x \ge 100,000$	3	4	3	8
10th	Maximum number of decimals to display	1	3	2	2

Consider for example the default rounding array for discharge data (parameter code 00060). The array is "0222233332." The first digit, "0," means that if the stored value is less than 0.01, the value will be printed as "0.00 ft^3/s"—the number of decimal places is determined from the last digit, "2," in the array. The second digit, "2," means that if the value is greater than or equal to 0.01 ft^3/s and less than 0.1 ft^3/s, then it will be printed to two significant figures; for example, if the stored value is 0.076, it will be printed as "0.08." The third digit, also a "2," means that if the value is greater than or equal to 0.1 and less than 1.0, it will be printed to two significant figures; a stored value of 0.1548 will be printed as "0.15 ft^3/s." The fourth through ninth digits work in a similar fashion: a stored value of 92.355 will be printed as "92 ft^3/s" and a stored value of 5,758.66 will be printed as "5,760 ft^3/s." The default rounding array for solar radiation is "3222234443." In this case, if the stored value is less than 0.01 calories/cm^2/day, it will be printed with three significant figures using 3 decimal places—"3" in the last position. For example, if the stored value is 0.0093, it will be printed as 0.009 calories/cm^2/day; if the value is 0.0097, it will be printed as 0.010 calories/cm^2/day. The rounding specifications are entered at the time the DD record is established in the site file. If a rounding array is not entered, ADAPS uses the rounding specifications stored in the parameter code dictionary.

3.6 Ratings

Ratings define the relationship between two parameters. They are entered into ADAPS using program RT_EDIT and are stored in the Rating Tables File either as equations or as tables. Ratings are in effect during the time periods specified with the rating. Discharge ratings are developed according to the methods presented in *Discharge Ratings at Gaging Stations* (Kennedy, 1984).

3.6.1 Rating Types

The types of ratings used in ADAPS and a brief description of each are given in table 3 below. The description indicates the measuring method for which the rating type is used.

Table 3: Rating Types

Rating Code	Rating Name	Dependent Variable – must ascend	Independent Variable - Minimum	Dependent Variable - Minimum	Rating Description
STGQ	stage-discharge	True	N/A	0.00	A rating used to compute the discharge of a stream on the basis of stage.
FALL	fall	False	N/A	0.00	A rating used to determine the adjusted fall as it relates to the mean gage height observed at the base gage in a reach where the fall in stage (slope of water surface), between auxiliary and base gages is affected by backwater.
FLFC	Fall-factor	False	0.00	0.00	A rating used to determine the factor value needed to compute an adjusted discharge on the basis of measured fall in the reach between auxiliary and base gages, and measured discharge.
STCO	stage-coefficient	False	N/A	N/A	A rating used to determine a velocity adjustment coefficient from its relation to stage, for the index velocity method.
STAR	stage-area	True	N/A	0.00	A rating used to determine the cross-sectional area of a stream on the basis of stage.
PARM	dependent, parameter	False	N/A	N/A	A rating used to compute one parameter on the basis of its relational parameter.
STOR	storage-correction	False	N/A	N/A	A rating used to determine the variable Sc/J from its relation to gage height.
VELO	velocity	False	N/A	N/A	A rating used to determine the mean velocity on the basis of the index velocity.
MEAS	input conversion	False	N/A	N/A	Conversion of input rating for measured unit values.

3.6.2 Equation Ratings

Equation ratings are of the form

$$y = a(b + x)^c + d$$

where y = output value (dependent variable),
x = input value (independent variable), and
a,b,c,d = coefficients.

Conversions are exact; that is, interpolation is not used to calculate intermediate values. Only the coefficients are stored in the Rating Tables File.

3.6.3 Table Ratings

Table ratings are stored as ordered input/output pairs. Generally input/output pairs are not stored for every possible input value. Instead, intermediate values are interpolated from the tabled values. Interpolation is either linear or logarithmic, depending on the rating type. The method of logarithmic interpolation is described in Kennedy (1984).

3.6.4 Rating Dates

A rating is in effect according to the starting date and time specified with the rating. It is used until it is superseded by the starting date of another rating. A rating may have more than one starting date because it can become valid again as environmental conditions change. Ratings used for a single DD are numbered sequentially as they are developed. Ratings that are used again at a later date are not renumbered.

3.7 Data Corrections and Shifts

Data corrections are applied to edited unit values to correct systematic errors. Shifts are special data corrections that are applied to corrected stage unit values to adjust the relationship between stage and discharge; the stage values are otherwise correct but the stage/discharge relationship has changed because of changes in the river environment. Data corrections are stored as computed unit values; shifted stage (or index-velocity) unit values are not stored after the discharge has been determined because shifts are automatically calculated. Shifts and their application are discussed in *Computation of Continuous Records of Streamflow* (Kennedy, 1983).

3.7.1 Starting/Ending Dates and Times

Data corrections are applied only between the starting and ending dates specified with the correction. Shifts are linked to stage-discharge ratings and are in effect only within the time frame of the ratings. Data corrections and shifts are carried across water-year boundaries. Explicit zero data corrections and shifts are not required for time periods during which corrections are not necessary.

3.7.2 Constant Data Corrections and Shifts

A constant data correction or shift is a single value that is added to each input value to produce the output value. The value is added only during the period between the starting and ending dates of the correction. No proration of any kind is performed. The most recent correction and (or) shift is applied during real-time data processing if an ending date was not specified with the correction. Note that, conceptually, a constant data correction or shift is a “single-point” variable shift diagram (next section).

3.7.3 Variable Data Corrections and Shifts

Shifts can be varied with the input value. (In this section “data correction” and “shift” are synonymous, as are “input value” and “stage.”) A variable shift is defined by a shift diagram comprising two or three points (figure 2). The input variable (stage in the figure) is the independent variable and the output (dependent) variable is the shift. Interpolation between the points is linear. A constant shift equal to the closest end point value is returned if the input value lies outside the defined domain of the shift diagram.

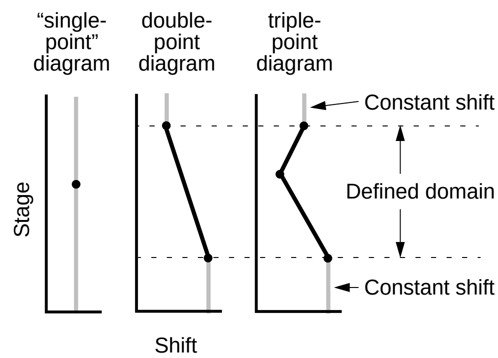


Figure 2. Variable shift diagrams. The shift is interpolated linearly in the defined domain and is constant above and below the defined domain. [Stage, input variable; shift, output variable.]

3.7.4 Data Correction and Shifts with Time Proration

Shifts can also be varied with time. (In this section also, “data correction” and “shift” are synonymous.) Time proration is based on the starting times of two consecutive shift diagrams (figure 3). First, the shifts corresponding to the stage measured at time, t, are determined from each shift diagram. Then, using the two shift values as endpoints, the shift is interpolated with respect to time, t. Shift-with-time proration also is linear.

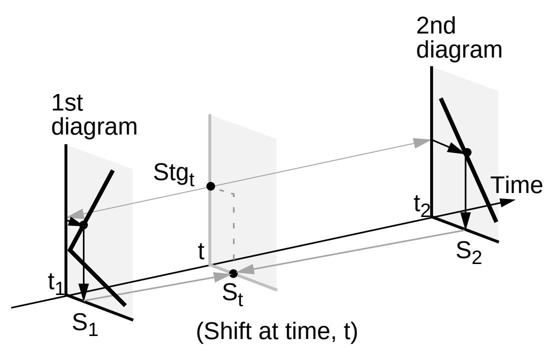


Figure 3. Schematic of proration of shift at time t between two variable-shift diagrams. [t_1, start time of 1st diagram; t_2, start time of 2nd diagram; Stg_t, stage at time t; S_1, shift from 1st diagram for Stg_t; S_2, shift from 2nd diagram for Stg_t; S_t, prorated shift at time t.]

Shift-with-time proration is not performed if an end date is explicitly entered with the shift diagram or if the shift diagram is the most recent one in use and does not have an explicit end date. In these cases the shift is that determined from the diagram.

3.8 Data Aging

Data in ADAPS are in one of three status levels: “Working,” “In-Review,” and “Approved.” Data aging is the process by which data are moved from one status level to the next. Each status level is called a data aging code. The codes and the database access levels associated with each code are listed in table 4.

Table 4: Data Aging Codes

Code	Description	ADAPS access level	Permitted actions at access level
Working	Data can be computed, edited, and deleted	USER	Process records and change data-aging code to “In-Review”
In-Review	Data are locked against further modification pending review	ADBA	Review records, change data-aging code to “Approved” or back to “Working”
Approved	Data are considered final and locked against any modifications	SYST	Change data-aging code back to “Working”

Data aging applies to most aspects of data processing: processor records, ratings, rating dates, shift curves, correction curves, unit values, daily values and summary statistics. Prior to NWIS version 4.2, data were flagged either “Provisional” or “Final.” Provisional data could be manipulated and edited, while final data could not be altered. With version 4.2, this concept was expanded to provide a more comprehensive method of controlling alterations to data and of preserving this status not only for the actual data items, but also for related items involved in processing the data. Also in 4.2, the “Provisional” and “Final” flags were replaced by the data aging codes. When data are marked “In-Review” and “Approved,” all of the pieces are marked the same. Similarly, when “Approved” data must be reset to “Working,” all of the associated pieces must be reset to “Working.” Discharge measurements/gage inspections are not included in the data aging process.

Data aging is handled slightly different in each of three categories: processor records, ratings, and data (rating dates, correction curves, shifts, unit values, daily values, and summary statistics. ADAPS programs for managing processor records (DD_EDIT) and ratings (RT_EDIT) also manage data aging. A utility program (SETSTATUS) allows users at different database access levels to manage data aging for the rest of the data. The utility program (STATUS_REPORT) lets users check on current data aging status.

3.8.1 Data Aging of Processor Records

Processor records are protected from modification by setting them to “Approved.” Data aging of processor records is managed using program DD_EDIT. The status level of a processor record does not affect the status of the data it processes, nor does changing the status of a processor record affect any data that were previously processed by it. If a processor record that has been used for approved data must be modified, it is recommended that a new version be created rather than changing the status back to “Working.”

3.8.2 Data Aging of Ratings

Ratings must be set to “Approved” before any data computed using the ratings can be set to “Approved.” Data aging of ratings is managed using program RT_EDIT. While the system allows an “Approved” rating that was used to compute “Approved” data to be set back to “Working” without also resetting the data, this is strongly discouraged. Instead, it is recommended that a new rating be created using the “copy” or “extend” options in RT_EDIT. Note that data aging of *rating dates* is managed separately (next section).

3.8.3 Data Aging of Data

Data correction curves, shift curves, rating dates, unit values, daily values and summary statistics pertaining to a single DD are data aged as a single unit. Other DDs may be included in the unit. For example, discharge data (one DD) are computed from gage-height data (a different DD); the data for both DDs are aged together. Data aging in this category is by water year and is managed using program SETSTATUS. Data in this category cannot be set to “Approved” if any ratings associated with the processing are not set to “Approved.”

3.9 Unit Values Screening Thresholds

Unit values are checked against several thresholds during processing to identify erroneous values (critical thresholds) and to specify warning levels (non-critical thresholds). Values that fail one or more threshold tests are flagged for review. Unit values that exceed any of the critical thresholds are blocked from display to the public on the NWISWeb pages. The threshold types and their descriptions are listed in table 5.

Table 5: Unit Values Screening Thresholds

Threshold	Flag	Description	Description editable?
		Magnitude thresholds	
Very high value	H	Critical. Value is impossibly high.	Yes
Very low value	L	Critical. Value is impossibly low.	Yes
High value	h	Non-critical. Value exceeds specified high warning level.	Yes
Low value	l	Non-critical. Value exceeds specified low warning level.	Yes
		Rate-of-change thresholds	
Very rapid increase	I	Critical. The rate of increase between this value and the immediately preceding value is impossibly large.	No
Very rapid decrease	D	Critical. The rate of decrease between this value and the immediately preceding value is impossibly large.	No
Rapid increase	i	Non-critical. The rate of increase between this value and the immediately preceding value exceeds the specified warning level.	No
Rapid decrease	d	Non-critical. The rate of decrease between this value and the immediately preceding value exceeds the specified warning level.	No
		Standard difference threshold	
Standard difference	T	Non-critical. The absolute value of the difference between this value and the immediately preceding value exceeds the specified warning level.	Yes

Unit values screening thresholds are specified using program DD_EDIT or THRESHOLD_EDIT. Some of the threshold descriptions are editable so that more specific messages can be included in printouts. Whether a description can be edited is indicated in the column labeled “Description editable.” Thresholds are not data-aged.

Unit values are screened in several places during data processing according to the unit value type. If a threshold is not established for a DD, the respective unit values are not screened. The threshold types and the situations under which unit values are screened are discussed in the following sections.

3.9.1 Magnitude Thresholds

Magnitude thresholds test whether each unit value exceeds a specific value.

3.9.2 Rate-of-Change Thresholds

Rate-of-change thresholds test whether the rate of change between successive unit values is reasonable as determined for the data type. The rate of change is calculated by subtracting the previous unit value from the current unit value and dividing by the time interval between the two values. Rate-of-change thresholds can be specified for up to three ranges of unit-value magnitudes.

3.9.3 Standard Difference Threshold

The standard difference threshold tests whether the absolute value of the difference between successive unit values is exceeded. The difference is calculated by subtracting the previous unit value from the current unit value.

3.9.4 Screening of Input-DD Unit Values

Input-DD unit values that are entered using SENTRY or STD_STOR are screened in the following situations:

1. When they are designated as “preferred input.”
2. When they are saved after editing (HYDRA).
3. When a re-computation is performed after adding or modifying data corrections (DC_EDIT).
4. When a re-computation is performed after adding or modifying shifts (only for slope-discharge and velocity-discharge type computations) (SV_EDIT).
5. When a primary computation is performed (PRIMARY).

3.9.5 Screening of Computed-DD Unit Values

Computed-DD unit values, such as discharge, are screened when they are computed by program PRIMARY.

3.10 Data Processing Steps

Data are processed and stored in ADAPS according to the data type. The various steps are described in the following sections. Data that are processed as they arrive at the server are often called real-time or near-real-time data.

3.10.1   Transferring Unit Values

Unit values data are transferred from the data collection site by any of several transport methods. The transport method is identified by a data transport code. Automatically-collected data generally are transported to the ADAPS system by telemetry or other digital media, whereas manually-collected data are entered into ADAPS manually.

Data transport code

The data transport method is identified by a transport code. The code is automatically added as a suffix to the DD by the transfer process.   The data transport codes are listed in table 6.

Table 6: Data Collection and Transport Method Codes

Code	Description
s	GOES DCP (Data Collection Platform) data. Data are collected and stored onsite in the DCP. They are transferred to ADAPS by satellite technologies, typically once every 4 hours.
e	EDL (Electronic Data Logger) data. Data are collected and stored onsite in the EDL. They are transferred to ADAPS by land-line telephone, cellular telephone, line-of-sight radio, or by downloading to a portable computer. Data typically are transferred once per day, or in the case of a portable computer, once per site visit.
a	ADR (Analog to Digital Recorder) punched paper tape data. Data are collected and mechanically stored onsite on punched paper tape. The punches are converted to electronic digital values prior to entry into ADAPS. Data typically are transferred once per site visit after the paper tape is retrieved.
c	Chart (graphical recorder paper chart, also known as “strip chart”) data. Data are collected and mechanically stored onsite as a line drawn on a moving paper chart. Data typically are transferred once per site visit after the chart is retrieved. The line is digitized prior to entry into ADAPS.
o	Observation data. Data are collected manually and entered into ADAPS by typing at a keyboard.

The transport code is the means by which data for a single DD that are transported by more than one method are differentiated in ADAPS. For example, stage data may be collected and transported by both a DCP and an EDL. The suffixes S and E differentiate the data.

Automatically-collected data

Automatically-collected data are collected onsite by continuously-operating sensors without manual (human) intervention. The data are stored in the data-collection instruments as digital values. Presently (2002), the most common onsite data storage medium is computer memory. The values are transferred to the ADAPS server by telemetry or by downloading to a portable computer.

Some automatically-collected data are stored at the data-collection site by mechanical media such as digital paper-tape recorders. Methods for transferring mechanically-recorded digital data to ADAPS servers are discussed in an appendix.

Transfer by satellite telemetry (DCP data)

Many automatically-collected data are transferred to ADAPS by satellite telemetry. Satellite telemetry comprises three major components: (1) on-site instrumentation called Data Collection Platforms (DCPs) that collect, store, and transmit the data; (2) geostationary satellites that relay the transmissions; and (3) a ground station where the data transmissions are combined and rebroadcast to local receive sites around the country. DCPs transmit the data at preset intervals, typically once every 3 or 4 hours. A schematic of the DCP data flow path to an ADAPS server is shown in figure 4.

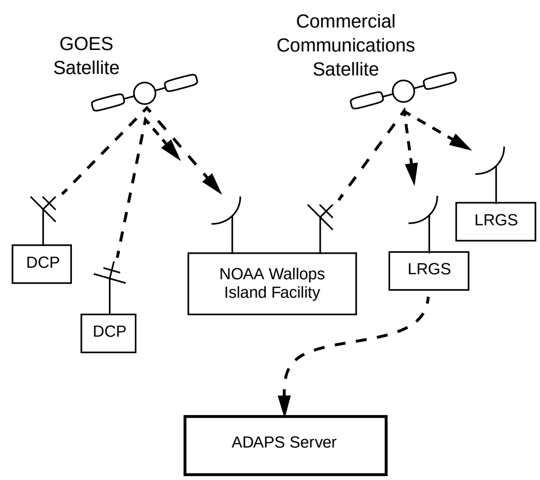


Figure 4. Data flow path from DCP sites to an ADAPS server

The relay satellites are part of the Geostationary Operational Earth Satellite Data Collection System (GOES), which is operated by the U.S. Department of Commerce National Oceanic and Atmospheric Administration (NOAA). The data are received by NOAA at its Wallops Island facility in Virginia where they are merged into a single data stream. The single data stream is transmitted via a commercial communications satellite to Local Readout Ground Stations (LRGS) that store it locally until programs on the ADAPS servers retrieve the data over the Internet or by telephone. The Puerto Rico District receives data directly from the GOES satellite and the Alaska and Hawaii Districts receive data via the Internet after it has been retrieved from a LRGS by the Washington District.

DCP data are retrieved from LRGS computers using a program on the ADAPS server called Satellite Telemetry Input (SATIN). SATIN processes the data into ADAPS standard input format for input to program SENTRY. SENTRY reads the data from the standard input file, adds the data transport code, and writes the data to ADAPS as measured unit values. The SATIN and SENTRY programs are automated processes that process data as they are received by the ADAPS server.

Transfer by other telemetry methods or portable computer (EDL data)

Automatically-collected data also are transferred to ADAPS by telemetry methods that include land-line telephones, cellular telephones, and line-of-sight radio. In some situations they are transferred by downloading to a portable computer. On-site instrumentation called Electronic Data Loggers (EDLs) collect and store the data. Data are transferred at less frequent intervals than DCP data, typically once per day, or in the case of a portable computer, once per site visit.

Transferred EDL data are processed by program DECODES, which converts the data to ADAPS standard input format, and by program Standard Store (STD_STOR), which adds the data transport code and writes the data to ADAPS as measured unit values. The DECODES and STD_STOR programs are initiated manually.

Transfer of a single data-type by multiple methods

Occasionally, data for a single data-type (typically stage) are transferred by more than one method. The additional data stream(s) serve as backup data. The data are differentiated in ADAPS by the data transport code.

Preferred-input data processing stream

When data are transported by more than one method, one of the methods is designated as the preferred-input data processing stream. The preferred-input data stream is processed automatically as the data arrive at the server. Data from the other data streams are kept as backup data. A schematic of a preferred-input stream is shown in figure 5.

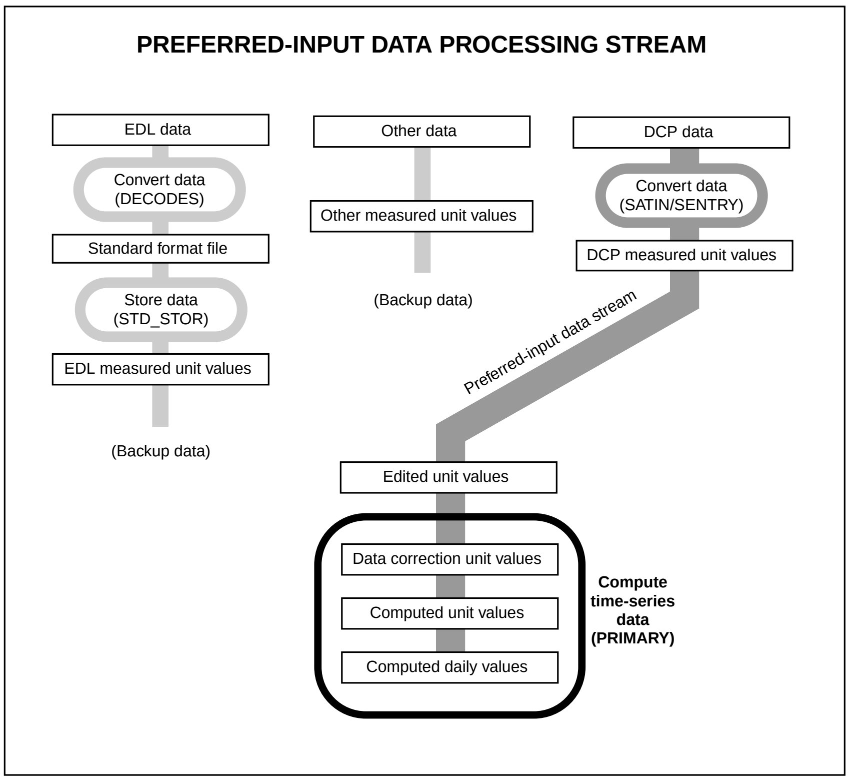


Figure 5. Schematic of preferred-input data processing stream. One data stream is chosen as the preferred input and is automatically processed to computed unit values and computed daily values.

Manually-collected data

Manually-collected data are collected onsite by humans and the data entered into ADAPS using various unit-values-entry or daily-values-entry programs. Manually-collected data typically are collected to verify automatically-collected data and in situations where it is not feasible or cost-effective to use automatic data-collection equipment. For example, discharge measurements are made to validate stage-discharge rating curves. The discharge measurement data are manually entered into ADAPS.

Some automatically-collected data stored on mechanical media may be manually transcribed. For example, stage data recorded by pen-and-ink strip chart recorders are digitized and the digitized values entered into ADAPS.

3.10.2 Editing Unit Values (HYDRA)

Measured unit values are reviewed and edited using HYDRA, a graphical editing program, and are stored as edited unit values. HYDRA has the capability of importing measured unit values from backup recorders, displaying data from other stations as reference curves, changing or deleting values, and flagging values. If edited values are later re-edited, HYDRA reloads them automatically. HYDRA also has the capability of reverting to the original measured unit values.

Unit values flags are used by ADAPS to track the status of each unit value. The flags are set (“turned on”) automatically according to the data type, the thresholds set up for the data type, and the type of data processing acting upon the data. Multiple flags can be set for a single data value. The flags used in ADAPS are listed in table 7.

Table 7: Unit Values Flags

Flag	Description
	Flags indicating thresholds
	[See table 4 for threshold explanations]
I	Value exceeds “very rapid increase” threshold
i	Value exceeds “rapid increase” threshold

Table 7: Unit Values Flags

Flag	Description
D	Value exceeds "very rapid decrease" threshold
d	Value exceeds "rapid decrease" threshold
L	Value exceeds "very low" threshold
l	Value exceeds "low" threshold
H	Value exceeds "very high" threshold
h	Value exceeds "high" threshold
T	Value exceeds "standard difference" threshold
	Flags indicating processing status
@	Value was reviewed by USGS personnel
*	Value was edited by USGS personnel
	Flags indicating data source
o	Value was observed in the field
a	Value is from paper tape
s	Value is from a DCP
~	Value is a system interpolated value
e	Value was recorded by a data logger
c	Value was recorded on a strip chart
p	Value was received by telephone transmission
r	Value was received by radio transmission
f	Value was received by machine readable file

Unit values remarks codes

Remarks codes can be assigned to unit values during review and editing in HYDRA. The codes are assigned by the user or automatically by the program. The remarks codes used in ADAPS are listed in table 8.

Table 8: Unit Values Remarks Codes

Code	Description
	Codes assignable by user
A	Value is affected by backwater from ice at the measurement site
B	Value is affected by backwater at the measurement site
R	Rating is undefined for this value
&	Value is affected by unspecified causes
K	Value is affected by instrument calibration drift.
X	Value is erroneous and will not be used
<	Value is known to be less than the reported value
>	Value is known to be greater than the reported value
	Code assignable by system
F	Value was modified by automated filtering

The following rules govern the processing of unit values that have been assigned remarks codes:

1. Remarks codes are initially stored with the edited unit values.
2. Corrected unit values inherit all remarks codes from edited unit values except "X". Unit values assigned "X" are filtered out (not included in the set of corrected unit values).

3. Computed unit values inherit all remarks codes from corrected unit values.
4. Daily values computed from unit values that were assigned one or more “value is affected” codes are flagged “&.”

Display hierarchy of unit values flags and remarks codes

Unit values flags and remarks codes are displayed with the values on unit values tables and during editing. Up to three flags/codes can be displayed at once for a single value. If there are more than three flags, the additional flags are included at the bottom of the page with a note indicating that these flags have also been set. The display hierarchy of the codes/flags is shown in table 9.

Table 9: Display hierarchy of unit values flags and remarks codes

[Multiple codes on a line are mutually exclusive; larger internal priority level values have higher priority]

Code	Internal priority level	Short description [See tables 6 and 7 for details]
A,B,R,&,K,X,<,>,F	99	Remarks codes
T	7	Standard difference threshold flag
H,h,L,l	6	Magnitude threshold flags
D,d,I,i	5	Rate-of-change threshold flags
*	4	Processing status (edited) flag
~	3	Interpolated value flag
c,e,r,f,p,o,a,s	2	Data source flags
@	1	Processing status (reviewed) flag

3.10.3 Correcting Unit Values (DC_EDIT)

Edited unit values are corrected for systematic errors using program DC_EDIT and are stored as final corrected unit values. Also available as output is the set of data correction unit values. Systematic errors comprise situations such as datum changes, instrument drift, and instrument calibration. For example, input gage-height unit values may have to be corrected both for a datum change and for an error in the sensing instrument. Up to three separate corrections using various algorithms (Section 3.7) can be made and each of the corrections can be prorated over time. Time proration is automatically applied when multiple starting dates are present in the corrections data. Time proration is not applied during real-time data processing.

3.10.4 Computing Time-Series Data (PRIMARY)

Time-series computations are performed using corrected unit values as input to calculate other (second-parameter) unit values and (or) to compute daily values. The program is called PRIMARY and the outputs are called primary computations or primary reports.

Primary computation codes

Eleven types of time-series computations are produced by PRIMARY. Each type is denoted with a primary computation code and has its own primary report format. Three processing types (NONE, STGO, and TIDE) compute daily values only. The other types entail processing steps that compute additional unit values as well as daily values. The primary computation codes are listed in table 10, grouped by principal processing method (following section).

Table 10: Primary computation codes

Code	Description
	Single-parameter computations
NONE	Compute daily values only. Primarily used for ground water and water quality processing.
STGO	Compute stage daily values only.
TIDE	Compute tidal daily values only.
ELEV	Compute reservoir/lake surface-elevations.
DIFF	Compute difference between successive unit values for parameters other than rainfall.
RAIN	Compute difference between successive rainfall unit values. Negative differences are ignored (set to zero).
	Two-parameter computations
GENR	Compute second parameter from input parameter using a rating.
RCNT	Compute reservoir contents.
	Stage-discharge computation
STGQ	Compute discharge from stage.
	Slope-discharge/velocity-discharge computations
SLPQ	Compute discharge from stage and water-surface slope.
VELQ	Compute discharge from stage and index velocity.

Processing methods

There are four principal processing methods. Listed in order of increasing complexity, they are: single-parameter processing, two-parameter non-discharge processing, stage-discharge processing, and slope-discharge/velocity-discharge processing. Note that stage-discharge processing is a special variation of two-parameter data processing. The methods are outlined in the following sections. Many steps within each method, particularly those related to transferring and processing unit values, are the same.

Single-parameter processing

Single-parameter data processing entails processing and storing data in the units in which they are received by ADAPS. The measured unit values are edited using HYDRA and corrected using correction curves. Single-parameter processing is used for primary computations denoted by codes NONE, STGO, TIDE, ELEV, DIFF, and RAIN. A schematic of the processing steps is shown in figure 6.

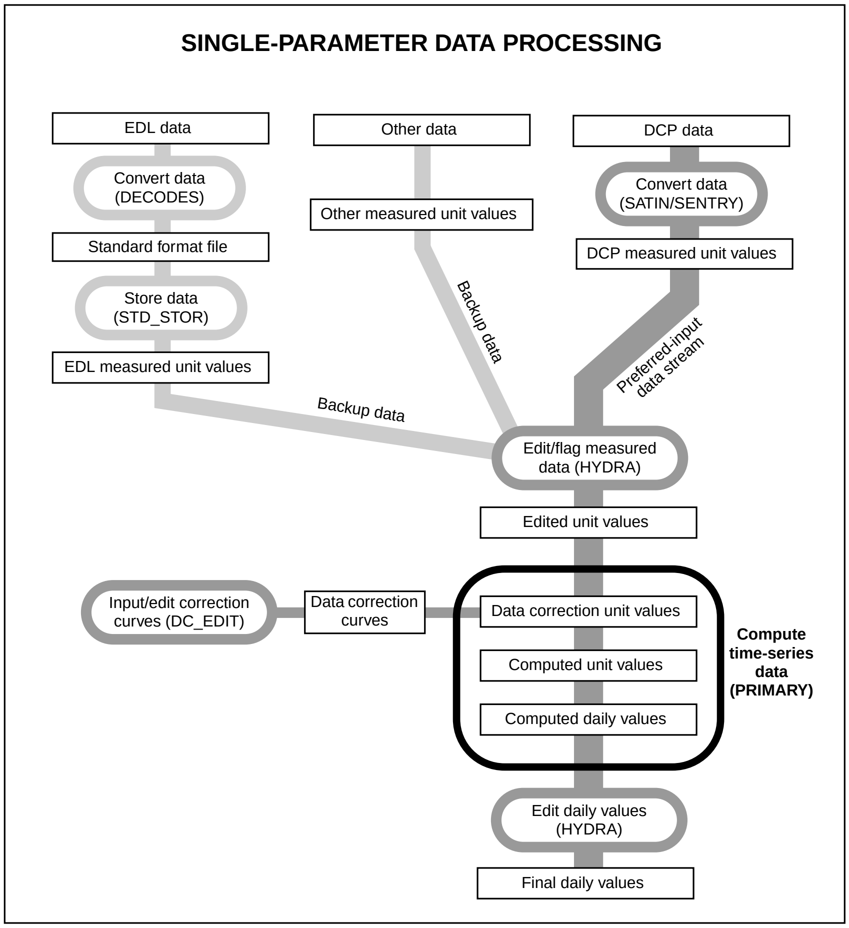


Figure 6. Schematic of processing steps for single-parameter data

Two-parameter processing (non-discharge)

Two-parameter non-discharge data processing entails computing a second parameter from the input parameter using rating curves. The input parameter is first processed as for single-parameter processing. Two-parameter processing is used for primary computations denoted by codes RCNT and GENR. A schematic of the processing steps is shown in figure 7.

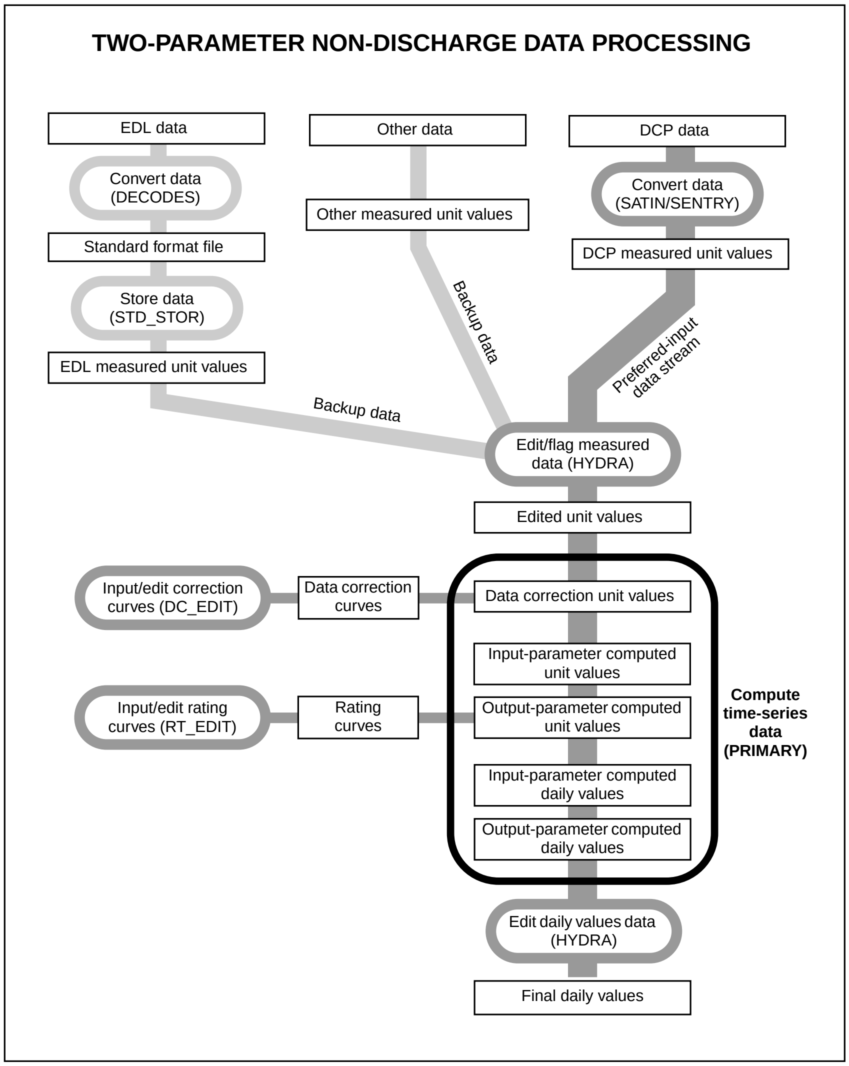


Figure 7. Schematic of processing steps for two-parameter non-discharge data

Stage-discharge processing

Stage-discharge data processing is a special type of two-parameter data processing. In addition to the steps for two-parameter processing, shifts can be applied to the stage values prior to computing discharge. The primary computations code for stage-discharge processing is STGQ. A schematic of the processing steps is shown in figure 8.

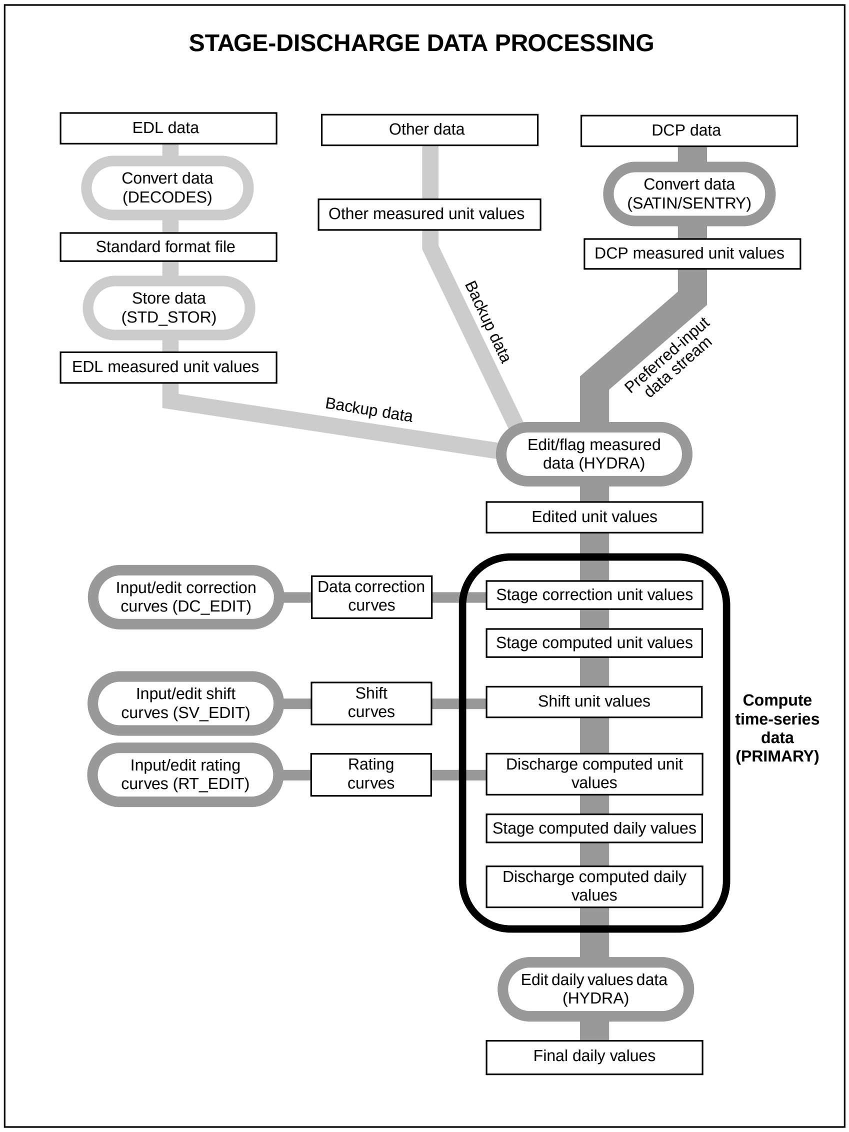


Figure 8. Schematic of processing steps for stage-discharge data

Slope-discharge/velocity-discharge processing

Slope-discharge and velocity-discharge data processing are the most complex types of processing in ADAPS. The output parameter, discharge, is computed from two input parameters, either the stages measured at two sites (one downstream of the other), or stage and velocity measured at the site. Shifts can be applied to the stage or velocity values. The primary computations code for slope-discharge processing is SLPQ; for velocity-discharge processing it is VELQ. A schematic of the processing steps is shown in figure 9.

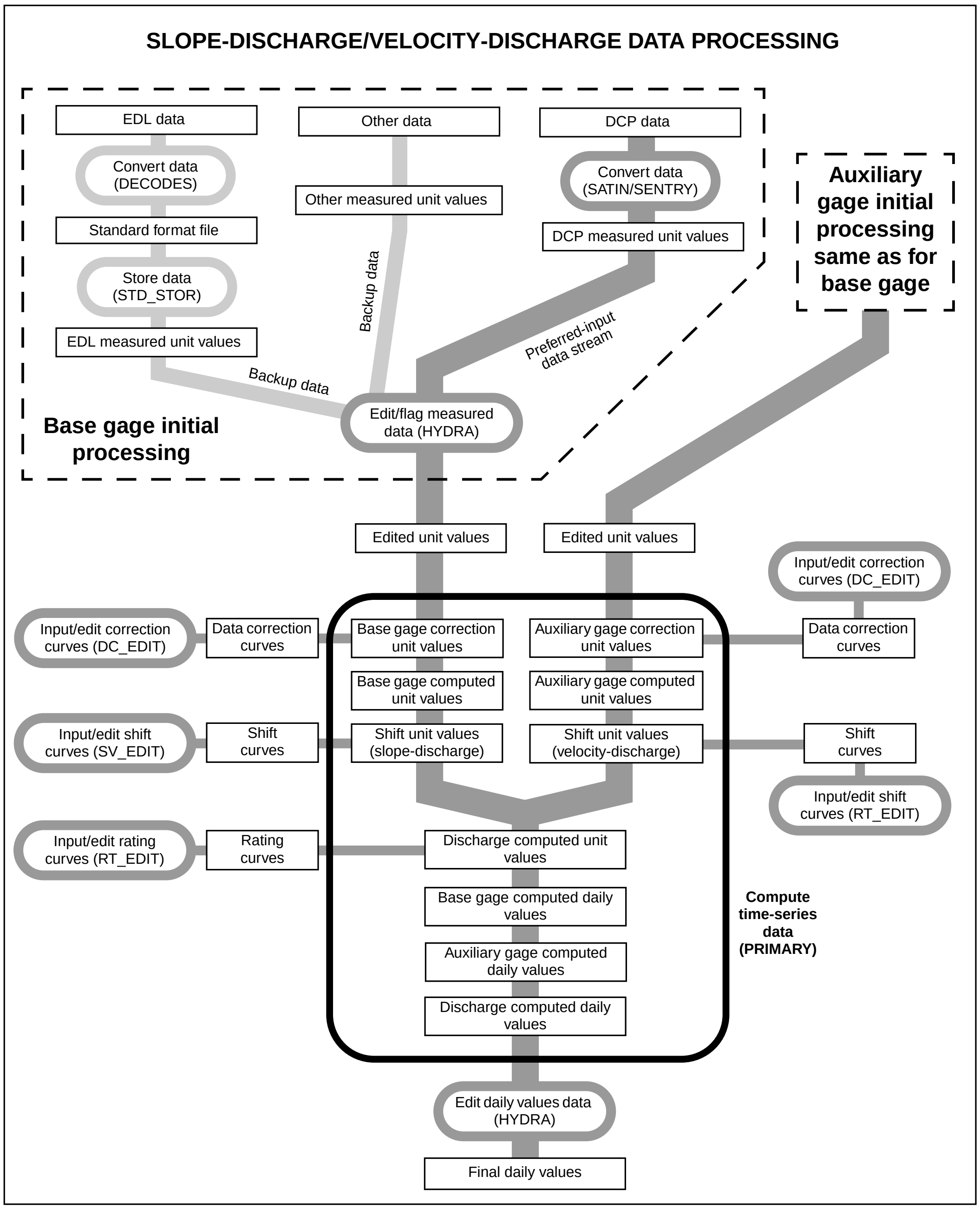


Figure 9. Schematic of processing steps for slope-discharge/velocity-discharge data

Primary computations

Each of the primary computation types listed in table 9 is described in the following paragraphs.

Compute daily values only (NONE)

PRIMARY computes only daily values from corrected unit values. It is used principally for processing water quality and ground water data. Output consists of computed daily values and a standard primary report.

Compute stage daily values only (STGO)

PRIMARY computes only stage daily values from corrected unit values. Output consists of computed daily values and a stage primary report.

Compute tide daily values only (TIDE)

PRIMARY computes special tide daily values. Output consists of high high-tide, low high-tide, high low-tide, and low low-tide daily values and a tide primary report.

Compute reservoir/lake surface elevations (ELEV)

PRIMARY computes water-surface elevations. If necessary, stage values are converted to elevations in the data correction processing step. Output consists of computed elevation unit values, computed daily values, and a water-surface-elevation primary report.

Compute accumulative differences (DIFF)

PRIMARY computes new unit values by calculating the difference between successive input unit values and computes daily values by accumulating the differences. Output consists of the difference unit values, the daily sum of the difference unit values, and a standard primary report.

Compute rainfall amounts (RAIN)

PRIMARY computes rainfall unit value amounts by calculating the difference between successive input unit values. It computes daily values by accumulating the differences. If specified in the computation instructions, the unit values are filtered for “noise,” that is, negative differences are set to zero. Output consists of the filtered unit value rainfall amounts, the daily sum of the amounts, and a rainfall primary report.

Compute second parameter using a rating (GENR)

PRIMARY computes generic output unit values from input unit values using a rating table or equation. This computation type is used for all two-parameter computations except reservoir contents and discharge. Output consists of computed unit values, computed daily values for both the input and output parameters, and a standard primary report.

Compute reservoir contents (RCNT)

PRIMARY computes reservoir contents unit values from elevation unit values using an elevation-contents rating, and it computes daily values of both elevations and contents. Output consists of computed contents unit values, computed elevation daily values, computed contents daily values, and a reservoir contents primary report.

Compute discharge from stage (STGQ)

PRIMARY computes discharge unit values from stage unit values using a rating table or equation. Shifts may be applied to the stage values prior to computing discharge to compensate for changes in the river environment. It computes daily values for both stage and discharge. Output consists of computed discharge unit values, stage daily values, discharge daily values, and a stage-discharge primary report.

Compute discharge from stage and water-surface slope (SLPQ)

PRIMARY computes discharge unit values from stages measured at two sites, one downstream of the other. One site is designated the base gage and the other site the auxiliary gage. Discharge is based on the stage at the base gage and the slope (fall) of the water surface between the two sites. The calculations require three ratings: the base discharge curve (rating type STGQ), the fall curve (FALL), and the discharge factor curve (FLFC). Shifts can be applied to the base gage height, but only to obtain a value from the base discharge curve. Shifts are not used when computing fall or when obtaining a value from the fall curve. Output consists of computed discharge unit values, base stage daily values, auxiliary gage daily values, discharge daily values, and a slope-discharge primary report.

Compute discharge from stage and index velocity (VELQ)

PRIMARY computes discharge unit values from the stage and index velocity measured at the site. The gage measuring index velocity is designated the base gage and the gage measuring stage the auxiliary gage. The discharge calculations are made using one of two methods. The first method uses up to three ratings: the index velocity versus mean velocity curve (rating type VELO), the stage versus cross-sectional-area curve for a standard cross section (STAR), and the stage velocity factor curve (STCO). The second method uses an equation that calculates mean velocity from the index velocity and stage. The equation is of the form

$$\bar{v} = C_x v + C_y vs + C_0$$

where $\bar{v}$ = mean velocity,
v = index velocity,
s = stage, and
C_x, C_y, C_0 = coefficients.

The coefficients are determined from a regression analysis of mean velocity, index velocity, and stage data. The equation replaces the VELO and STCO ratings. The type of calculation that is performed is specified in the processor record. When used, the equation coefficients also are stored in the processor record.

Shifts can be applied to the index velocity, but not to the gage height. Output consists of discharge unit values, stage daily values, mean velocity daily values, and a velocity-discharge primary report.

Daily values computations

Daily values are computed by all primary computations types. A daily value summarizes the unit values collected during the day into a single value according to the statistics code(s) assigned for computation. The daily interval is measured from midnight to midnight. Unit values from which daily values are computed must meet various relational criteria, depending on the data type.

Daily values primary computations statistics codes

The ADAPS statistics codes that can be processed during primary computations are listed in table 11. The statistic code 32400 denotes end-of-day midnight observations.

Table 11: Statistics codes processed by PRIMARY

Code	Name	Description
00001	Maximum	Maximum values
00002	Minimum	Minimum values
00003	Mean	Mean values
00006	Sum	Sum of values
00007	Mode	Modal values
00008	Median	Median values
00009	STD	Standard deviation values
00010	Variance	Variance values
00021	Tidal high	High high-tide values
00022	Tidal low-high	Low high-tide values
00023	Tidal high-low	High low-tide values
00024	Tidal low	Low low-tide values
3hhmm	Observation at hhmm	Instantaneous observation at time hhmm where hhmm runs from 0001 to 2400.

Daily values time interval

Daily values are computed using unit values collected between midnights local time. Both beginning and ending midnight values are used in the calculation of all statistics except sum (statistics code 00006), whereupon only the ending midnight value is used. Because both midnight values are used in the interval, it is possible (for example) that one day's maximum value is the next day's minimum value. Similarly, if a maximum value occurs at midnight the value can be the same maximum value for the two adjacent days.

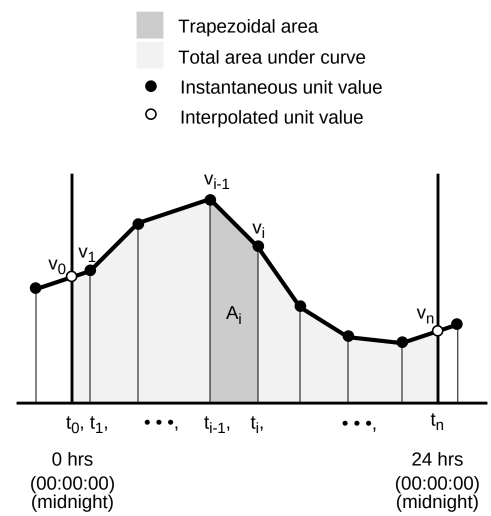
Daily values computations criteria

Daily values are computed only from unit values that meet these relational criteria: (1) the maximum difference between any two adjacent unit values is less than or equal to a preset threshold, and (2) the maximum time interval between any two adjacent unit values is less than a preset time interval. When a threshold is exceeded during daily values computations, a message describing the failed threshold is displayed in the primary report and a daily value is not computed for the day. The thresholds are established individually for each DD.

Daily mean values computations

Daily mean values are computed for parameters that have instantaneous unit values (statistics code 00011). They are computed using the trapezoidal method of approximate integration: the daily mean value is equal to the total area under the unit-values curve divided by 24 hours (or 1,440 minutes or 86,400 seconds). The total area is the sum of the trapezoidal areas defined by the unit values. A schematic of the trapezoidal method is shown in figure 10.

The instantaneous values can be irregularly spaced, that is, the time interval between values can be of varying lengths. If an instantaneous value is not measured at a day boundary (00:00:00, or midnight), a value is interpolated from the two values measured before and after midnight. The values and the time interval between the values from which the interpolated midnight values are computed must satisfy the criteria established for computing daily values.



Trapezoidal area: $A_i = \dfrac{(v_i + v_{i-1}) \cdot (t_i - t_{i-1})}{2}$, $i = 1, 2, ..., n$

Daily mean value: $\overline{DV} = \dfrac{1}{t_n} \cdot \sum_{i=1}^{n} A_i$

Figure 10. Schematic of computation of daily mean values. [v_0, value at midnight; v_i, i^{th} value after midnight; t_i, elapsed time since midnight of i^{th} value; n, number of trapezoids; t_0, starting time (= 0 hrs); t_n, ending time (= 24 hours).]

Daylight savings computations

Mean daily values are computed as follows on days when the time changes to ("spring forward") or from ("fall back") daylight savings time: On the spring forward day, the mean daily value is computed for a 23-hour day; on the fall back day, it is computed for a 25-hour day.

Partial-day computations

Mean daily values are computed for days that do not have a complete set of unit values, but the values are not stored in ADAPS. They are computed only for display in the primary report.

Daily values editing (HYDRA)

Computed daily values are edited using HYDRA. Just as for editing unit values, HYDRA has the capability of importing other data as reference curves, changing or deleting values, and flagging values. Daily values also can be estimated using the estimation routine MISTE.

Daily values that have been edited can be flagged and write-protected. Write-protected values are called final daily values. They can no longer be altered within ADAPS unless the write-protect flag is explicitly removed. The daily values remarks codes are listed in table 12.

Table 12: Daily values remarks codes

Code	Description
e	Value was edited or estimated by USGS personnel and is write protected
&	Value was computed from affected unit values
<	Value is known to be less than the reported value and is write protected
>	Value is known to be greater than the reported value and is write protected
1	Value is write protected without any remark code to be printed
(blank)	No remark

3.10.5 Preparing Final Records

The following paragraphs describe procedures that are done after the unit and daily values have been processed.

Summary statistics computation

Summary statistics are computed and stored as separate data in ADAPS. The procedure to compute and store them is initiated manually.

Peak above base computations

Unit values for a particular DD may be analyzed for peaks occurring above a threshold value. This computation is generally performed on discharge data, but it can be used for other parameters.

Peak flow file

Annual peak discharges are stored manually in the peak flow file.

Station analysis

A preliminary station analysis report may be generated to list for a year all of the data corrections, ratings, and shifts with comments that were used, the periods of missing daily values, and the periods of estimated daily values. The procedure is initiated manually.

3.10.6 Approving Data

Data that have been processed must be officially approved. The initial status of all data is "Working." After they have been processed, the status is changed to "In-Review," and after they are reviewed, to "Approved." Only persons with ADBA or SYST access (table 1) can change the data status level to "Approved." If data marked "Approved" must be subsequently re-edited, the status must be changed back to "Working." Only persons with SYST access can change the status of "Approved" data back to "Working." The section on data aging (Section 3.8) describes the three status levels of data in ADAPS.

3.10.7 Publishing State Annual Water-Data Reports

Water data are published annually in State water-data reports. Each District is responsible for publishing the data collected within its jurisdiction. The reports are produced using guidelines recommended by the U.S. Geological Survey and guidelines specific to the needs of each State. Generally the data that are published include for each site: site information (location, drainage area, period of record, and other facts), a daily values table for each data type, and current-year and period-of-record statistics about the unit and daily values for each data type as appropriate. Some States also include hydrographs. Most States use the daily values tables in the format produced by ADAPS.