

Appendix B

HEC-RAS Import/Export Files for Geospatial Data

At version 2.0, HEC-RAS has introduced three-dimensional (3D) geometry for the description of river networks and cross-sections. This capability makes it possible to import channel geometry from CADD or GIS programs without conversion from real-world coordinates to station-elevation descriptions for the cross sections, as HEC-2 required. Similarly, water-surface elevations calculated at cross sections can be exported to CADD or GIS programs, where they can be used to create model water surfaces for inundation mapping.

Supported HEC-RAS Data Exchange

Using a formatted ASCII text file, HEC-RAS will import a basic description of the channel geometry including:

- The structure of the stream network, as represented by interconnected reaches.
- The location and description of cross sections.
- Manning's n values for each cross section.
- Levee alignment information for each cross section.
- Ineffective flow area locations for each cross section.
- Storage area information for each cross section.

Using the same file format, HEC-RAS can write a file exporting the results of a hydraulic model run to a CADD or GIS program. At a minimum, reported results include the locations of cross sections and the calculated water-surface elevations at those cross sections.

The Import/Export Data File Structure

This section gives general rules for the construction of an HEC-RAS geometric data import or export file. It is not necessary to understand all these rules to build an import file, but they may be useful when debugging failed imports. The rules given here are a portion of the definition of a general-purpose geometric data exchange format being developed at HEC for its NexGen model programs. **Note: These file formats are evolving,**

in that additional data types will be added, and some of the existing ones may be modified for future versions. If you are writing software to read and write these file formats, please keep in mind that you may need to modify your software to stay compatible with future versions of HEC-RAS.

Records and Keywords

The HEC-RAS geometric data import file is composed of records, which in turn are composed of keywords and values. All records must contain one keyword, and all keywords end with a colon (:). A record can also contain a value or a set of values following the keyword, i.e., after the colon. Spaces, tabs, or line ends can be placed between a keyword and values within a record.

A record that contains a keyword and no value marks the beginning or the end of a group of related records (for example, the record "BEGIN HEADER:" marks the beginning of the header section of a data file). A record that contains a keyword and a value assigns that value to the part of the model named by the keyword.

When a keyword is read, all spaces up to the colon are removed and all letters are capitalized. The keywords "Begin Header:", "Begin header:", and "Be GiNH eadEr:" are all equivalent to "BEGINHEADER:". For readability, keywords named in this manual will contain internal spaces.

Values

A record can assign a single value to a single variable, or multiple values to an array. Values can be integers, floating point numbers, text strings, or locations (X,Y,Z, label). A single value in an array of values is called an "element" of that array.

A **numerical value (integer or floating point)** cannot contain internal blanks. A floating point number can contain a decimal point; an integer cannot. Elements in an array of numerical values can be separated by commas, blanks, tabs, or line ends.

A **text string** can contain internal blanks, tabs, and commas, but cannot contain internal line ends. Elements in an array of text strings must be separated by line ends.

A **location** consists of three coordinate values and a label (X, Y, Z, label). The first two coordinates are planar, the third gives elevation. The coordinate values are floating point numbers, and the label can be any type of value (although the label can be restricted to a particular data type

in a particular context). In certain contexts, the elevation value or the label may not be required. If a label is used, all three coordinate values must be given; the value "NULL" is valid for the elevation coordinate only. The coordinate values and the label can be separated by commas, blanks, or tabs, but a location cannot contain internal line ends. Elements in an array of locations must be separated by line ends.

Data Groups

Records in the data file can be collected in two types of groups: objects and file sections. An object is a group of records that combine to describe an entity within the model, a cross-section for example. A file section is a logical or functional grouping of data, the file header, for example, is a section that contains a description of the whole file.

Objects and file sections begin and end with records that contain keywords, but no values. A file section starts with a record containing a keyword composed of the word "BEGIN" followed by the section name and a colon, and ends with a keyword composed of the word "END" followed by the section name and a colon. For example, records containing only the keywords "BEGIN HEADER:" and "END HEADER:" are used to start and end the header section of a file. An object starts with a record containing a keyword naming the object type and ends with a record containing the keyword "END:" only. For example, a cross-section object begins and ends with records containing the keywords "CROSS-SECTION:" and "END:" only.

Comments

Hash characters (#) are used to identify comments. When a hash character is encountered in the file, all data from the hash to the next line end are ignored. A line that begins with a hash is equivalent to a blank line.

HEC-RAS Channel Geometry Import File

HEC-RAS reads channel geometry from a text file composed of three data sections:

1. A header containing descriptions that apply to all data in the file.
2. A description of the stream network identifying reach locations and connectivity.
3. A description of the model cross-sections containing their location on the stream network and data required to support the HEC-RAS model.

An example HEC-RAS Channel Geometry Import file and HEC-RAS

model results export file is shown at the end of this appendix.

Header

The header is bounded by the records "BEGIN HEADER:" and "END HEADER:" and must contain a record to identify the units system used in the imported data set. The units system can be ENGLISH or METRIC.

BEGIN HEADER:

UNITS: ENGLISH END HEADER:

Records that may be included in the header are listed in the Table B.1:

Table B.1

Keyword	Value Type	Value
UNITS:	string	ENGLISH or METRIC
PROFILES:	string array	List of profiles exported from HEC-RAS. Not used on import.
DTM TYPE:	string	type (e.g., TIN or raster)
DTM:	string	name of digital terrain model
STREAM LAYER:	string	name of stream layer in CADD or GIS
NUMBER OF REACHES	integer	number of hydraulic reaches contained in the file.
CROSS-SECTION LAYER:	string	name of cross-section layer in CADD or GIS
NUMBER OF CROSS-SECTIONS:	integer	number of cross sections in the file
MAP PROJECTION:	string	projection (coordinate) system used (e.g., STATEPLANE)
PROJECTION ZONE:	string	projection zone (if applicable, e.g., 5101)
DATUM:	string	reference datum for planar coordinates
VERTICAL DATUM:	string	reference datum for vertical coordinates

Stream Network

The stream network section is bounded by the records "BEGIN STREAM NETWORK:" and "END STREAM NETWORK:" and contains records describing reaches and reach endpoints. At a minimum, the stream network section must contain at least two endpoints and one reach. The minimum requirements for a stream network are shown below.

```
BEGIN STREAM NETWORK:
  ENDPOINT:  476132.66, 65291.86, 155.28, 1
  ENDPOINT:  478144.53, 64296.61, 123.72, 2

  REACH:
    STREAM ID: Below Springfield
    REACH ID: Blue River
    FROM POINT: 1
    TO POINT: 2
    CENTERLINE:
      476132.66, 65291.86, 155.28, 23.13
      476196.08, 65196.61, 154.47, 23.09
      lines omitted
      478144.53, 64296.61, 123.72, 22.41
  END:
END STREAM NETWORK:
```

A reach endpoint is represented by a record containing the keyword "ENDPOINT:" followed by four comma-delimited fields containing the endpoints X,Y,Z coordinates and an integer ID.

A reach is represented by a multi-record object that begins with a record containing only the keyword "REACH:" and ends with a record containing only the keyword "END:". At a minimum, a reach object must contain records setting values for a stream ID, a reach ID, a FROM point, and a TO point. A reach's FROM and TO point IDs must match IDs for endpoints listed before the reach object in the file. The reach object must also contain an array of locations defining the stream centerline. This array begins with a record containing only the keyword "CENTERLINE:" and ends when any keyword is encountered. A location element in the array contains the X, Y, and Z coordinates of a point on the stream centerline, and the point's river station. In HEC-RAS, elevation and stationing are optional in the stream network definition. If a location element includes a station value, it must occupy the fourth field in the element. If the elevation is not known, the word "null" must take its place.

Station values are assumed to be in miles for data sets in English units, and in kilometers for data sets in metric units. Stationing is used for indexing locations along reaches, and is not used to precisely locate objects in the model.

Records that may be included in a stream network section are listed in Table B.2:

Table B.2

Keyword	Value Type	Value
ENDPOINT:	location	coordinates and integer ID
REACH:	none	marks beginning of reach object
END:	none	marks end of reach object
The following records are required for a reach object.		
STREAM ID:	string	identifies reach's membership in stream
REACH ID:	string	unique ID for reach within stream
FROM POINT:	string	integer reference to upstream endpoint
TO POINT:	string	integer reference to downstream endpoint
CENTERLINE:	location array	array elements contain coordinates and (optionally) floating point station value.

Cross Sections

The cross-sectional file section begins with a record containing the only the keyword "BEGIN CROSS-SECTIONS:" and ends with a record containing the only the keyword "END CROSS-SECTIONS:." A cross section is represented by multi-record object beginning with a record containing only the keyword "CROSS-SECTION:" and ending with a record containing only the keyword "END:."

A cross-sectional object must include records identifying the stream, reach, and station value of the cross-section, a 2D cut line, and a series of 3D locations on the cross section. A cut line is composed of the label "CUT LINE:" followed by an array of 2D locations. A cross-sectional polyline consists of the label "SURFACE LINE:" plus 3D coordinates written as comma-delimited X,Y, Z real-number triples, one triple to a line.

Records that may be included in the cross-section file section are listed in Table B.3:

Table B.3

Keyword	Value Type	Value
CROSS-SECTION:	none	marks beginning of cross-section object
END:	none	marks end of cross-section object
The following records are required for a cross-section object.		
STREAM ID:	string	identifiers for stream and reach where cross-section is located (must refer to existing streams and reaches in the model)
REACH ID:	string	
STATION:	floating point	relative position of cross-section on stream
CUT LINE:	location array	array elements contain 2D coordinates of cross section stike line
SURFACE LINE:	location array	array elements contain 3D coordinates of cross section points
The following records are optional for a cross-section object.		
BANK POSITIONS:	floating point (2 elements)	Fraction of length along cut line where main channel bank stations are located. (values 0.0 - 1.0)
REACH LENGTHS:	floating point (3 elements)	Distance along left overbank, center channel, and right overbank flow paths to next cross-section downstream (units are feet or meters).
NVALUES:	floating point (n paired elements)	Manning's n values expressed as fraction along cut line to start of n-value (<i>fraction, n-value</i>).

Keyword	Value Type	Value
LEVEE POSITIONS:	mixed array elements	Levee positions expressed as a unique ID, fraction along the cut line and levee elevation (<i>Levee_ID, fraction, elevation</i>)
LEVEE ID:	integer	Unique integer value identifying a levee
INEFFECTIVE POSITIONS:	floating point (paired element arrays)	Ineffective flow area information along the cut line is specified by a unique ID, beginning and ending fraction along the cut line, and elevation (<i>Ineffective_ID, BeginPct, EndPct, Elevation</i>)
INEFFECTIVE ID:	integer	Unique integer value identifying ineffective flow area.
SA ID:	integer	Unique integer value identifying a storage area.
POLYGON:	floating point (n paired elements)	Location of ineffective flow areas or storage areas used for plotting.
ELEVATION-VOLUME:	floating point (n paired elements)	Elevation-volume information for a storage area (<i>elevation, volume</i>).
TERRAIN:	floating point (n x,y,z elements)	Elevation data describing the land surface at a storage area (<i>X,Y,Z</i>).
WATER ELEVATION:	floating point array	Water surface elevation values. Used for export of model results. Not read on import.

HEC-RAS Model Results Export File

HEC-RAS exports model results to a text file using the same format as the data import file. The contents of the files, however, are not identical. The stream network section is not required for data export, and the surface line may be omitted from the cross-section objects. An example HEC-RAS model export file is shown at the end of this discussion. Model results are reported with the following elements (Table B.4), which are not required (and are not read) in the import file.

Table B.4

Keyword	Value Type	Value
The following record is optional in the Header section of the export file.		
PROFILE NAMES:	string array	name(s) of water surface profiles reported in the file. This record is required if more than one profile is reported.
The following record is required for each cross-section object.		
WATER ELEVATIONS:	floating point array	Elevation of water surface at the cross-section. The array must contain one value for each profile.
The following records are optional for a cross-section object.		
PROFILE ID:	string	Water surface profile name. This must match a name in the Profile Names record in the header.
VELOCITIES:	floating point (pair)	Fraction along cut line and value of velocity (<i>fraction, value</i>). <i>Velocities record must follow Profile ID record.</i>
The following records make up a section defining a bounding polygon of the water surface limits.		
BEGIN BOUNDARIES:	none	Marks start of boundaries file section.
END BOUNDARIES:	none	Marks end of boundaries file section.
PROFILE LIMITS:	none	Marks start of an object defining the limits of a single water surface profile.
PROFILE ID:	string	Name of profile. This must match a name in the Profile Names record in the header.
POLYGON	location array	A series of 2D locations marking the limits of a water surface. A single profile limit can be merged from multiple polygons.

1. HEC-RAS allows the user 16 character profile names. However, **profile names can contain up to 9 characters for HEC-GeoRAS ArcView Extension Version 3.0 or 11 characters for HEC-GeoRAS for ArcInfo.** They must begin with a letter.
2. If no profile name is provided, only one water elevation will be written for each cross section.

Water Surface Bounding Polygon

In addition to a water surface elevation at each cross section (one for each profile), the HEC-RAS program sends a bounding polygon for each hydraulic reach in the model (the program outputs a new set of bounding polygons for each profile computed). The bounding polygon is used as an additional tool in assisting the GIS (or CADD) software to figure out the boundary of the water surface on top of the terrain.

In most cases, the bounding polygon will represent the outer limits of the cross section data, and the actual intersection of the water surface with the terrain will be inside of the polygon. In this case, the GIS software will use the water surface elevations at each cross section and create a surface that extends out to the edges of the bounding polygon. That surface is then intersected with the terrain data, and the actual water limits are found as the location where the water depth is zero.

However, in some cases, the bounding polygon may not represent the extents of the cross-section data. For example, if there are levees represented in the HEC-RAS model, which limit the flow of water, then the bounding polygon will only extend out to the levees at each cross section. By doing this, when the information is sent to the GIS, the bounding polygon will prevent the GIS system from allowing water to show up on both sides of the levees.

In addition to levees, the bounding polygon is also used at hydraulic structures such as bridges, culverts, weirs, and spillways. For example, if all of the flow is going under a bridge, the bounding polygon is brought into the edges of the bridge opening along the road embankment on the upstream side, and then back out to the extent of the cross-section data on the downstream side. By doing this, the GIS will be able to show the contraction and expansion of the flow through the hydraulic structures, even if the hydraulic structures are not geometrically represented in the GIS.

Another application of the bounding polygon is in FEMA floodway studies. When a floodway study is done, the first profile represents the existing conditions of the flood plain. The second and subsequent profiles are run by encroaching on the floodplain until some target increase in water surface elevation is met. When the encroached profile is sent to the GIS, the bounding polygon is set to the limits of the encroachment for each cross section. This will allow the GIS to display the encroached water surface (floodway) over the terrain, even though the water surface does not intersect the ground.

Import/Export Guidelines

The following rules apply to channel and cross-section import/export data.

Defining The Stream Network

1. The stream network is represented by a set of interconnected reaches. A stream is a set of one or more connected reaches that share a common stream ID.
2. A stream is composed of one or more reaches with the same stream ID, and each reach in a stream must have a unique reach ID. Every reach must be identified by a unique combination of stream and reach IDs.
3. Stream IDs and Reach IDs are alphanumeric strings up to 16 characters long. Reach endpoint IDs are integers.
4. Streams cannot contain parallel flow paths. (If three reaches connect at a node, only two can have the same stream ID.) This prevents ambiguity in stationing along a stream.
5. A reach is represented by an ordered series of 3D coordinates, and identified by a stream ID, a reach ID, and IDs for its endpoints.
6. A reach endpoint is represented by its 3D coordinates and identified by an integer ID.
7. Reaches are not allowed to cross, but can be connected at their endpoints (junctions) to form a network.
8. The normal direction of flow on a reach is indicated by the order of its endpoints. One point marks the upstream or "from" end of the reach, the other marks the downstream or "to" end of the reach.

Defining Cross Sections

1. Each cross section is defined by a series of 3D coordinates, and identified by a stream name and reach name (which must refer to an existing stream and reach) and a station, indicating the distance from the cross-section to the downstream end of the stream.
2. Careful attention must be given to cross-sectional stationing.
3. A cross-section line can cross a reach line exactly once, and cannot

cross another cross-section line.

Results of a water surface calculation are exported in a file that contains cross-section locations in plane (2D) coordinates, water-surface elevations for the cross-sections, and boundary polygons for the reaches.

The Following Rules Apply to Water-Surface Export Data

1. A cross-section is represented by a water surface elevation and a series of 2D coordinates on the cross-section cut line. The full width of the cross-section is included.
2. One bounding polygon is created for each reach in the stream network, and for each profile.
3. A reach's bounding polygon is made up of the most upstream cross-section on the reach, the endpoints of all cross-sections on the reach, and the most upstream cross-sections of reaches downstream of the reach.
4. For purposes of defining bounding polygons *only*, the endpoints of a cross-section are adjusted to the edge of the water surface at the cross-section if the cross-section is part of a floodway, a leveed section of the reach, or the water extent is controlled by a hydraulic structure. This allows calculated water surfaces that are higher than the land surface to be reported back to the CADD or GIS program.

Sample HEC-RAS Geometry Import File

```
# RAS input file created on Thu Nov 18 13:12:37 1999
# by ArcView extension HEC-GeoRAS
```

```
BEGIN HEADER:
```

```
DTM TYPE: TIN
DTM: d:\georas\wailupe\wai_tin
STREAM LAYER: d:\georas\wailupe\stream3d.shp
NUMBER OF REACHES: 3
CROSS-SECTION LAYER: d:\georas\wailupe\xscutlines3d.shp
NUMBER OF CROSS-SECTIONS: 40
MAP PROJECTION: STATEPLANE
PROJECTION ZONE: 5103
DATUM: NAD27
UNITS: ENGLISH
```

```
END HEADER:
```

```
BEGIN STREAM NETWORK:
```

```
ENDPOINT: 582090.487, 49258.898, 218.609, 1
ENDPOINT: 582331.707, 47063.536, 114.164, 2
ENDPOINT: 583735.405, 47715.344, 278.222, 3
ENDPOINT: 584138.295, 41249.225, 1.140, 4
```

```
REACH:
```

```
STREAM ID: Wailupe
REACH ID: Upper
FROM POINT: 1
TO POINT: 2
CENTERLINE:
  582090.487, 49258.898, 218.609, 8640.151
  many lines omitted
  582331.707, 47063.536, 114.164, 6402.057
```

```
END:
```

```
REACH:
```

```
STREAM ID: Kulai Gorge
REACH ID: Tributary
FROM POINT: 3
TO POINT: 2
CENTERLINE:
  583735.405, 47715.344, 278.222, 1813.116
  many lines omitted
  582331.707, 47063.536, 114.164, -0.000
```

```
END:
```

```
REACH:
```

```
STREAM ID: Wailupe
REACH ID: Lower
FROM POINT: 2
TO POINT: 4
```

```
CENTERLINE:
  582331.707, 47063.536, 114.164, 6402.057
  many lines omitted
  584138.295, 41249.225, 1.140, 0.000
END:
```

END STREAM NETWORK:

BEGIN CROSS-SECTIONS:

```
CROSS-SECTION:
  STREAM ID: Wailupe
  REACH ID: Lower
  STATION: 220.827
  BANK POSITIONS: 0.503, 0.515
  REACH LENGTHS: 87.418, 220.827, 159.365
  NVALUES:
    0.000, 0.150
    0.501, 0.035
    0.532, 0.150
  LEVEE POSITIONS:
    1, 0.312, 6.234
  INEFFECTIVE POSITIONS:
    1, 0.000, 0.478, 5.789
  CUT LINE:
    586214.122, 42127.918
    581980.991, 40806.059
  SURFACE LINE:
    586214.122, 42127.918, 4.007
    many lines omitted
    581980.991, 40806.059, 6.390
END:
```

```
CROSS-SECTION:
  STREAM ID: Wailupe
  REACH ID: Lower
  STATION: 346.249
  BANK POSITIONS: 0.506, 0.518
  REACH LENGTHS: 128.209, 125.422, 199.366
  NVALUES:
    0.000, 0.066
    0.021, 0.150
    0.503, 0.035
    0.532, 0.150
  LEVEE POSITIONS:
    1, 0.345, 7.123
  INEFFECTIVE POSITIONS:
    1, 0.000, 0.412, 5.987
  CUT LINE:
    586190.939, 42248.509
    583923.687, 41543.517
    581883.624, 41116.812

  SURFACE LINE:
    586190.939, 42248.509, 13.293
```

many lines omitted
581883.624, 41116.812, 7.145
END:

many cross sections omitted

CROSS-SECTION:
STREAM ID: Wailupe
REACH ID: Lower
STATION: 6269.258
BANK POSITIONS: 0.524, 0.569
REACH LENGTHS: 170.100, 164.521, 158.965
NVALUES:
0.00, 0.066
0.19, 0.150
0.47, 0.035
0.56, 0.150
0.94, 0.066
CUT LINE:
582723.174, 46846.449
582426.438, 46878.916
581953.514, 47082.992
SURFACE LINE:
582723.174, 46846.449, 161.917
many lines omitted
581953.514, 47082.992, 165.010
END:

CROSS-SECTION:
STREAM ID: Wailupe
REACH ID: Upper
STATION: 6822.378
BANK POSITIONS: 0.492, 0.555
REACH LENGTHS: 142.689, 139.905, 126.201
NVALUES:
0.00, 0.066
0.27, 0.150
CUT LINE:
582774.257, 47502.740
582593.433, 47493.464
582343.062, 47465.635
582083.418, 47502.740
SURFACE LINE:
582774.257, 47502.740, 170.548
many lines omitted
582083.418, 47502.740, 164.059
END:

many cross sections omitted

CROSS-SECTION:
STREAM ID: Wailupe
REACH ID: Upper
STATION: 6682.474
BANK POSITIONS: 0.380, 0.472
REACH LENGTHS: 454.362, 413.216, 375.704

NVALUES:
0.00, 0.150
CUT LINE:
582641.922, 47366.533
582444.447, 47335.449
582336.567, 47337.277
582062.296, 47381.161
SURFACE LINE:
582641.922, 47366.533, 149.810
many lines omitted
582062.296, 47381.161, 160.799
END:

CROSS-SECTION:
STREAM ID: Kulai Gorge
REACH ID: Tributary
STATION: 1089.584
BANK POSITIONS: 0.373, 0.579
REACH LENGTHS: 263.179, 255.877, 223.864
NVALUES:
0.00, 0.150
0.48, 0.055
0.59, 0.150
0.70, 0.066
CUT LINE:
583337.968, 47187.952
583207.930, 47327.062
583153.496, 47381.496
583126.279, 47608.306
SURFACE LINE:
583337.968, 47187.952, 257.736
many lines omitted
583126.279, 47608.306, 326.921
END:

CROSS-SECTION:
STREAM ID: Kulai Gorge
REACH ID: Tributary
STATION: 273.138
BANK POSITIONS: 0.541, 0.655
REACH LENGTHS: 139.815, 273.138, 79.293
NVALUES:
0.00, 0.150
0.37, 0.055
0.62, 0.035
0.64, 0.150
CUT LINE:
582546.842, 47088.605
582555.984, 47189.171
582550.499, 47240.368
582552.327, 47295.223
SURFACE LINE:
582546.842, 47088.605, 145.787
many lines omitted
582552.327, 47295.223, 144.778
END:

END CROSS-SECTIONS:

BEGIN LEVEES:

LEVEE ID: 1
SURFACE LINE:
584579.800, 41808.166, 7.222
many lines omitted
584631.334, 41572.921, 5.922
END:

END LEVEES:

BEGIN INEFFECTIVE AREAS:

INEFFECTIVE ID: 1
POLYGON:
584422.114, 41883.166
584452.132, 41787.626
many lines omitted
584552.852, 41577.321
END:

END INEFFECTIVE AREAS:

BEGIN STORAGE AREAS:

SA ID: 1
POLYGON:
581919.014, 43565.358
many lines omitted
581895.224, 43443.864
END:

ELEVATION-VOLUME:
20.000, 0
22.000, 675000
many lines omitted
30.000, 421300
END:

TERRAIN:
581898.124, 43566.478, 33.442
582361.222, 43216.332, 20.369
many lines omitted
581867.484, 43432.612, 33.356
END:

END STORAGE AREAS:

Sample HEC-RAS Geographic Data Export File

```
BEGIN HEADER:
  UNITS: ENGLISH
  DTM TYPE: TIN
  DTM: d:\georas\wailupe\wai_tin
  STREAM LAYER: d:\georas\wailupe\stream3d.shp
  CROSS-SECTION LAYER: d:\georas\wailupe\xscutlines3d.shp
  MAP PROJECTION: STATEPLANE
  PROJECTION ZONE: 5103
  DATUM: NAD27
  VERTICAL DATUM:
  NUMBER OF PROFILES: 3
  PROFILE NAMES:
    Big
    Bigger
    Biggest
  NUMBER OF REACHES: 3
  NUMBER OF CROSS-SECTIONS: 103
END HEADER:
```

```
BEGIN STREAM NETWORK:
```

```
ENDPOINT: 582090.487, 49258.898, 218.609, 1
ENDPOINT: 582331.707, 47063.536, 114.164, 2
ENDPOINT: 583735.405, 47715.344, 278.222, 3
ENDPOINT: 584138.295, 41249.225, 1.140, 4
```

```
REACH:
```

```
  STREAM ID: Wailupe
  REACH ID: Upper
  FROM POINT: 1
  TO POINT: 2
  CENTERLINE:
    582090.487, 49258.898, 218.609, 8640.151
    many lines omitted
    582331.707, 47063.536, 114.164, 6402.057
```

```
END:
```

```
REACH:
```

```
  STREAM ID: Kulai Gorge
  REACH ID: Tributary
  FROM POINT: 3
  TO POINT: 2
  CENTERLINE:
    583735.405, 47715.344, 278.222, 1813.116
    many lines omitted
    582331.707, 47063.536, 114.164, -0.000
```

```
END:
```

```
REACH:
```

```
  STREAM ID: Wailupe
  REACH ID: Lower
  FROM POINT: 2
```

```

TO POINT: 4
CENTERLINE:
  582331.707, 47063.536, 114.164, 6402.057
  many lines omitted
  584138.295, 41249.225, 1.140, 0.000
END:

END STREAM NETWORK:

BEGIN CROSS-SECTIONS:

CROSS-SECTION:
  STREAM ID: Wailupe
  REACH ID: Upper
  STATION: 8032.371
  CUT LINE:
    582496.067, 48736.476
    582190.057, 48657.628
    581893.321, 48625.161
  BANK POSITIONS: 0.42600, 0.47700
  WATER ELEVATION: 199.3957, 200.6774, 203.5746
  WATER SURFACE EXTENTS:
    582242.56, 48671.16, 582212.81, 48663.49
    582246.10, 48672.07, 582209.73, 48662.70
    582262.79, 48676.37, 582197.27, 48659.49
  PROFILE ID:Big
    VELOCITIES:
      0.43251, 5.29
      0.44147, 11.31
      0.45140, 11.48
      0.46148, 10.50
      0.46968, 4.35
  PROFILE ID:Bigger
    VELOCITIES:
      0.42484, 1.25
      0.43231, 5.93
      0.44145, 12.24
      0.45141, 12.40
      0.46151, 11.44
      0.47008, 4.88
      0.47839, 1.21
  PROFILE ID:Biggest
    VELOCITIES:
      0.41496, 3.61
      0.43201, 6.82
      0.44142, 13.32
      0.45143, 13.44
      0.46155, 12.59
      0.47070, 6.09
      0.48537, 3.64

END:

```

many cross sections omitted

CROSS-SECTION:

STREAM ID: Wailupe

REACH ID: Upper

STATION: 6682.474

CUT LINE:

582641.922, 47366.533

582444.447, 47335.449

582336.567, 47337.277

582062.296, 47381.161

BANK POSITIONS:0.38000, 0.47199

WATER ELEVATION: 133.7104, 135.6018, 139.3349

WATER SURFACE EXTENTS:

582417.69, 47335.90, 582377.28, 47336.59

582419.39, 47335.87, 582375.14, 47336.62

582437.89, 47335.56, 582370.92, 47336.69

PROFILE ID:Big

VELOCITIES:

0.39480, 4.79

0.40794, 10.33

0.42583, 11.09

0.44240, 7.20

0.45444, 1.62

PROFILE ID:Bigger

VELOCITIES:

0.39368, 4.71

0.40788, 10.07

0.42586, 10.67

0.44287, 7.40

0.45565, 2.49

PROFILE ID:Biggest

VELOCITIES:

0.36681, 2.52

0.39108, 5.05

0.40781, 10.10

0.42589, 10.52

0.44336, 7.84

0.45805, 3.38

END:

CROSS-SECTION:

STREAM ID: Kulai Gorge

REACH ID: Tributary

STATION: 1089.584

CUT LINE:

583337.968, 47187.952

583207.93, 47327.062

583153.496, 47381.496

583126.279, 47608.306

BANK POSITIONS: 0.37300, 0.57900

WATER ELEVATION: 219.1924, 220.2025, 221.5454

WATER SURFACE EXTENTS:

```

583192.52, 47342.48, 583177.65, 47357.34
583193.66, 47341.33, 583176.64, 47358.36
583195.18, 47339.81, 583175.29, 47359.70
PROFILE ID: Big
  VELOCITIES:
    0.44533, 10.34
    0.46033, 8.44
PROFILE ID: Bigger
  VELOCITIES:
    0.44432, 11.33
    0.46129, 9.32
PROFILE ID: Biggest
  VELOCITIES:
    0.44296, 12.44
    0.46257, 10.34

```

END:

many cross sections omitted

CROSS-SECTION:

```

STREAM ID: Kulai Gorge
REACH ID: Tributary
STATION: 273.138
CUT LINE:
  582546.842, 47088.605
  582555.984, 47189.171
  582550.499, 47240.368
  582552.327, 47295.223
BANK POSITIONS: 0.54099, 0.65500
WATER ELEVATION: 135.2666, 136.3284, 137.8818
WATER SURFACE EXTENTS:
  582554.32, 47204.74, 582552.81, 47218.77
  582554.37, 47204.24, 582552.76, 47219.30
  582554.45, 47203.51, 582552.67, 47220.11
PROFILE ID: Big
  VELOCITIES:
    0.56337, 1.54
    0.57644, 10.95
    0.59787, 15.34
    0.61730, 13.10
PROFILE ID: Bigger
  VELOCITIES:
    0.56256, 2.97
    0.57620, 12.59
    0.59789, 17.18
    0.61875, 14.67
    0.63251, 1.86
PROFILE ID: Biggest
  VELOCITIES:
    0.56137, 4.30
    0.57597, 14.31
    0.59791, 19.12
    0.61927, 16.89

```

0.63330, 5.09
END:

CROSS-SECTION:

STREAM ID: Wailupe

REACH ID: Lower

STATION: 6269.258

CUT LINE:

582723.174, 46846.449

582426.438, 46878.916

581953.514, 47082.992

BANK POSITIONS: 0.52401, 0.56900

WATER ELEVATION: 123.9078, 125.2825, 127.845

WATER SURFACE EXTENTS:

582309.53, 46929.36, 582276.02, 46943.82

582309.55, 46929.35, 582275.92, 46943.87

582326.40, 46922.09, 582195.49, 46978.57

PROFILE ID: Big

VELOCITIES:

0.52365, 2.47

0.52857, 9.22

0.53762, 10.37

0.54643, 10.39

0.55542, 10.13

0.56408, 1.21

PROFILE ID: Bigger

VELOCITIES:

0.52363, 2.70

0.52856, 10.14

0.53761, 11.38

0.54644, 11.40

0.55543, 11.15

0.56380, 1.27

PROFILE ID: Biggest

VELOCITIES:

0.51786, 2.90

0.52855, 12.07

0.53759, 13.52

0.54645, 13.53

0.55544, 13.29

0.56421, 1.42

0.60838, 1.12

0.66018, 0.35

END:

Many cross sections (and interpolated cross sections) omitted

CROSS-SECTION:

STREAM ID: Wailupe

REACH ID: Lower

STATION: 220.827

CUT LINE:

586214.122, 42127.918

```

581980.991, 40806.059
BANK POSITIONS: 0.50300, 0.51500
LEVEE POSITIONS:
  1, 0.345, 7.123
INEFFECTIVE POSITIONS:
  1, 0.000, 0.412, 5.987
WATER ELEVATION: 5.503006, 5.881266, 6.600093
WATER SURFACE EXTENTS:
  586214.12, 42127.92, 583114.30, 41159.95
  586214.12, 42127.92, 583049.46, 41139.70
  586214.12, 42127.92, 581980.99, 40806.06
PROFILE ID: Big
  VELOCITIES:
    0.00851, 0.55
    many lines omitted
    0.71676, 0.18
PROFILE ID: Bigger
  VELOCITIES:
    0.00855, 0.63
    many lines omitted
    0.72186, 0.25
PROFILE ID: Biggest
  VELOCITIES:
    0.01783, 0.55
    many lines omitted
    0.99398, 0.11
END:

END CROSS-SECTIONS:

BEGIN BOUNDS:

PROFILE LIMITS:
  PROFILE ID: Big
  POLYGON:
    581893.32, 48625.16
    many lines omitted
    581908.77, 48563.31
  POLYGON:
    583126.27, 47608.3
    many lines omitted
    583090.99, 47539.75
  POLYGON:
    581953.51, 47082.99
    many lines omitted
    581934.96, 47008.78
END:

PROFILE LIMITS:
  PROFILE ID: Bigger
  581893.32, 48625.16
  many lines omitted
  581908.77, 48563.31

```

```
POLYGON:
  583126.27, 47608.3
  many lines omitted
  583090.99, 47539.75
POLYGON:
  581953.51, 47082.99
  many lines omitted
  581934.96, 47008.78
END:

PROFILE LIMITS:
PROFILE ID: Biggest
  581893.32, 48625.16
  many lines omitted
  581908.77, 48563.31
POLYGON:
  583126.27, 47608.3
  many lines omitted
  583090.99, 47539.75
POLYGON:
  581953.51, 47082.99
  many lines omitted
  581934.96, 47008.78
END:
END BOUNDS:

BEGIN LEVEES:

LEVEE ID: 1
SURFACE LINE:
  584579.800, 41808.166, 7.222
  many lines omitted
  584631.334, 41572.921, 5.922
END:

END LEVEES:

BEGIN INEFFECTIVE AREAS:

INEFFECTIVE ID: 1
POLYGON:
  584422.114, 41883.166
  584452.132, 41787.626
  many lines omitted
  584552.852, 41577.321
END:

END INEFFECTIVE AREAS:

BEGIN STORAGE AREAS:

SA ID: 1
POLYGON:
  581919.014, 43565.358
```

many lines omitted
581895.224, 43443.864

END:

ELEVATION-VOLUME:

20.000, 0
22.000, 675000

many lines omitted
30.000, 421300

END:

TERRAIN:

581898.124, 43566.478, 33.442
582361.222, 43216.332, 20.369

many lines omitted
581867.484, 43432.612, 33.356

END:

END STORAGE AREAS: