SRH-1D-VEG2D User's Manual

Sedimentation and River Hydraulics—
One-Dimensional and Vegetation Two-Dimensional,
Version 1.0

Final Report ST-2020-1781-01

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14. ABSTRACT This report provides a user's manual for SRH-1D-VEG2D. SRH-1D-VEG2D is developed as a reach scale numerical model to simulate long-term vegetation establishment, growth, and desiccation. Reclamation's SRH-1D model is first used to simulate flow, sediment transport, and channel geomorphology change. SRH-1D-VEG2D then translates the 1D flow, sediment, and channel topography into a 2D form to simulate vegetation processes.

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Acronyms and Abbreviations

EPA	U.S. Environmental Protection Agency
ft/s	feet per second
GIS	Geographic Information System
HEC-RAS	Hydrologic Engineering Center's River Analysis System
m	meters
m/s	meters per second
Reclamation	Bureau of Reclamation
RHEM	Riparian Habitat Establishment Model
s	seconds
SED-VEG	Sediment-Vegetation
SEI	Stockholm Environment Institute
SRH-1D	Sediment River Hydraulics- One Dimension
SRH-1DV	Sediment River Hydraulics- One Dimension Vegetation
SRH-2DV	Sediment River Hydraulics- Two Dimension Vegetation
TDD	total degree days
TSC	Technical Service Center

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Executive Summary

This Science and Technology Research Program (S&T) project builds on Reclamation's sedimentation and vegetation modeling software suites. These hydraulic and sediment transport numerical models simulate flows in rivers and channels with or without movable boundaries. The Sedimentation and River Hydraulics (SRH) model simulates changes to rivers and canals caused by sediment transport. Simulation capabilities include steady or unsteady flows, internal boundary conditions, looped river networks, cohesive and non-cohesive sediment transport, and lateral inflows. The model uses cross section based river information.

Sediment River Hydraulics- One Dimension Vegetation (SRH-1DV) includes simulating changes to vegetation growth and mortality modules caused by river conditions (i.e. groundwater levels) and air temperatures. However, a fully two-dimensional (2D) model of vegetation growth and mortality modes requires too much computing power to provide long-term simulations.

This model, the Sediment River Hydraulics One-Dimensional and Vegetation Two-Dimensional (SRH-1D-VEG2D) is intended to bridge the gap between a 1D numerical model that only computes vegetation properties at cross sections and a fully 2D model that requires large computational resources. This model builds on the original SRH-1D model (which was the first used to simulate flow, sediment transport, and channel geomorphology change). SRH-1D-VEG2D then translates the 1D flow, sediment, and channel topography into a 2D form to simulate vegetation processes on a 2D grid.

This manual explains the model process, equations, input files required, and output files generated.

Reclamation's Research Office funded SRH-1D-VEG2D's development.

1. Introduction

1.1. Background

Sediment River Hydraulics-One Dimension (SRH-1D) is a one-dimensional hydraulic and sediment transport model developed by the Technical Service Center's (TSC) Sedimentation and River Hydraulics Group at the Bureau of Reclamation (Reclamation) (Huang and Greimann, 2007). It was initially funded by Reclamation's Science and Technology and U.S. Environmental Protection Agency (EPA) to simulate flows in rivers and channels with or without movable boundaries. Currently, it is a well-known numerical model used nationally and internationally. The in-house model also makes it possible to add new features to simulate unique applications.

Sediment-Vegetation (SED-VEG) was the first dynamic vegetation simulation tool developed in the Sedimentation and River Hydraulics Group. It was developed specifically for the Platte River Recovery Implementation Program's environmental compliance and adaptive management to evaluate the interactions among hydrology, river hydraulics and vegetation.

Sediment River Hydraulics- One Dimension Vegetation (SRH-1DV) is an adaption of SRH-1D incorporating many vegetation modules from SED-VEG and can simulate vegetation response to changes to rivers and canals caused by sediment transport. SRH-1DV simulates:

- the processes of seedling growth and mortality as a function of species type,
- changing river stage and groundwater level,
  the rate of root growth, and
- the potential for scour due to high flow velocity.

SRH-1DV tracks the:

- Potential for species-specific plant mortality due to drowning, velocity scour, and desiccation.

- Establishment, growth, and mortality of vegetation on a daily basis in response to dynamic physical conditions. Vegetation is tracked as individual plants located on every node at every cross section in the model.

SRH-1DV has been used in analyses for the Sacramento River, San Joaquin River, Rio Grande, and Trinity River.

A fully two-dimensional (2D) model, Sediment River Hydraulics- Two Dimension Vegetation (SRH-2DV), was previously developed in Sedimentation and River Hydraulics Group, and the Trinity River analyses attempted to use this model with limited success. The long computational time makes it difficult to perform long-term predictions in a reach scale—especially desired when modeling vegetation.

This model, the Sediment River Hydraulics One-Dimensional and Vegetation Two-Dimensional (SRH-1D-VEG2D) is intended to bridge the gap between a 1D numerical model that only computes vegetation properties at cross sections and a fully 2D model that requires large computational resources. This model builds on the original SRH-1D model (which was the first used to simulate flow, sediment transport, and channel geomorphology change). SRH-1D-VEG2D then translates the 1D flow, sediment, and channel topography into a 2D form to simulate vegetation processes on a 2D grid. Reclamation's Research Office funded SRH-1D-VEG2D's development.

1.2. SRH-1D-VEG2D Capabilities

SRH-1D-VEG2D simulates flow, sediment transport, and riparian vegetation processes. Some of the model's functionalities are:

- Importing Geographic Information System (GIS) geo-referenced vegetation map.
- Importing GIS geo-referenced channel bank and floodplain boundaries.
- Creating 2D mesh automatically for vegetation simulation, or input from 2D mesh generated using other software.
- Simulating:
  - Groundwater from channel water surface elevation
  - 2D vegetation representation
  - Vegetation air/water germination
  - Vegetation growth of trunk, root depth, and canopy size
  - Vegetation mortality due to age, drowning, velocity scour, and desiccation
  - Vegetation competition

1.3. Acquiring SRH-1D-VEG2D

Requests may be sent directly to Reclamation's Sedimentation and River Hydraulics Group (Attention: SRH Support, Sedimentation and River Hydraulics Group, P.O. Box 25007 (86-68540), Denver, Colorado, 80225-0007). Users may also check this page for office release of this model: https://www.usbr.gov/tsc/techreferences/computer%20software/compsoft.html.

SRH-1D-VEG2D is under continuous development and improvement.

1.4. Disclaimer

The program SRH-1D-VEG2D and information in this manual are developed for use at Reclamation. Reclamation does not guarantee the performance of the program, nor help external users solve their problems. Reclamation assumes no responsibility for the correct use of SRH-1D-VEG2D and makes no warranties concerning the accuracy, completeness, reliability, usability, or suitability for any particular purpose of the software or the information contained in this manual.

Like other computer programs, SRH-1D-VEG2D is potentially fallible. SRH-1D-VEG2D is a program that requires engineering expertise to be used correctly. All results obtained from the use of the program should be carefully examined by an experienced engineer to determine if they are reasonable and accurate. Reclamation will not be liable for any special, collateral, incidental, or consequential damages in connection with the use of the software.

2. Model Description

SRH-1D-VEG2D is an extension of the SRH-1D, a 1D flow and sediment transport model (Huang and Greimann, 2012). SRH-1D-VEG2D was written to include groundwater and vegetation simulation.

The flow module of SRH-1D-VEG2D can compute steady or unsteady water surface profiles, however, only the steady flow model is expected to be used for vegetation applications with varying flow rate at each time step. The flow and sediment transport simulations are cross-section based. The sediment module computes sediment transport capacity and resulting vertical bed changes using several different transport functions. More details on the numerical solution of the flow model, sediment transport algorithms, and channel representation can be found in Huang and Greimann (2012).

2.1. Groundwater Module

The groundwater elevation is a critical factor in the survival of riparian vegetation and is predicted in the model from the computed water surface in the river. The groundwater module within SRH-1D-VEG2D is a cross-section based saturated flow model that solves Equation 2.1.

$$\frac{\partial z_g}{\partial t} = K \frac{\partial^2 z_g}{\partial y^2} \tag{2.1}$$

Where:

z_g	=	Groundwater elevation (in meters [m] or feet)
t	=	Time (in seconds [s])
K	=	Saturated flow hydraulic conductivity (in meters per second [m/s] or feet per second [ft/s])
y	=	Direction along the cross section (m or feet).

Groundwater levels are a function of the river's water elevation and a soil permeability coefficient. The module solves for the groundwater level and assumes no groundwater interaction between cross sections. Therefore, the groundwater solutions obtained from SRH-1D-VEG2D will only be applicable near the river, i.e., generally within the alluvial soils of the floodplain. The boundary conditions imposed in the model are:

1. A known water surface elevation wherever the water surface intersects the cross section

2. No flux boundary conditions at the cross-section end points

The user can enter separate saturated hydraulic conductivities for the left and right overbanks. Soil type and hydraulic conductivity can be specified at each cross section.

2.2. Vegetation Module

Most concepts for the vegetation module of SRH-1D-VEG2D are from SRH-1DV, but several new concepts have been introduced. Vegetation density is introduced in the simulation, which allows the computation of partial vegetation mortalities under certain conditions.

The vegetation module in SRH-1D-VEG2D is intended to be generic and applicable to a variety of species. Most of the data used to support the model have been collected on cottonwoods and willows; however, the processes included in the model should be valid for a wide variety of riparian plant species. The model offers a highly parameterized simulation of vegetation that relies upon significant user input. These user-entered parameters need to be determined by field and laboratory studies for each species simulated.

The vegetation module SRH-1DV is composed of three sub-models of vegetation processes:

1. Germination (establishment)
2. Growth
3. Removal (mortality)

The model uses 2D triangular or quadrilateral cells to represent vegetation status (age, trunk height, root depth, canopy width, and density) at each mesh cell. Average velocity, water surface elevation, sediment transport, and channel morphology at each cross section is simulated in SRH-1D model. The velocity is then redistributed according to local conveyance to obtain velocity at each point in the cross section. The velocity, water and groundwater surface, and bed elevation at each point of each cross section are used to interpolate values at each cell center of 2D mesh, which are then used to update vegetation status at each mesh cell.

2.2.1. Vegetation Establishment Module

The Vegetation Establishment Module simulates germination due to air dispersal, water dispersal, and lateral spread of roots. Vegetation germination is strongly influenced by the ambient temperature. For a given type of vegetation, germination starts at a fixed Julian day or starts when the condition of total degree days of air temperature is met. The total degree days (*TDD*) are accumulated by adding each day's degree contribution as the season progresses. The calculation is performed by taking the integral of temperature above a base temperature T_{base} as shown in Equation 2.2:

$$TDD = \int (T(t) - T_{base})dt \qquad (2.2)$$

Where:

$T(t)$	=	air temperature in Celsius
T_{base}	=	base air temperature in Celsius
t	=	time in days

The last day of germination is given by the seed release duration added to the starting day of germination.

2.2.1.1 Air Dispersal

If air dispersal is being simulated, a plant is assumed to germinate if there is available space, available seeds, and moist soil.

2.2.1.1.1 Available Space Criterion

The "available space" criterion is met if no other vegetation is present at that location that would outcompete the plant. At every cell, a plant type can establish if all of the following conditions are met:

- an older plant of the same type is not already growing in that cell;
- competition rules for other established plants do not prevent germination;
- the plant type tolerates existing shade conditions at that location;
- the date is after the germination starting day, defined by a fixed Julian day or germination TDD; and
- the date is before the germination end day, defined by a fixed Julian day or a seed release duration after germination TDD.

For example, if there are five plant types in the model, all five plant types can potentially establish in a single cell at one time. However, an older plant and a new plant of the same type cannot grow in the same cell. Also, all competition stipulations between plant types and shading conditions for that plant type must be met at that location. Plants specified as non-tolerant of shade cannot establish when the canopy of a plant at the same or adjacent cell is shading the cell.

2.2.1.1.2 Available Seeds Criterion

The "available seeds" criterion determines whether or not seeds are available to germinate. Start and end days for seed germination are user specified. The date must be between the start and end date for seed germination for a plant to establish. It is assumed that an unlimited number of seeds are available between the start and end dates, regardless of the presence or absence of mature plants.

2.2.1.1.3 Moist Soil Criterion

The "moist soil" criterion determines if the soil has enough soil moisture for the seed to begin germination. For each plant type, the user enters a distance above the groundwater table within which germination is allowed. Also, the user enters a specified number of days which accounts for the time that the soil remains moist after the river stage recedes.

2.2.1.2 Water Dispersal

If water dispersal and establishment is being simulated, the seed is dispersed only when water depth exceeds a critical depth at a cell where vegetation exists. Once seeds are dispersed at a cell, new seeds (age 0) are available in a reach downstream of the cell in a specific distance (called travel distance). Seeds whose age are younger than a specific age (maximum seed travel time) can germinate in a cell near the bank. Thus, at every cell, a vegetation type can establish if all of the following conditions are met in additional of the conditions defined in the air dispersal:

- seed was released in a distance less than a critical travel time;
- seed was released in a time less than a maximum travel time;
- the current cell is under water and near the bank (i.e., a neighbor cell is above water).

2.2.1.3 Lateral Root Spread

Plants that can expand through lateral growth of roots can be simulated with the lateral root spread. In this simulation, these plants can colonize closely spaced adjacent points in the neighboring cells. Before plants can spread laterally to an adjacent cell, root growth must reach the adjacent cell. Lateral root spread rate is specified for each plant type in the input file.

2.2.2. Vegetation Growth Module

The Vegetation Growth Module calculates growth of the root (depth), stalk (height), and canopy (width). User-specified growth rates for the roots, stalks, and canopy are based upon the month and age of the plant; that is, a growth rate can be assigned for each month of the first year, and then different growth rates can be assigned for each subsequent year of the plant's life. Root growth is computed at the specified rates until reaching a user-specified depth with respect to the ground level. Stalk growth and canopy width are also computed and tracked in the Vegetation Growth Module until the plant reaches an assigned maximum height or width for the vegetation type.

2.2.3. Vegetation Mortality Module

The Vegetation Mortality Module determines whether the plant survives each time step. There are multiple ways a plant may die in this study, and thus be removed from the simulation:

- Desiccation, if a plant experiences too much stress due to lack of water;
- Scour, if the local flow velocity at the plant becomes larger than the plant can tolerant;
- Inundation, if flows exceed the root crown by an assigned depth and flow duration;
- Competition, where assigned rules define the dominant plants; and
- Shading, when a susceptible plant is under the canopy of another plant.

In some of the mortality modes (competition and shading), the plants are all removed once a certain condition is met, in other modes (desiccation, scour, and inundation), the decrease in vegetation population is calculated as shown in Equation 2.3:

$$\frac{dr}{dt} = -rR \tag{2.3}$$

Where:

r	=	vegetation population (density)
R	=	vegetation reduction rate (1/day)
dt	=	time step of simulation (days)

2.2.3.1 Desiccation

Two methods are used to predict desiccation, both of which depend on the relative location of the root and capillary fringe. The capillary fringe is assumed to be a constant distance above the groundwater elevation. The groundwater elevation is calculated as described in the Groundwater Module section. One method assumes that desiccation occurs when the root is separated from the capillary fringe for a user-specified number of days. The other method tracks a "water stress" variable. When the value of that variable exceeds a user-specified value, then desiccation occurs. This water stress method was developed from the Stockholm Environment Institute (SEI) laboratory studies and development of the Riparian Habitat Establishment Model (RHEM), (Reclamation, 2011).

2.2.3.1.1 Time of Separation

The "time of separation" method tracks the relative elevation of the plant root and the capillary fringe. When a plant root is a user-specified distance above the capillary fringe of the water table for more than the number of days specified, the critical time of separation is reached, and the plant dies. The critical time of separation can also be a function of the plant age. The user can vary each plant's resistance to desiccation with age.

2.2.3.1.2 Water Stress

The other method of desiccation tracks a water stress parameter, which can increase or decrease every time step—depending upon whether the plant is experiencing or recovering from water stress. This method was developed based upon research on Freemont Cottonwood conducted by the SEI (Reclamation, 2011). Cumulative stress imposed on the young plant is tracked until a user-specified water stress is reached and the plant is removed. The user enters a desiccation table of water stress values (desiccation rates) versus water table change, where a negative desiccation rate indicates recovery as shown in Table 2.1 and Figure 2-1. If the water table is declining faster than the root can grow, then the desiccation rate is positive and the plant may eventually die. However, if the water table rises or stabilizes, the desiccation rate is negative, and the plant may recover. The relationship between rate of desiccation and the water table for each plant type is a function of soil type. The program has one relationship for sand and one for gravel. Soil type for every location is specified by the cross section and is interpolated for each cell.

Water stress desiccation method is generally selected for young cottonwood less than 1 year old. Cottonwoods usually perish when the water stress parameter exceeds 0.6. Time of separation method should be used for cottonwood plants older than 1 year.

Table 2.1 Cottonwoods water stress rates for sand and gravel soils (Fotherby, 2013)

WT decline (ft/d)	Desiccation Rate (d^{-1})	
	Sand Gravel	Sand Gravel
-3.280	-1.510	-1.510
-0.0328	-0.018	-0.021
0.000	-0.012	-0.013
0.0328	0.005	0.009
0.0656	0.030	0.032
0.0984	0.051	0.115

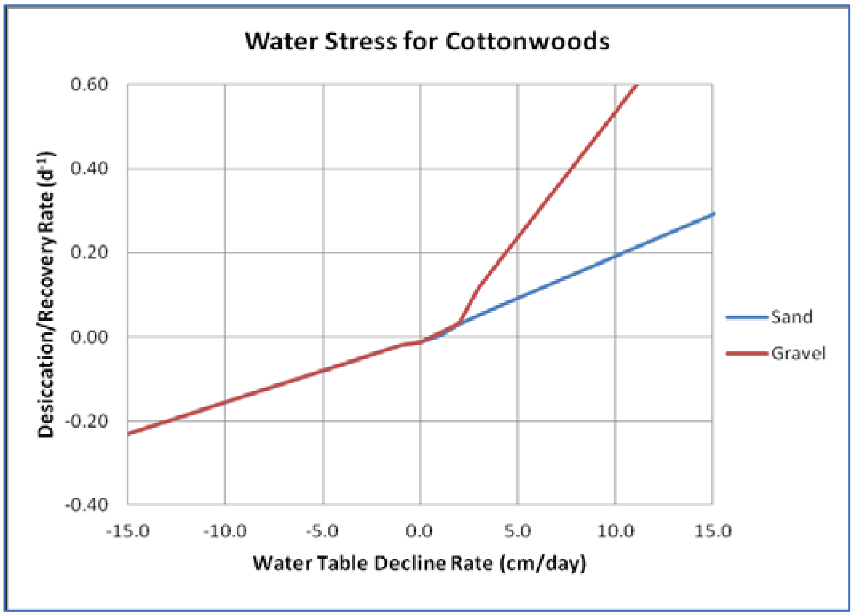

Figure 2-1. Water stress values from laboratory study of cottonwood desiccation as the water table declined (WRIME, Inc., 2009)

2.2.3.2 Scour

Removal due to scour occurs when the local scour velocity at the plant becomes larger than a user-specified value—the "critical scour velocity". This critical scour velocity value can be assigned for various ages for each plant type.

In this model, local scour velocity at each cross-sectional point is estimated from the cross-sectional averaged flow velocity and from the ratio of local conveyance and total conveyance of the cross section. The velocity at each cell is interpolated from local velocities at cross-sectional points.

2.2.3.3 Inundation

The inundation mortality in SRH-1D-VEG2D is dependent on the depth of water submerging a plant and duration flooding. These coupled values are assigned for various ages for each plant type. Wetland plants and riparian species often have certain coping mechanisms including metabolic adaptions, oxygen transport and rhizospheric oxidation, aerenchyma tissue, and adventitious roots (Shaw and Schmidt, 2003; Koch et al., 1990) that help sustain the plant when the root cap is submerged. However, depth and duration of submergence beyond threshold values have significant negative effect on some riparian vegetation survival.

Removal due to inundation occurs when flows exceed the root crown by an assigned depth and duration. Water depth is at each cell is interpolated from water and groundwater surface at cross-sectional points.

2.2.3.4 Competition

Competition is implemented through a matrix for each plant type, containing rules between each plant type based on plant age. For example, a new cottonwood seedling could be prevented from establishing if 3-year-old herbaceous grass, a 2-year-old invasive plant, or an agricultural plant of any age is already present at the point. Although two plant types could be established at the same point, the dominant plant could eliminate the second plant at a user-specified age. For example, a 3-year-old invasive plant can eliminate any age of herbaceous grass or a 0-, 1-, or 2-year-old cottonwood.

2.2.3.5 Shading

Plants can be prevented from growing in areas that are shaded or can experience mortality when conditions exceed their shade tolerance. A canopy growth function is used to track locations of shade. The shaded area around each plant is determined based on age of the plant and growth rate of the canopy specified by month. During simulation, the model computes if the plant at a point is shaded by other vegetation on adjacent cells. The user can enter the age at which the plant becomes shade tolerant.

3. Running SRH-1D-VEG2D

3.1. Input Data Format

SRH-1D-VEG2D reads several input files that contains all the necessary information to perform a simulation. Input files are organized in sequential records. Those sequential files are presented in flow charts in Appendix A.

A line starting with "*" is a comment line and will be ignored by the model.

A record is a line of up to 300 characters long. A record starts with a specific record name containing 3 characters. Each record name is unique and inputs specific data to the program. A comprehensive list of all records names used by SRH-1D-VEG2D is given in Appendix B. A detailed explanation of all the records is given in Appendix C. Not all records are used (for example, some are mutually exclusive) but they have to be in an appropriate sequence.

Data after the record name is in an unformatted form to prevent any user input error. Error checking is provided to prevent some human errors, such as:

- empty lines,
- lines started with space instead of the record name,
- incorrect record names,
- incorrect number of data following the record name, or
- incorrect data values.

The data are prepared in ASCII files. For easy data input, sample examples are provided in the Microsoft EXCEL format, users may save the data in type of "Text Formatted (Space delimited) *.prn". It is recommended that the user study the example input files included in the distribution of SRH-1D-VEG2D to become familiar with the input data format. The EXCEL sample input files also contain the explanation of each variable in the comment field.

3.2. Executing SRH-1D-VEG2D

After preparing the input data file, SRH-1D can be executed by double-clicking the filename in Windows Explorer. SRH-1D-VEG2D can also be used from the command line interface. At the prompt, simply type:

C:\> PROGRAM_NAME FILENAME

or

C:\> PROGRAM_NAME –e FILENAME

where PROGRAM_NAME is the name of the SRH-1D-VEG2D executable and FILENAME is the input filename (including the filename extension) that will be run. The argument "-e" in the commend line forces the program to exit all windows when the program is terminated.

Make sure the executables exist in the system PATH variable. If SRH-1D-VEG2D is launched without an input file name, the program prompts the user to enter it. For consistency, the input data file should have an extension .SRH (or .srh), but the program will work with any other extension. The FILENAME argument can also include the drive letter and path information if the entire string is encapsulated by quotes.

SRH-1D-VEG2D displays the current bed profile and user specified cross sections during the simulation. Using this real time display, one can monitor the simulation during a run. This feature is useful in debugging the simulation.

3.3. Input Files

SRH-1D-VEG2D requires these input files:

- **sample.srh**: The *.srh is the input file SRH-1D requires to perform hydraulics and sediment transport processes. Please refer SRH-1D model (Huang and Greimann, 2007) for the input format. User can use a user-specified case name for his file.
- **vegetation.txt**: The text file to input vegetation names, types, parameters.
- **groundwater.txt**: The text file to input groundwater parameters.
- **temperature.txt**: The text file to input air temperatures for the duration of the simulation.
- **vegInv.shp** and **vegIny.dbf**: the ARC-GIS polygon shapefile and related database file for vegetation inventory map. The file name "vegInv.shp" is defined in Record VIN. See Record VIN for details.

- **bankAndBoundary.shp**: the ARC-GIS polyline shapefile for river banks and riparian boundaries. The file name "bankAndBoundary.shp" is defined in Record VBL. See Record VBL for details.

SRH-1D-VEG2D has one optional input file:

- **vegetationMesh.2dm**: 2D mesh file for vegetation simulation. This file is optional and can be defined in Record VMH. See Record VMH for details.

3.4. Output Files

The model generates hydraulics and sediment transport output files. For example, for a given input file named sample.dat, the following files may be generated:

sample_OUT.dat: contains the *_OUT.dat file, which first summarizes the dimensions used by the model, such as the river number, the sediment size fractions, the bed layer number, the cross-section number, the maximum points in a cross section, etc. Then it repeats the input data. When an error occurs on reading the input files, the users should first check this file for possible warnings.

sample_ERR.dat: contains errors encountered during run time. If the program stops, please check this file for error messages.

sample_HEC_RAS_GEOMETRY.g01: contains the Hydrologic Engineering Center's River Analysis System (HEC-RAS) geometry file. It is updated each DTPLT time step defined in record YDT. User may use the HEC_RAS model to check the initial input geometry and the final geometry.

sample_OUT_Profile.dat: is the bed profile file, which contains the cross-section number, the cross section location, the discharge, the lateral water discharge, the original thalweg elevation, the current thalweg elevation, the current water surface elevation, the average bed elevation of the main channel, the friction slope, the channel top width, the hydraulic radius, the sediment sizes d_{16}, d_{35}, d_{50}, d_{86}, and the bed shear stress.

sample_OUT_XC.dat: contains the cross-section data. The program will not permit the cross-section file to be written more than 20 times.

sample_OUT_MaterialVolume.dat: contains the cumulative material volume of deposition in all sub-channels and in each sub-channel.

sample_OUT_Volume.dat: contains the cumulative volume of deposition material in all size fractions and as calculated in the main channel and left and right floodplains.

sample_OUT_MassBalance.dat: is the mass balance file, which contains the mass balance, sediment coming in from upstream entrances, sediment flowing out from downstream exits, sediment coming in from lateral point and not-point sources, and sediment erosion. The sediment mass balance is only valid for a steady sediment transport model.

sample_OUT_Conc.dat: contains the sediment concentration data of each size fraction.

sample_OUT_BedLayer.dat: contains the bed thickness data of each bed layer in each sub-channel.

sample_OUT_BedFraction.dat: contains the sediment size fraction data of each bed layer in each sub-channel.

sample_OUT_Porosity.dat: contains the sediment porosity data of each bed layer in each sub-channel.

sample_OUT_SedimentLoad.dat: contains the sediment load passing each cross section for each size fraction in each sub-channel.

sample_OUT_TimeSeries.dat: contains time series information at the cross sections being viewed on screen during run time.

The following file may be generated for vegetation.

veg_out.dat: file containing vegetation age, density, crown elevation, plant height, and root depth at each cell.

4. References

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Huang, J. and B.P. Greimann (2007). User's Manual for SRH-1D 2.0 (Sedimentation and River Hydraulics – One Dimension Version 2.0). Sedimentation and River Hydraulics Group, Technical Service Center, Bureau of Reclamation, Denver, CO. (www.usbr.gov/pmts/sediment).

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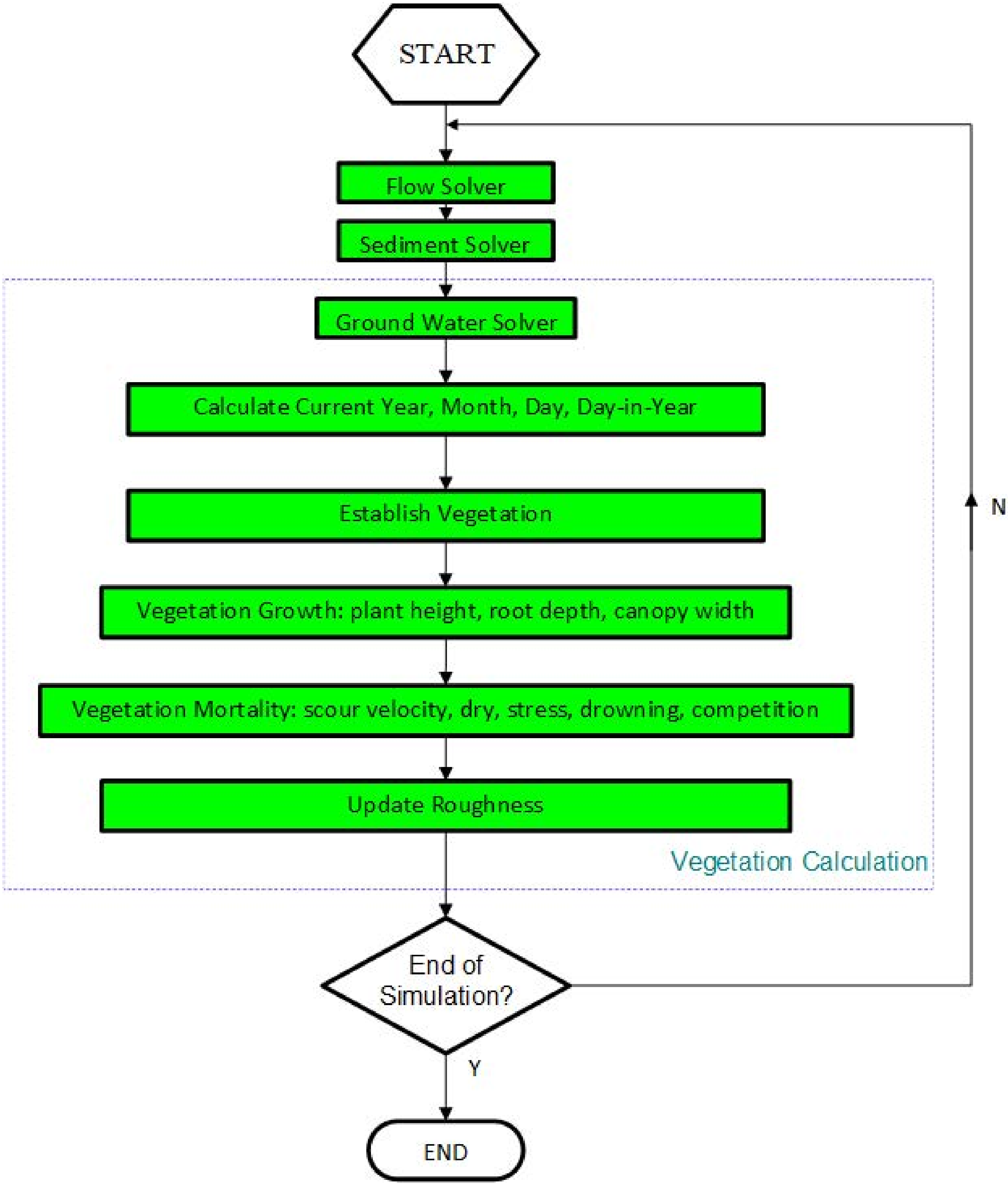
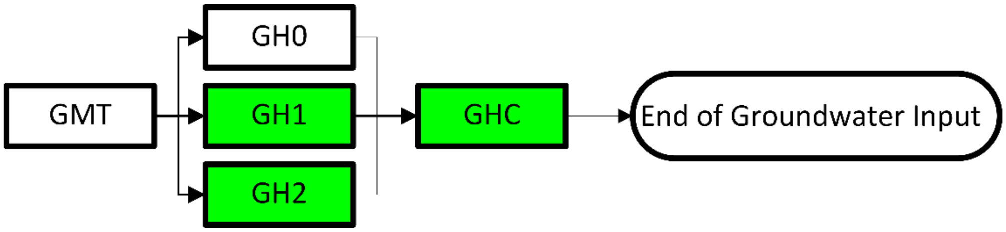
WRIME, Inc. (2009). Riparian Habitat Establishment Model Parameter Development and Modeling Study. Task Order 06A3204097F in support of Reclamation's IDIQ Contract No. 06CS204097F. Stockholm Environment Institute and UC Davis, Prepared for the Bureau of Reclamation, Mid-Pacific Region, Sacramento.

APPENDIX A - Flow Charts

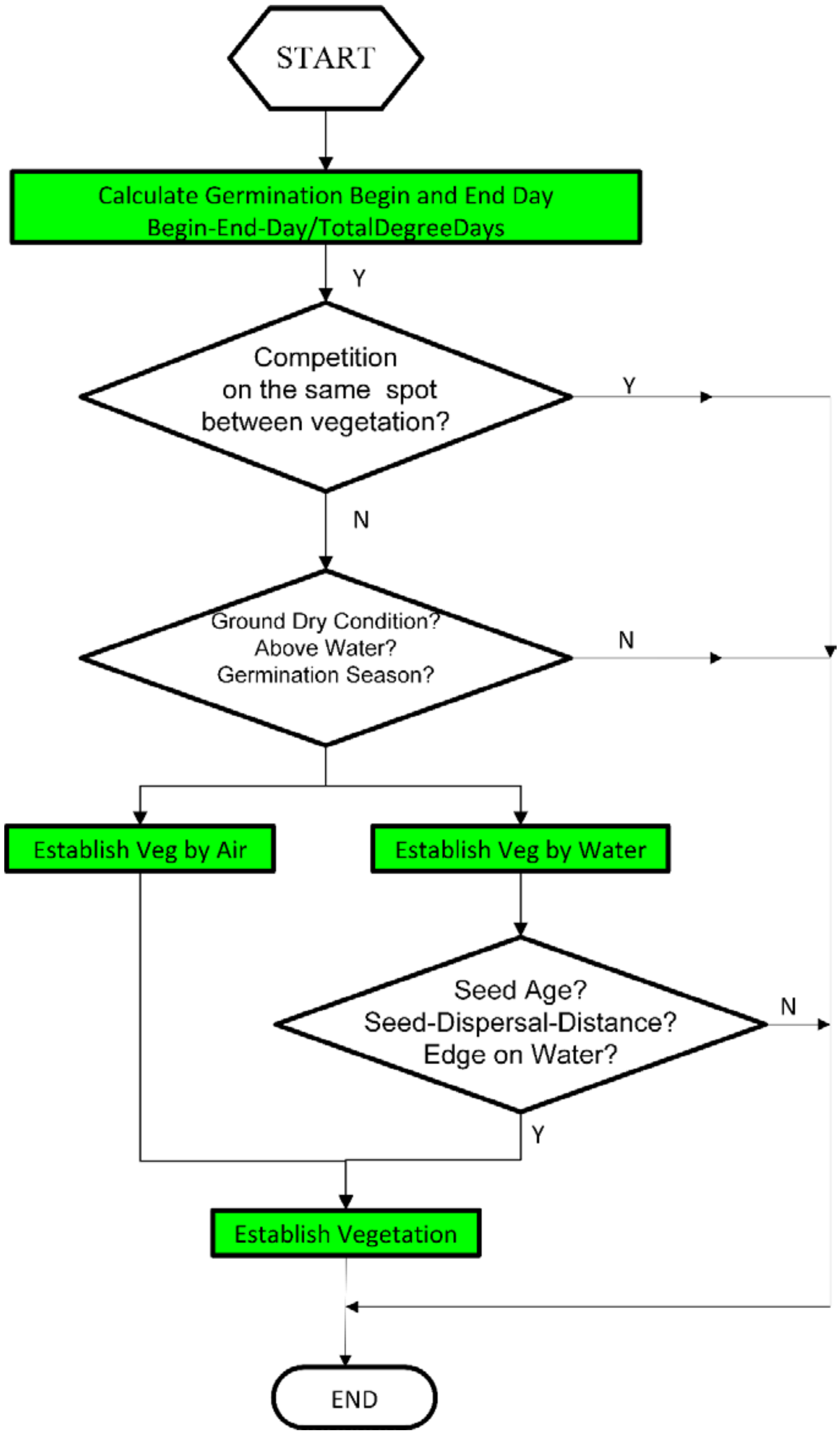
Flow, Sediment Transport, and Vegetation Simulation



Groundwater Input Data Records

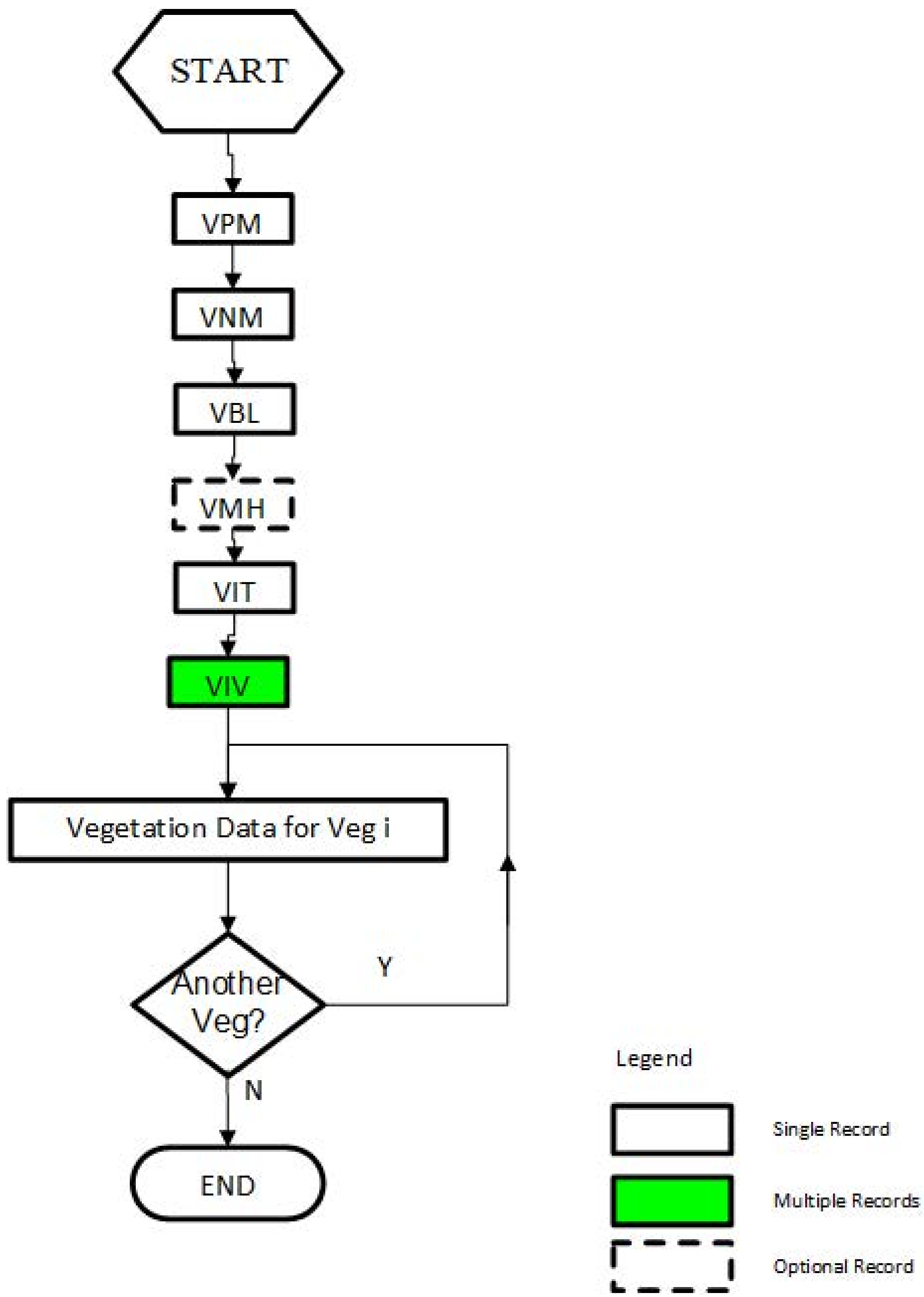


Vegetation Establishment

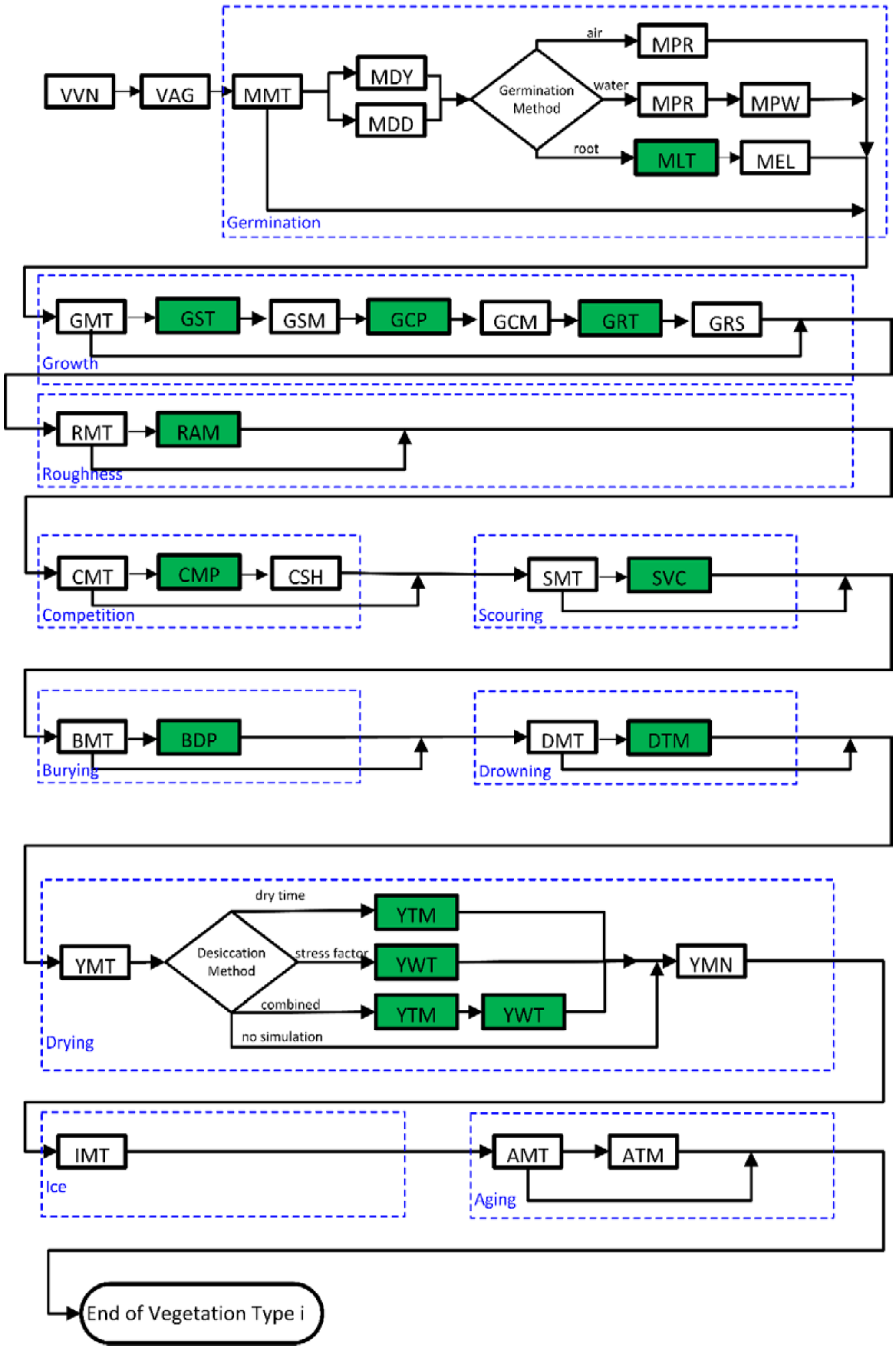


Temperature Input Data Records

Vegetation Input Data Records



Vegetation Type Input Data Records



APPENDIX B – List of Records

Alphabetical List of Records

Appendix page

Sequential List of Records

Vegetation Records

Appendix C Page

Groundwater Records

Appendix D page

Air Temperature Records

Appendix E page

APPENDIX C - Descriptions of Vegetation Records

The following sections detail the vegetation input data for each of the 13 data groups. Each record is defined by a three-letter code followed by variables. Each variable can be one of three types: text, integer, or real number data. Each record may contain several variables. Each record is described as follows:

Variable: Gives the variable name.

Type: The type can be either text, integer (int), or real (float).

Value: Give the potential ranges for this variable.

Description: Describes the significance of this variable.

Data Group 1. Vegetation Model Parameters

VPM

VPM: Time Step

Required

This record defines the time step for vegetation simulation and for printing.

VPM DTV DTP

Variable	Type	Value	Description
DTV	float	+	Vegetation simulation time step (day)
DTP	float	+	Vegetation output time step (day)

VNM

VNM: Vegetation Type Numbers and Soil Type Numbers

Required

The VNM record specifies vegetation type numbers and soil type numbers.

VNM nVeg nSoil

Variable	Type	Value	Description
nVeg	int	+	Number of vegetation types.
nSoil	int	+	Number of soil types.

VBL

VBL: Bank and Boundary

Required

This record defines the bank and boundary of the simulation. The bank and boundary lines are defined in an ArcGIS polyline shapefile. The shapefile must have a field of "Name" and must include exactly four lines with name given in field "Name" as "Left Bank", "Right Bank", "Left Boundary", and "Right Boundary". The shapefile (***.shp) and related database file (***.dbf) should be in the same folder as vegetation.txt file. The interpolation of hydraulic property values from 1D flow and sediment transport model to 2D vegetation cells is performed in the areas from left boundary to left bank, from left bank to right bank, and from right bank to right boundary.

VBL fileName spaceT spaceS

Variable	Type	Value	Description
Filename	char		Shapefile for bank and boundary lines. If there is space in the file name, then it should be given inside double quotes (e.g. "03Riparian statePlane.shp")
spaceT	float	+	Transversal grid resolution used to create 2D vegetation mesh and used for interpolation
spaceS	float	+	Streamwise grid resolution used to create 2D vegetation mesh and used for interpolation

VMH

VMH: Vegetation Mesh

Optional

This record defines the mesh for vegetation simulation. The mesh file can be in SRH-MESH format (***.srhm) or SMS format (***.2dm). , Please refer to the SRH-MESH or SMS user's menu for details of the format of mesh files. If no mesh file is provided, the model creates three structured sub-meshes between two cross sections bounded by left boundary and left bank, left and right banks, and right bank and right boundary. The model then combines all sub-meshes between all cross sections to create a final mesh for vegetation simulation. The streamwise distance is calculated for each cell from the bank and boundary lines. The coordinates of the mesh should be in the same projection with the bank and boundary lines defined in Record VBL.

VMH fileName

Variable	Type	Value	Description
fileName	char		2D vegetation mesh file in SRH-MESH format (***.srhm) or SMS format (***.2dm). If there is space in the file name, then it should be given inside double quotes (e.g. "veg mesh.srhm"). The coordinates of the mesh should be in the same projection with the bank and boundary lines defined in Record VBL.

VIN

VIN: Vegetation Inventory File

Required

This record is used to input vegetation inventory map in ArcGIS polygon shapefile. The vegetation map delineates the amount, composition, and conditions of vegetation types with geographic distribution and extent, and groups them into each vegetation code. The shapefile (***.shp) and related database file (***.dbf) should be in the same folder as vegetation.txt file. The projection of the vegetation inventory should be the same with the bank and boundary lines defined in Record VBL. Vegetation should include a field for vegetation code, defined in Record VIT.

VIN fileName

Variable	Type	Value	Description
fileName	char		Shapefile containing vegetation inventory map. If there is space in the file name, then it should be given inside double quotes (e.g. "03Riparian_statePlane.shp"). The shapefile (***.shp) and related database file (***.dbf) should be in the same folder as vegetation.txt file. The projection of the vegetation invitatory should be the same with the bank and boundary lines defined in Record VBL.

VIT

VIT: Title of Vegetation Field

Required

This record defines title of vegetation field in ArcGIS polygon shapefile for vegetation inventory map.

VIT TITLE

Variable	Type	Value	Description
TITLE	char		Title of vegetation field in ArcGIS polygon shapefile for vegetation inventory map. If there is space in the title, then it should be given inside double quotes (e.g. "veg code"). An error message will be given if there is no field with the title given here.

VIV

VIV: Vegetation Inventory Table

Required

This record defines vegetation age and density for each vegetation code. Each polygon has a vegetation code defined in the field with a title defined in record VIV. One VIV record should be used for one vegetation code. The table defined in records VIV should include all vegetation codes found in the GIS attribute table.

VIV CODE (AGE_i $DENSITY_i$) with i=1 to nVEG

Variable	Type	Value	Description
CODE	char		Vegetation code.
AGE_i	int	0/+	Age of vegetation i.
$DENSITY_i$	float	0/+	Density of vegetation i.

Data Group 2. Vegetation Name and Age Groups

VVN

VVN: Vegetation Name

Required

The VVN record specifies the name of vegetation.

VVN Name

Variable	Type	Value	Description
Name	char		Vegetation name.

VAG

VAG: Vegetation Age Group

Required

The VAG record specifies vegetation age group upper limits. For example, "VAG 1 3 5 20 100" means that this vegetation type will be divided into 5 groups with ago 0 to 1, 1 to 3, 3 to 5, 5 to 20, and 20 to 100. If no ago group is divided in this vegetation, record "VAG 100" is used.

Variable	Type	Value	Description
AGE_i	int	+	upper age limit of group i

Data Group 3. Vegetation Germination

MMT

MMT: Germination Method

Required

The MMT record specifies the germination method.

MMT gMETHOD

Variable	Type	Value	Description
gMETHOD	int	0/1/2	Germination method
		0	No germination will be simulated.
		1	Germination by air.
		2	Germination by water.
		3	Germination by root.

MDY

MDY: Germination Days

Require MDY or MDD records if gMETHOD = 1 or 2

The MDY record specifies germination start and end days according to Julian calendar day. More than one period can be specified in MDY. For example, "MDY 120 180" means that the germination season is from Julian days 120 to 180, and "MDY 120 150 200 230" means that the germination seasons are from Julian days 120 to 150 and from days 200 to 230.

MDY $bgnDay_1$ $endDay_1$ …

Variable	Type	Value	Description
$bgnDay_i$	Int	+	beginning day of germination season i
$endDay_i$	Int	+	ending day of germination season i

MDD

MDD: Germination Total Degree Days

Require MDY or MDD records if gMETHOD= 1 or 2

The MDD record specifies germination parameters determined by the total degree days (TDD) of air temperature. Refer to Section 2.2.1 for details.

MDD tBase TDD duration …

Variable	Type	Value	Description
tBase	float	+	Base air temperature in Celsius
TDD	float	+	TDD (in degree-days) when the germination starts
duration	float	+	Germination duration after the starting day of germination.

MPR

MPR: Germination Parameters

Required if gMETHOD = 1 or 2

The MPR record specifies germination parameters.

MPR gDay dDay BELOW iDensity

Variable	Type	Value	Description
gDay	float	0/+	Germination is possible only when ground has been dry for a period of days greater than gDay
dDay	float	0/+	Germination is possible only when ground has been dry for a period of days less than dDay
BELOW	float	+	The ground is considered dry and suitable of germination when the water depth is less than BELOW
iDensity	float	+	Initial density of vegetation after germination.

MPW

MPW: Water Germination Parameters

Optional, Required if gMETHOD = 2 (water germination)

The MPW record specifies the germination parameters.

MPW cDepth tDistance tTime

Variable	Type	Value	Description
cDepth	float	0/+	Seed distribution by water is possible when the water depth is great than a critical depth (cDepth)
tDistance	float	0/+	Maximum seed travel distance
tTime	float	0/+	Maximum seed travel time

MLT

MLT: Lateral Root Spread Rate

Required if gMETHOD= 3 (root germination)

The MLT record specifies lateral root spread rate at a specific age and month. More than one MLT record can be used. No interpolation or extrapolation is used. If the age is smaller than the time MLT at the first record, the value at the first record is used. If the age is larger than the time MLT at the last record, the value at the last record is used.

MLT age rate (1:12)

Variable	Type	Value	Description
age	INT	0/+	Age at or under which the root later spread rates are given
$rate_i$	float	0/+	Lateral root spread rate at each month at the age given

MEL

MEL: Maximum Establishment Height

Required if gMETHOD= 3 (root germination)

The MEL record specifies maximum establishment height above groundwater elevation by root germination. Root germination is possible if all three conditions are met:

1. the ground is dry,

2. the height from the ground to the groundwater surface is less than the maximum establishment height defined here, and

3. the root is the neighbor cell reaches the cell center to be established.

MEL HeightME

Variable	Type	Value	Description
HeightME	float	0/+	Maximum establishment height above the groundwater surface root germination is possible.

Data Group 4. Vegetation Growth

GMT

GMT: Vegetation Growth

Required

The GMT record specifies the plant growth method.

GMT pgMETHOD

Variable	Type	Value	Description
pgMETHOD	int	0/1	Growth method
		0	No growth is simulated
		1	Vegetation growth is simulated

GST

GST: Stalk Growth Rate

Required if pgMETHOD = 1 (plant growth is simulated)

The GST record specifies the stalk growth rate at specific age and month. More than one GST record can be used. No interpolation or extrapolation is used. If the age is smaller than the age at the first record, the growth rate at the first record is used. If the age is larger than the age at the last record, the growth rate at the last record is used.

GST age rate (1:12)

Variable	Type	Value	Description
age	INT	0/+	age at or under which the stalk growth rates are given
$rate_i$	float	0/+	stalk growth rate at each month at the given age

GSM

GSM: Maximum Stalk Height

Required if pgMETHOD = 1 (plant growth is simulated)

The GSM record specifies the maximum stalk height for a plant.

GSM stHeight

Variable	Type	Value	Description
stHeight	float	+	maximum stalk height for a species

GCP

GCP: Canopy Width Growth Rate

Required if pgMETHOD = 1 (plant growth is simulated)

The GCP record specifies canopy width growth rate at a specific age and month. More than one GCP record can be used. No interpolation or extrapolation is used. If the age is smaller than the age at the first record, the growth rate at the first record is used. If the age is larger than the age at the last record, the growth rate at the last record is used.

GCP age cRate (1:12)

Variable	Type	Value	Description
age	INT	0/+	age at or under which the canopy width growth rates are given
$cRate_i$	float	0/+	canopy width growth rate at each month at the given age

GCM

GCM: Maximum Canopy Width

Required if pgMETHOD = 1 (plant growth is simulated)

The GCM record specifies the maximum canopy height above ground that a plant can growth.

GCM MaxCPWidth

Variable	Type	Value	Description
MaxCPWidth	float	+	maximum canopy width that a plant can growth

GRT

GRT: Root Depth Growth Rate

Required if pgMETHOD = 1 (plant growth is simulated)

The GRT record specifies the root depth growth rate at specific age and month. More than one GRT record can be used. No interpolation or extrapolation is used. If the age is smaller than the age at the first record, the growth rate at the first record is used. If the age is larger than the age at the last record, the growth rate at the last record is used.

GRT age rtRate (1:12)

Variable	Type	Value	Description
age	int	0/+	Age at or under which the root depth growth rates are given
$rtRate_i$	float	0/+	Root depth growth rate at each month at the given age

GRS

GRS: Maximum Saturated Root Depth and Maximum Root Depth

Required if pgMETHOD = 1 (plant growth is simulated)

The GRS record specifies the maximum root depth below the groundwater elevation and maximum root depth.

GRS rootDepthSat MaxRootDepth

Variable	Type	Value	Description
rootDepthSat	float	0/+	Maximum saturated root depth that a plant can grow. If the root depth reaches this value below the groundwater, the root can no longer grow.
MaxRootDepth	float	0/+	Maximum root depth that a plant can grow.

Data Group 5. Roughness Simulation

RMT

RMT: Vegetation Growth

Required

The RMT record specifies the roughness method.

RMT rgMETHOD

Variable	Type	Value	Description
rgMETHOD	int	0/1	Roughness method
		0	Constant roughness is used
		1	Roughness is calculated according to age of vegetation

RAM

RAM: Roughness Table

Required if rgMETHOD = 1 (plant roughness is simulated)

The RAM records define the age-roughness table. Roughness is given in term of Manning's coefficient. The RAM record is repeated until the entire table is input. One record is used for each age-roughness pair. The roughness is interpolated in time between the specified *AGE* values. For values of the age outside of the table, no extrapolation is done; i.e., if $age < AGE_1$ the roughness for AGE_1 is used; if $age > AGE_n$ the roughness for AGE_n is used, where *n* is the total rows of the table.

RAM AGE ROUGHNESS

Variable	Type	Value	Description
AGE	float	0/+	The age at which the roughness is given
ROUGHNESS	float	+	Manning's coefficient at the given age

Data Group 6. Mortality by Competition

CMT

CMT: Competition Method

Required

The CMT record specifies the competition method.

CMT cpMETHOD

Variable	Type	Value	Description
cpMETHOD	int	0/1	Competition method
		0	No mortality due competition is simulated
		1	Mortality due to competition is simulated

CMP

CMP: Competition

Required if cpMETHOD = 1 (competition is simulated)

The CMP record defines competition between the current vegetation type (x) with all other vegetation type y. It starts with the current vegetation age (AGE_x) and is followed by the age of all other vegetation type, AGE_y. Vegetation type *y* at and above age of AGE_y will remove the current vegetation *x* at and below age AGE_x. When *y* = *x* (the same vegetation), AGE_y should be set as a very large number (e.g., 99.0). When the current vegetation (*x*) is not influenced by vegetation (*y*), AGE_y should be set as a very large number (e.g., 99.0). When the vegetation (*x*) can't survive whenever vegetation *y* exists, AGE_y should be set as a very small number (e.g., 0.01)

More than one CMP record can be used. No interpolation or extrapolation is used. If the current vegetation age is smaller than AGE_x at the first record, the ages (AGE_y) at the first record are used. If the current vegetation age is larger than AGE_x at the last record, the ages (AGE_y) at the last record are used.

CMP AGE_x AGE_y(1:nVEG)

Variable	Type	Value	Description
AGE_x	float	0/+	Age of the current vegetation (x)
AGE_y	float	0/+	Vegetation type *y* at and above age of AGE_y will remove the current vegetation *x* at and below age of AGE_x

CSH

CSH: Shade Tolerance

Required if cpMETHOD = 1 (competition is simulated)

The CSH records define the shade tolerance age at and above which the current vegetation cannot be removed by any canopy shade.

CSH stAGE

Variable	Type	Value	Description
stAGE	float	0/+	Shade tolerance age at and above which the current vegetation cannot be removed by any canopy shade

Data Group 7. Mortality by Scouring

SMT

SMT: Scouring Method

Required

The SMT record specifies scouring method of vegetation mortality.

SMT srMETHOD

Variable	Type	Value	Description
srMETHOD	int	0/1	Scouring method
		0	No mortality due to scouring
		1	Mortality due to scouring is simulated

SVC

SVC: Scouring Parameter

Required when srMETHOD = 1 in SMT record.

The SVC record specifies a table of age and scouring parameters. The vegetation population is reduced by the vegetation reduction rate as in Equation *2.3*. In scouring mortality mode, the vegetation reduction rate is presented as:

$$R = \begin{cases} 0 & \text{when } V < V_c \\ RS_0 + D_{RV}(V - V_c) & \text{when } V \geq V_c \end{cases}$$

where

R	=	vegetation reduction rate (1/day),
RS_0	=	initial vegetation reduction (1/day) at critical velocity,
V_c	=	critical velocity (m/s or ft/s) above which vegetation reduction starts, and
D_{RV}	=	rate (s/m/day or s/ft/day) at which the vegetation population reduction rate increases with velocity.

More than one SVC record can be used. No interpolation or extrapolation is used. If the current vegetation age is smaller than *AGE* at the first record, the parameters at the first record are used. If the current vegetation age is larger than *AGE* at the last record, the parameters at the last record are used.

SVC AGE vCrit rStart DRV

Variable	Type	Value	Description
AGE	float	0/+	Age at or under which the scouring parameters are given
vCrit	float	0/+	The critical velocity (V_c) above which mortality due to scouring starts
rStart	float	0/+	The vegetation population reduction rate (RS_0) at critical scouring velocity
DRV	float	0/+	The rate (D_{RV}) at which the vegetation population reduction rate increases with velocity

Data Group 8. Mortality by Burying

BMT

BMT: Burying Method

Required

The BMT record specifies the burying method of vegetation mortality.

BMT brMETHOD

Variable	Type	Value	Description
brMETHOD	int	0/1	Burying method
		0	No mortality due to burying
		1	Mortality due to burying is simulated

BDP

BDP: Burying Depth

Required when brMETHOD=1

The BDP record specifies the critical burying depth. The burying depth is defined as the depth that a tree trunk is under the deposited sediment, calculated from the bed surface to the junction between the trunk and roots. If the burying depth is above a critical value, the vegetation is considered dead and removed by burying.

SVC AGE buryingD

Variable	Type	Value	Description
AGE	float	0/+	Age at or under which the burying depth is given
buryingD	float	0/+	The critical burying depth above which the vegetation is removed by burying

Data Group 9. Mortality by Drowning

DMT

DMT: Drowning Method

Required

The DMT record specifies the drowning method of vegetation mortality.

DMT dwMETHOD

Variable	Type	Value	Description
dwMETHOD	int	0/1	Drowning method
		0	No mortality due to drowning
		1	Mortality due to drowning is simulated

DTM

DTM: Drowning Parameter

Required when dwMETHOD=1

The DTM record specifies a table of age and drowning parameters. The vegetation population is calculated by the vegetation reduction rate as in Equation *2.3*. In drowning mortality mode, the vegetation reduction rate is presented as:

$$R = \begin{cases} 0 & \text{when } T < T_c \text{ or } D < D_c \\ RD_0 + D_{RT}(T - T_c) + D_{RD}(D - D_c) & \text{when } T \geq T_c \text{ and } D \geq D_c \end{cases}$$

Where:

R	=	vegetation reduction rate (1/day)
RD_0	=	initial vegetation reduction (1/day) at critical depth and after a critical drowning period
T_c	=	critical drowning period (day) when vegetation reduction starts
D_c	=	critical drowning depth (m or ft) when vegetation reduction starts
D_{RT}	=	rate (1/day^2) at which the vegetation population reduction rate increases with drowning period
D_{RD}	=	rate (1/m/day or 1/ft/day) at which the vegetation population reduction rate increases with drowning depth

More than one DTM record can be used. No interpolation or extrapolation is used. If the current vegetation age is smaller than *AGE* at the first record, the parameters at the first record are used. If the current vegetation age is larger than *AGE* at the last record, the parameters at the last record are used.

DTM AGE tCrit dCrit rStart DRT DRD

Variable	Type	Value	Description
AGE	float	0/+	Age at or under which the drowning parameters are given
tCrit	float	0/+	The critical drowning time (T_c) above which mortality due to drowning starts
dCrit	float	0/+	The critical drowning depth (D_c) above which mortality due to drowning starts
rStart	float	0/+	Initial vegetation reduction (RD_0 in 1/day) at critical drowning depth (D_c) and after a critical drowning period
DRT	float	0/+	The rate (D_{RT}) at which the vegetation population reduction rate increases with drowning time
DRD	float	0/+	The rate (D_{RD}) at which the vegetation population reduction rate increases with drowning depth

Data Group 10. Mortality by Desiccation

YMT

YMT: Desiccation Method

Required

The YMT record specifies desiccation method of vegetation mortality. The mortality by desiccation can be simulated by desiccation time, the time of separation of water with root, or by a water stress factor, or a combination. During the combination method, the vegetation plant that is younger than 1 year old will be simulated by water stress factor, and the older will be simulated by time of water separation.

YMT dyMETHOD

Variable	Type	Value	Description
dyMETHOD	int	0/1	Desiccation method
		0	No mortality due to drying
		1	Simulated by desiccation time
		2	Simulated by desiccation stress facto.
		3	Simulated by a combination of water stress factor and desiccation tim.

YTM

YTM: Time of Water Separation Parameters

Required when dyMETHOD=1 or dyMETHOD=3

The YTM record specifies a table of age and drying parameters. The vegetation population is calculated by the vegetation reduction rate as in Eq. *2.3*. The time of separation is counted only when the root elevation (the bottom of the root) cannot reach the capillary fringe (Z_{cap}) plus a constant height (D_{dry}), represented as:

$$Z_{root} > Z_{CAP} + D_{dry}$$

In drying mortality mode, the vegetation reduction rate is presented as:

$$R = \begin{cases} 0 & \text{when } T < T_c \\ RY_0 + D_{RT}(T - T_c) & \text{when } T \geq T_c \end{cases}$$

Where;

R=	vegetation reduction rate (1/day)
RY_0 =	initial vegetation reduction (1/day) after a critical drying period
T_c=	critical drying period (day) when vegetation reduction starts
D_{RT} =	rate (1/day^2) at which the vegetation population reduction rate increases with drying period

More than one YTM record can be used. No interpolation or extrapolation is used. If the current vegetation age is smaller than *AGE* at the first record, the parameters at the first record are used. If the current vegetation age is larger than *AGE* at the last record, the parameters at the last record are used.

YTM AGE tCrit dDry rStart DRT

Variable	Type	Value	Description
AGE	float	0/+	Age at or under which the drying parameters are given
tCrit	float	0/+	The critical drying time (T_c) above which mortality due to drying starts
dDry	float	0/+	The constant depth (D_{dry}) plus capillary fringe above which the root is considered separated from water
rStart	float	0/+	Initial vegetation reduction rate (RY_0 in 1/day) after a critical drying period
DRT	float	0/+	The rate (D_{RT}) at which the vegetation population reduction rate increases with drying time

YWT

YWT: Water Stress Table

Required when dyMETHOD=2 or dyMETHOD=3

The YWT record specifies a table of water table decline rates and desiccation/recovery rates for each soil type as shown in Table 2.1. The water stress table is usually used for cottonwoods lesss than 1 year old.

More than one YWT record is be used. No interpolation or extrapolation is used. If the current water decline rate is smaller than rate at the first record, the desiccation/recovery rate at the first record are used. If the current water decline is larger than rate at the last record, the parameters at the last record are used.

YWT ddRate dsRate(1:nSoil)

Variable	Type	Value	Description
ddRate	float	-/0/+	Water table decline rate (m/day or ft/day)
		-	Water table rises
		+	Water table declines
dsRate	float	-/0/+	Water stress desiccation/recovery rate (1/day)
		-	Water stress reduces (recovery)
		+	Water stress increases (desiccation)
nSoil	int	+	Number of soil types given in record VNM

YMN

YMN: Desiccation Mortality Months

Required when dyMETHOD<>0

The YMN record specifies the months that desiccation mortality is allowed.

YMN dryAllowed(1:12)

Variable	Type	Value	Description
dryAllowed	logical	F/T	If desiccation mortality is allowed in the month
		F	desiccation mortality is not allowed in this month
		T	desiccation mortality is allowed in this month

Data Group 11. Mortality by Ice

IMT

IMT: Ice Mortality Method

Required

The IMT record specifies vegetation mortality by ice. Currently, this is only a placeholder for ice mortality, and no mortality by ice is simulated.

IMT icMETHOD

Variable	Type	Value	Description
icMETHOD	int	0	Mortality method by ice
		0	No mortality due to ice is simulated
		1	Mortality due to ice is simulated

Data Group 12. Mortality by Aging

AMT

AMT: Aging Method

Required

The AMT record specifies the aging method of vegetation mortality.

AMT agMETHOD

Variable	Type	Value	Description
agMETHOD	int	0/1	Aging method
		0	No mortality due to aging
		1	Mortality due to aging is simulated

ATM

ATM: Maximum Age

Required when agMETHOD=1

The ATM record specifies the age of the vegetation type. If the age is older than the maximum allowed age, then the vegetation is removed.

ATM maxAGE

Variable	Type	Value	Description
maxAGE	int	+	Maximum age of the vegetation

Data Group 13. End

END

END: End of Input

Required.

The record END is required at the end of the input data file to terminate the data input operations. No variable is required.

END

APPENDIX D - Descriptions of Groundwater Records

The following sections detail the input data for groundwater records. Each record is defined by a three-letter code followed by variables. Each variable can be one of three types: text, integer, or real number data. Each record may contain several variables. Each variable is described as follows:

Variable: Gives the variable name.

Type: The type can be either text, integer (int), or real (float).

Value: Give the potential ranges for this variable.

Description: Describes the significance of this variable.

GMT

GMT: Groundwater Simulation

Required

The GMT record specifies the groundwater simulation method.

GMT gwMETHOD

Variable	Type	Value	Description
gwMETHOD	int	1/2	Groundwater simulation method
		1	Groundwater parameters input by channel location.
		2	Groundwater parameters input by GIS shapefile (currently not available).

GH0/GH1/GH2

GH0/GH1/GH2: Groundwater Parameters—Locations

One of three records is required

The GH0/GH1/GH2 record specifies the locations where the groundwater parameters are given.

If the record GH0 is used, groundwater parameters will be given at each station listed in XST records, in the SRH-1D input file, and no variable is required.

If the record GH1 is used, groundwater parameters will be given at specific stations in the form of station indexes, defined in the SRH-1D input file.

If the record GH2 is used, groundwater parameters will be given at specific locations in the form of longitudinal coordinates (x).

Both location indexes and longitudinal coordinates can be given in ascending or descending order. Additional GH1/GH2 records can be used until all locations are input.

GH0	
GH1	II(1:nt)
GH2	XC(1:nt)

Variable	Type	Value	Description
II	int	+	Station index where groundwater parameters will be given. nt = total number of stations where parameters are given.
XC	float	0/+	Longitudinal coordinate (feet or m) where groundwater parameters will be given. nt = total number of stations where parameters are given.

GHC

GHC: Groundwater Parameters

Required

The GHC record specifies the groundwater parameters. These parameters are given at locations defined in the GH0/GH1/GH2 record.

GHC soil_type hc_l hc_r hcap hv hmin hmax

Variable	Type	Value	Description
soil_type	int	+	Soil type which is linked with the water stress table in record YWT. The soil type input there should be an integer between 1 and nSoil defined in record YWT.
hc_l	float	+	Left floodplain hydraulic conductivity (ft/day or m/day).
hc_r	float	+	Right floodplain hydraulic conductivity (ft/day or m/day).
hcap	float	+	Capillary fringe height (m or ft).
hv	float	+	Groundwater drop velocity (m/s or ft/s).
hmin	float	+	Minimum groundwater elevation below bed surface (m or ft).
hmax	float	0/+	Maximum groundwater elevation above bed surface (m or ft) when the ground is dry.

END

END: End of Input

Required.

The record END is required at the end of the groundwater input data file to terminate the data input operations. No variable is required.

END

APPENDIX E - Descriptions of Air Temperature Records

Each record is defined by a three-letter code followed by variables for air temperature records. Each variable can be one of three types: text, integer, or real number data. Each record may contain several variables. Each variable is described as follows:

Variable: Gives the variable name.

Type: The type can be either text, integer (int), or real (float).

Value: Give the potential ranges for this variable.

Description: Describes the significance of this variable.

TMP

TMP: Temperature

Required

The TMP record provides air temperature as a time-temperature table.

TMP TTMP TMP

Variable	Type	Value	Description
TTMP	float	0/+	Time (hr) at which the air temperature is given.
TMP	float	-/0/+	Air temperature (Fahrenheit or Celsius).