HEC-RAS v.6.0.0 Update for the FEWS

Configuration Manual

DRAFT

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TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 INTRODUCTION

The USACE Hydrologic Engineering Center (HEC) released version 6.0.0 of the HEC-RAS river analysis system software in May 2021. The HEC-RAS v. 6.0.0 updates the v.5.0.7 public release of March 2019 and the v.5.10 currently used by the TVA. New features with the version 6.0.0 include wind forcing, spatial precipitation and infiltration, a 1D Finite Volume solver, DSS7 format output and numerous other enhancements. For the complete description of the new features and changes with v.6.0.0, see the HEC-RAS 6.0 release notes:

https://www.hec.usace.army.mil/confluence/rasdocs/rasrn

The HEC-RAS in FEWS is being updated to stay current with the new HEC-RAS v.6.0.0 and to provide new functionality requested by the National Weather Service (NWS) for their FEWS based CHPS. The NWS requested for enhancements include:

- Wind forcing functionality (Sec. 6)
- 1D Finite Volume solver option (Sec. 5)
- Levee Breaching interactivity with the CHPS/FEWS (Sec. 9)
- Navigation Dams and Elevation Controlled Gates interactivity with the CHPS/FEWS (Sec. 7 & 8)

Other additions and modifications to the new HEC-RAS in CHPS/FEWS include:

- Time series stage output at point locations in 2D areas (Sec. 4.2)
- Option to skip Geometry Processor compute (Sec. 3.1.2 & Sec. 4.2)
- Some Logging changes (Sec. 4.3)

This configuration manual guides the update of the HEC-RAS running in the FEWS. The update of the HEC-RAS to v.6.0.0 in the FEWS consists of:

1) Update of the Java-based HEC-RAS/FEWS model adapter jar files, and update of the HEC-RAS v.6.0.0 compute programs for unsteady and steady flow. (Sec. 2)

2) Update of the HEC-RAS model input files to the v.6.0.0. (Sec. 3)

3) Modifications to the HEC-RAS/FEWS General Adapter and Model Parameter Files. (Sec. 4)

The update of the RAS Mapper in the FEWS follows a similar three-step process (Sec. 10)

1.1 HEC-RAS v.6.0.0, DSS7 Output

The HEC-RAS v.6.0.0 software and program documentation may be downloaded from the HEC website:

https://www.hec.usace.army.mil/software/hec-ras/download.aspx

The HEC-RAS Unsteady compute program stores time series results for 1D cross-sections, hydraulic structures and boundary conditions, and longitudinal profile results in the DSS file format. The DSS file format for the HEC-RAS v.5.0 and earlier versions was DSS6. The HEC-RAS v.6.0.0 now stores computed output in DSS7 format.

DSS format files may be visualized using the HEC-DSSVue program. However older versions of the HEC-DSSVue cannot read the DSS7 file format. To read the DSS7 format files, download the latest version of the HEC-DSSVue program, version.3.2, from the HEC website:

https://www.hec.usace.army.mil/software/hec-dssvue/downloads.aspx

1.2 Versioning for HEC-RAS Adapter

The new adapter has been tested for the Delft-FEWS 2019.02 & 2020.02 and 64-bit Java 11.0.4.

The Java-based HEC-RAS/FEWS model adapter utilizes several Deltares java jar files for PIXML I/O and other processes. The Deltares and supporting libraries used for the v.6.0.0 of the adapter are from the FEWS v.2019.02.

2 HEC-RAS ADAPTER

The HEC-RAS model provides the compute engine for running a hydraulic model schematization for a section of a river or a part of a river system. Two adapters, the FEWS General Adapter and the HEC-RAS Model Adapter form the interface between the FEWS Forecasting Shell and the HEC-RAS model.

The HEC-RAS compute engine is, as its name suggests, the component that performs the HEC-RAS simulation. This simulation is controlled from the adapters, and all run time data such as initial and boundary conditions, and parameter settings are passed through the adapters from and to the FEWS Forecasting Shell.

2.1 INTERFACE BETWEEN FEWS AND HEC-RAS

The adapters for the HEC-RAS forms the interface between the FEWS Forecasting Shell and the HEC-RAS model. The FEWS General Adapter of the Forecasting Shell provides the required run-time data to run HEC-RAS, and calls the HEC-RAS Model Adapter. The data is provided in a standardized XML interface format, the FEWS Published Interface. The HEC-RAS Model Adapter transfers the XML-data into the native HEC-RAS file formats.

Once a HEC-RAS run has been completed, relevant results are passed back by the HEC-RAS Model Adapter to the Forecasting Shell (FEWS General Adapter) in the form of the standardized XML interface format.

A schematic representation of the communication between the Forecasting Shell and the HEC-RAS model via the FEWS Adapter is shown in the Figure 1.

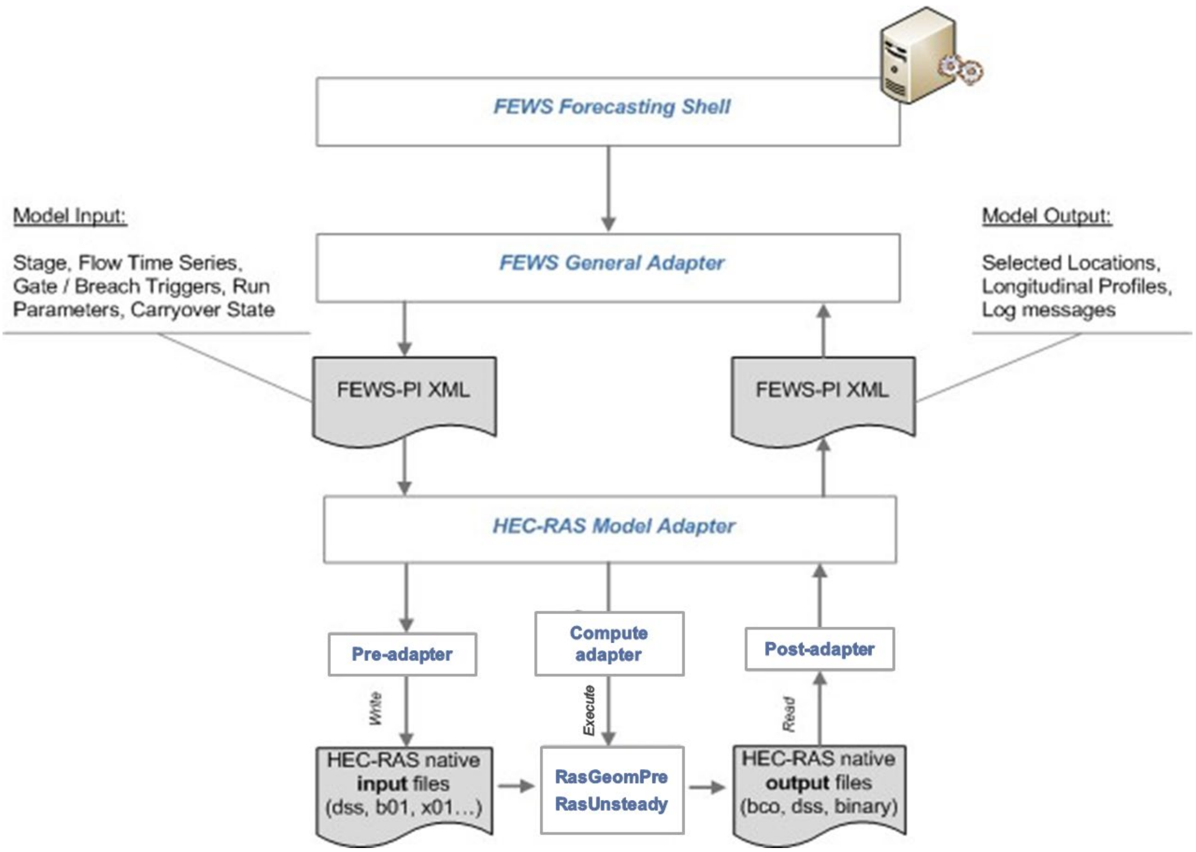


Figure 1 Data flows involved during run of the HEC-RAS model FEWS adapter (modified from Deltares, 2011). The FEWS Adapter allows running of HEC-RAS by FEWS. The FEWS Adapter should be considered as a thin communication (software) layer on top the existing HEC-RAS engine. The adapter is tightly connected to the model engine.

Note that the HEC-RAS/FEWS adapter operates in three steps for a forecast run:

1) PreProcess (Pre-adapter) step - Inputs the PIXML time series boundary conditions and model options from the FEWS to update the HEC-RAS model input files for the forecast.
2) Compute step - Launches the HEC-RAS executable programs, RasGeomPreprocess and RasUnsteadyFlow, to perform an unsteady flow compute.
3) PostProcess (Post-adapter) step - Reads the HEC-RAS DSS results file and writes the computed time series and longitudinal profiles in PIXML format for import back into the CHPS. Optionally sets up and runs the HEC-RAS Post Processor program, RasSteady, to compute the detailed hydraulic output variables.

2.2 Directory Structure and Model Adapter Update

The directory structure of HEC-RAS in the FEWS is pictured in Figure 2. The figure identifies the directories which the contents need to be updated:

ColdStateFiles – need to regenerate the model *.rst file for HEC-RAS v.6.0.0 by running the HEC-RAS GUI (Sec 3.1.5).

ModuleDataSetFiles – update HEC-RAS model input files to v.6.0.0 by running the HEC-RAS GUI (Sec 0).

ModuleConfigFiles – update the HEC-RAS General Adapter as needed (Sec 4).

Models/HEC-RAS/bin/ HECRAS_v.6.0.0 – HEC-RAS v.6.0.0 compute executables and supporting libraries

Models/HEC-RAS/bin/RAS_Adapter_6_0_0 – Java based HEC-RAS/FEWS model adapter files for the HEC-RAS v.6.0.0.

Models/HEC-RAS/bin/ RasMapper_Adapter_6_0_0 – Java based RAS Mapper/FEWS model adapter files for the RAS Mapper v.6.0.0 module (Sec. 10).

The contents of the Java based HEC-RAS/FEWS model adapter in the Models/HEC-RAS/bin/RAS_Adapter_6_0_0 directory are shown in Figure 3. The model adapter utilizes several Deltares Java libraries for PIXML I/O. The Deltares jar files used by the model adapter are from the FEWS 2019.02. HEC Java libraries and supporting *.dll libraries are used for DSS file I/O.

The nwsras.jar and module-adapter-hec-ras.jar Java jar files are the customized HEC-RAS specific files of the model adapter.

nwsras.jar – Provides the I/O interface and utilities for the HEC-RAS model files.

module-adapter-hec-ras.jar – Reads the PIXML time series, run file and model parameter file from the CHPS and updates the HEC-RAS model files with calls to the nwsras.jar functions. Sets up and launches the HEC-RAS computational programs. Converts HEC-RAS results to PIXML format for input back to the CHPS.

NOTE! When running inside the FEWS GUI, a “DuplicateJars” warning may occur for the slf4j-api logger jar as the logger classes may also be loaded from the netcdfAll jar:

```

INFO - LocalTaskDispatcher.ExecuteJavaActivity.run
        - GA Execution Started nl.wldelft.fews.adapter.hec.HecRasAdapter
WARN - nl.wldelft.fews.adapter.hec.HecRasAdapter.main.BinDirClassLoader.detectAndLogDuplicateJars -
        Class org/slf4j/LoggerFactory.class found in multiple jars
          /home/NWS_FEWS_2021/RMA_Test/Models/HEC-RAS/bin/RAS_Adapter/slf4j-api-1.7.5.jar;
          /home/NWS_FEWS_2021/RMA_Test/Models/HEC-RAS/bin/RAS_Adapter/netcdfAll-4.6.10.jar
```

Remove the slf4j-api-1.7.5.jar file from the adapter directory if the warning occurs.

The HEC-RAS executables and supporting libraries are located in the Models/HEC-RAS/bin/HECRAS_v.6.0.0 directory. The directory contents are shown in Figure 4, and consist of the programs and files from the standard HEC-RAS v.6.0 install package. The computational programs and supporting libraries are contained in the \x64 directory. Some of the unused compute programs, such as the RasUnsteadySediment.exe, have been removed to conserve space. When setting up the HEC-RAS/FEWS General Adapter, the path to the executables location is set with the run file property, hecRasBinDirectory:

<string key="hecRasBinDirectory" value="$HECRASBINDIR$/HECRAS_v.6.0.0/x64"/>

The RAS Mapper program and libraries are in the top directory and the GDAL support directory. The RAS Mapper computes are launched through the HECRAS_v.6.0.0/RasProcess.exe, thus the hecRasBinDirectory for the RAS Mapper run should be:

<string key="hecRasBinDirectory" value="$HECRASBINDIR$/HECRAS_v.6.0.0"/>

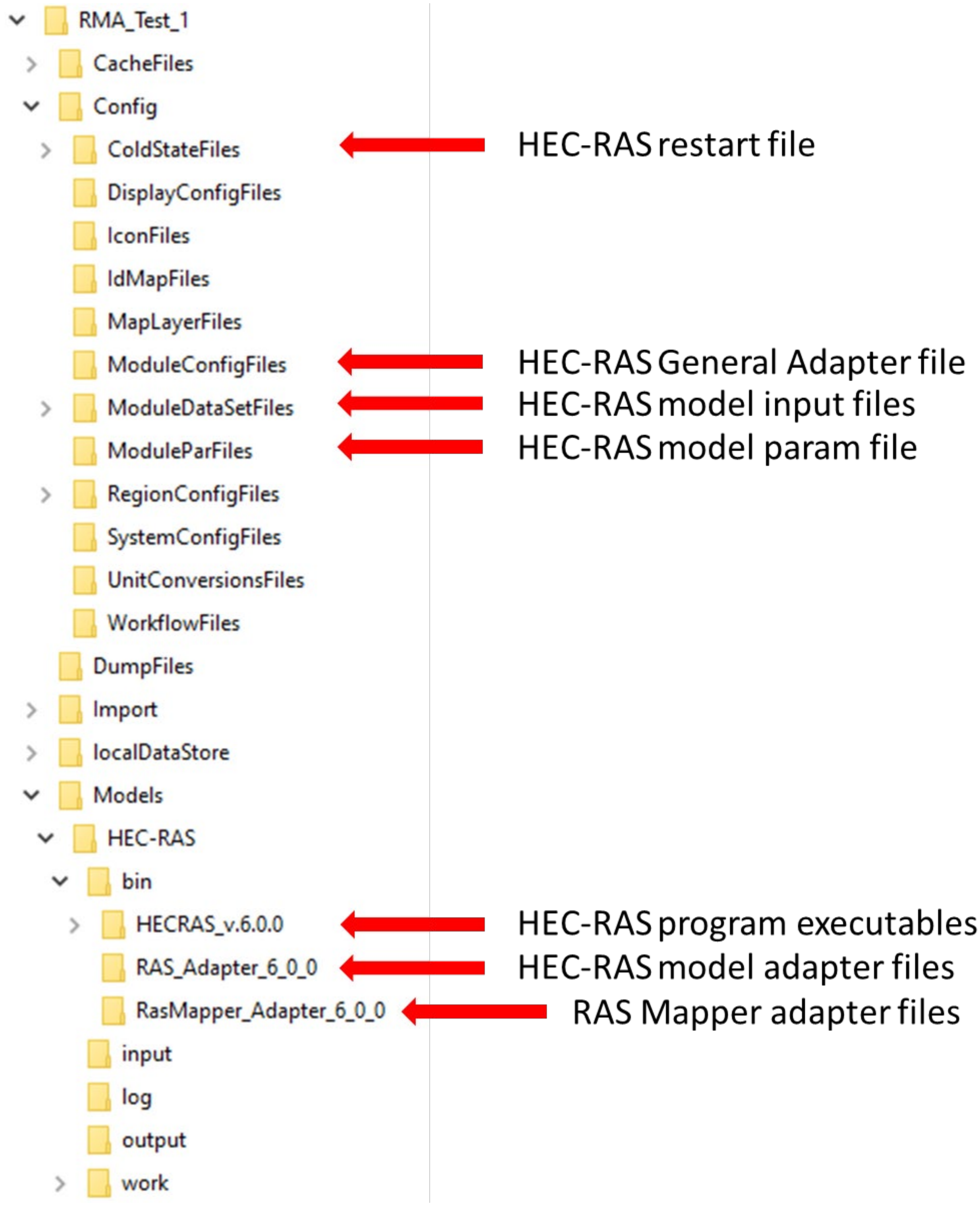


Figure 2 Directory structure for the HEC-RAS in FEWS. The directories requiring updates for the HEC-RAS v.6.0.0 are indicated.

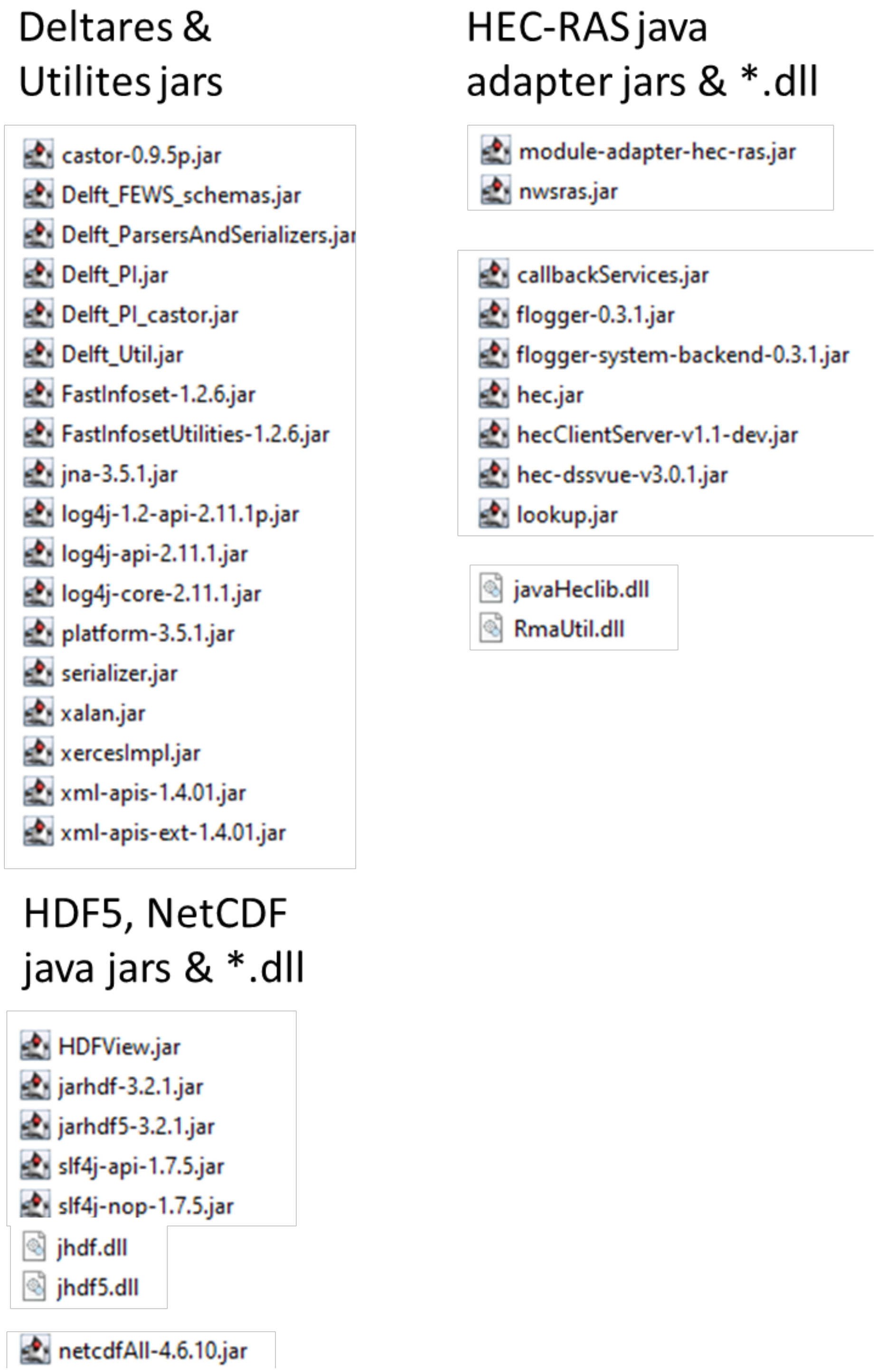


Figure 3 HEC-RAS Model Adapter files in the Models/HEC-RAS/bin/RAS_Adapter_6_0_0 directory. The Deltares & Utilities jar files are from the FEWS 2019.02.

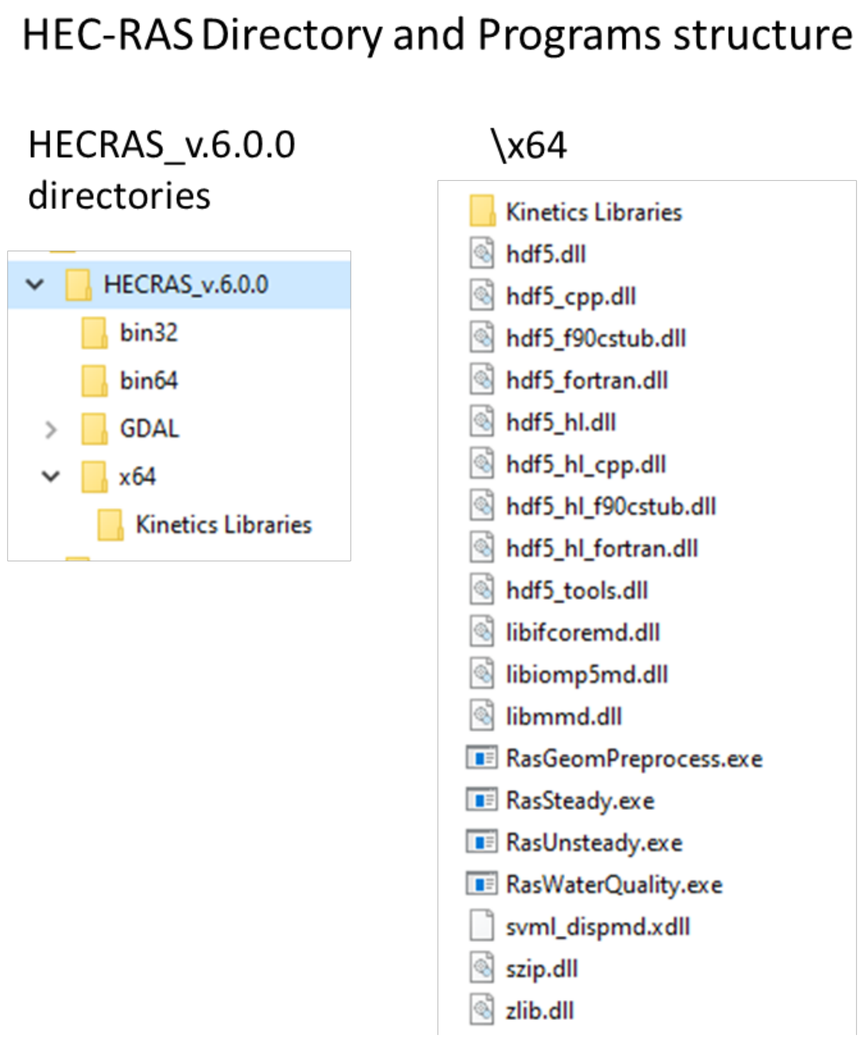


Figure 4 HEC-RAS v.6.0.0 directories and executables in the Models/HEC-RAS/bin/ HECRAS_v.6.0.0 directory.

3 UPDATE OF THE HEC-RAS MODEL FILES FOR V.6.0.0 OF THE HEC-RAS

The procedures outlined below assumes the update of an existing HEC-RAS v.5.0 system to v.6.0.0.

In short, the approach to update a HEC-RAS model in CHPS is as follows.

1) Run the HEC-RAS model system with the v.6.0.0 GUI to update the model input files.
2) Copy the HEC-RAS GUI generated files to the FEWS environment.

The HEC-RAS v.6.0.0 Windows based software may be downloaded from the HEC website here:

https://www.hec.usace.army.mil/software/hec-ras/download.aspx

The update of files for the RAS Mapper module is covered in Sec. 10.

3.1 UPDATE THE HEC-RAS MODEL FILES WITH THE V.6.0.0 HEC-RAS GUI

The HEC-RAS model river system created in from the earlier v.5.0 will need to be run from the HEC-RAS GUI to update the model files for the new version of the HEC-RAS in FEWS. **The HEC-RAS v.6.0.0 in the FEWS is not compatible with the v.5.0 model files.**

To generate the new model files, use the HEC-RAS GUI v.6.0.0 to import the existing HEC-RAS river system project. If a new HEC-RAS river system (not already in the FEWS) has been developed with the HEC-RAS GUI v.6.0.0, the required model files are the same and the subsequent discussion still applies. The procedures below assume the presence of an existing HEC-RAS project on the Windows OS. If the model files are only available from current FEWS configurations, the required HEC-RAS GUI input files are:

<u>1D Systems</u>

*.prj - HEC-RAS project file
*.p01 - model input plan file
*.g01 - model input geometry
*.u01 - model input unsteady flow file

NOTE! HEC-RAS systems with 2D regions have the 2D geometry data stored in the *.g01.hdf file that will need to be updated. Updating river system models with 2D regions in the HEC-RAS GUI will require the terrain data used in developing the original v.5.0 files.

3.1.1 Open HEC-RAS project in Windows GUI

The RAS "Levee Breach" example project is used for illustration. The set of v.5.0 files previously setup for the FEWS are used as an example. The demonstration assumes the user has a working knowledge of the HEC-RAS GUI.

Open the HEC-RAS project file in the working directory as shown in Figure 5.

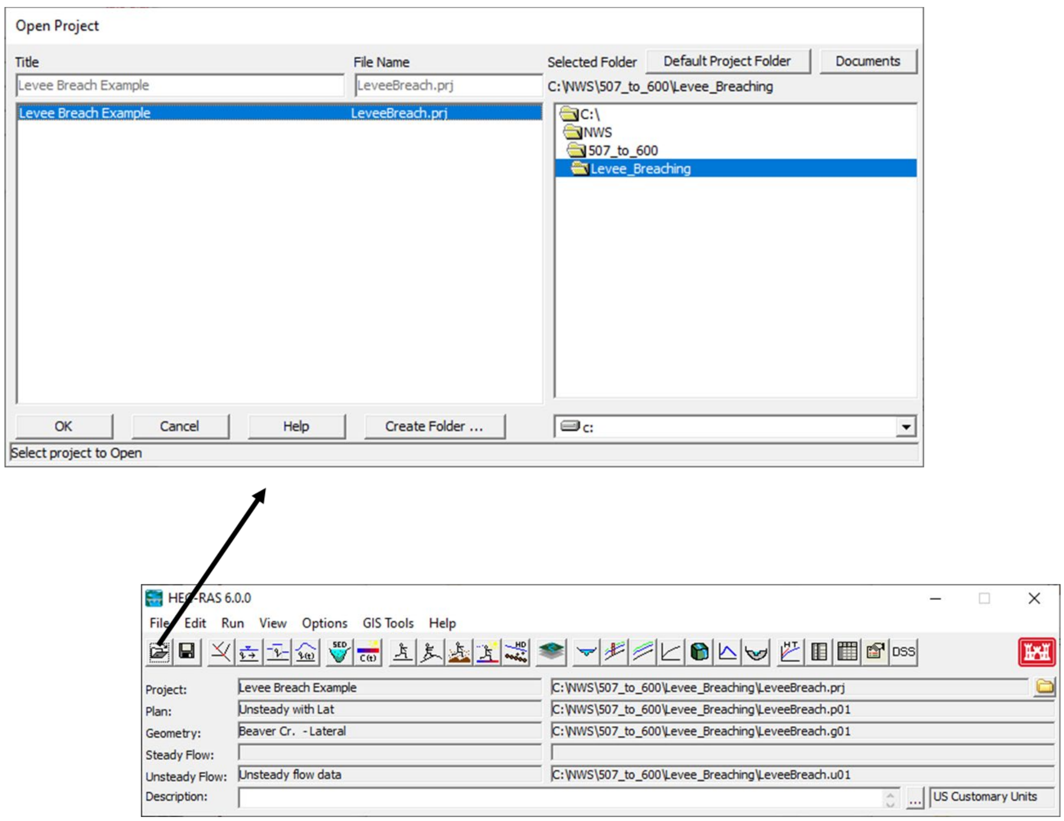


Figure 5 HEC-RAS GUI open project dialog (top) and main dialog (bottom).

3.1.2 Generate HEC-RAS model files for v.6.0.0, Overview

The new HEC-RAS model adapter and compute executables are only able to read v.6.0.0 of the model input files. The older (e.g. v.5.0.3, v.5.0.7, v.5.10) version of the files will need to be updated using the HEC-RAS GUI v.6.0.0. The HEC-RAS GUI generates several text based and two HDF5 format model files that will be transferred to the HEC-RAS/FEWS "ModuleDataSetFiles" directory replacing those generated with the v.5.0 GUI.

Presently the new HDF5 format files primarily store data pertinent to the HEC-RAS 2D regions. Over the longer term, the HDF5 format files are intended to replace the text based input files in the future versions of the HEC-RAS.

The text based files required by the HEC-RAS in FEWS are divided into two groups (1) and (2). For the example "LeveeBreach" project these are:

1) The model files input to the HEC-RAS GUI:

   LeveeBreach.prj
   LeveeBreach.p01
   LeveeBreach.g01
   LeveeBreach.u01

2) The text based files generated by the HEC-RAS GUI for a Geometry Preprocessor (*.x01) and Unsteady flow run (*.b01):

   LeveeBreach.x01
   LeveeBreach.b01

In addition to the text base files,

3) The HDF5 format files required by the HEC-RAS geometry and unsteady programs are:

   LeveeBreach.g01.hdf
   LeveeBreach.p01.tmp.hdf

4) **NEW!** - The RAS Geometry Preprocessor compute can now be optionally skipped in the HEC-RAS/FEWS forecast run. The HEC-RAS geometry preprocessor program (RasGeomPreprocess) inputs the *.x01 text file to create a binary format *.c01 file containing the hydraulic properties and rating curves for the model 1D cross-sections and structures. The *.c01 file is then read in by the RasUnsteady program for the unsteady flow compute.

   LeveeBreach.c01

3.1.3 Update versions of the HEC-RAS GUI model input files.

The HEC-RAS GUI input files listed in (1) are updated by opening the corresponding data editor and performing the file "Save" operation. The program version number appears in the second line of the text model file and should be 6.00. Figure 6 illustrates this for the Unsteady Flow and Geometric Data editors. The *.p01 (Plan file) is updated with the file save operation in the Unsteady Flow Analysis dialog. The *.prj (RAS project) file is saved from the main HEC-RAS GUI dialog.

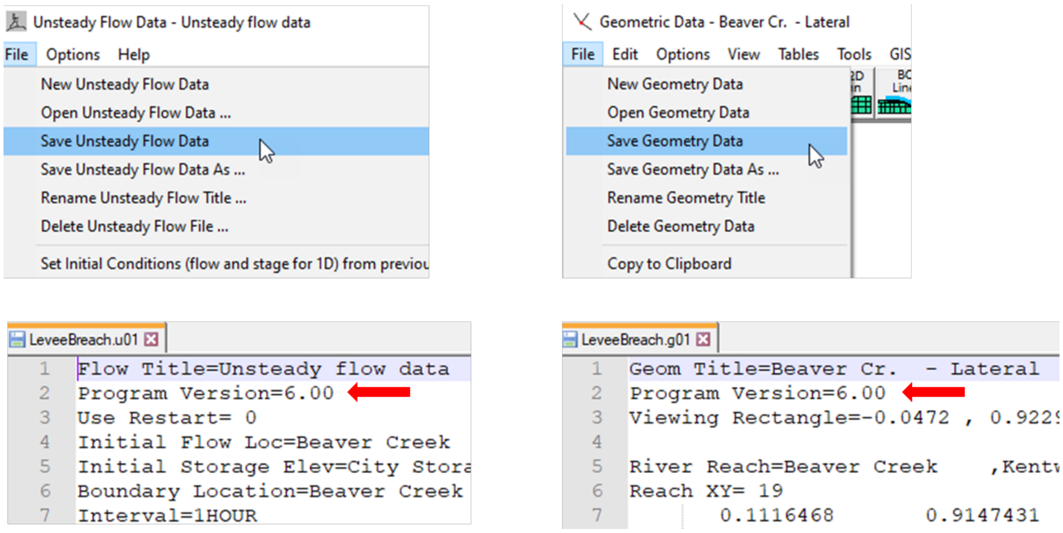


Figure 6 Update of the Unsteady Flow Data (left) and Geometry Data (right) text files through the HEC-RAS data editors.

3.1.4 Open the Unsteady Flow Analysis dialog and run computes

The Geometry Preprocessor and Unsteady Flow Simulation computes will need to be run to create several of the updated model input files for the HEC-RAS model in the FEWS – the *.x01, *.b01, *.g01.hdf and *p01.tmp.hdf, and *.c01 files noted above.

Open the “Unsteady Flow Analysis” dialog (Figure 7) and check the “Geometry Preprocessor” and “Unsteady Flow Simulation” boxes and click “Compute”.

The generation of a HEC-RAS restart file may also be needed for the HEC-RAS setup in the FEWS – **See 3.1.5 for restart file considerations**.

The compute will generate a *.p01.hdf file with the plan information and the computed results. The *.p01.hdf will need to have the “Results” HDF data group removed and the file renamed to *.p01.tmp.hdf. The “*.p01.tmp.hdf” file contains only the input run information and can be a much smaller file, especially for 2D models. The contents of the two plan HDF files are compared in Figure 8. **The RasUnsteady compute will not proceed if the “Results” data group is detected in the plan hdf file.**

The “Results” data group can be removed from the plan hdf file using a small Python program (Figure 9):

C:>python remove_HDF5_Results.py LeveeBreach.p01.hdf

In this case, the output of the program is the file, LeveeBreach.p01.tmp.hdf.

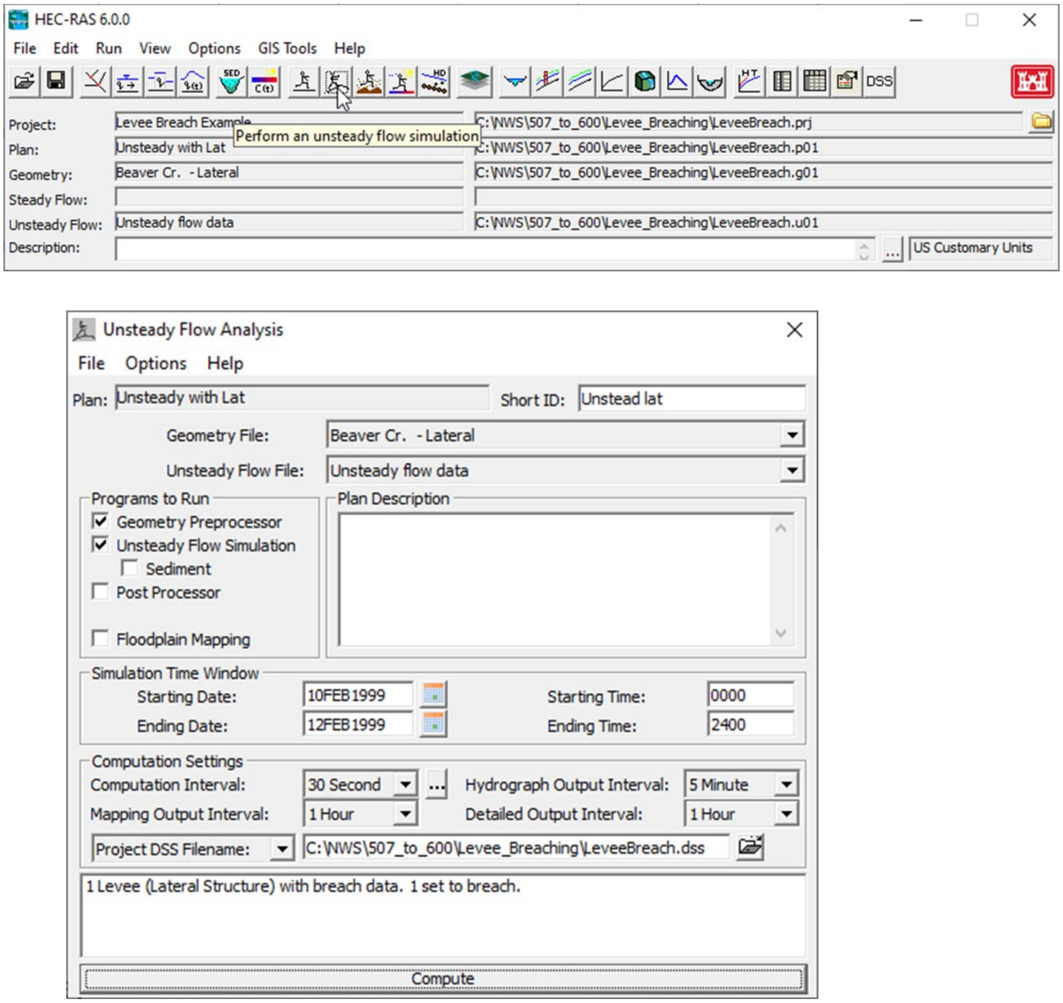


Figure 7 HEC-RAS GUI Unsteady Flow Analysis dialog for performing the Geometry Preprocessor and Unsteady Flow Simulation computes for generating the model input files for the HEC-RAS in FEWS. The Unsteady Flow Analysis dialog is accessed from the HEC-RAS main dialog (note cursor in top figure).

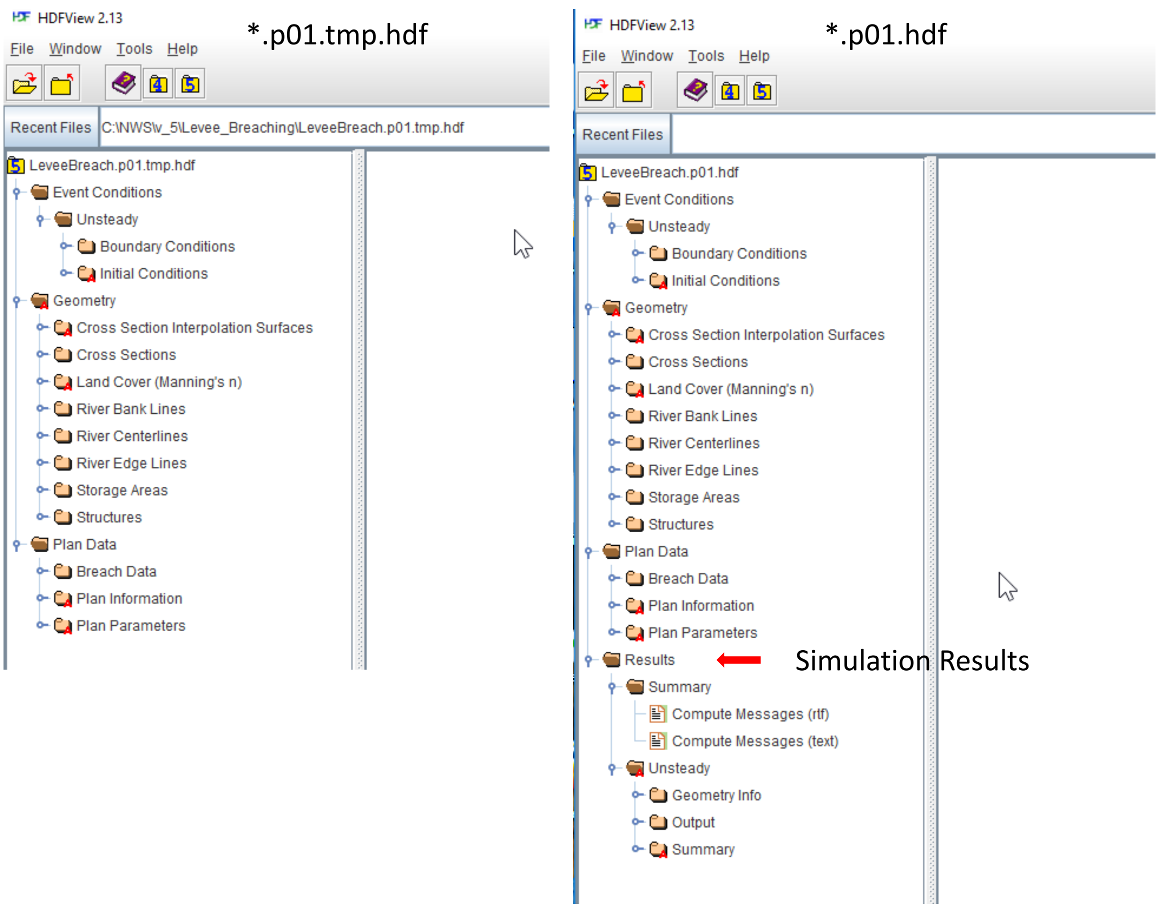


*Figure 8 Comparison of the contents for the *.p01.tmp.hdf (left) and the *.p01.hdf (right) HDF5 files.*

remove_HDF5_Results.py

```python
'''
Created on Mar 29, 2019

@author: scott
'''
import h5py
import sys
from shutil import copyfile
import os

filename = sys.argv[1]

fsource = h5py.File(filename, 'r')
fdest = h5py.File(os.path.splitext(filename)[0] + '.tmp.hdf', 'w')

# copy attributes
for fattr in  fsource.attrs.keys() :
    fdest.attrs[fattr]= fsource.attrs.get(fattr)

# copy groups, except Results
for fg in  fsource.keys() :
    if fg != "Results" :
        fsource.copy( fg, fdest )

fdest.close()
fsource.close()
```

*Figure 9 Python script for creating the *.p01.tmp.hdf file from the computed *.p01.hdf file with the "Results" data group removed. The command line argument is the name of the *.p01.hdf file for processing. The Python utility requires the "h5py" library.*

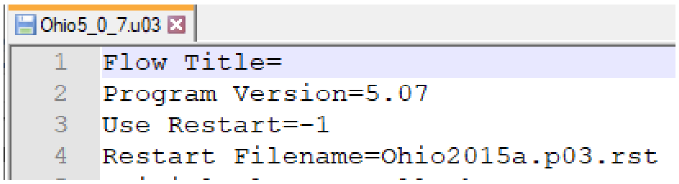
3.1.5 HEC-RAS restart file considerations

If the HEC-RAS GUI unsteady flow compute attempts to input a restart file from an earlier version of HEC-RAS, a compute error will likely occur (Figure 10). A new restart file will need to be generated starting from initial conditions set on the Unsteady Flow Data dialog. With HEC-RAS v.6.0.0, initial flows left blank in the Initial Conditions tab of the Unsteady Flow Data dialog result in the initial flow being set to the first value of the input hydrograph.

For the HEC-RAS setup in the FEWS, a restart file will need to be generated for the later copy to the ColdStateFiles directory in the HEC-RAS/FEWS. Figure 11 presents the HEC-RAS – Set Output Control Options dialog, where the output restart file option will be set. The dialog is accessed from the "Options->Output Options …" menu on the Unsteady Flow Analysis dialog.

Make sure the "Write Initial Conditions file at the end of the simulation" box is checked. The FEWS may require this *.rst file for state handling and will be copied to the ColdStateFiles directory (see Sec. 3.2). The FEWS will not use additional initial condition files written during the simulation, so there is no need to choose the option "Write Initial Condition file(s) during simulation."

IMPORTANT NOTE: If you generate these files using the HEC-RAS GUI, you will need to be sure that the *.b01 and *.u01 files reference the same restart file name used in the General Adapter file/ModuleConfigFiles directory. **It is recommended to edit the restart file names in *.b01 and *.u01 produced by Windows HECRAS to eliminate the data time stamp**. For example, 'ctdamlevee.p29.01FEB2008 0100.rst' would be changed to 'ctdamlevee.p29.' Note the "Restart Filename" in the unsteady flow file,



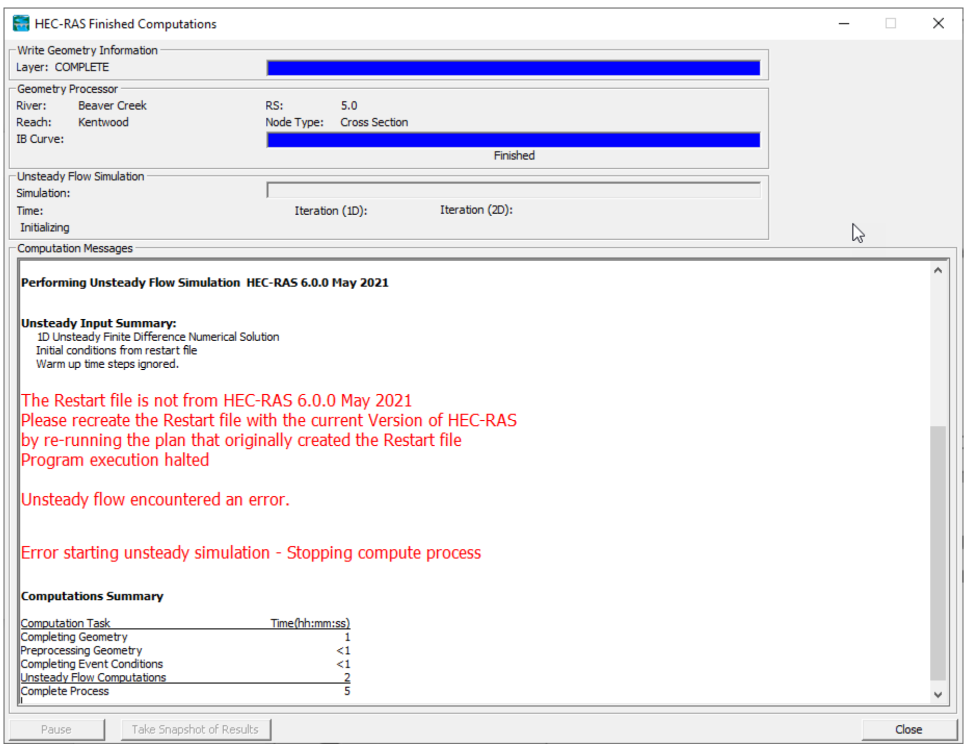


Figure 10 Error generated in the HEC-RAS GUI Unsteady Flow Simulation when using a restart file from an earlier version of HEC-RAS.

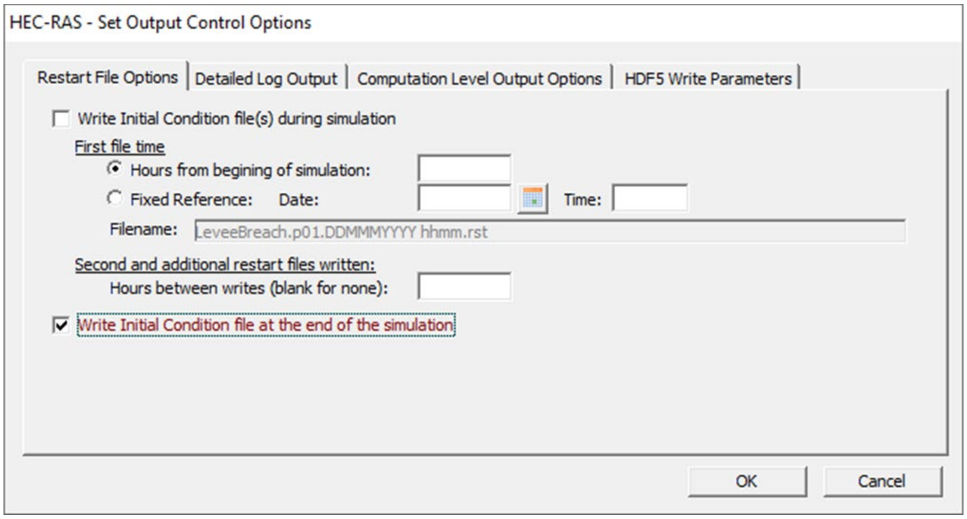


Figure 11 Setting option to write restart file.

3.2 COPY THE HEC-RAS MODEL FILES TO THE FEWS ENVIRONMENT

The HEC-RAS model files discussed in Sec. 3.1 must be copied from the HEC-RAS GUI work directory to the FEWS environment. These file are:

- .prj
- .p01
- .g01
- .u01
- .b01
- .x01
- .p01.tmp.hdf
- .g01.hdf

- .c01 if the Geometry Preprocess step is to be skipped in the FEWS forecast run.

After the procedures above, the files will be zipped and copied to the "Config/ModuleDataSetFiles" directory.

If used, the HEC-RAS restart file (e.g. "*.p01.rst") will be copied to the "Config/ColdStateFiles" directory.

4 UPDATE OF THE HEC-RAS V.6.0.0 GENERAL ADAPTER

Some change may be required to the existing to the HEC-RAS/FEWS General Adapter for the v.6.0.0. The new items for consideration are:

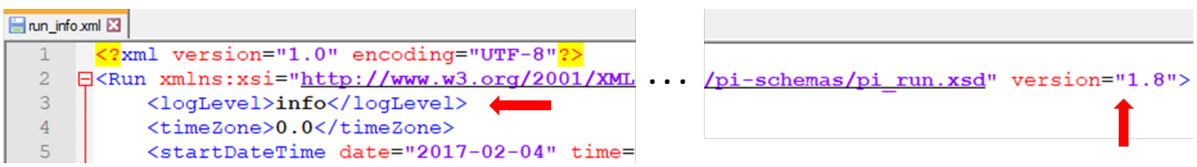
- PiVersion ID (required)
- NetCDF Wind File Input (unsteady runs with wind)
- New Run Info properties

The HEC-RAS/FEWS model adapter v.6.0.0 is compliant with PiVersion 1.8 and requires the piVersion element be specified in the “general” settings of the General Adapter:

```
<general>
    <description>HECRAS Model for Test</description>
    <piVersion>1.8</piVersion>

    . . .
<general/>
```

The result of the piVersion setting to the run info file is the “logLevel” line reflecting the FEWS logging level, and the “version=1.8” field.



The HEC-RAS model adapter expects the <logLevel> element and will fail if not found.

4.1 EXPORT GRIDDED WIND FILE (WHEN WIND FORCING IS MODELED)

If the HEC-RAS system is properly setup for wind forcing, the time series gridded wind field is exported by the FEWS in NetCDF format. In the example below, the time series gridded wind direction (UD) and speed (US) records are exported to the NetCDF format file “Wind.nc” for input and processing by the HEC-RAS model adapter:

```xml
<exportNetcdfActivity>
    <exportFile>Wind.nc</exportFile>
    <timeSeriesSets>
        <timeSeriesSet>
            <moduleInstanceId>Preprocess_UD_HECRAS</moduleInstanceId>
            <valueType>grid</valueType>
            <parameterId>UD</parameterId>
            <locationId>RAS_KYBK</locationId>
            <timeSeriesType>external forecasting</timeSeriesType>
            <timeStep unit="hour" multiplier="1"/>
            <relativeViewPeriod unit="hour" start="-360" startOverrulable="true"
            <readWriteMode>read only</readWriteMode>
        </timeSeriesSet>
        <timeSeriesSet>
            <moduleInstanceId>Preprocess_US_HECRAS</moduleInstanceId>
            <valueType>grid</valueType>
            <parameterId>US</parameterId>
            <locationId>RAS_KYBK</locationId>
            <timeSeriesType>external forecasting</timeSeriesType>
            <timeStep unit="hour" multiplier="1"/>
            <relativeViewPeriod unit="hour" start="-360" startOverrulable="true"
            <readWriteMode>read only</readWriteMode>
        </timeSeriesSet>
    </timeSeriesSets>
</exportNetcdfActivity>
```

The corresponding output line to run file line is:

```xml
<inputNetcdfFile>/test-data/KentuckyBarkley_600/input/Wind.nc</inputNetcdfFile>
```

Setup of the HEC-RAS model for wind forcing is further discussed in section 6.

4.2 Run File Properties

Some basic information and model options are set in the <exportRunFileActivity> <properties> section and exported to the run info file for the HEC-RAS/FEWS run:

```xml
<exportRunFileActivity>
    <exportFile>%ROOT_DIR%/run_info.xml</exportFile>
    <properties>
        <string key="logLevel" value="DEBUG"/>
        <string key="showRasWindows" value="false"/>
        <string key="skipGeometryPreprocessor" value="true"/>
        <string key="hecRasBinDirectory" value="$HECRASBINDIR$/HECRAS_v.6.0.0"/>
        <string key="hecRasProjectFile" value="%ROOT_DIR%/work/model.prj"/>
        <string key="skipBinaryOutput" value="true"/>
        <string key="outputTimeSeriesParametersFilter" value="^STAGE$|^FLOW$"/>
        <string key="outputLongtitudionalProfileParametersFilter" value="^LOCATION-FLOW$|^LOCATION-ELEV$"/>
        <string key="2dOutputParametersFilter" value="WSE"/>
        <string key="2dOutputLocation" value="2D Interior Area:cell 2117"/>
        <string key="2dOutputLocation1" value="2D Interior Area:cell 1960"/>
    </properties>
</exportRunFileActivity>
```

Some new run file options have been added, and features of the new and existing run properties are detailed below.

*Table 1 List and description of the HEC-RAS/FEWS run file properties. New properties shown in **bold**.*

Property key	**Default**	**Value, description**
logLevel	FEWS Log Level	Sets the log level for saving messages to the HEC-RAS adapter diagnostic log file.
showRasWindows	false	**true** = Save the console output from RAS programs to the diagnostic log file (only if logLevel is DEBUG)
skipGeometryPreprocessor	false	**false** = Run the rasGeomPreprocess program to generate 1D geometry file (*.c01) and *.g01.hdf file. **true** = Use the *.c01 and *.g01.hdf files copied from the ModuleDataSet
hecRasBinDirectory		Directory containing HEC-RAS compute programs
hecRasEnvironment **Linux Only**		Use to add the HEC-RAS programs directory for finding required HEC-RAS and system *.so libraries.
hecRasProjectFile		HEC-RAS GUI project file name.
skipBinaryOutput	false	**false** = Run the HEC-RAS post processor program to generate detailed hydraulic output for *1D cross-sections* (e.g. E.G. Elev, Flow Area). **true** = Do not run the HEC-RAS post processor program
outputTimeSeries ParametersFilter		HEC-RAS parameters for time series export to FEWS PIXML format.
outputLongtitudional ProfileParametersFilter		HEC-RAS parameters for profile time series export to FEWS PIXML format
2dOutputLocation, 2dOutputLocation1, 2dOutputLocation2, etc.		Time series output location for 2D Areas. The form for the string value is, <2D Area Name>:cell <cell number>. e.g. "Upper Reservoir:cell 294"
2dOutputParametersFilter		Currently only water surface elevation (WSE) is available for output. "WSE", "STAGE", and "ELEV" all output a "STAGE" time series in PIXML format.

Selected run file properties are described in detail below.

logLevel

Sets the log level for saving messages to the HEC-RAS adapter diagnostic log xml file. If set to "DEBUG", the DEBUG level messages may not appear in the FEWS GUI "Logs" window, however the DEBUG log messages will be written to the HEC-RAS diagnostic log file. If the logLevel property is not provided, adapter logging defaults to FEWS logging level.

showRasWindows

During execution, the HEC-RAS compute programs output text messages to the console to show progress or to message run time errors. If showRasWindows=true and the logLevel set to DEBUG, the compute messages are saved to the diagnostic log file. This feature was turned off in some previous versions of the HEC-RAS adapter as the HEC-RAS programs console output contain Null characters causing the logging parser to crash. This situation does not occur with the HEC-RAS v.6.0 programs.

Figure 12 shows the partial console output from the RasUnsteady program. NOTE! Setting the option to “true” may result in large volumes of output written to the diagnostic log file.

However, saving the console output can be useful in debugging issues with the compute programs. Figure 13 displays the logfile output from the RasUnsteady program in a Linux FEWS environment, and indicates a missing *.so library.

skipGeometryPreprocessor

The HEC-RAS geometry preprocessor program (RasGeomPreprocess) inputs the *.x01 text file to create a binary *.c01 file containing the hydraulic properties and rating curves for the model cross-sections and structures for an unsteady flow compute. If there are no geometry changes for a forecast run, then the geometry preprocessor compute is not necessary.

Setting the “skipGeometryPreprocessor=true” will save time in the forecast run by skipping the geometry preprocessor step. NOTE! The *.c01 file generated by the HEC-RAS GUI compute will need to be included in the ModuleDataSet files for the HEC-RAS system (Sec. 3.1.2 & 3.2). The text based *.x01 still needs to be provided in the ModuleDataSet files.

skipBinaryOutput

The HEC-RAS GUI “Post Processor” compute is replicated in the HEC-RAS/FEWS run when the “skipBinaryOutput=false”. In the standard HEC-RAS unsteady flow compute, stage and flow are the only parameters output at the 1D cross-sections and structures. The HEC-RAS post processor program will generate detailed hydraulic output for 1D cross-sections, for example “E.G. Elev” and “Flow Area”. The complete list of parameters for output is available in the HEC-RAS GUI “Create a Table Heading” dialog accessed from the Profile Output Table dialog “Options->Define Table” menu. The list of available output parameters is also written to the diagnostic log file when the “skipBinaryOutput=false” and the “logLevel=DEBUG”.

If the additional hydraulic parameters are not of interest, set the “skipBinaryOutput=true” to save compute time during the forecast run. NOTE! The Post Processor compute does NOT generate the additional parameter output for the 2D system areas.

outputTimeSeriesParametersFilter

The HEC-RAS adapter uses the “regular expression” or “regex” syntax for filtering the time series output from the HEC-RAS compute for results export back to the FEWS in PIXML format. The DSS pathnames written on the HEC-RAS results DSS file are scanned using the filter and those with parameter names (DSS Part-C) fitting the filter are written to the output.xml file. The common regex special characters for defining filters are:

^	begins with
$	ends with
|	or

Thus “^FLOW$” would return only the DSS records with parameters of only “FLOW”, whereas “^FLOW” would return all DSS starting with “FLOW”, such as “FLOW-HW-DS” and “FLOW-TOTAL”

The Post Process compute (skipBindaryOutput=false) generates additional hydraulic parameters stored on the HEC-RAS binary result file (*.O01). To output these parameters back to the FEWS, add the desired parameters to the filter (e.g. “^STAGE$|^Flow Area$). Note that these additional parameter times series are written out to the output.xml file for ALL cross-sections.

outputLongtitudionalProfileParametersFilter

The regex filter process is similar to the outputTimeSeriesParametersFilter. Currently the supported time series profile parameters from the HEC-RAS unsteady compute are “LOCATION-ELEV” and “LOCATION-FLOW”.

2dOutputLocation

Identifies a 2D area and computational cell for outputting a WSE (STAGE) time series to the PIXML output.xml file. With the FEWS software, each run file property key must be unique. Thus each 2dOutputLocation key must carry a different suffix, e.g. “2dOutputLocation”, “2dOutputLocation1”, “2dOutputLocation2”, etc.

For the HEC-RAS Muncie example problem, the locations would be:

```
<string key="2dOutputLocation" value="2D Interior Area:cell 2117"/>
<string key="2dOutputLocation1" value="2D Interior Area:cell 1960"/>
```

Figure 14 illustrates how to identify the cell numbers in the 2D regions using the RAS Mapper display.

```
FONT= BOLD

Performing Unsteady Flow Simulation  HEC-RAS 6.0
FONT= NORMAL
 PROGRESS=     .1000000
LABEL= Reading Data
 PROGRESS=     .2000000
 PROGRESS=     .3000000
LABEL= Initializing
 PROGRESS=      .000000
LABEL= Reading 2D Area(s)
LABEL= initializing 2D Area(s)
FONT= BOLD

Unsteady Input Summary:
FONT= BLACK
     1D Unsteady Finite Difference Numerical Solution
     Number of warm up time steps:   20
     2D Unsteady Diffusion Wave Equation Set (fastest)
 PROGRESS=     .3000000
 PROGRESS=     .4000000
 PROGRESS=     .5000000
 PROGRESS=     .6000000
 PROGRESS=     .7000000
 PROGRESS=     .8000001
 PROGRESS=     .9000001
 PROGRESS=     .6000000

Maximum adaptive timestep = 05:00.0    Minimum adaptive timestep = 00:09.375
FONT= GREEN
Initial adaptive timestep = 00:37.5


FONT= BLACK
 PROGRESS=      .000000
LABEL= Initial Backwater
LABEL= Initial Backwater
 PROGRESS=     .6125000
 PROGRESS=     .6250000
```

Figure 12 Console output from the RasUnsteady program.

```
19      <line level="3" description="Skipping GeometryPreprocessor, will use existing model files"/>
20      <line level="3" description="Running Unsteady ..."/>
21      <line level="4" description="Running program: /home/Ras_6_cmd_line_tests/bin/RAS_Prog_6_0_0/ra
22      <line level="4" description="Enviroment vars: LD_LIBRARY_PATH=/home/Ras_6_cmd_line_tests/bin/R
23      <line level="4" description="exec %s"/>
24      <line level="4" description="/home/Ras_6_cmd_line_tests/bin/RAS_Prog_6_0_0/rasUnsteady:
25                          error while loading shared libraries: libquadmath.so.0:
26                          cannot open shared object file: No such file or directory"/>
27      <line level="4" description="/"/>
28      <line level="3" description="Parsing HEC-RAS log files  ..."/>
```

Figure 13 RasUnsteady console output echoed to the diagnostic log file. Line 24 shows the program did not find the shared object library, “libquadmath.so.0” (from a Linux FEWS run).

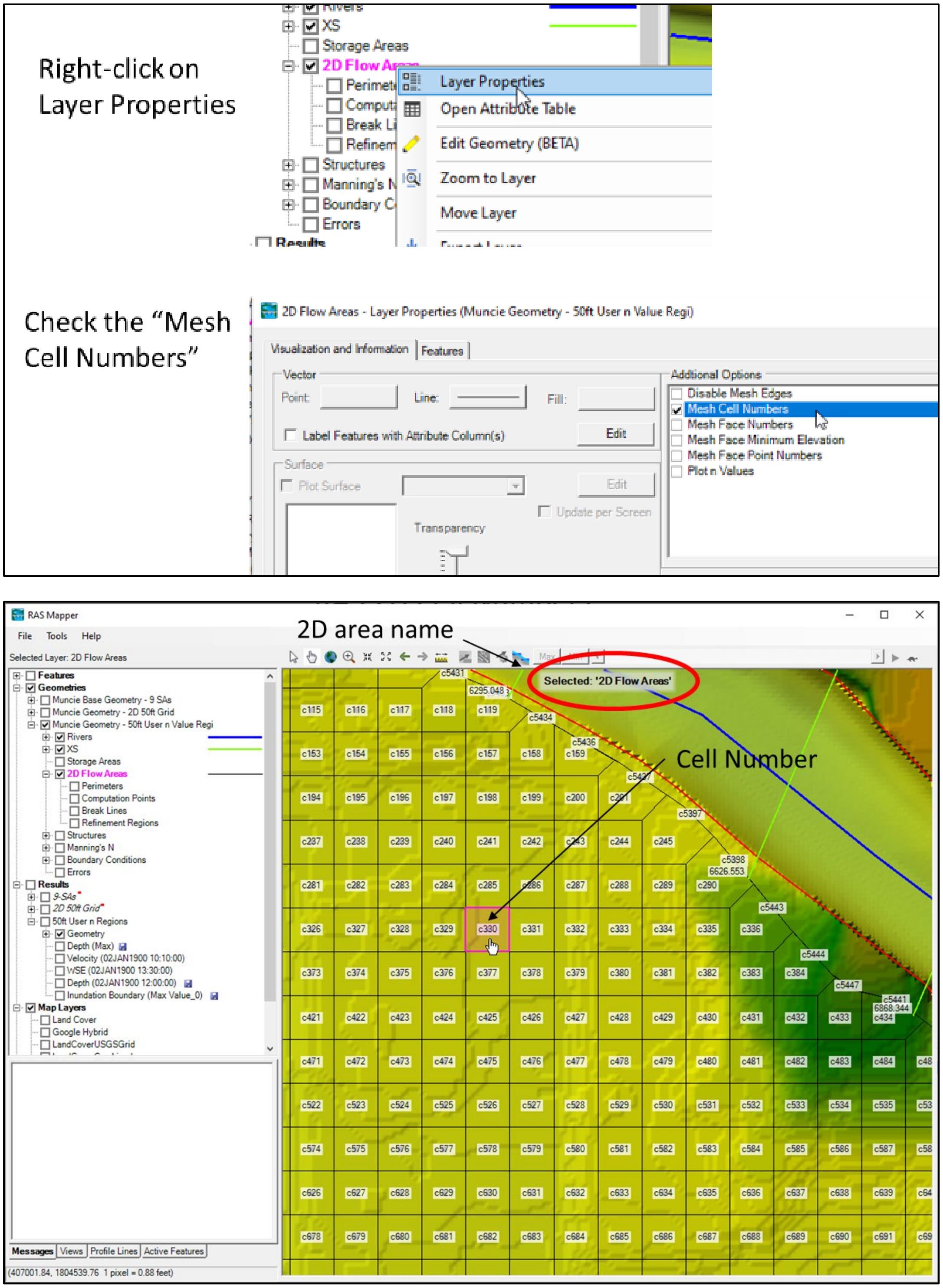


Figure 14 Identifying cell numbers and 2D area names using the RAS Mapper display.

4.3 Additional Log File Changes

A diagnostic xml logfile is output by the model adapter during each adapter step. Typically, any existing diagnostic log file is deleted at the beginning of an adapter step, thus losing the detailed logging information from the previous step. With the new HEC-RAS model adapter, at the end of the adapter step, the diagnostic log file is duplicated and appended with the process step name. For example, the contents of the workflow log directory of the HEC-RAS run now become:

/log directory

adapter.xml	72 KB
adapter.xml._compute	358 KB
adapter.xml._postProcess	72 KB
adapter.xml._preProcess	5 KB

(Note. This was implemented in v.5.10)

The model adapter now checks the HEC-RAS results HDF file for the status of the Unsteady compute. In the diagnostic file for the compute step, the adapter will log an "ERROR" when the Unsteady status message is "Unsteady failed to run":

```
<line level="3" description="Checking the Plan HDF file for Unsteady Compute Status "/>
<line level="1" description="Unsteady Compute Message:Unsteady failed to run"/>
```

An "ERROR" will also be logged if the Unsteady Results or Results Summary are not found.

To obtain further details set the run file properties **showRasWindows=true** and **logLevel=DEBUG** to redirect the HEC-RAS Unsteady console output to the diagnostic log file.

If the Unsteady compute is successful, the status message shows "Unsteady Finished Successfully":

```
<line level="3" description="Running Unsteady ..."/>
<line level="4" description="Running program: C:\Program Files (x86)\HEC\HEC-RAS\6.0\x64\RasUns
<line level="4" description="exec %s"/>
<line level="3" description="Checking the Plan HDF file for Unsteady Compute Status "/>
<line level="3" description="Unsteady Compute Message:Unsteady Finished Successfully"/>
```

If the Unsteady compute status is "'Unsteady Went Unstable", the message is logged at the WARN log level.

4.4 PIXML Output Changes

The HEC-RAS/FEWS adapter reads in time series and profile results from the HEC-RAS DSS result file for export back to the FEWS in PIXML format. Version v.5.0.7 and v.5.10 of the HEC-RAS adapter utilized the DSS6 format for the output of the time series results. The DSS6 was limited to only uppercase characters for the DSS path parts and units. The new DSS7 format can store both upper and lower case characters.

The practical effect is the change in case for the PIXML <units> element. The form of the <units> output now become:

Parameter	Units Label		
	v.5.0.7	v.5.10	v.6.0.0
STAGE	FEET	FT	ft
FLOW	CFS	CFS	cfs

The FEWS user should be aware of any impacts the units change has on the import of the HEC-RAS results back to the FEWS.

5 1D FINITE VOLUME OPTION

The default 1D equation solver for the unsteady flow compute is a Finite Difference based scheme. New with the HEC-RAS v.6.0.0 is an optional 1D Finite Volume solution scheme. The 1D Finite Volume approach has several advantages to the 1D Finite Difference solver:

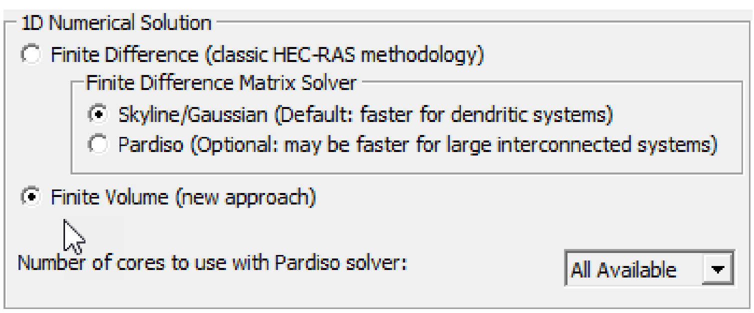
- Can start with dry channels or channels which go dry during the simulation.
- Very stable for low flow modeling
- Readily models and conserves momentum through 1D junctions.

However, there are some limitations, deficiencies with the 1D Finite Volume scheme:

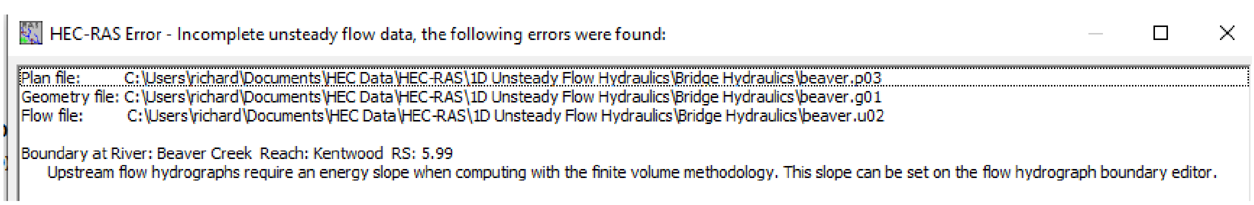
- Cannot use lidded cross-sections
- Computationally slower.

The advantages and disadvantages of the 1D Finite Volume scheme are presented in detail in Chapter 7 of the HEC-RAS User's Manual.

For the HEC-RAS, the 1D Finite Volume solution option is set in the HEC-RAS Plan file in the "HEC-RAS Unsteady Compute Options and Tolerances" dialog accessed from the "Unsteady Flow Analysis" dialog, "Options->Compute Options and Tolerances …" menu:



NOTE! The 1D Finite Volume method requires the energy slope be specified for upstream flow hydrographs:



NOTE! The 1D Finite Volume/Finite Difference solver option is stored on the Plan *.p01 file and the upstream BC energy slope stored on the Plan *.p01.hdf file. The *.p01.hdf file will need to be processed with the "remove_HDF5_Results.py" and the resulting *.p01.tmp.hdf, along with the Plan *.p01 file set in the HEC-RAS Module Data Set files (Sec. 3.1.4).

The Unsteady Compute with the Finite Volume option in the HEC-RAS GUI should be run to detect any issues with this option before inclusion of the files to the Module Data Set.

6 MODELING WITH WIND FORCES

The HEC-RAS v.6.0.0 now includes wind forces in both the 1D and 2D unsteady flow modeling. The HEC-RAS/FEWS model adapter supports the inclusion of the wind forcing, reading in and applying a time varying (e.g. hourly) gridded wind field.

The requirements and limitations for modeling wind in the HEC-RAS/FEWS are:

1. The HEC-RAS river system must be georeferenced
2. Only NetCDF format gridded wind data is currently supported.

There are two steps to implementing wind forcing for the HEC-RAS/FEWS forecast run:

1. Use the HEC-RAS GUI to setup the spatial mapping of the gridded wind data to the HEC-RAS river system.
2. Modify the HEC-RAS General Adapter and Parameter model files to include the wind forcing for the HEC-RAS/FEWS.

6.1 SETUP OF WIND FORCES IN THE HEC-RAS GUI

The spatial properties of the gridded wind data need to be first established for the HEC-RAS river system. This is accomplished by setting up and computing a wind forcing run in the HEC-RAS GUI. The HEC-RAS GUI compute maps the gridded wind cells to the HEC-RAS 1D cross-sections and storage areas, and the 2D grid cells. This mapping is stored on the Plan *.p01.hdf file and is used by the adapter for mapping gridded wind data provided by the FEWS for the HEC-RAS forecast runs.

Thus, it is important that the spatial properties of the gridded wind data fields exported to a HEC-RAS/FEWS run remain consistent with the spatial properties of the original setup.

If the spatial dimensions or location origin for the gridded wind data changes, the new gridded wind data will need to be remapped to the HEC-RAS river system using the Windows GUI.

The setup and import of wind data in the HEC-RAS GUI is detailed in the HEC-RAS “2D Modeling User’s Manual”, Chapter 4, “Boundary and Initial Conditions for 2D Flow Areas”. The wind forcing input is setup from the “Unsteady Flow Data” dialog, “Meteorological Data” tab (Figure 15). The wind data parameters are selected as “Speed/Direction” or “Velocity X/Y”. For the example case, the data is “Speed/Direction”. In the “Meteorological Variables – Wind Speed”, select “Gridded” as the Mode. Click the “Import Raster Data …” to start the process for import from the NetCDF wind file.

Figure 16 shows the “Import Gridded Data” dialog. Click the open file icon to select the file for import. Clicking the “Import Grids …” button will show the “Select Subdataset” dialog. For the example case, the variable “US” is the gridded data variable for the wind speed. The process is repeated for the Wind Direction import.

For the example wind case, NetCDF gridded wind data in both Lat-Lon and State Plane coordinate systems were successfully imported and projected to the HEC-RAS river system coordinate system.

Note in the main dialog (Figure 15) the “Ratio (Optional) field for the Wind Speed. The value entered will be used to scale the gridded wind speed values for the compute. In the HEC-RAS/FEWS model adapter, this value can be set at forecast time in the params.xml file, independent of the HEC-RAS GUI value.

The imported gridded wind speed can be viewed in the RAS Mapper dialog under the “Event Conditions – Wind” tree node (Figure 17). Note that the displayed wind speed has been scaled by the “Ratio” value. The RAS Mapper animation control can be used to view the data over time.

Perform the Unsteady Flow compute in the HEC-RAS GUI. This step writes out the mapping of the gridded wind field to the model river system to the Plan *.p01.hdf file. The plan HDF file from the GUI compute is processed with the python script to remove the “Results” data group (Sec 3.1.4), and transferred with the other HEC-RAS model files to the appropriate Module Data Sets folder.

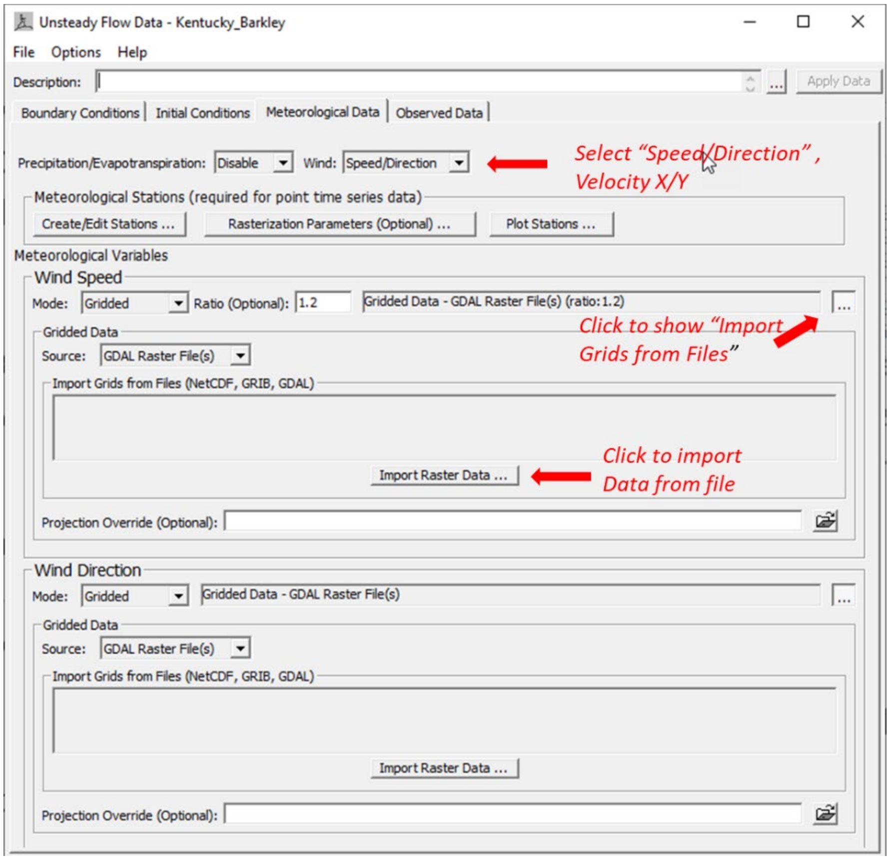


Figure 15 Meteorological Data tab for setup of the gridded wind input.

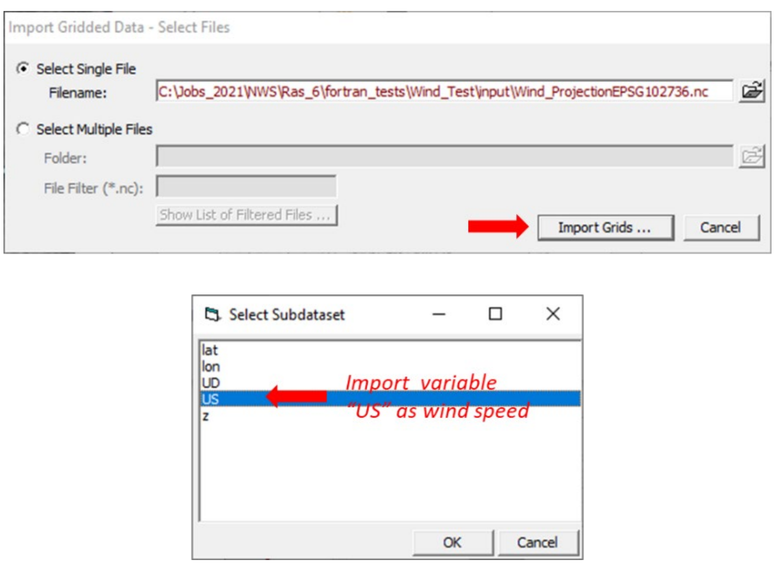


Figure 16 Dialogs for selecting gridded wind file and variable ID.

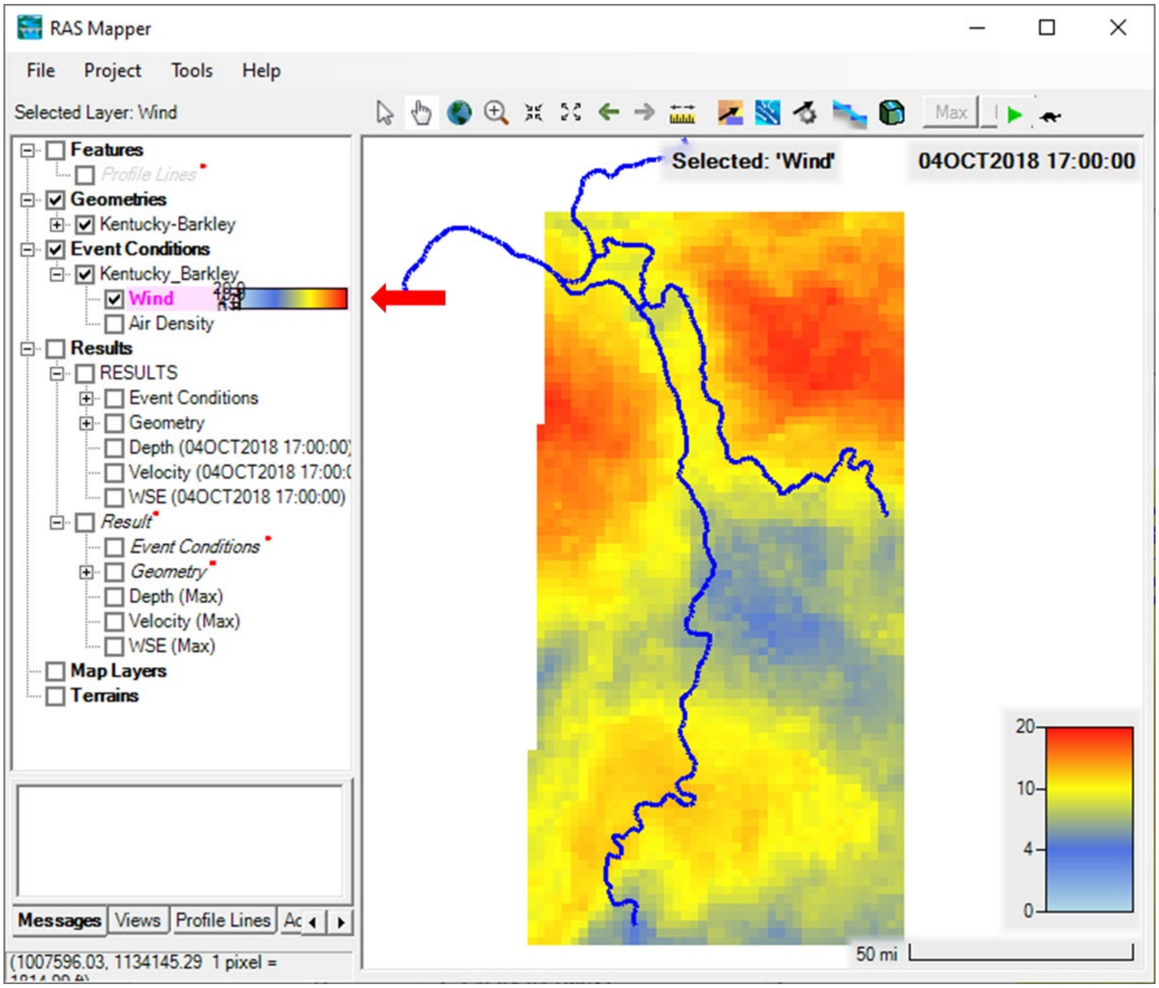


Figure 17 Display of the imported and scaled gridded wind data in the RAS Mapper GUI.

6.2 Setup of the Wind Forces in the HEC-RAS/FEWS Configuration

Additions are required to the HEC-RAS General Adapter and Model Parameter files to turn on the wind functionality in the HEC-RAS/FEWS forecast run.

The model adapter wind options are set in the model parameters file (params.xml) under the "**hec-ras run parameters**" group (Table 2 and Figure 18).

Table 2 Parameter IDs and values for the wind options in the HEC-RAS/FEWS model adapter. These are only required for forecast runs with wind.

Parameter ID	Value, Description
IncludeWind	**true** = Include wind forces in forecast run **false** = No wind forces in forecast run
WindScalingFactor	The value to scale the gridded wind speed values dblValue

params.xml

```xml
<?xml version="1.0" encoding="UTF-8"?>
<parameters xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://
    <modifierType>HECRAS</modifierType>
    <group id="ComputationInterval" name="hec-ras run parameters">
        <parameter id="ComputationInterval">
            <description>Computation interval in minutes. Does not change interv
            <intValue>15</intValue>
        </parameter>
        <parameter id="IncludeWind" name="IncludeWind">
            <description>Flag to include or exclude wind calculations in HEC-RAS
            <boolValue>true</boolValue>
        </parameter>
        <parameter id="WindScalingFactor" name="WindScalingFactor">
            <description>Multiplier to scale the wind velocity up/down over the
            <dblValue>1.0</dblValue>
        </parameter>
    </group>
</parameters
```

Figure 18 HEC-RAS model parameter file (params.xml) showing the use of the wind forcing options.

The HEC-RAS General Adapters requires modifications for the FEWS to export the NetCDF wind file for the HEC-RAS compute. The setup of the General Adapter for the export of the gridded wind data file was presented in Sec 4.1.

During the FEWS forecast, the HEC-RAS model adapter reads in the gridded wind file and writes out the scaled wind values to the *.p01.tmp.hdf file, replicating the import gridded data action of the HEC-RAS GUI. The gridded scaled wind data when viewed in the RAS Mapper is seen in the “RESULTS” tree node:

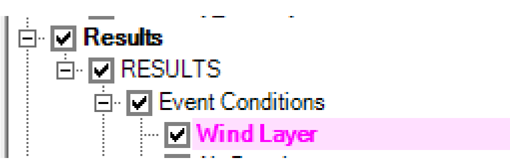


Figure 19 compares the computed water surface elevation time series for a HEC-RAS Storage Area for a small and a large wind scaling factor.

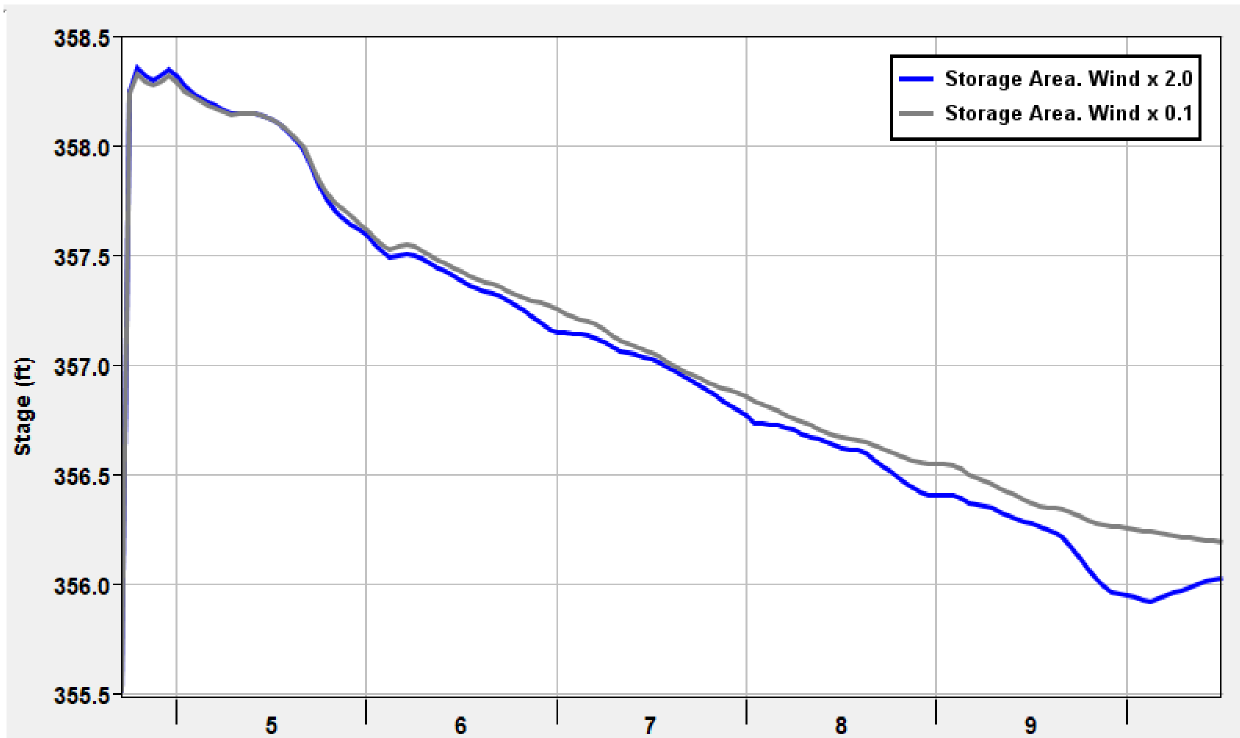


Figure 19 Computed water surface elevations for a HEC-RAS Storage Area, for a wind scaling of 0.1 and 2.0.

7 NAVIGATION DAMS

The new HEC-RAS/FEWS model adapter implements some basic control of the HEC-RAS Navigation Controlled Gates (Navigation Dams) through interaction with the FEWS.

Navigation Dams are available in the HEC-RAS to provide program control of the minimum and maximum water surface elevation at one or more locations along a navigation channel. The User sets water surface target elevations, gate opening/closing rates, etc. which the Unsteady Flow program applies to control gate operations for the structure in order to reach the target conditions. See Chapter 14 in the HEC-RAS v.6.0 User's Manual for a detailed discussion of the Navigation Dams data and operation.

A Navigation Dam is associated with a HEC-RAS Inline Structure through the "Unsteady Flow Data" dialog, "Boundary Conditions" tab by selecting the Inline Structure in the boundary condition table, and setting the boundary condition type to "Navigation Dams" (Figure 20). The physical and operational parameters to the Navigation Dam are specified in the "Navigation Controlled Gates" dialog. The Navigation Dam data is stored in the HEC-RAS unsteady flow file (*.u01).

The HEC-RAS/FEWS model adapter provides the User some control of the Navigation Dam operation for a forecast run. In high flow conditions, the desire may be to set the Navigation Dams to an "Open River" operation of the gates. The model adapter now allows the User to "toggle" open river operation for a structure on/off through the FEWS.

1. Edit and save an alternate Unsteady Flow file (e.g. *.u02) in the HEC-RAS GUI, with the Navigation Dams "Open River" operations.
2. Add the alternative unsteady flow file to the HEC-RAS Module Data Set in the FEWS
3. Setup the HEC-RAS model params file in the FEWS with the alternative file name and the locations of the navigation dams

The Navigation Dam operations are setup in the model parameter file contained within the parameter group, **name="hec-ras navigation dam parameters".** The basic structure of the parameter group is outlined in the Table 3.

Table 3 Parameter Group and Parameter IDs and values for controlling the Navigation Dams operations with the model parameter file (params.xml).

Group ID	**Name**
user selected name	**hec-ras navigation dam parameters**
Parameter ID	**Value, Description**
Alternative_Flow_File	Alternative Unsteady Flow file containing Open River settings for the Navigation Dams, e.g. ***ROCK_TEST.u02***
For each Navigation Dam location …	
Parameter ID	**Value, Description**
River_Reach_RS	HEC-RAS 1D Inline Structure location with the Navigation Dam, e.g. ***MISSISSIPPI REACH # 17/273.47***
OpenRiverOp	**true** = Use Open River operation from the alternative flow file **false** = Use default operation

An annotated listing of the Navigation Dams parameter group is presented in Figure 21.

NOTE! The **"hec-ras navigation dam parameters"** group is optional. The parameter group is only needed if there is to be the override of the Navigation Dam operations.

Figure 22 compares the water surface elevation upstream of a navigation dam for the default operation and the "open river" operation. The "open river" parameters differ only in the threshold for "Flow Open River" targets for the Min and Max pool control. The results shown were computed using the model adapter, with the parameter **OpenRiverOp** "false" for the default case, and "true" for the Open River case.

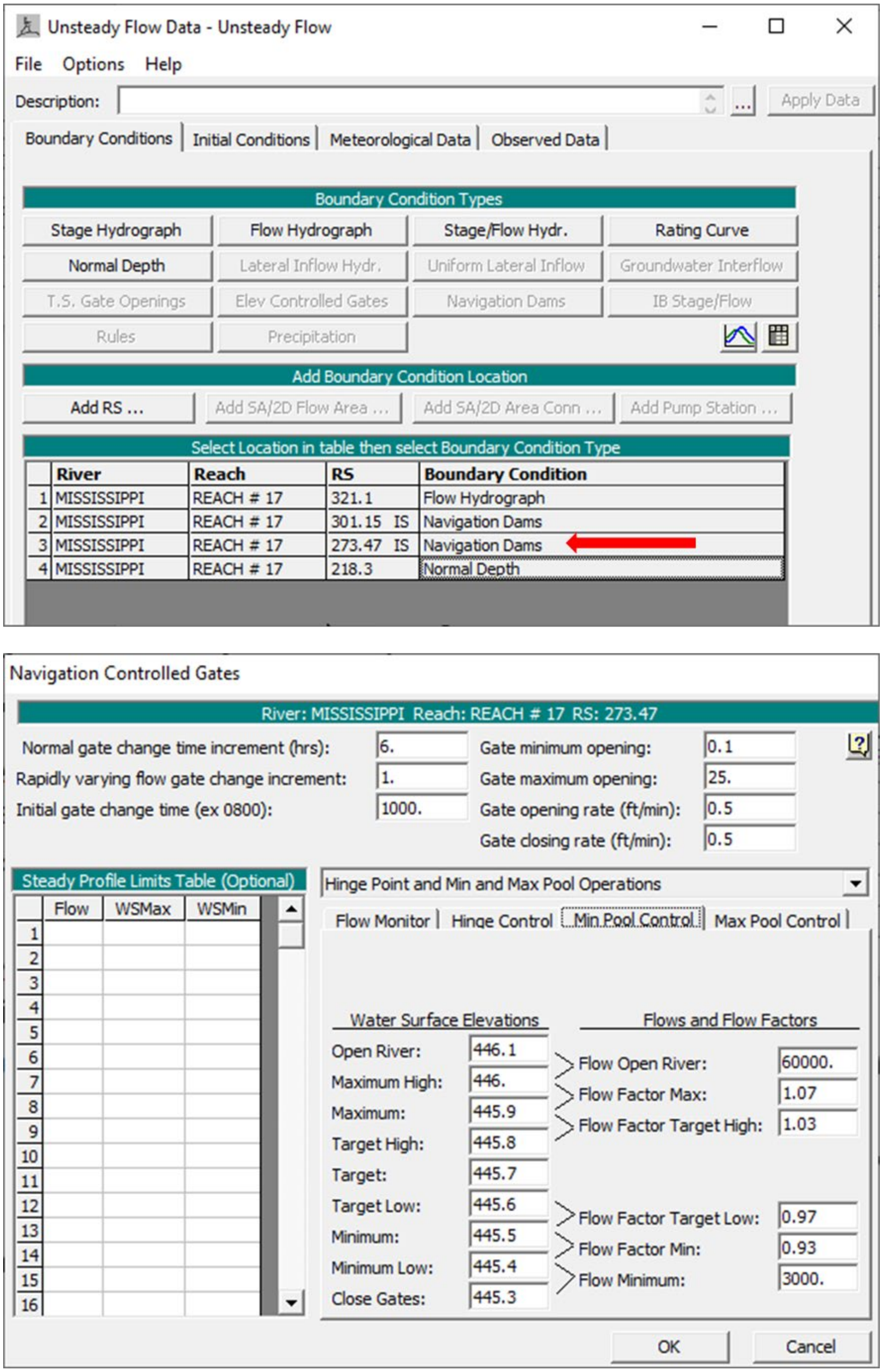


Figure 20 The HEC-RAS GUI dialogs for setting the Navigation Dams data for an Inline Structure.

Parameter Group Listing for Navigation Dam Operations

```
<group id="OpenRiverOps" name="hec-ras navigation dam parameters">      Group name to flag Navigation Dam param input
  <parameter id="Alternative_Flow_File">
    <description>Alternative Unsteady Flow file with Open River Ops for Navigation Dams</description>
    <stringValue>ROCK_TEST.u02</stringValue>                      RAS Unsteady Flow file with Open Operations
  </parameter>
  <parameter id="River_Reach_RS">                                  parameter id for Navigation Dam location
    <description>Navigation Location</description>
    <stringValue>MISSISSIPPI REACH # 17/273.47</stringValue>      River, Reach/RS of Navigation Dam
  </parameter>
  <parameter id="OpenRiverOp">                                     parameter id for Open River Op
    <description>
      Toggle Open River operation for this nav dam
      if TRUE will use the nav dam ops in the alternative file
    </description>
    <boolValue>true</boolValue>                       Use Open River Op from alternative if true, false to use default setting
  </parameter>

  <parameter id="River_Reach_RS">                     the next Navigation dam
               .
               .
               .
</group>
```

Figure 21 Annotated listing of the Navigation Dams settings in the params.xml file.

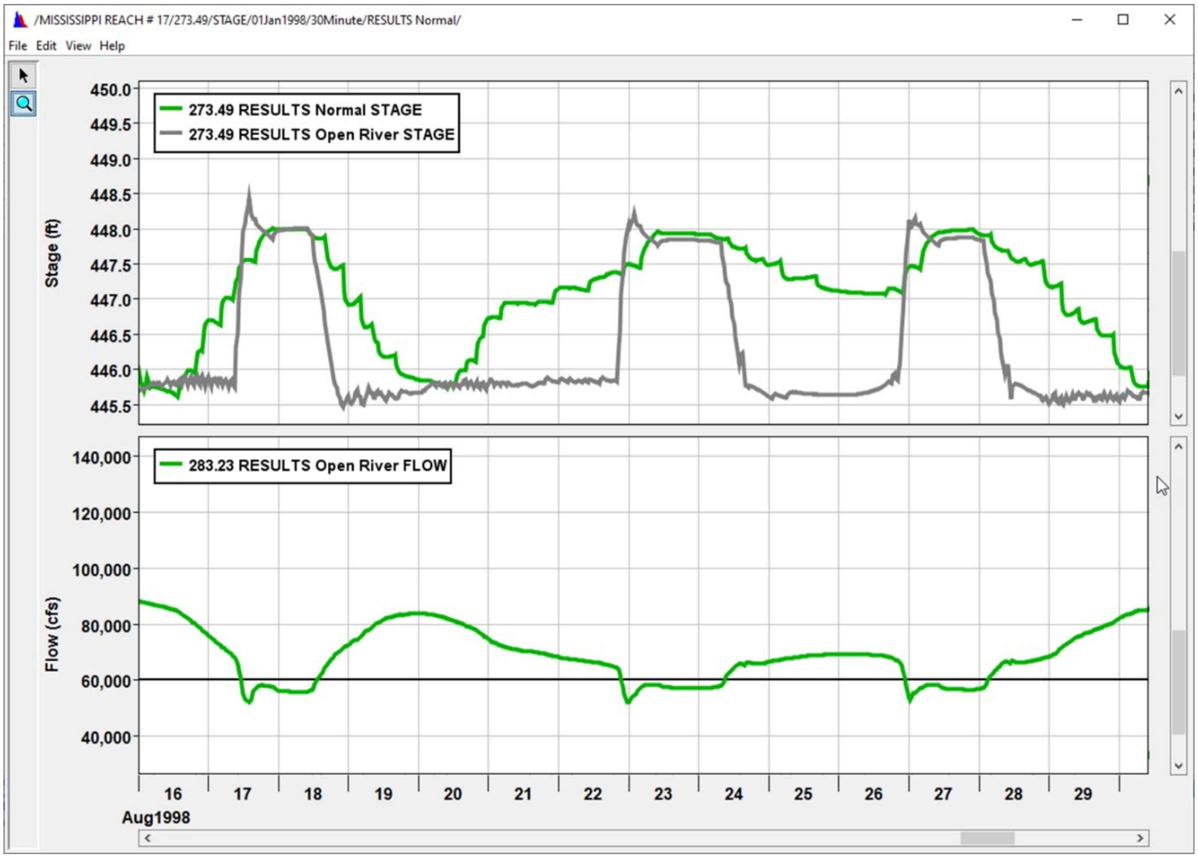


Figure 22 Comparison of the water surface elevations behind the navigation dam for the default operation (green) and the open river operation (gray). The "Open River" case has a flow threshold of >60,000 cfs, the default case is >150,000 cfs.

8 Elevation Controlled Gates

The new HEC-RAS/FEWS model adapter implements control of the HEC-RAS Elevation Controlled Gates through interaction with the FEWS. Some features were available in earlier versions of the model adapter. The parameter names have been updated to better match the field names in the HEC-RAS GUI, Elevation Controlled Gates dialog. If the User has previously specified model parameters for this option, the parameter IDs need to be updated.

The Elevation Controlled Gates dialog allows the User to control in the opening and closing of gates in an Inline Structure “Based on upstream WS” (Figure 23a); or “Based on specified reference” - the water surface at a user specified cross section or storage area, from any location in the model (Figure 23b); or “Based on difference in stage” – the difference in water surface elevation from any two user defined reference locations (Figure 23c). The params.xml values are required only when overriding the gate values in the unsteady flow file from the Model Data Set. Table 4 lists the parameter IDs and values for overriding the default elevation gate operations. Figure 24 provides an example listing of the Elevation Controlled Gates parameters and values in the params.xml file. Figure 25 plots the computed gate openings and gate flows for the three reference types of the example case.

Table 4 Parameter Group and Parameter IDs and values for Elevation Controlled Gates used in the model parameters file (params.xml). The listed parameters are for overriding the values in the HEC-RAS unsteady flow file. A parameter does not need to be provided if an update is not desired.

For each Gate Group & Structure Location …	
Group ID	**Name**
Gate Group Name, e.g. ***Left Group***	**hec-ras elev controlled gates parameters**
Location ID	**Description**
River Reach/RS	HEC-RAS location ID, e.g. ***NITTANY RIVER WEIR REACH/41.75***
Parameter ID	**Value, Description**
Reference Type	HEC-RAS “Reference” type for opening and closing gates **upstream WS** - Based on Upstream water surface reference **specified reference** - Based on specified reference WS **difference in stage** - Based on difference in stage
Parameters for all Reference Types	
Gate Opening Rate	“Gate Opening Rate (ft/min)” dblValue
Gate Closing Rate	“Gate Closing Rate (ft/min)” dblValue
Maximum Gate Opening	“Maximum Gate Opening” dblValue
Minimum Gate Opening	“Minimum Gate Opening” dblValue
Initial Gate Opening	“Initial Gate Opening” dblValue
Parameters for “Based on upstream WS” Reference	
Upstream WS Elevation Gate Open	"Upstream WS elevation at which gate begins to open” dblValue
Upstream WS Elevation Gate Close	"Upstream WS elevation at which gate begins to close” dblValue

Parameters for "Based on specified reference"	
Specified Reference Location	Cross-section or Storage area location, HEC-RAS location ID, e.g. ***NITTANY RIVER WEIR REACH/44***
Reference Elevation Gate Open	"Reference elevation at which gate begins to open" dblValue
Reference Elevation Gate Close	"Reference elevation at which gate begins to close" dblValue
Parameters for "Based on difference in stage"	
First Reference Location	Cross-section or Storage area location, HEC-RAS location ID, e.g. ***NITTANY RIVER WEIR REACH/42***
Second Reference Location	Cross-section or Storage area location, HEC-RAS location ID, e.g. ***NITTANY RIVER WEIR REACH/41.5***
Stage Difference Gate Open	"Stage difference at which gate begins to open" dblValue
Stage Difference Gate Close	"Stage difference at which gate begins to close" dblValue

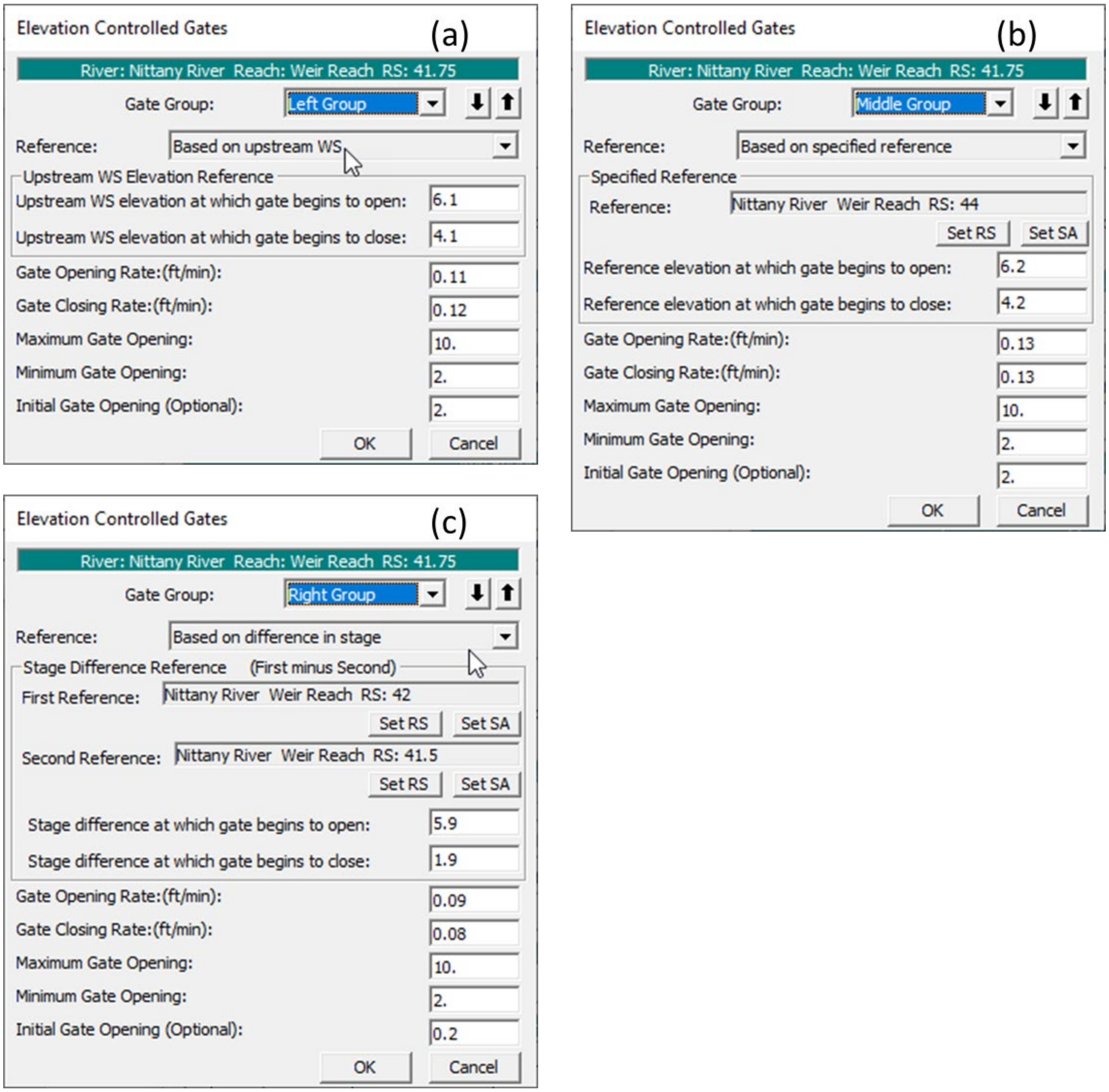


Figure 23 HEC-RAS GUI, Elevation Controlled Gates dialog illustrating the three "Reference" options for the gates operations.

params.xml

```xml
    <group id="Left Group" name="hec-ras elev controlled gates parameters">
        <locationId>NITTANY RIVER WEIR REACH/41.75</locationId>
        <parameter id="Reference Type">
            <stringValue>upstream WS</stringValue>
        </parameter>
        <parameter id="Upstream WS Elevation Gate Open">
            <description>Upstream WSE at which gate begins to open.</description>
            <dblValue>6.1</dblValue>
        </parameter>
        <parameter id="Upstream WS Elevation Gate Close">
            <description>Upstream WSE at which gate begins to close.</description>
            <dblValue>4.1</dblValue>
        </parameter>
        <parameter id="Gate Opening Rate">
            <description>Gate opening rate (ft/min).</description>
            <dblValue>0.11</dblValue>
        </parameter>
        <parameter id="Gate Closing Rate">
            <description>Gate closing rate (ft/min).</description>
            <dblValue>0.12</dblValue>
        </parameter>
        <parameter id="Maximum Gate Opening">
            <dblValue>9.9</dblValue>
        </parameter>
        <parameter id="Minimum Gate Opening">
            <dblValue>1.9</dblValue>
        </parameter>
        <parameter id="Initial Gate Opening">
            <dblValue>2.1</dblValue>
        </parameter>
    </group>
    <group id="Middle Group" name="hec-ras elev controlled gates parameters">
        <locationId>NITTANY RIVER WEIR REACH/41.75</locationId>
        <parameter id="Reference Type">
            <stringValue>specified reference</stringValue>
        </parameter>
        <parameter id="Specified Reference Location">
            <stringValue>Nittany River Weir Reach/44</stringValue>
        </parameter>
        <parameter id="Reference Elevation Gate Open">
            <description>Location WSE at which gate begins to open.</description>
            <dblValue>6.2</dblValue>
        </parameter>
        <parameter id="Reference Elevation Gate Close">
            <description>Location WSE at which gate begins to close.</description>
            <dblValue>4.2</dblValue>
        </parameter>
        <parameter id="Gate Opening Rate">
            <description>Gate opening rate (ft/min).</description>
            <dblValue>0.13</dblValue>
        </parameter>
        <parameter id="Gate Closing Rate">
            <description>Gate closing rate (ft/min).</description>
            <dblValue>0.13</dblValue>
        </parameter>
    </group>
    <group id="Right Group" name="hec-ras elev controlled gates parameters">
        <locationId>NITTANY RIVER WEIR REACH/41.75</locationId>
        <parameter id="Reference Type">
            <stringValue>difference in stage</stringValue>
        </parameter>
        <parameter id="First Reference Location">
            <stringValue>Nittany River Weir Reach/42</stringValue>
        </parameter>
        <parameter id="Second Reference Location">
            <stringValue>Nittany River Weir Reach/41.5</stringValue>
        </parameter>
```

Figure 24 Example listing for the Elevation Controlled Gates in the params.xml file.

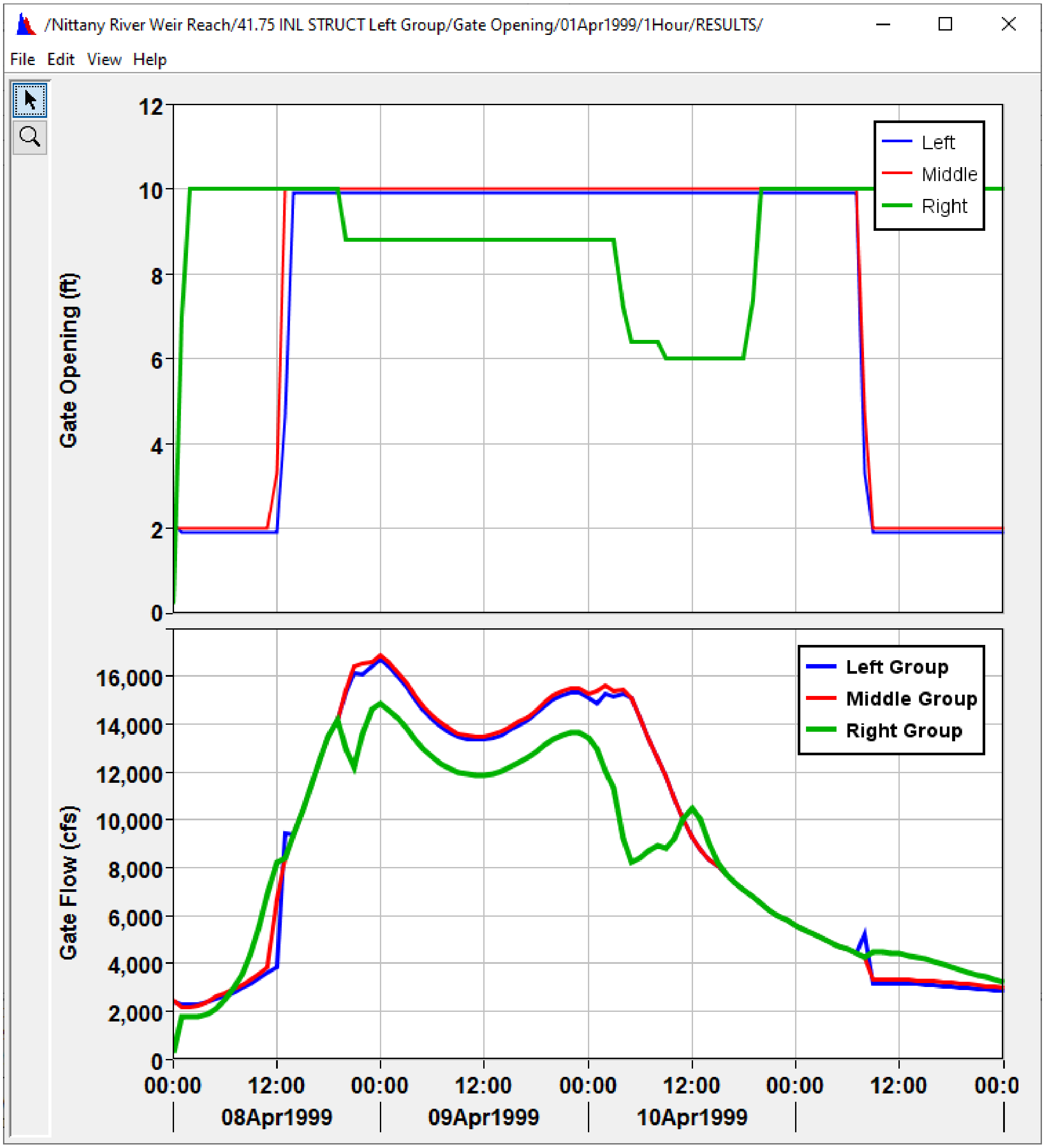


Figure 25 Computed gate opening and gate flow for the three gate reference types in the example.

9 LEVEE BREACHING

Previous versions of the HEC-RAS/FEWS model adapter have supported Levee Breaching overrides with the FEWS through input of parameters in model parameter file (params.xml). Although it is not anticipated FEWS forecast runs with levee breaching to be modeled during a flood event, the existing functionality is documented and tested.

Figure 26 Displays the HEC-RAS GUI Levee Breach dialog. The model adapter allows the FEWS User to override a number of the Levee Breaching values input from the base model Plan file (*.p01).

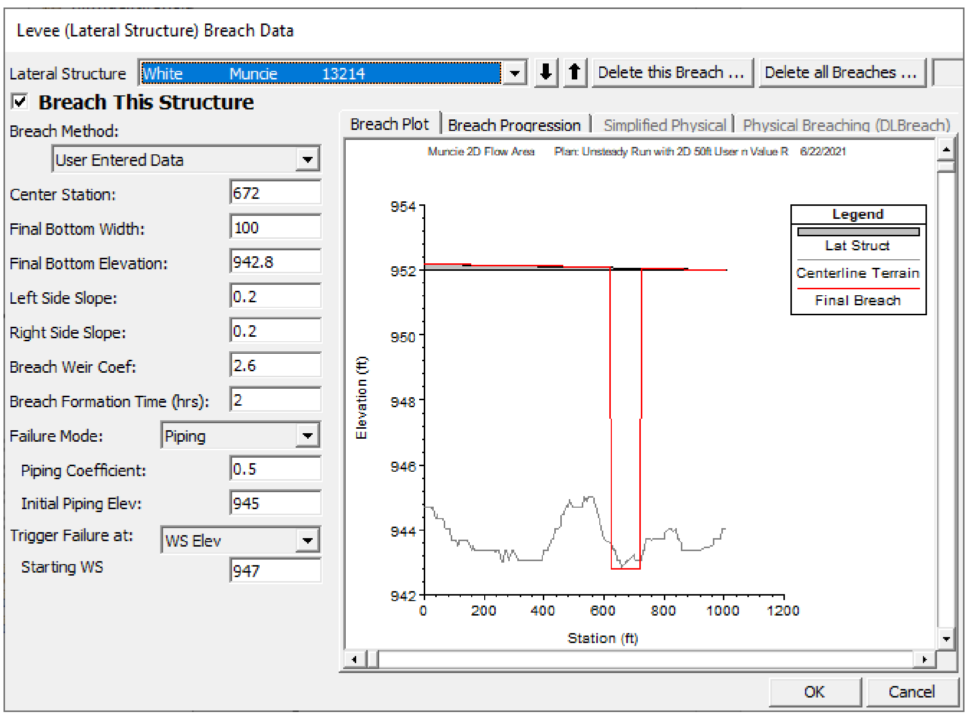


Figure 26 The HEC-RAS Levee breach dialog. The HEC-RAS/FEWS Levee Breach model parameters rep

Table 5 Parameter Group and Parameter IDs and values for controlling Levee Breaching with the model parameters file (params.xml). The listed parameters are for overriding the values in the HEC-RAS plan file. A parameter does not need to be provided if an update is not desired.

Group ID	**Name**
user selected name	**hec-ras levee breach parameters**
For each Levee Breach Location …	
Locatation ID	**Description**
River Reach/RS	HEC-RAS location ID, e.g. ***White Muncie/13214***
Parameter ID	**Value, Description**
IsActive	"Breach This Structure" **true** = Model this breach **false** = Do Not model breaching for this location
IsPipe	"Failure Mode" **true** = Piping **false** = Overtopping
PipingCoefficient	"Piping Coefficient" dblValue
IsWSStart	"Trigger Failure at: WS Elev" **true** = WS elev trigger
StartingWS	"Starting WS" Starting surface elevation for breaching. For WS Elev Trigger dblValue Note! Also applies to Threshold Duration case "Immediate Initiation WS"
IsThresholdDuration	"Trigger Failure at: WS Elev + Duration" **true** = WS Elev + Duration trigger
ThresholdWS	"Threshold WS" Starting surface elevation Duration breaching dblValue
ThresholdDuration	"Duration Above" Threshold time for breaching (hours) dblValue

StartDate	If *IsWSStart=false* and *IsThresholdDuration=false* “Trigger Failure at Set Time” Start date for breaching (e.g. 01MAR2001)
StartTime	“Trigger Failure at Set Time” Start time for breaching (e.g. 1630). Use with StartDate
CenterStation	“Center Station” dblValue
BottomWidth	“Final Bottom Width” dblValue
BottomElevation	“Final Bottom Elevation” dblValue
LeftSideSlope	“Left Side Slope” dblValue
RightSideSlope	“Right Side Slope” dblValue
BreachTime	“Breach Formation Time (hrs)” dblValue
WierCoef	“Breach Weir Coef” dblVaue

For “dblValue”, HEC Undefined (3.4028E38) is equivalent to “blank” in the dialog field

```xml
<group id="Levee Breach" name="hec-ras levee breach parameters">
    <locationId>CT River R1/248658</locationId>

    <parameter id="IsActive">
        <description>true when breach is activated, otherwise model skips it during computations</description>
        <boolValue>false</boolValue>
    </parameter>

    <parameter id="IsWSStart">
        <description>true if trigger for failure is WS elevation</description>
        <boolValue>true</boolValue>
    </parameter>

    <parameter id="ThresholdWS">
        <description>water surface elevation for breaching</description>
        <dblValue>3.4028E38</dblValue>
    </parameter>

    <parameter id="ThresholdDuration">
        <description>threshold time (hours) for breaching</description>
        <dblValue>3.4028E38</dblValue>
    </parameter>

    <parameter id="StartDate">
        <description>Start date for breaching (e.g. 01MAR2001)</description>
        <stringValue></stringValue>
    </parameter>

    <parameter id="StartTime">
        <description>Start time for breaching (e.g. 1630)</description>
        <stringValue></stringValue>
    </parameter>

    <parameter id="CenterStation">
        <description>Center of breach (XS station / location)</description>
        <dblValue>8800.0</dblValue>
    </parameter>

    <parameter id="BottomWidth">
        <description>Final bottom width</description>
        <dblValue>500.0</dblValue>
    </parameter>

    <parameter id="BottomElevation">
        <description>Final bottom elevation</description>
        <dblValue>-10.0</dblValue>
    </parameter>

    <parameter id="LeftSideSlope">
        <description>Left side slope</description>
        <dblValue>2.0</dblValue>
    </parameter>

    <parameter id="RightSideSlope">
        <description>Right side slope</description>
        <dblValue>2.0</dblValue>
    </parameter>

    <parameter id="BreachTime">
        <description>Full formation time (hours)</description>
        <dblValue>1.0</dblValue>
    </parameter>

    <parameter id="WeirCoef">
        <description>Breach weir coefficient</description>
        <dblValue>2.6</dblValue>
    </parameter>

    <!-- parameter below are used only when IsPipe = true -->
    <parameter id="IsPipe">
        <description>true if piping failure, false if overtopping</description>
        <boolValue>true</boolValue>
    </parameter>

    <parameter id="PipingCoefficient">
        <description>Piping coefficient (default is .8)</description>
        <dblValue>0.8</dblValue>
    </parameter>

    <parameter id="InitialPipingElevation">
        <description>Initial piping elevation</description>
        <dblValue>-0.5</dblValue>
    </parameter>
</group>
```

Figure 27 Example Listing for the levee breaching overrides in the params.xml file (From Deltares-FEWS Wiki for the HEC-RAS).

10 UPDATE OF THE RAS MAPPER FILES FOR V.6.0.0

The update of the java-based adapter files and executables for the RAS Mapper in the FEWS was detailed in Sec. 2.2. This section describes the update of the *.rasmap template file and RAS Mapper/FEWS General Adapter for the new v.6.0.0. In addition, a new parameter file option is available for controlling the raster and inundation boundary output timing.

10.1 UPDATE THE *.RASMAP TEMPLATE FILE

The format and contents of the *.rasmap template file have changed from the v.5.0.7 and v.5.10 of the RAS Mapper. To update the *.rasmap file to the v.6.0.0 format, open the old HEC-RAS data set files in the HEC-RAS v.6.0 GUI, and then open the RAS Mapper GUI. The update is accomplished by the File->Save menu command (Figure 28). The new *.rasmap file then should replace the file in the appropriate FEWS ModuleDataSet directory.

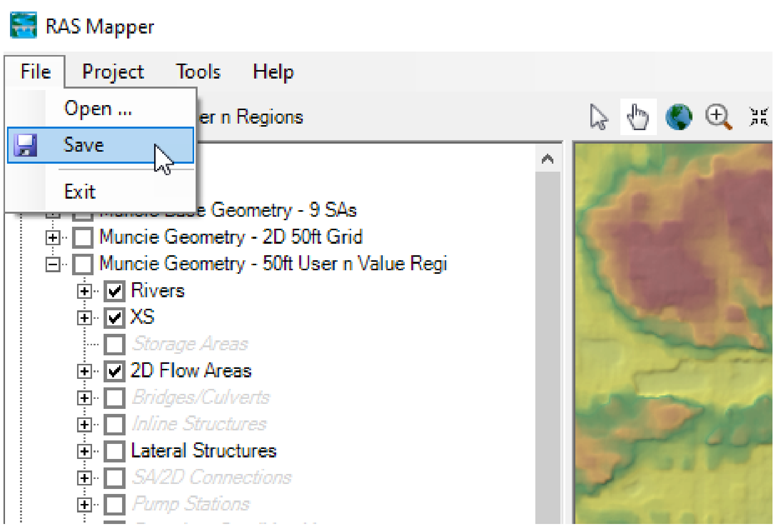


*Figure 28 Update of the *.rasmap by performing the File "Save" operation in the RAS Mapper GUI.*

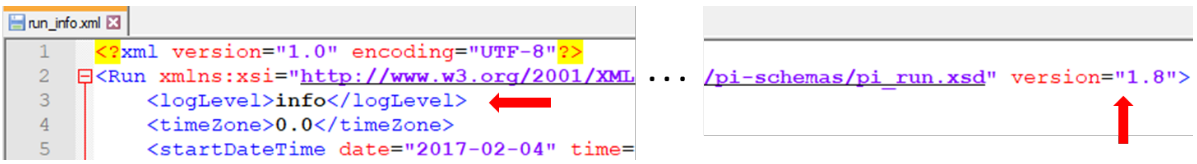
10.2 UPDATE OF THE RAS MAPPER GENERAL ADAPTER

As with the HEC-RAS/FEWS adapter, the RAS Mapper/FEWS model adapter v.6.0.0 is compliant with PiVersion 1.8 and requires the piVersion element be specified in the "general" settings of the General Adapter:

<general>
<description>HECRAS Model for Test</description>
<piVersion>1.8</piVersion>

. . .
<general/>

The result of the piVersion setting to the run info file is the “logLevel” line reflecting the FEWS logging level, and the “version=1.8” field.



The RAS Mapper model adapter expects the <logLevel> element and will fail if not found.

The RAS Mapper adapter now supports the “showRasWindows” runfile property. If the showRasWindows=true and the logLevel set to DEBUG, the compute messages from the RAS Mapper executable program are saved to the diagnostic log file (e.g. rasmapper.xml._compute).

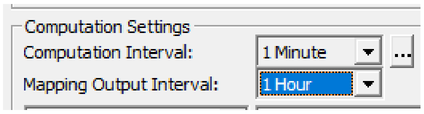
The RAS Mapper computes are launched using the HECRAS_v.6.0.0/RasProcess.exe, thus the hecRasBinDirectory for the RAS Mapper run should be:

<string key="hecRasBinDirectory" value="$HECRASBINDIR$/HECRAS_v.6.0.0"/>

10.3 New Model Parameter option

A new “StartIntervalOutput” option is provided for the RAS Mapper parameter file to add flexibility to the timing of the inundation boundary and raster map output. Previously the timing of the map output was limited by the output interval (ComputationInterval). For example, with a daily map output interval (ComputationInterval = 1440 minutes), the map generation was limited to output only at midnight. The “StartIntervalOutput” parameter option may be used to offset the time of the daily map generation. For the example shown in Figure 29, the “StartIntervalOutput” parameter offset the daily map generation to 6:00 am. For a ComputationInterval of 720, mapping output would occur at 0600 and 1800 hours.

Note that the “Mapping Output Interval” in the HEC-RAS GUI, Unsteady Flow Analysis dialog must have been set to cover any requested map output time by the RAS Mapper/FEWS run. For the above example, the GUI output interval would need to be at least 6 hours:



params_rasmap.xml

```xml
<?xml version="1.0" encoding="UTF-8"?>
<parameters xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns="http://www.wldelft.nl/fews/PI" xsi:sch
    <modifierType>RasMapper</modifierType>
    <group id="rasmapper run parameters" name="rasmapper run parameters" readonly="false" modified="false">
        <parameter id="ComputationInterval" name="ComputationInterval">
            <description>Computation interval in minutes. Does not change interval of output data.</description
            <intValue>1440</intValue>
        </parameter>
        <parameter id="StartIntervalOutput" name="StartIntervalOutput">
            <description>Time of day for starting interval offset computes.</description>
            <stringValue>6:00</stringValue>
        </parameter>
```

Figure 29 Offset of the map generation timing by use of the “StartIntervalOutput” option to 6:00 am.