cHECk-RAS Version 2.0.1

User Guide

December 2013

Table of Contents

1. Introduction

1.1. Overview

cHECk-RAS is a program designed to check the reasonableness of data used in and outputted from the U.S. Army Corps of Engineers' (USACE) Hydrologic Engineering Center, River Analysis System program, HEC-RAS. Plan, geometric, steady flow, and output data are used by cHECk-RAS to verify that hydraulic estimates and assumptions made in a HEC-RAS model are justified and in accordance with the assumptions and limitations of the HEC-RAS program and applicable FEMA requirements. cHECk-RAS does not support unsteady flow models.

cHECk-RAS allows users to examine a variety of parameters from HEC-RAS data files, and generate, view, and print reports on the results of checking routines performed by the program in the form of tables and messages.

cHECk-RAS performs the following:

- Assesses the suitability of roughness coefficients and transition loss coefficients;
- Assesses the suitability of starting water-surface elevations;
- Assesses the modeling of bridges and culverts;
- Provides a detailed check of floodway analyses;
- Compares important parameters among multiple profiles;
- Proposes solutions for specific errors in the Help section provided in program-generated messages.

While the purpose of cHECk-RAS is to facilitate the production of more accurate HEC-RAS models, the program is not intended to be a replacement for engineering judgment. ***cHECk-RAS only flags areas of potential error or concern, and the user must determine if modifications to the HEC-RAS model are warranted***.

1.2. How to Use this Guide

This guide contains instructions and specifications users need to run cHECk-RAS successfully. This guide is not intended to explain how to use the HEC-RAS program. A basic knowledge of HEC-RAS and familiarity with the HEC-RAS *User's Manual, Applications Guide* and *Hydraulic Reference Manual* are necessary to understand the error and warning messages that cHECk-RAS generates.

Prior to running cHECk-RAS for the first time, users should:

- have a good understanding of stream hydraulics;
- be familiar with the U.S. Army Corps of Engineer's HEC-RAS program, and the HEC-RAS *User's Manual*, *Applications Guide* and *Hydraulic Reference Manual*; and
- read this Guide.

An assortment of HEC-RAS variables and parameters will be referenced throughout this guide without providing complete descriptions. For a complete description of HEC-RAS variables and parameters please refer to the U.S. Army Corps of Engineer's HEC-RAS documentation referenced above.

1.3. System Requirements

The following system hardware requirements apply in order for cHECk-RAS 2.0.1 to be fully functional:

- 1 gigahertz (GHz) or faster 32-bit (x86) or 64-bit (x64) processor
- 1 gigabyte (GB) RAM (32-bit) or 2 GB RAM (64-bit)
- 16 GB available hard disk space (32-bit) or 20 GB (64-bit)
- VGA or above display type

The following software requirements apply in order for cHECk-RAS 2.0.1 to be fully functional:

- A Windows XP, 7 or 8 operating system (32- or 64-bit) must be installed on the computer.
- The U.S. Army Corps of Engineers' HEC-RAS program, version 4.1.0 must be installed on the computer. *Note that HEC-RAS project files created from other versions of HEC-RAS can be used in cHECk-RAS. However, in order for the program to function correctly, HEC-RAS version 4.1.0 must be installed.*
- Adobe Reader or equivalent must be installed for viewing PDF files.

1.4. Installation and Setup

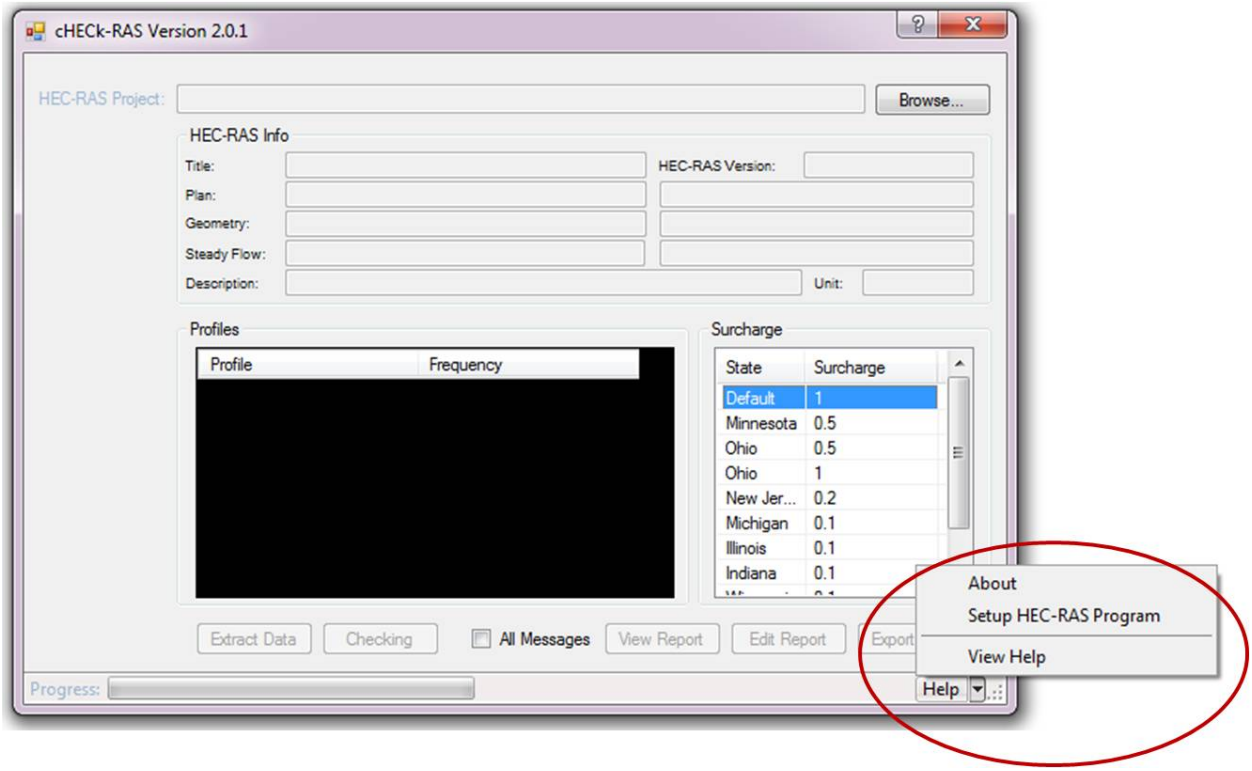
After insuring your computer meets the system and software requirements noted above, double click on the cHECk-RAS Setup.exe file and follow the directions on the screen to install the program. Administrative privileges will be needed in order to perform this operation. The default installation location is: C:\Program Files (x86)\FEMA\cHECk-RAS.

After installation, cHECk-RAS can be accessed by navigating to the Windows Start menu and clicking on the *cHECk-RAS* shortcut in the list of programs.

cHECk-RAS will assume the program (.exe) file for HEC-RAS 4.1.0 is installed at the following location:

- C:\Program Files (x86)\HEC\HEC-RAS\4.1.0

If HEC-RAS 4.1 is installed at another location on your computer, you will need to specify it by navigating to the 'Help' dropdown box in the lower right corner of the main interface (see figure below), selecting "Setup HEC-RAS Program" from the menu, and specifying the location. This must be done before the program can be used.



1.5. What is cHECk-RAS?

cHECk-RAS consists of a collection of checking programs. The checking programs cover five areas:

- NT (Manning's roughness coefficients and transition loss coefficients)
- XS (Cross sections)
- Floodways
- Structures
- Profiles

The following checking routines are performed as part of each check listed above. For more detailed information on these checks, refer to Section 3 "*Program Description*" of this user guide.

NT Check
The **NT Check** will generate summary tables of extracted data and statistics and perform the following:

- Check first user selected profile
- Check roughness coefficients at cross sections and structures
- Check transition loss coefficients

XS Check
The **XS Check** will generate a summary table of extracted data and perform the following:

- Check all user selected profiles
- Check distances between cross sections and junctions
- Check ineffective flow areas
- Check special conditions
- Check locations of cross sections
- Check locations of discharges
- Check boundary conditions
- Check flow regime

Floodway Check
The **Floodway Check** will generate a summary table of extracted data and perform the following:

- Compare the 1%-annual-chance flood and floodway profile
- Check the encroachment method used
- Check the starting water-surface elevation of the floodway profile
- Check floodway widths
- Check surcharge values
- Check floodway discharges
- Check the floodway at structures

Structure Check
The **Structure Check** will generate a summary table of extracted data and perform the following:

- Check all user selected profiles
- Check distances between structure sections
- Check type of flow
- Check culvert coefficients
- Check culvert solution criteria
- Check ineffective flow
- Check deck/roadway data and ground data

Profiles Check
The **Profiles Check** will generate a summary table of extracted data and perform the following:

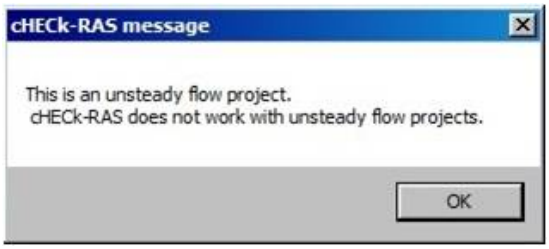
- Check all user selected profiles except the floodway
- Check boundary conditions
- Check if water-surface elevations of profiles, excluding the floodway, are crossing
- Check top widths

2. Running cHECk-RAS

2.1. Overview

Users have the ability to open and extract data from the HEC-RAS project (.prj) file and select profiles to be checked, all within cHECk-RAS.

The HEC-RAS project (.prj) file contains a plan file, geometry file, and flow file and an output file associated with the plan file. Users may examine data from a single profile, two profiles for a floodway analysis, or two to seven profiles for a floodway and multiple profile analyses. *Note that cHECk-RAS does not support unsteady flow models.* If a user attempts to run cHECk-RAS using an unsteady flow model, the following message will appear:



If a single profile is chosen, cHECk-RAS will run the **NT**, **XS**, and **Structure Checks.**

If two profiles are chosen and one of them is a floodway profile, cHECk-RAS will run the **NT**, **XS**, **Structure**, and **Floodway Checks.** When two profiles are chosen, the discharges should represent the 1%-annual-chance flood and floodway. The first profile must be the 1%-annual-chance flood and the second profile must be the floodway.

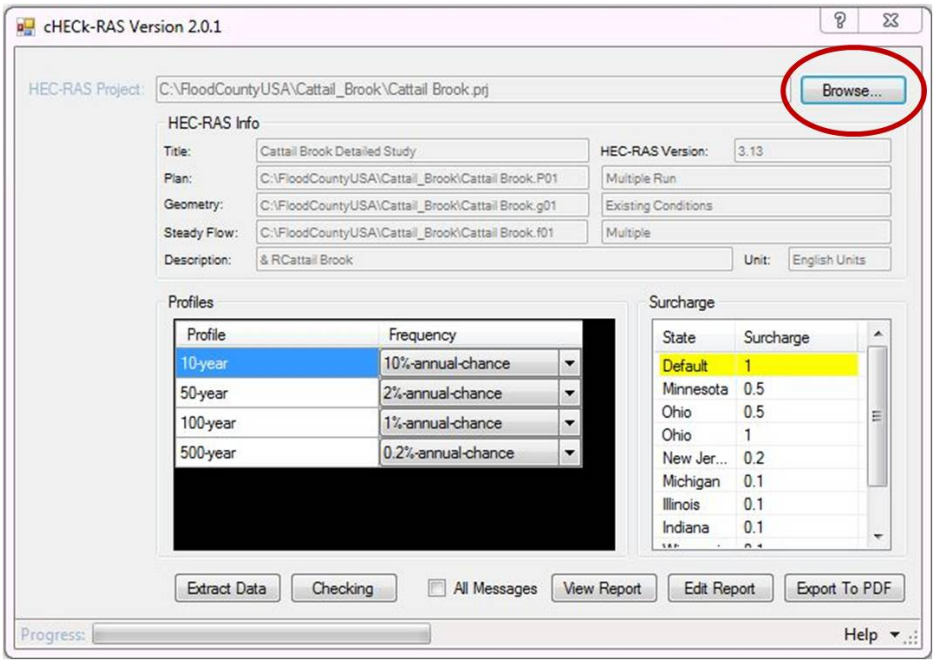
When a floodway profile is selected, a default surcharge value of 1.0 foot will be used to perform the checking routines unless a different surcharge value is specified by the user in the **Surcharge** section of the program interface. Additionally, the Default surcharge value can be changed by double clicking on the "Default" row in the **Surcharge** section, and entering the desired default surcharge value. *It is the responsibility of the user to ensure that the appropriate surcharge value is used for a given project, based on National Flood Insurance Program, state, and local requirements.*

If two or more profiles are chosen and a floodway profile is not included, cHECk-RAS will run the **NT, XS, Structure** and **Profiles Checks.** If more than two profiles are chosen and one of the profiles is a floodway, cHECk-RAS will run the **NT, XS, Structure, Floodway** and **Profiles Checks**.

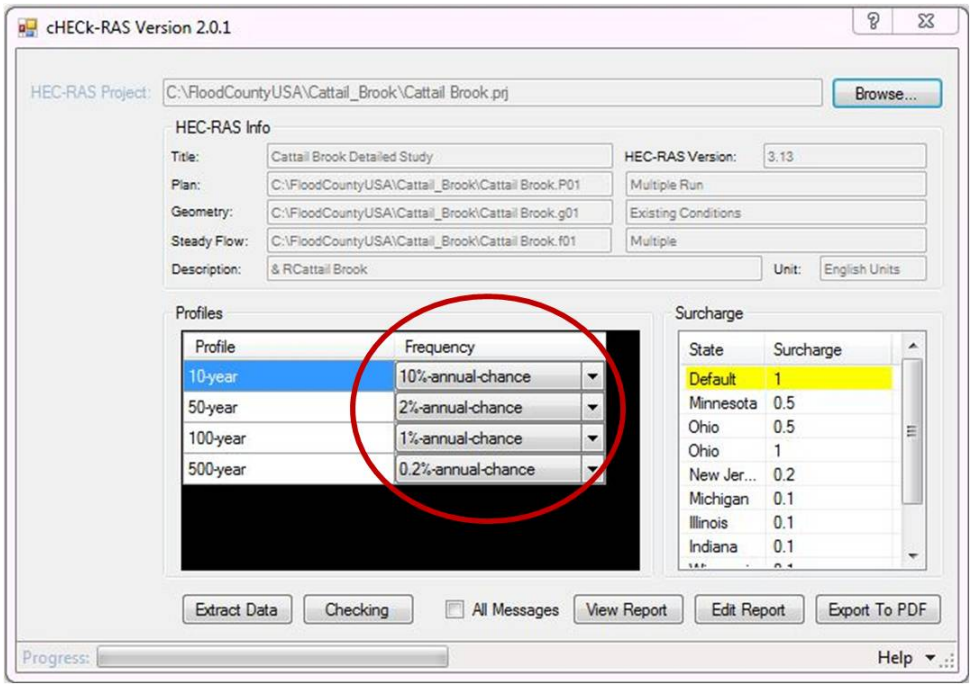
2.2. Data Setup

Once the cHECk-RAS program has been opened, perform the following steps to add and set up the HEC-RAS project (.prj) file to be checked:

1. Click the *Browse* button on the top right side of the program interface window and navigate to the location of the HEC-RAS project (.prj) file on your computer. *Note that in order for the cHECk-RAS Help and Reporting functions to be fully functional, the project file must be accessed from your local computer.* Select the file and click the *Open* button in the pop up window that appears.



2. Information about the HEC-RAS project will be displayed in the **HEC-RAS Info** section of the interface window. Additionally, the names of all profiles in the project will be displayed in the **Profile** column of the **Profiles** section. Click on the row in the **Frequency** column that corresponds to each profile listed in the **Profile** column to the left (see figure below). Using the dropdown menu, select the appropriate flood frequency for each profile listed. For additional information, refer to the **Selecting Profiles** section below.



2.3. Selecting Profiles

There are three different types of profiles that cHECk-RAS will analyze:

- Single Profile
- Floodway Profile
- Multiple Profile

cHECk-RAS performs different checks depending upon the selected profile. For specific information on each of these checks, refer to Section 3 "*Program Description*" of this user guide.

After extracting the data from the latest plan of the HEC-RAS project (.prj) file, the **Profiles** section of the interface window will display the list of profiles available. In order to assign the frequency to the profiles easily, the user should give the profiles names such as, "1%" or "100-yr," "0.2%" or "500-yr," and "FW" for the floodway profile, instead of "prof1", " prof2", etc. when creating the HEC-RAS flow file. To rename profiles in HEC-RAS, navigate to **Edit/Steady Flow Data/File/Rename Flow Title**. Then re-run the project plan in HEC-RAS.

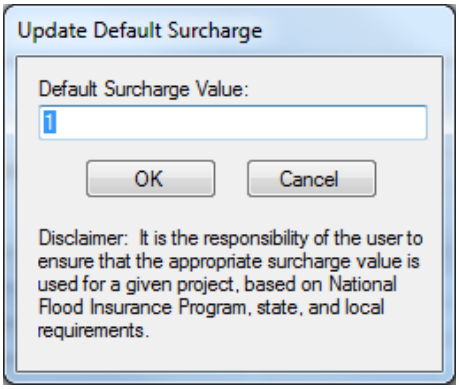
Single Profile

Although more than one profile is displayed in the **Profile** column, if the user assigns the frequency to only one profile, cHECk-RAS will perform **NT**, **XS**, and **Structure Checks** for that profile only. A single profile should be selected for streams without floodways. Typically the 1%-annual-chance profile is used for FEMA Flood Insurance Studies for approximate-studied streams.

Floodway Profile

Although more than one profile is displayed in the **Profile** column, if the user assigns the "1%-annual-chance" frequency to the first profile and the "Floodway" to one of the remaining profiles, cHECk-RAS will perform **NT**, **XS**, **Structure**, and **Floodway Checks** if the second profile has an encroachment method specified. Otherwise, cHECk-RAS will flag that the second profile does not have an encroachment method.

Selecting Surcharge Values
A default surcharge value of 1.0 foot will be used to perform the **Floodway Check** unless a different surcharge value is specified by the user in the **Surcharge** section of the program interface window. The **Surcharge** section lists acceptable surcharge values less than 1 foot by state, which may be selected by clicking on the desired state name/surcharge value prior to running the program. Additionally, the Default surcharge value can be changed, by double clicking on the "Default" row in the **Surcharge** section and entering the desired default surcharge value. *It is the responsibility of the user to ensure that the appropriate surcharge value is used for a given project, based on National Flood Insurance Program, state, and local requirements.*



Multiple Profiles

The user can choose two or all of the profiles displayed under the **Profile** column. If two or more profiles are chosen and a floodway profile is not included, cHECk-RAS will run the **NT, XS, Structure** and **Profiles Checks.** If more than two profiles are chosen and one of the profiles is a floodway, cHECk-RAS will run the **NT, XS, Structure, Floodway** and **Profiles Checks**.

Up to seven profiles, including the floodway, can be selected from the Frequency column. cHECk-RAS will check without the Floodway profile when running the **Profiles Check**.

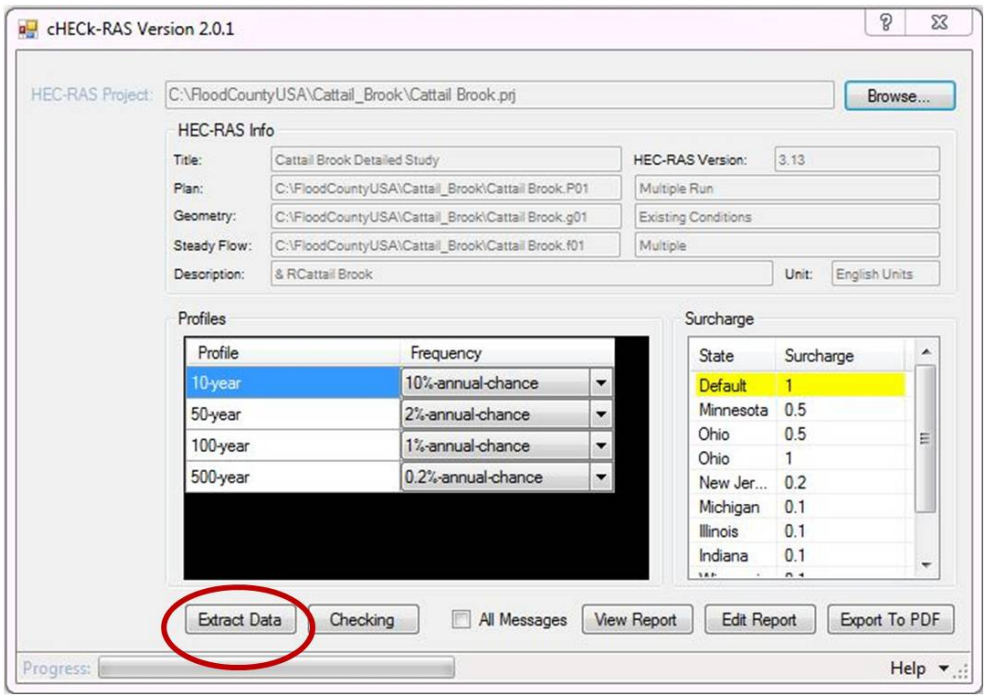
Please note that cHECk-RAS will automatically sort the profiles according to the assigned frequency.

2.4. Extracting and Checking Data

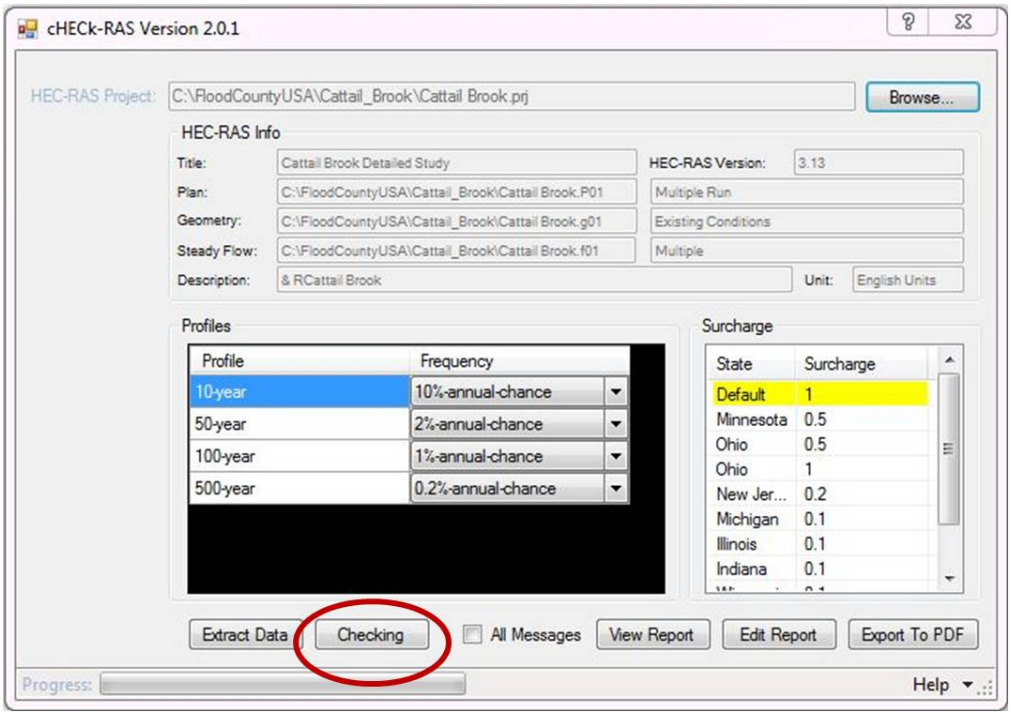
Once the HEC-RAS project (.prj) file has been properly added and set up in cHECk-RAS, perform the following steps to run the program:

1. To allow cHECk-RAS to extract the necessary data from the loaded HEC-RAS project (.prj file), click on the *Extract Data* button at the bottom of the interface window. Note that the extraction process may take several minutes depending on the size and complexity of the file. Progress can be seen in the Progress bar at the bottom lefthand side of the interface window. Upon completion, a pop-up message will appear indicating that the data has been successfully extracted.

   Note that once the Extract Data function has been performed for a specific HEC-RAS project (.prj) file, it will not be necessary to perform again unless the project file is modified in HEC-RAS.



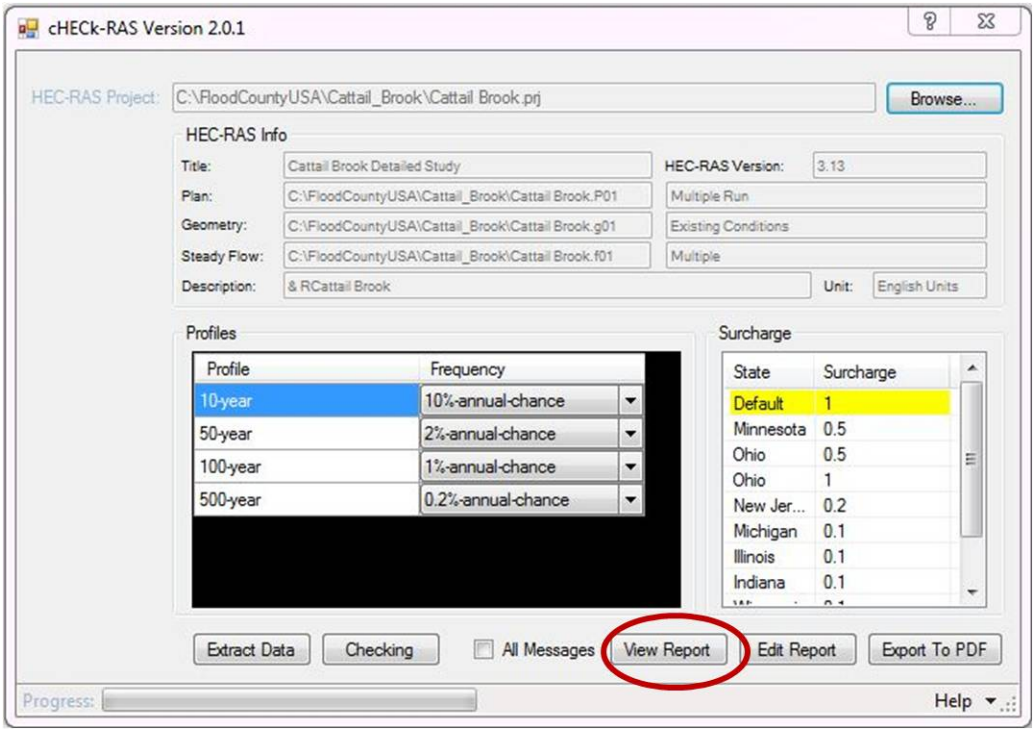
2. Click the *Checking* button to the right of the *Extract Data* button.



Note that the checking process may take several minutes depending on the size and complexity of the file. Progress can be seen in the Progress bar at the bottom lefthand side of the interface window. Upon completion, a pop-up message will appear indicating that the checking routine has been completed.

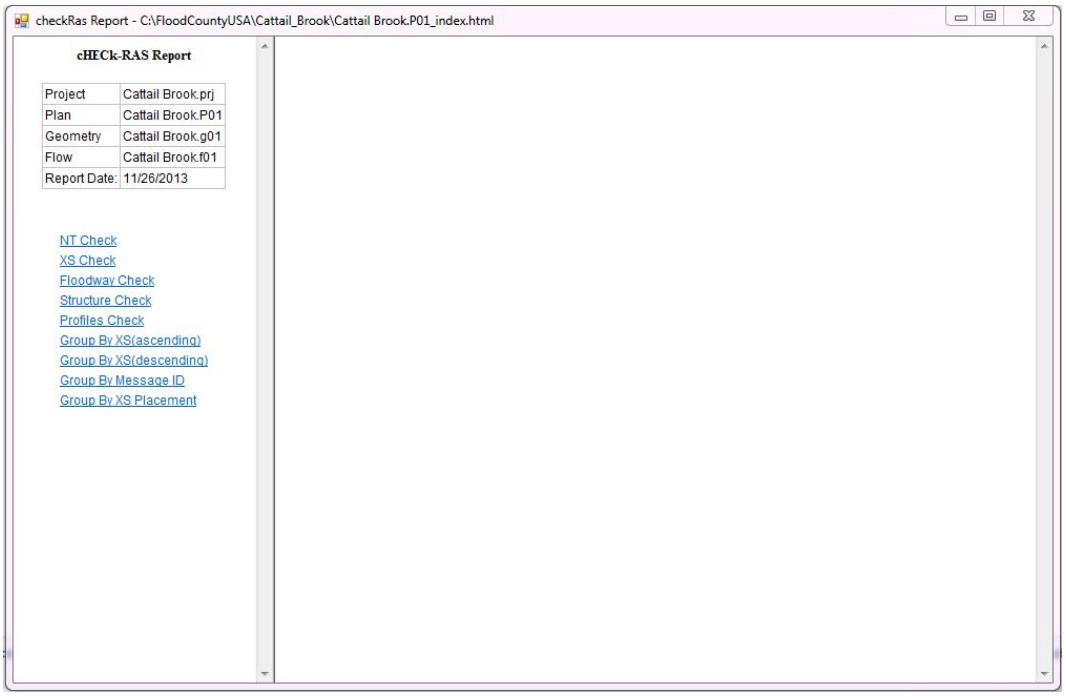
2.5. Viewing Reports

1. After extracting and checking data in cHECk-RAS, click on the *View Report* button to view the results of the checking routines.



2. A Report window will pop up displaying the results of the checking process and will contain the following information on the lefthand side of the window:

   - the name of the original HEC-RAS project (.prj) files checked
   - the date the report was generated
   - hyperlinks to the available reports generated by cHECk-RAS



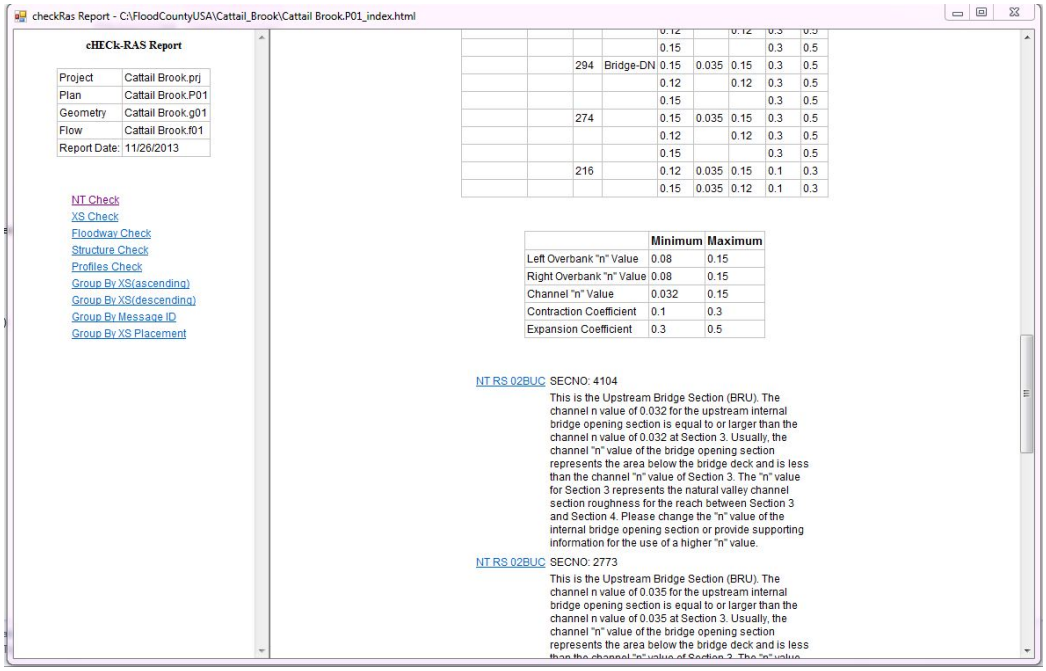
Depending on the profiles checked (single profile, multiple profiles, floodway profile), the relevant reports below will be generated. For a detailed listing of the specific checks performed to generate each of these reports, refer to Section 3 "*Program Description*" of this user guide.

- NT Check
- XS Check
- Floodway Check
- Structure Check
- Profiles Check

Additional reports are also available and accessible from the Report window with generated program messages organized in the following ways:

- **Group by XS**: All messages generated by cHECk-RAS are arranged by cross section order (either ascending or descending).
- **Group by Message ID**: All messages generated by cHECk-RAS are arranged by cHECk-RAS **Message ID** number.
- **Group by XS Placement**: Only messages that indicate that additional cross sections may need to be added using a GIS software program will be included. It is recommended that this report be reviewed first prior to making corrections based on other messages generated by cHECk-RAS.

3. To view a report, click on the hyperlinked text on the left hand side of the window. The report will appear on the right hand side of the window.



At the top of each report is a summary table of the data extracted from the HEC-RAS project (.prj) file and used by cHECk-RAS in its checking routines. Each message generated by cHECk-RAS that flags a potential issue is listed following the table(s) generated for each type of check. By clicking the hyperlinked **Message ID** to the left of each message, additional Help information for that particular message will display in a separate pop-up window.

For additional information on the report generated for each check, please refer to Section 3 "*Program Description*" of this user guide.

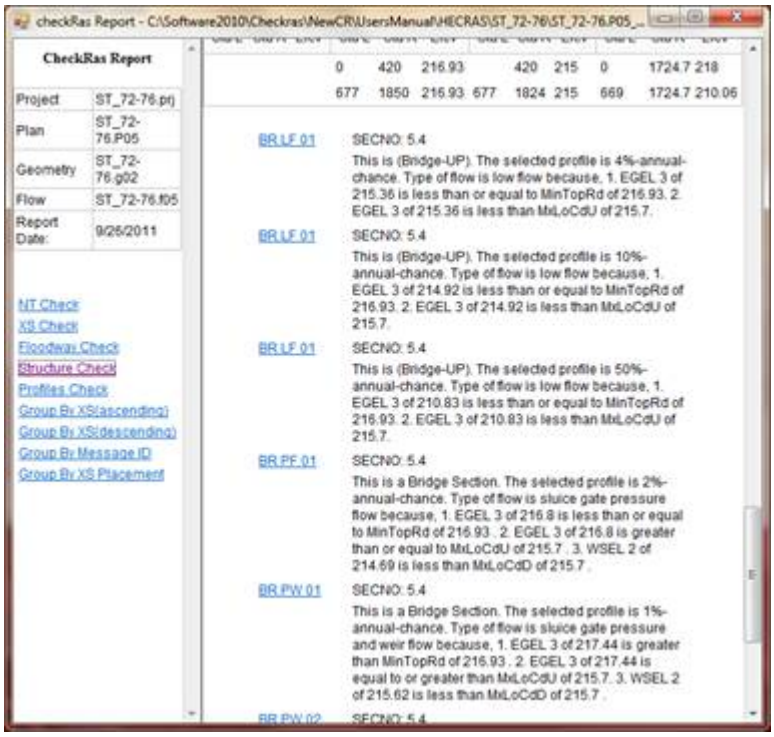
Note that in some cases, a problem flagged by cHECk-RAS may be a justifiable modeling approach, even though it may be outside the normal parameters of the HEC-RAS program.

2.6. Editing Reports

2.6.1. Flagging Basics

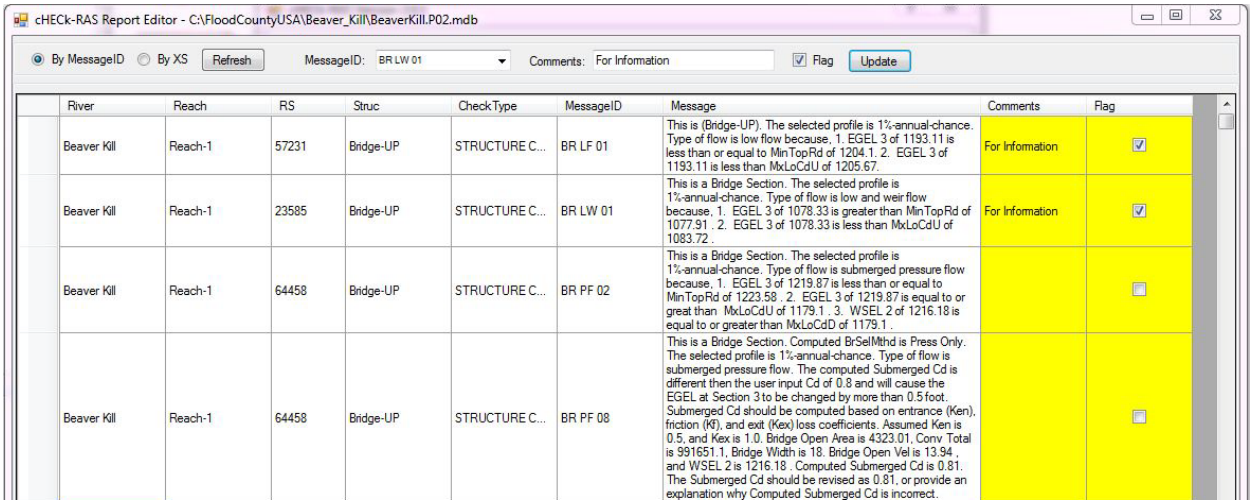
The **Edit Report** function in cHECk-RAS allows the user to add comments and suppress specific messages from cHECk-RAS-generated reports using the **Flag** function. Flagging can be used to remove multiple instances of the same message to avoid lengthy repetitive reports. Flagging can also be used to remove messages shown for informational purposes only or those determined to not be applicable for a particular cross section or cross sections. The process for Flagging is explained in detail below.

After clicking on the *Extract Data* button and then the *Checking* button from the main cHECk-RAS window, click the *View Report* button.



The cHECk-RAS **Report** window will be displayed. Select one of the reports from the left side of the window. The above figure shows the Structure Check Report. The first few messages listed in the report are flow type messages for all the profiles in the flow file, except for the floodway. Using the flagging function in the **Report Editor** window, the user can suppress informational messages such as these.

1. To flag messages, close the Report window and click on the *Edit Report* button from the cHECk-RAS main window. The Report Editor window will open and will contain all of the messages generated by cHECk-RAS for the HEC-RAS project (.prj) file.



The report can be ordered either by Message ID or by cross section number by using the radio buttons at the top lefthand side of the window and then clicking the Refresh button. By default, the report will be ordered by Message ID.

2. Select the Message ID of the message to be suppressed from the **MessageID** box. Type any desired comments in the **Comments** box. Click the *Flag* radio button to the right of the **Comments** box and then click on the *Update* button. Additionally, individual messages at each river station may be flagged by checking the *Flag* box at each cross section/message in the report. The above figure shows the flow type messages flagged with comments added. Note that messages that are not flagged will need to be resolved by fixing the model in HEC-RAS.

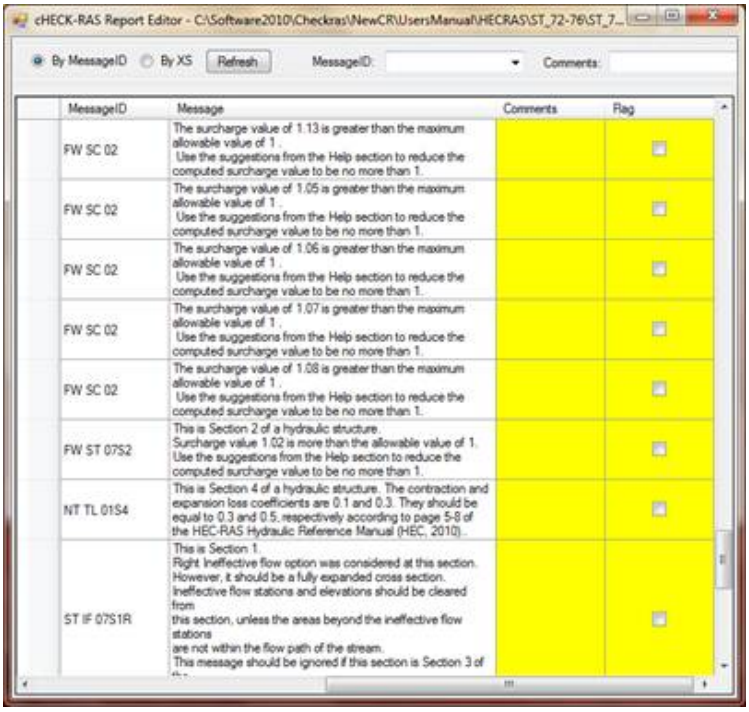
3. Close the **Report Editor** window after adding all desired comments and flags. Click the *Checking* button from the cHECk-RAS main window. When the Checking routine is complete, click on the *View Report* button. The reports generated will no longer display any flagged messages.

Note that the suppressed (flagged) messages are still stored in the editable report accessible through the *Edit Report* button. Additionally, by checking the *All Messages* box on the main program interface window, and rerunning the **Checking** function, all previously flagged messages will be included in the reports once again.

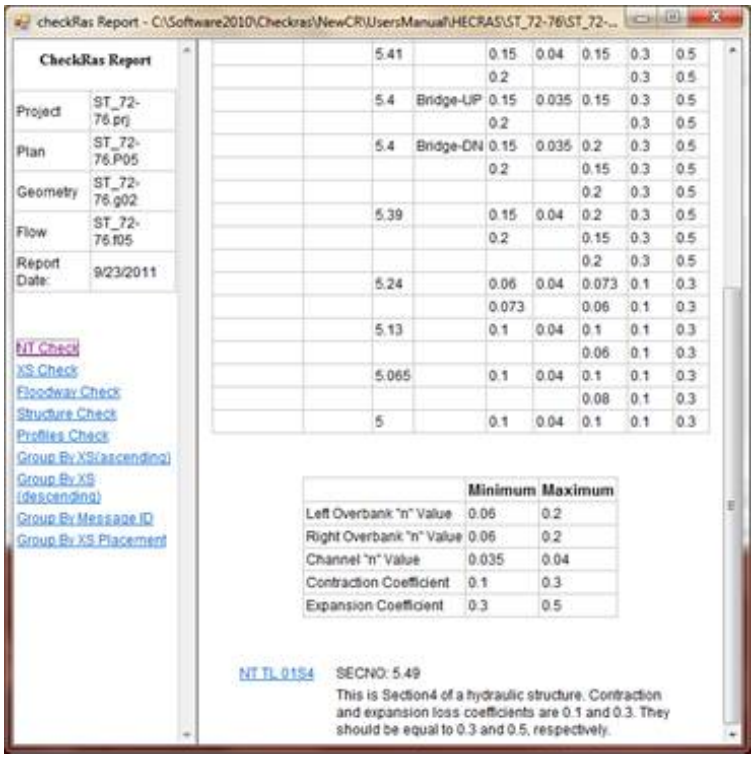
Reports may be exported from the **Report Editor** window including user-inputted comments. See detailed information in Section 2.6.3. below.

2.6.2. Resolving messages by editing the project file in HEC-RAS

The figure below shows some of the remaining messages in the Report Editor window that have not been flagged and which still need to be resolved. One of the messages is NT TL 01S4.



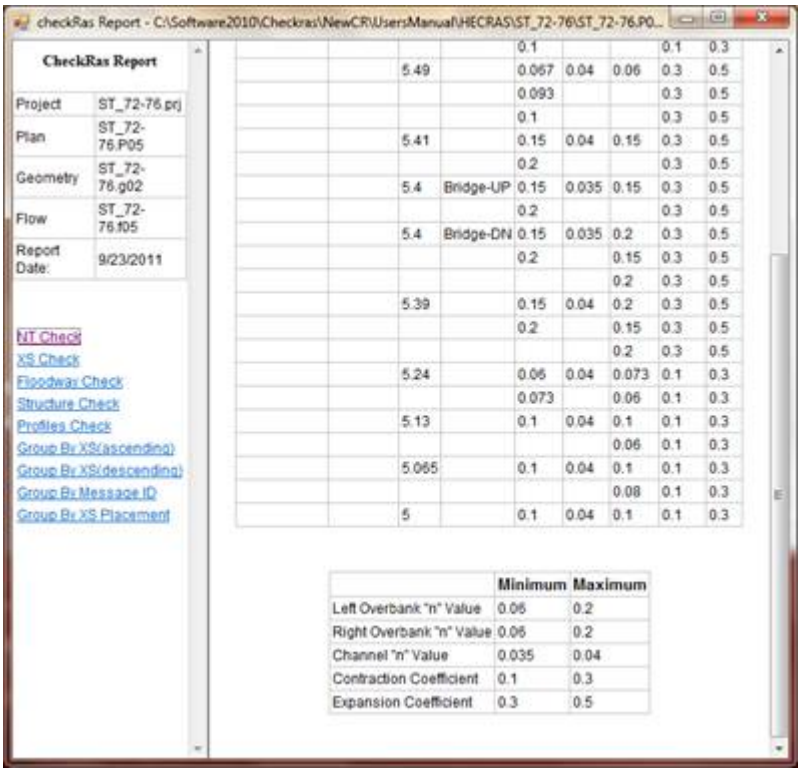
The figure below shows the NT report generated by cHECk-RAS.



It shows that there is a message for transition loss coefficients at RS 5.49. The user can fix this issue by opening the HEC-RAS program, selecting the project and ensuring that the plan, geometry and flow files are the same as in the cHECk-RAS report. The user can then change the transition loss coefficients, save the geometry file, rerun the plan and then save the HEC-RAS project.

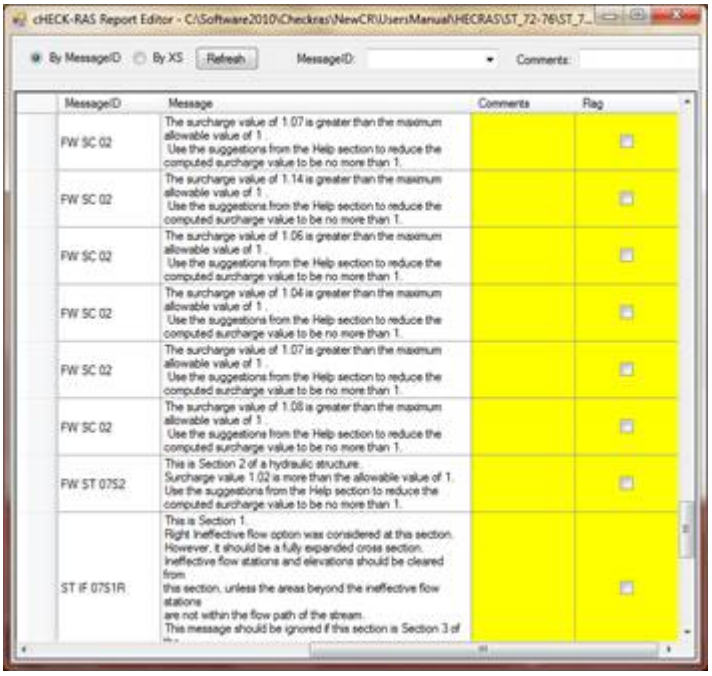
Since the HEC-RAS project has been changed, the user must click on the *Extract Data* button from the cHECk-RAS main window and then click on the *Checking* button. Once the Checking routine is complete, click on the *View Report* button.

The figure below shows that the NT TL 01S4 message is no longer in the NT Report. The Summary Table shows that the transition loss coefficients of 0.3 and 0.5 are at RS 5.49.



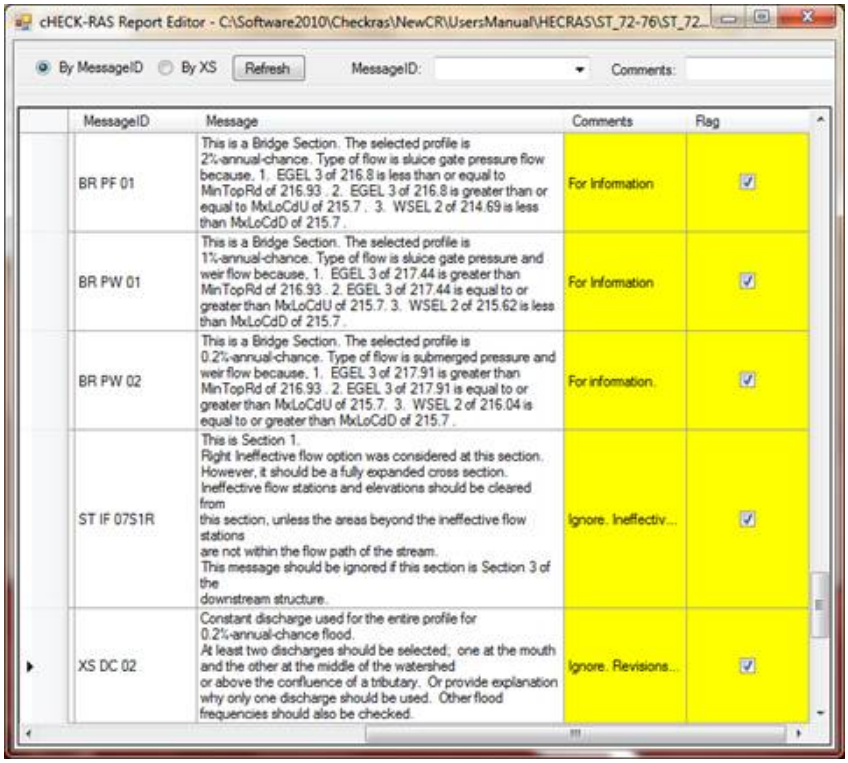
Close the cHECk-RAS **Report** window. Then click on the *Edit Report* button from the cHECk-RAS main window.

The figure below shows that the NT TL 01S4 message is no longer shown in the **Report Editor** window. However, all other unresolved messages are still shown. The user will need to resolve these messages by fixing the issues identified by cHECk-RAS in the HEC-RAS program.



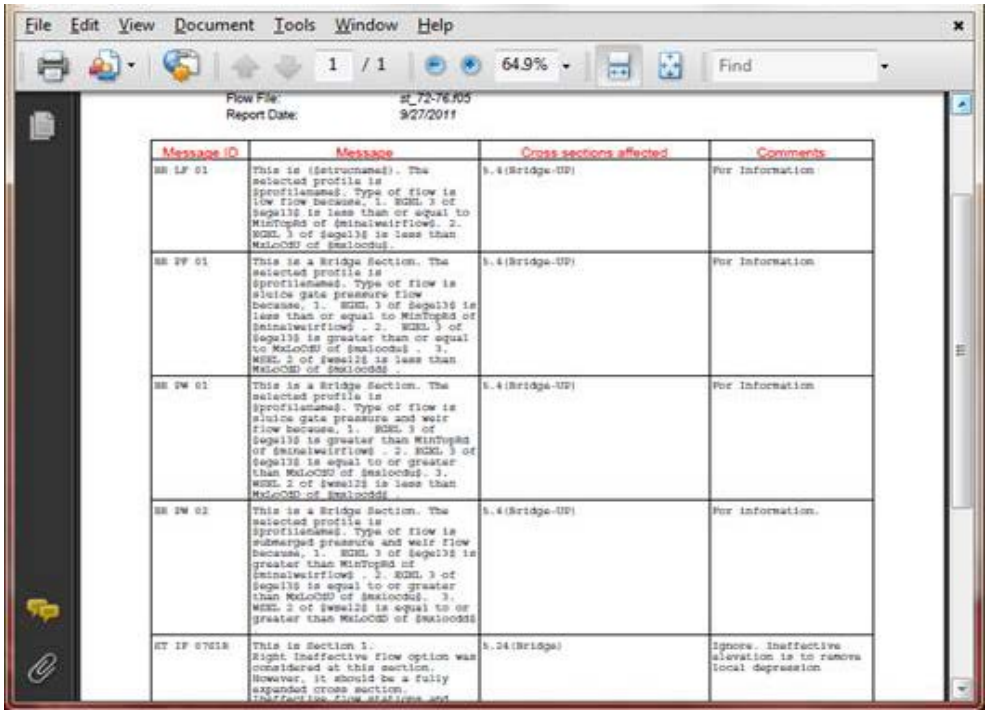
2.6.3. Exporting Reports from the Report Editor Window

The final report shown in the **Report Editor** window should include only the messages that have comments, as shown in the figure below. The report will show other messages if they are not resolved by making the needed corrections in HEC-RAS.



Exporting a .pdf version of the report

The user can create a .pdf file of the report shown in the **Report Editor** window. However, all the flags must be first unchecked in the **Report Editor** window. Additionally, in order for the comments shown in the Report Window to appear in the .pdf report, the Checking routine must be run after the comments are added. Once this is done, close the **Report Editor** window. Then click the *Export to PDF* button on the cHECk-RAS main window. All of the River Stations with the same applicable message will be grouped together in the .pdf report file. An example of the generated report is shown in the figure below. A copy of this report should be included with all FEMA Letter of Map Change (LOMC) and flood study submissions, as appropriate.



3. Program Description

3.1. Overview

Within cHECk-RAS there are 5 checking programs used to verify information for the HEC-RAS hydraulic model:

- The **NT Check** evaluates roughness (Manning's "n") and transition loss coefficients.
- The **XS Check** evaluates distances, ineffective flow areas, levees, divided flow, extended cross sections, known water-surface elevation, location of cross sections, placement of discharges, boundary conditions and flow regimes.
- The **Structure Check** evaluates distances, type of flow, culvert coefficients, culvert solution criteria, ineffective flow, deck/roadway and ground data, and floodway at the structure.
- The **Floodway Check** evaluates the **Encroachment** method, starting water-surface elevation, floodway widths, surcharge values, floodway discharge, and the floodway at hydraulic structures.
- The **Profiles Check** evaluates the starting water-surface elevation methods, water-surface elevations, and top widths for two to six profiles.

3.2. NT Check

Summary Table
A summary table of the data extracted from the HEC-RAS project (.prj) file is featured in the **NT Check** report generated by cHECk-RAS. It contains the following fields:

- River
- Reach
- River Station (RS)
- Type of Structure (Structure)
- Left Overbank "n" Value (NLOB)
- Channel “n” Value (NCHL)
- Right Overbank "n" Value (NROB)
- Contraction Loss Coefficient (CNTR)
- Expansion Loss Coefficient (EXP)

Note: When a **Horizontal Variation in “n” Value** option is used and the left overbank, right overbank, and channel "n" values specify more than 1 value, each "n" value is shown on one line so that it is evident that multiple "n" values are used at that section.

Summary of Statistics Table

A table including the maximum and minimum values for roughness coefficients of the left and right overbanks and the channel from all cross sections in the inputted HEC-RAS project (.prj) file is also featured in the **NT Check** report generated by cHECk-RAS. This table also shows the maximum and minimum values of contraction and expansion loss coefficients.

Checks Performed

Roughness Coefficients at Cross Sections

Roughness coefficient values used at cross sections that are not at structures are evaluated to determine whether:

- Left and right overbank "n" values at each cross section are between 0.030 and 0.200.
- Channel "n" values at each cross section are between 0.025 and 0.100.

Transition Loss Coefficients

Transition loss coefficient values used at all cross sections are evaluated to determine whether:

- The contraction loss coefficient is equal to 0.3 and the expansion loss coefficient is equal to 0.5 at Sections 2, 3, and 4 of the structure.
- The transition loss coefficients used are 0.1 and 0.3 at cross sections that are not at Sections 2, 3, and 4 of the structure.

Roughness Coefficient at Structures

Roughness coefficient values used at structures are evaluated to determine whether:

- The channel "n" values at Sections 2 and 3 of the structure are less than the channel “n” value of Sections 1 and 4, respectively, by 0.005.
- The channel "n" values downstream and upstream of an internal bridge opening section are equal to or larger than the channel “n” value of Sections 2 and 3, respectively.

3.3. XS Check

Summary Table

A summary table of the data extracted from the HEC-RAS project (.prj) file is featured in the **XS Check** report generated by cHECk-RAS. It contains the following fields:

- River Station (RS)
- Left Overbank Distance (Len LOB)
- Channel Distance (Len Chl)
- Right Overbank Distance (Len ROB)

- Floodplain Top Width (TopwdthAct)
- Total Discharge (Q Total)
- Flow Code (Flow Code)

Checks Performed

Reach Distances
Reach distances are evaluated to determine whether:

- The length across the junction is not equal to zero.
- Both the left and right overbank distances at each cross section are greater than the channel distance.
- A ratio of 2:1 is exceeded at any cross section between the right overbank and the channel distance and the left overbank and the channel distance.

Cross Section Spacing
Cross section spacing is evaluated to determine whether:

The change in velocity head (**HV**) value exceeds 0.5.
The conveyance change (**Kratio**) is outside the range of 0.7 and 1.4.
Water depth changes by a factor of 1.1.
The floodplain top width (**TopWdthAct**) varies by a factor of 2.
The distance between 2 cross sections is more than 550 feet.

If all the above conditions occur, one or more additional cross sections should be inserted between the existing cross sections.

Ineffective Flow
cHECk-RAS checks whether the following options are selected or used at a river station:

- Levee
- Normal Ineffective Flow
- Multiple (blocked) Ineffective Flow

Special Conditions
cHECk-RAS indicates special conditions at river stations using the following codes as shown in the Flow Code column of the **XS Check Report Summary Table**:

B = Blocked obstruction
C = Critical depth
D = Divided flow
E = An extended cross section (where the computed water-surface elevation exceeds the elevation of the starting and end stations specified in the ground data

Location

cHECk-RAS evaluates whether the cross section upstream of a critical depth cross section is located at a distance no greater than the top width of the critical depth cross section.

Discharges

Discharges are evaluated to determine whether:

- Discharges decrease in the downstream direction.
- A constant discharge is used for the entire profile.
- The same discharge is used at the downstream and upstream side of a structure.
- There is no discharge shift between the left and right overbanks between any 2 consecutive cross sections.

Boundary Conditions

Boundary conditions are evaluated to determine whether:

- A **Friction Slope** method other than the average **Conveyance** method is used. (only reports this if the channel length is more than 500 feet).

Additionally, cHECk-RAS provides the following information regarding the starting water surface elevation method at the downstream and upstream boundaries:

- Known water-surface elevation
- Energy slope
- Critical depth
- Elevation-discharge relationship

Flow Regime

cHECk-RAS verifies whether the profiles are computed using a:

- Super critical flow regime; or
- Mixed flow regime.

3.4. ST Check

Summary Table

A summary table of the data extracted from the HEC-RAS project (.prj) file is featured in the **Structure Check** report generated by cHECk-RAS. It contains the following fields:

- River Station (RS)
- Maximum Low Cord Elevation (MaxLoChord)
- Minimum Road Elevation (MnTpRd)
- Energy Gradient Elevation (EGEL)

- Water-Surface Elevation (WSEL)
- Minimum Channel Elevation (MinChEl)
- Type of Structure (Structure)
- Lateral Station
- Lateral Type

Checks Performed

Distance
cHECk-RAS evaluates whether the distance between Section 3 and the upstream face of the structure and the distance between the downstream face of the structure and Section 2 are less than the height of the opening.

Flow Type
Flow type is evaluated to determine whether:

- the type of flow at the structure is either **Low Flow, Pressure Flow, Low and Weir Flow**, or **Pressure and Weir Flow**.
- the criteria used for computing pressure flow is the upstream energy grade line.
- the **Pressure/Weir** or **Energy** method is used at a bridge when the type of flow is **Sluicegate Pressure Flow** or **Sluicegate Pressure and Weir Flow**.
- the sluicegate **Cd value** has been specified by the user.
- the **Pressure/Weir** or **Energy** method is used at a bridge when the type of flow is **Submerged Pressure Flow.**
- a de**fault submerg**ed **Cd value** of 0.8 is used when the type of flow is **Submerged Pressure Flow.**

Culvert Co*efficients*
Culvert **coefficie**nts are evaluated to determine whether:

- **The entrance and exit** loss coefficients are specified properly.
- The culvert“n”value is specified properly.

Culvert Solution Criteria
Culvert solution criteria are evaluated to determine whether:

- **highest U.S. EG** is selected as the criterion.
- the **Energy Gradien**t at Section 3 is lower than the specified **MinWeirFlowEl** and higher than the **MnTpRd.**

Ineffective Flow

cHECk-RAS evaluates ineffective flow areas to determine whether:

- the **Multiple (Blocked) Ineffective Flow Areas** option is used for single opening bridges, culvert groups, or inline weirs.
- the **Normal Ineffective Flow Area** option or the **Multiple (Blocked) Ineffective Flow Areas** option is used at Sections 1 and 4 of a structure.
- the ineffective flow elevations are higher than **MnTpRd** when weir flow occurs for **Multiple (Blocked) Ineffective Flow Areas.**
- the **Ineffective Flow Area** option is not considered at Sections 2 and 3 when pressure or low flow occurs at a structure.
- the ineffective flow elevation is specified properly at Sections 2 and 3 of a structure.
- the effective flow area is too narrow when pressure flow occurs at a structure.
- the ineffective flow stations are within the abutments of a structure.

Geometric Data

cHECk-RAS evaluates geometric data to determine whether:

- deck/roadway data is aligned properly with the ground data.
- the low chord line crosses the ground line at more than 2 locations for a single opening bridge or within the stagnation limits of a bridge opening for a multiple opening analysis.
- Sections 2 and 3 are coded as narrowly as the bridge (culvert) opening.
- the **MnTpRdD** is higher than **MnTpRdU** if the combination of **Qweir** and **CulvQ** is larger than **Qtotal** by 1%.
- the Centerline station of Section 3 is different than that of Section 2 if encroachment stations are not computed at the Culvert Section and Section 3.
- the **Cross Section Lid** option is used at Sections 1, 2, 3, and 4 of a structure.

Floodway

cHECk-RAS evaluates the floodway to determine whether:

- the **Encroachment** method is specified at Section 3, Structure Sections, and Section 2.
- **Encroachment Methods 2** and **3** are specified at Section 3, Structure Sections, and Section 2.
- encroachment stations are within the abutment stations.
- encroachment stations are within the channel bank stations at Section 3, Bridge Sections, and Section 2.
- encroachment stations are computed at Section 3 when **Encroachment Method 1** is specified at the Structure Section, and **Encroachment Method 4** or **5** is specified at Section 3.

- negative surcharge values at Section 3, Bridge-Up Section, Bridge-Dn Section, and Section 2, are less than –0.09.
- the surcharge value is more than the allowable value at Section 3, the Bridge-Up Section, Bridge-Dn Section, and Section 2.
- the encroachment stations are within the 1%-annual-chance floodplain.
- encroachment stations over the road for culverts and inline weirs are within the weir stations of the natural profile.

3.5. Floodway Check

Summary Table

A summary table of the data extracted from the HEC-RAS project (.prj) file is featured in the **Floodway Check** report generated by cHECk-RAS. It contains the following fields:

- River
- Reach
- River Station (RS)
- Encroachment Method (Method)
- Surcharge Values (Surcharge)
- Left Encroachment Station (EncStaL)
- Right Encroachment Station (EncStaR)
- Left Station Effective (LStaEff)
- Right Station Effective (RStaEff)
- Structure Type (Structure)
- Lateral Weir Station

Checks Performed

Encroachment Method

cHECk-RAS checks to determine whether:

- **Encroachment Methods 2** and **3** are used to compute the floodway encroachment stations.
- A target surcharge value for water-surface elevation is not specified for **Encroachment Methods 4** or **5**.
- A surcharge target value greater than 1 foot or the maximum allowable surcharge value for the state where the stream is located is specified at each cross section.

Starting Water-Surface Elevation
cHECk-RAS checks to determine whether:

- The starting water-surface elevation of the floodway profile is equal to the computed water-surface elevation of the natural profile plus the specified surcharge value.
- The difference in conveyance between the floodway profile and the natural profile is more than 1%.

Floodway Width
cHECk-RAS checks to determine whether:

- Encroachment stations are specified within the channel bank stations.
- Encroachment stations are outside the 1%-annual-chance floodplain.
- Channel bank stations are selected such that a relatively flat overbank exists outside of the channel bank stations.

Surcharge Value
cHECk-RAS checks to determine whether:

- Negative surcharge values exist in the floodway computations.
- Computed surcharge values exceed the maximum allowable surcharge value at any cross section.
- The **Change in WS or EG** option is used to specify the floodway water-surface elevation.

Floodway Discharge
cHECk-RAS checks whether the total discharge in the natural and floodway profiles are the same at every cross section.

3.6. Profiles Check

Summary Table

A summary table of the data extracted from the HEC-RAS project (.prj) file is featured in the **Profiles Check** report generated by cHECk-RAS. It contains the following fields:

- River Station
- Water-surface elevation (WSEL)
- Total Discharge (Q Total)
- Floodplain Top Width (TopwdthAct)
- Velocity Head (Vel Head)
- Profile

Checks Performed

Boundary Conditions
cHECk-RAS checks the **Starting Water-Surface Elevation** method for the downstream and upstream boundary conditions for each selected profile.

Discharges
cHECk-RAS checks whether the discharges at each river station are in increasing order.

Crossing of water-surface elevations
cHECk-RAS checks whether the water-surface elevations of a profile with a lower discharge are higher than that of a profile with a higher discharge.

Top Width
cHECk-RAS checks whether the top width of a profile with a higher discharge is the same as that of a profile with a lower discharge, and if so, whether the velocity head for the profile with the higher discharge is more than 0.5 foot.