Appendix G

Economic Model Documentation

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1 Economic Model Documentation – Appendix G

MISSOURI RIVER BED DEGRADATION ECONOMIC MODEL DOCUMENTATION

Missouri River, Kansas and Missouri

Avoided Costs Analysis

Model Name: Missouri River Bed Degradation Economic Model

Functional Area: Missouri River, Kansas and Missouri

Model Proponent: USACE, Kansas City District

Model Developer: David Miller & Associates, Inc.

May 2013

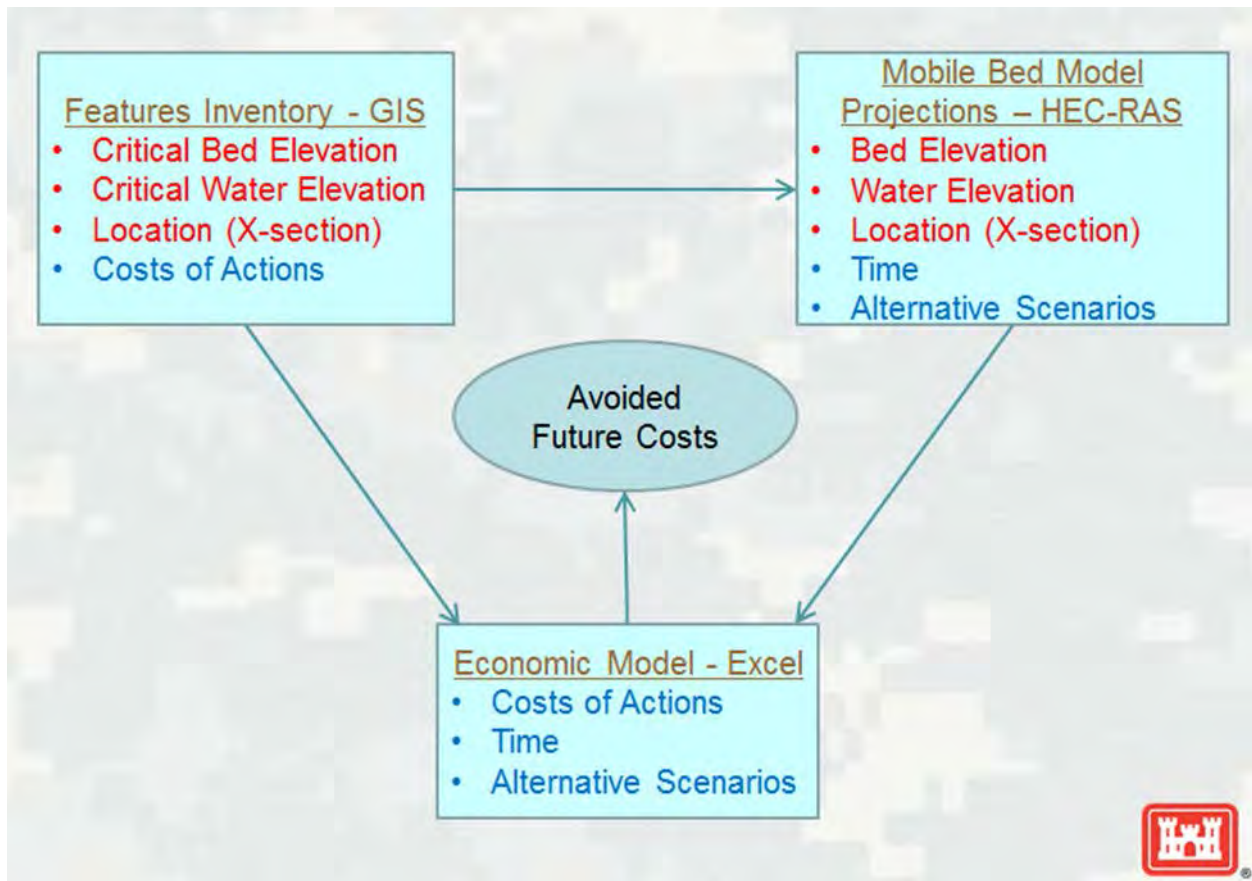**Missouri River Bed Degradation Economic Model Documentation**

Table of Contents

1 Background

This model is a single-use, study specific model, which calculates future infrastructure-related costs due to Missouri River bed degradation. Model inputs include outputs from a HEC-RAS model which identifies water and bed elevation changes each year for 50 years, infrastructure repair costs due to changes in elevation and the elevation at which the costs would be incurred, and GIS program outputs which identify physical characteristics of the infrastructure.

1.1 Purpose of the Model

The purpose of the model is to estimate future infrastructure costs due to Missouri River bed degradation. The model will be used to calculate infrastructure costs under without-project and under with-project conditions. The ultimate goal of the modeling effort is to compare the results of the model under without and with-project conditions to evaluate the costs avoided under with-project conditions. The avoided costs are project benefits, which will be used in plan formulation.

1.2 Model Description and Depiction

The model consists of a single EXCEL spreadsheet, which depicts a single project condition. The spreadsheet contains nine tabs:

1. Model Documentation;
2. Inputs;
3. Raw features list;
4. Raw MBM bed output;
5. Raw MBM water output;
6. Feature-Output table bed;
7. Feature-Output table water;
8. Current Capital Costs;
9. Current Maint Costs; and
10. AAEQ.

The function of each tab is described briefly below.

1.2.1 Model Documentation

The contents of section 1.2 Model Description and Depiction are included in the Model Documentation worksheet.

1.2.2 Inputs Worksheet

The Inputs Worksheet includes the discount rate and the costs associated with each feature. Costs are listed by feature type, or if cost information is available for an individual feature, then costs are listed by feature ID number. All information on this worksheet is determined outside of the model. The values listed on this worksheet will be revised as additional data becomes available.

1.2.3 Raw Features List Worksheet

The Raw Features List Worksheet is generated by the GIS program, which contains information on the physical characteristics of each feature in the study area. The Feature ID is a unique identifier for each feature[1]. Although each characteristic listed on this worksheet is not used in the model, all the characteristics are listed for reference purposes. Characteristics used in the model include:

- Feature ID, which is the unique identifier for each feature;
- Critical Elevation Type, which identifies whether costs are incurred due to water elevation or bed elevation changes;
- Xs_river_mile, which is used to reference the HEC model output, and
- Critical Change, which is the change in elevation that causes a cost to be incurred (i.e., the threshold point).

All information on this worksheet is determined outside of the model. The values listed on this worksheet will be revised as additional data becomes available.

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[1] Note that the Object ID, which is generated by the GIS program is not used as the unique identifier in this spreadsheet because the Object ID is and output of the GIS program. The feature ID is an input into the GIS program.

1.2.4 Raw MBM Bed Output Worksheet

The Raw MBM Bed Output worksheet is the output from the HEC-RAS mobile bed model (MBM) depicting bed elevation changes ate each river mile in the study area for each of 50 years. All information on this worksheet is determined outside of the model. The values listed on this worksheet will be revised as additional data becomes available.

1.2.5 Raw MBM Water Output Worksheet

The Raw MBM Water Output worksheet is the output from the HEC-RAS mobile bed model (MBM) depicting water elevation changes ate each river mile in the study area for each of 50 years. All information on this worksheet is determined outside of the model. The values listed on this worksheet will be revised as additional data becomes available.

1.2.6 Feature-Output Table Bed Worksheet

The Feature-Output Table Bed worksheet links the HEC-RAS mobile bed model output to each of the infrastructure features. The link between the feature list and the HEC-RAS output is made via a lookup function, which compares the feature's xs_river_mile to the river mile listed in the HEC-RAS output. The lookup function returns "water" if the critical elevation type listed in the features list is not the bed elevation.

1.2.7 Feature-Output Table Water Worksheet

The Feature-Output Table Water worksheet links the HEC-RAS mobile bed model output to each of the infrastructure features. The link between the feature list and the HEC-RAS output is made via a lookup function, which compares the feature's xs_river_mile to the river mile listed in the HEC-RAS output. The lookup function returns "bed" if the critical elevation type listed in the features list is not the water elevation.

1.2.8 Current Capital Costs Worksheet

The Current Capital Costs worksheet looks to the HEC-RAS outputs to see if the critical elevation has been achieved in any year. If a feature's critical elevation has been achieved, then the appropriate cost is entered into the cell representing the year that the critical elevation was achieved. The linkages between HEC-RAS model outputs and costs are created via conditional lookup functions. The critical change and feature type (columns B and C) are presented for reference. These costs are considered capital costs, which are assumed to occur no more than once in the 50-year planning period (i.e., once the costs are incurred and the problem is fixed further elevation changes do not cause additional expenditure).

Columns BD – BG provide a check on the calculation made in the worksheet. Column BD, which is the sum of expenditures at that feature over the 50-year period, should be zero or equal to the unit cost because the cost should only be incurred once if at all. If column BD is greater than zero, then the maximum change (column BF) should be greater, in absolute terms, than the critical change (column BG). Alternatively, if the sum of expenditures is zero, then the

maximum change should be less, in absolute terms, than the critical change, which indicates that the cost threshold has not be achieved.

1.2.9 Current Maint Costs Worksheet

The Current Maint Cost worksheet works in exactly the same way as the Current Capital Cost worksheet with the exception that maintenance costs recur each time the critical elevation is achieved. The check system calculates the number of times the cost is incurred and recalculates the total maintenance cost for that feature as a check.

1.2.10 AAEQ Worksheet

The AAEQ worksheet sums the annual discounted expenditures and calculates the average annual equivalent (AAEQ). This value can be compared to other Missouri River Bed Degradation Economic Model outputs based on alternative project conditions to evaluate the avoided costs associated with each condition.

1.3 Contribution to the Planning Effort

This model calculates the projected infrastructure costs related to bed degradation, which when calculated for without and with-project conditions provides an average annual equivalent value of project benefits.

1.4 Description of Input Data

Input data includes

- Feature characteristics provided by engineering staff;
- Feature repair costs provided by engineering staff and feature owners;
- HEC-RAS mobile bed model output provided by engineering staff; and
- Discount rate provided by EGM 13-01.

1.5 Description of Output Data

The model's output data is the average annual equivalent cost of infrastructure repairs due to Missouri River Bed degradation for the project condition modeled by HEC-RAS. The Missouri River Bed Degradation Economic Model must be run separately for each project condition modeled by HEC-RAS.

1.6 Capabilities and Limitations

The Missouri River Bed Degradation Economic Model is designed specifically to operate with GIS and HEC-RAS model output and cannot be used with other model outputs without considerable reconfiguration.

1.7 Model Development and Testing

The model has been developed in coordination with engineering personnel who developed the infrastructure characteristics and the HEC-RAS model. A developmental version of the model has been through a quality control audit (attached) and recommended modifications have been made and are included in the current version.

2   Technical Quality

2.1   Theory
The theory underlying the model is that Missouri River bed degradation causes infrastructure owners to incur repair costs when the bed and water profiles fall below a critical elevation. The difference between costs incurred under without-project conditions and costs incurred under with-project conditions are avoided costs and may be considered project benefits.

2.2   Description of System Represented in the Model
The model represents a system of infrastructure maintenance and repair which exhibits, in the historical data, repair costs incurred due to bed degradation.

2.3   Analytical Requirements
The model is heavily dependent on the HEC-RAS model output, which determines the degree of bed degradation and the timing of degradation. The model is also dependent on engineering calculations including critical elevations for infrastructure features and repair costs.

2.4   Conformance with Corps Policies and Procedures
The model appropriately uses the federal discount rate for FY13 (EM13-01) and calculates avoided costs as a project NED benefit.

2.5   Identification of Formulas and Proof that Computations are Correct
Formulas are readily displayed in the formula bar for each cell containing a formula. The check columns described in section 1.2.7 Current Cost Worksheet (above) indicate whether computations have been done correctly.

3   System Quality

3.1   Rationale for Software Selection
EXCEL is a widely available and widely used program, which is fully capable of performing the necessary functions and calculations.

3.2   Proof that Programming Was Done Correctly
A quality control audit was performed on the model and the model contains internal checks.

3.3   Availability of Software
EXCEL is the standard spreadsheet software and is readily available.

3.4   Process Used to test and Validate Model
A quality control audit was performed on the model and the model contains internal checks as described in section 1.2.7 Current Cost Worksheet.

3.5   Interoperability

The model output, which is the average annual equivalent of projected infrastructure expenditures, can be input into other EXCEL spreadsheets, which can be used to compare projected infrastructure expenditures for alternative project conditions.

4   Usability

4.1   Availability of Input Data

Input data is developed specifically for use in this model. There is no generally available input data.

4.2   Formatting of Output

Model output is formatted in standard average annual equivalent terms.

4.3   Usefulness of Results

Model results will be used directly in plan formulation.

4.4   Ability to Export Results into Project Reports

Model results from multiple model runs may be exported to a single spreadsheet, which can easily be exported as a table and inserted into project reports.

4.5   Training Availability

Training is likely to be unnecessary because the model is in EXCEL software.

4.6   Users Documentation

User documentation is included in the first worksheet.

4.7   Technical Support Availability

The software includes substantial technical support through the "help" function.

4.8   Software Availability

EXCEL software is widely available and is the industry standard for spreadsheets.

4.9   Model Accessibility

This is a single use model. Access is controlled by the USACE Kansas City District.

4.10   Model Transparency

All functions and calculations are exhibited in the formula bar for each cell. One system of checks is included in the model. Other verification methods may be developed by the user.

Appendix A: Quality Control Audit

Missouri River Bed Degradation Feasibility Study

Quality Control Audit Report – May 2013

The purpose of this review is to examine and comment upon the model used to calculate the avoided costs associated with the Missouri River Bed Degradation project. Specifically, the audit is intended to determine whether the model formulas are internally consistent and mathematically accurate. This audit does NOT, however, question the underlying logic of the model, nor does it include any validation of hard data used in the calculations.

The Excel file to be reviewed is:

MOBed Econ Model Test 2

In general, this is a well-designed and logical model, with no obvious errors.

Specific page comments follow:

Inputs

- Three cells appear to be unnecessary and can be deleted: A3, G12 and H12.

Raw Feature List, Raw MBM Bed Output and Raw MS Water Output

- These pages contain hard data, so no review is necessary. It would be helpful, however, to use the Freeze Pane function for ease of review.

Feature-Output Table Bed and Feature-Output Table Water

- Column B should use a lookup function and not hard data.

- For the formulas in columns C-BA, the review consisted of examining the formula in the first cell, assessing whether the correct anchoring functions were used, and then spot-checking a few cells in the remainder of the data. Based on this review, the original formula is constructed correctly, and the correct anchors are in place. So assuming that the modeler did a simple copy/paste, the remaining formulas should be correct. A random check of formulas throughout the page confirmed that the formulas were correct and that the correct data were pulled. Therefore, even though the review did not include a check of every single formula on the page, it is reasonable to assume that all of the formulas are correct.

- When comparing the xs_river_mile column B with the Feature RM in the *Raw MBM pages*, the Vlookup formula defaults to the next lowest value. The modeler should confirm that rounding down, rather than up, is in fact their intent.

- The Freeze Pane function would be useful here as well.

Current Costs

- For Columns A-C, the formulas in the first line are correct, and the correct anchors are in place. So it is reasonable to assume that other formulas in those columns are correct as well.

- Similarly, the formulas in the first lines of Columns E-G are correct, and the slight differences between the three formulas have the desired effect of eliminating the possibility of counting duplicate costs. All anchors in those formulas are also applied correctly, so if the modeler used copy/paste, it is reasonable to assume that all formulas in columns E-BC are correct. A random check of formulas throughout the page confirmed that the formulas were correct and that the correct data were pulled.

- Data in columns BD-BG are not necessary for the calculations, but do provide a quick visual check that the model is performing accurately.

- The Freeze Pane function would be useful here as well.

AAEQ

- All formulas on this page are correct.

In summary, the model formulas are internally consistent and mathematically accurate. Any comments above pertain to theoretical questions or matters of style.

Kurt Shanfield

David Miller & Associates

May 8, 2013

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF:

CECW-P

10 March 2015

MEMORANDUM FOR Director, National Flood Risk Management Planning Center of Expertise (FRM-PCX)

SUBJECT: Missouri River Bed Degradation Economic Benefits Model - Approval for Use

1. The HQUSACE Model Certification Panel has reviewed the Missouri River Bed Degradation Economic Benefits model in accordance with EC 1105-2-412 and has determined that the model and accompanying documentation are sufficient to approve the model for use on the Missouri River Bed Degradation Feasibility Study. This determination was based on consideration of the assessments of the WMRS-PCX and the Agency Technical Review (ATR) team. Adequate technical reviews have been accomplished and the model meets the certification criteria contained in EC 1105-2-412.

2. During the model review process the ATR team identified some concerns pertaining to the model incorporating risk and uncertainty around key economic and hydrodynamic inputs. Some of these concerns were addressed in revisions within the model and some of these concerns were agreed to be dealt with during the ATR of the study. It is the responsibility of the FRM-PCX to assure that the appropriate sensitivity analyses are conducted to adequately address uncertainties in the study analysis and recommendations.

3. APPLICABILITY: This approval for use is limited to the Missouri River Bed Degradation Feasibility Study.

BRUCE D. CARLSON
Deputy Chief,
Planning and Policy Division
Directorate of Civil Works

5   References:

National Research Council (NRC). 2002. The Missouri River Ecosystem – Exploring the Prospects for Recovery. Committee on Missouri River Ecosystem Science, Water Science and Technology Board, Division of Earth and Life Studies and National Research Council. National Academy Press. Washington, D.C.

U.S. Army Corps of Engineers (USACE). 1979. Missouri River Bank- Stabilization and Navigation Project, Final Environmental Statement Continuing Construction and Maintenance. Omaha District.