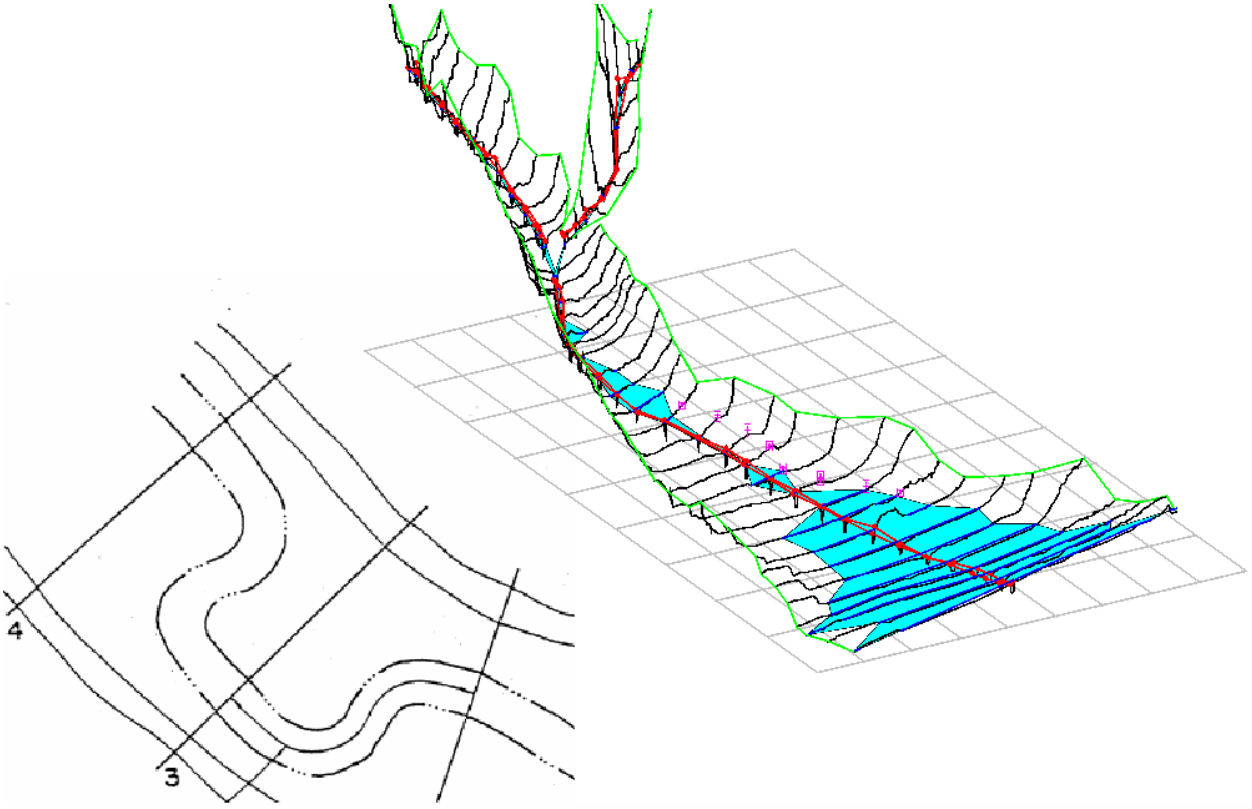
Michigan Department of Environment, Great Lakes, and Energy

Hydraulic Report Guidelines

Revised May 2019



EGLE

Environmental Assistance Center 800-662-9278
www.michigan.gov/egle

Water Resources Division

Table of Contents

Introduction

A hydraulic analysis is required on streams/drains with a drainage area of two square miles or more when a proposed project may cause an increase in flood elevations or change in the direction of flow. When it is not definitive as to whether a project will or will not cause an increase, then an analysis should be provided to show that there will be no increase.

When a hydraulic analysis is required, a $1,500 hydraulic review fee for each analysis should be submitted in addition to the normal application fee. If multiple analyses are submitted for multiple locations, a $1,500 fee must be provided for each.

The hydraulic analysis should compare the existing floodplain energy grade line elevations with the proposed energy grade line elevations for a range of discharges up to and including the 100-year flood frequency discharge. Flood discharges for watercourses may be requested free of charge from the Michigan Department of Environment, Great Lakes, and Energy (EGLE) (page 10). If you develop discharges, they must be approved by EGLE prior to submittal of the model.

If you are considering using a hydraulic model other than the Hydrologic Engineering Center's - River Analysis System (HEC-RAS), it is recommended you contact the district engineer prior to starting the modeling to discuss if the hydraulic program is appropriate for the project and if the particular staff has access to properly review the model.

Do not include print-outs from the digital hydraulic model in the report unless making a specific reference.

If the proposed project causes an increase in the floodplain elevations, then an engineer licensed in Michigan must certify that the increase is non-harmful. Harmful interference is defined as "causing an increase stage or change in the direction of flow that causes or is likely to cause: damage to property; a threat to life; pollution, impairment, or destruction of water or other natural resources." A copy of the damage assessment guidelines and certification language is found on pages 11-13.

If the project causes an increase in flood elevations that are above the stream banks and occurs outside of the applicant's property, then affected property owner statements (pages 13-14) need to be sent by certified mail to all the affected property owners, or the project must be redesigned.

A project that is determined by EGLE to cause a harmful interference cannot be permitted.

These guidelines are designed to assist those submitting a hydraulic analysis and report for state permitting under the State's Floodplain Regulatory Authority found in Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA), for state concurrence of a Letter of Map Revision, or any other modeling that is submitted for review. The guidelines are intended for professional engineers familiar with floodplain management and hydraulic modeling. They do not provide instructions for using hydraulic modeling programs.

Hydraulic Analysis and Report Submittal Requirements

ALL the following information must be included as part of the submittal of a hydraulic model/report to EGLE. Failure to supply ALL the items listed below will result in an incomplete application.

A $1,500 hydraulic review fee (in addition to the normal application fee) for each model submitted.
A functioning digital copy of the modeling runs for existing and proposed conditions. Each run should be labeled appropriately and referenced in the hydraulic report. Extraneous runs should not be included.
A detailed Hydraulic Report (including supporting data, plans, and other documentation) prepared and sealed by an engineer licensed in Michigan.
Location map(s) showing the project location, all model cross-sections (with labels), existing and proposed grades and all existing structures in/near the floodplain that could potentially be impacted by the project.
For projects where there is an increase in the energy grade (an increase of 0.005 feet or greater) for the proposed versus the existing conditions, the following requirements apply:

- The engineer must certify that the increase does not interfere harmfully with the discharge or stage characteristics of the stream.
- If any increase extends beyond the banks of the main channel and occurs outside of the applicant's property, affected property owner statements need to be sent by certified mail to all the affected property owners (or the project must be redesigned to eliminate the increase).
- A project that causes a harmful interference cannot be permitted.

For projects located within a detailed floodplain study area mapped by the Federal Emergency Management Agency (FEMA), the following modeling may be required in addition to the existing and proposed conditions:
Duplicate Effective Model – this is the currently effective FEMA model with **zero** changes. For information on how to obtain copies of the effective Flood Insurance Study (FIS) models, see the Department of Homeland Security (DHS)-FEMA's Internet site at https://www.fema.gov/flood-maps/know-your-risk/engineer-surveyor-architect.

Corrected Effective Model (CEM) – this corrects any errors that occur in the Duplicate Effective Model, adds any additional cross-sections to the Duplicate Effective Model, or incorporates more detailed topographic information than that used in the Duplicate Effective Model. The CEM must not reflect any man-made changes since the date of the Duplicate Effective Model. An error could be a technical error in the modeling procedures, or any construction in the floodplain that occurred prior to the date of the Duplicate Effective Model but was not included in the Duplicate Effective Model. *All* differences between the models need to be documented and explained.

Existing Conditions Model – Most of the time, this is the same as the CEM. This should reflect any changes to the floodplain since the date of the effective study. Any changes between Existing Conditions Model and CEM need to be documented and explained in detail.

Proposed Conditions – encroachments added to reflect proposed project.

Construction Models – may be needed to evaluate the impacts of temporary floodway obstructions during the construction process, such as sheet piling. Sheet pile height and locations need to be specified in plans. Plans to remove sheet piling above certain flow rates can be used to offset potential increases; but details on who removes the sheet piles, which sheet piles are to be removed, what type of equipment will be used, if equipment is onsite, time it takes to remove sheet piles, and flowrates when this will occur, should be provided.

All changes to the Duplicate Effective Model and subsequent models must be supported by certified topographic information, bridge plans, construction plans, survey notes, etc.

Changes to the hydraulic models should be limited to the stream reach for which the revision is being requested. Cross-sections upstream and downstream of the revised reach should be identical to those in the effective model.

Projects that alter the mapped floodway boundary or increase the base flood elevations of the FEMA mapped floodplain will generally require the applicant to obtain a conditional letter of map revision (CLOMR) from FEMA prior to the project. FEMA's review of a CLOMR can take six to nine months.

When is a Hydraulic Analysis Needed?

This is a general list of when a hydraulic analysis is needed for review under the State's Floodplain Regulatory Authority found in Part 31, Water Resources Protection, of the NREPA. It does not indicate when a hydraulic analysis may be required by other agencies such as the county drain commissioner or the local community.

A hydraulic analysis is required for the following:

1. Filling or construction in the floodway that exceeds one percent of the cross-sectional area of the 100-year floodway unless the construction is directly in-line, adjacent to and on the downstream side of an existing obstruction.
2. Stream relocation.
3. Changing the FEMA floodway line.
4. Culvert or bridge replacement projects that have the following characteristics (with all other items remaining equal):
    a. An increase in road grade more than the addition of a new wearing course (assumed to be four inches or less) unless the existing road grade is above the 100-year floodplain elevation
    b. A reduction in end area.
    c. An increase in the Manning's roughness coefficient (i.e., going from a concrete to metal culvert).
    d. A reduction in the efficiency of the entrance condition (i.e., going from a headwall condition to a projecting or mitered end section.
    e. An extension onto an existing structure that exceeds 24 feet.
    f. A new culvert/bridge that is longer/wider than the existing structure.
    g. A change in slope.
5. Developing a floodway boundary in an area without a mapped floodway.

A hydraulic analysis is not needed for the following:

1. If the stream/drain has a drainage area of less than two square miles.
2. If a project meets a minor project category found in Part 31 of the NREPA.
3. Outside of a mapped floodway if a detailed map exists.
4. Encroachments representing one percent or less of the floodway cross-sectional area. The one percent must be an equal and opposite encroachment.
5. Culvert or bridge replacement where the opening is increased below the 100-year floodplain elevation with all other hydraulic factors remaining the same-i.e., same road grade unless the existing road grade is above the 100-year floodplain elevation, same culvert length/bridge width, same or improved roughness condition, same or improved entrance conditions, same slope.
6. A temporary crossing that is in place for 14 days or less where there is minimal blockage. Minimal blockage would be defined as having the top of the blockage no higher than two feet above the ordinary highwater mark. This type of work should be done during low flow conditions with the impounded water being pumped or culverted around the project site to maintain flow to the channel downstream of the work area.
7. Part width blockage of a stream where the blockage is 1/2 of the stream width or less, extends no more than two feet above the ordinary high-water mark and the work is completed in 14 days or less.
8. For the installation of temporary sheet piling around bridge abutments/piers where the sheet piling is used to isolate the construction activity from the stream flow and allow work to occur in the dry.
9. A temporary bridge that is not more than 24 feet in width and that matches or exceeds and is directly adjacent to upstream bridge crossing.
10. A temporary culvert that is not more than 24 feet in length and that matches or exceeds and is directly adjacent to the upstream culvert crossing.

11. Removal of a dam except in a mapped floodplain area where it would be a benefit to the local community to show a lower 100-year floodplain elevation and where no grade control structures (cross vanes, rock ramps, J hooks, weirs) are being added.
12. Fish habitat structures that meet the minor project category under Part 301 of the NREPA and the following:
    a. The width of the in-stream structure shall not exceed 10 percent of the stream width.
    b. Fish habitat structures shall not be closer than 100 feet of each other.
    c. Structures that deflect flow from the channel bank shall not extend into the stream more than 25 percent of the width of the stream. These structures shall not redirect flow to cause erosion of the opposite bank.
    d. Solid structures that extend from the water surface to the stream bottom shall have a deflection angle of 25 degrees or less.

Some projects may or may not require a hydraulic analysis. (Contact the district floodplain engineer to discuss.)

1. Dam removal projects where grade control structures (cross vanes, rock ramps, J hooks, weirs) are being added.
2. J-hooks, weir, and cross vanes projects.

When in doubt on other types of projects please contact your district floodplain engineer.

The Hydraulic Report

The Hydraulic Report provides an analysis of the proposed project compared to the existing conditions, on the floodplain and floodway for a range of discharges up to and including the 100-year discharge. The report should contain the following information.

Introduction

- Preparers name, company name, telephone number, and email.
- Describe the watercourse and location of investigation.
- Name for whom the report is being prepared.
- Date of report and topographic data used in model.
- Name and type of project.
- Describe the scope of investigation including the alternatives analyzed and evaluated.
- Describe the scope of the analysis.
- Identify any existing studies or any history of work on the watercourse in the vicinity of the project including past flooding events.

Method of Analysis

- A description of ALL modeling runs submitted must be included in the report.
- Explain why the modeling method was chosen and why it is appropriate for the project evaluation.

- Explain any assumptions made in the application of the chosen method.
- Include references and provide a description and source of any computer programs used.
- Use EGLE generated or approved discharges in the analysis.
- Explain any modeling iterations including the use of previous data (i.e., FEMA study), the addition of updated/corrected geometry, etc.

Upstream and Downstream Modeling Limits

- Show the location of the modeling limits on the site development plan.
- The model needs to start sufficiently downstream of the project (page 18 for more details).
- The analysis must extend upstream to the point where any increase caused by the proposed project is dissipated, for all flood profiles.
- The location of all cross-sections should be shown on the plans. Cross-sections should all be labeled.
- Explain why the location was selected and the method used to determine the starting water surface elevation. Include an analysis of calibration of the model(s) to existing FEMA FIS profiles if they exist or other methods used to develop stable boundary downstream water surface conditions if no FIS is available.
- Describe all modeling boundary conditions.

Variables, Coefficients, and Modeling Strategies

- Discuss all modeling variables and coefficients. Indicate references and explain all assumptions for the variables used in the model.
- Ineffective Flow Areas – should be included when appropriate – up and downstream of crossings, encroachments, and ponding areas.
- Culvert modeling approaches should not show flow below the stream bottom.
- Expansion and contraction.
- Orifice.
- Weir discharge.
- Friction.
- Provide photographs of present conditions and any other supporting information to justify modeling variable values selected for existing and/or proposed conditions.
- Describe and provide supporting justification for the bridge/culvert modeling options used.
- When a floodway is defined as part of the analysis, list the encroachment method used and provide justification of the encroachment method.
- For encroachments located in the floodway, equal and opposite encroachment into the floodway should be modeled in the proposed conditions run. Assume an equal percent reduction in conveyance in both overbanks if overbank areas are not uniform.

Discussion

- Discuss and evaluate the computations and analysis.
- Provide a description of the present channel and floodway, the nature and distribution of flow, and the proposed alterations and their resultant effect.

- Explain any unusual conditions that occur, and all assumptions not previously addressed that were part of the analysis.
- Address all model error reports.

Conclusion

- The conclusion must include the definition of “harmful interference.” Harmful interference is defined as “causing an increase stage or change in the direction of flow that causes or is likely to cause: damage to property; a threat to life; pollution, impairment, or destruction of water or other natural resources.”
- The conclusion must include the engineer’s opinion as to whether or not the project will cause harmful interreference, based on the model results.
- Evaluate the effects of the proposed conditions on the watercourse, floodplain, floodway and potentially affected properties (including upstream and, where appropriate, downstream effects) for the range of discharges up to and including the 100-year discharge.

SUPPORTING DOCUMENTS TO INCLUDE WITH REPORT

- A site plan for existing and proposed conditions. Note: The dimensions and work depicted in the model must match the permit plans and information in the application.
  - Scaled plan view drawing(s) at sufficient scale to show proposed work and elevations.
  - Location of all cross-sections used in the analysis. Cross-sections should be labeled to match cross-sections in the digital model.
  - Flood Insurance Rate Map and flood profile (if available).
  - Existing and proposed topography.
  - Property boundaries.
  - Floodway delineation.
  - Floodway alterations.
  - Proposed floodway obstruction.
  - River channel.
  - Fill, excavation and grading.
  - Existing and proposed bridges and culverts. Include the profiles of the road grade along its highest points. (The information provided should be sufficient to analyze the crossings.)
  - The elevation datum used. Plans and the model should be in the same datum.
- Cross-sections showing existing conditions and the proposed alterations. Cross-sections should include the following information. Do not include printouts from the HEC-RAS model.
  - Channel limits (the channel limits can be defined by the ordinary high-water mark of the watercourse).
  - Floodway limits, if mapped or modeled.
  - Floodplain boundary limits.
  - Roughness coefficients.
  - The coordinates of plotted points.

- If the proposed project causes an increase in the energy grade elevation (greater than an increase of 0.005 feet or greater), you must provide a Damage Assessment Certificate (see example on page 11) to certify that the increase does not interfere harmfully with the discharge or stage characteristics of the stream.
  - A harmful interference is defined as an increased stage or change in the discharge or direction of flow that causes or is likely to cause any of the following: damage to property; a threat to life; a threat to personal injury; pollution, impairment, or destruction of water or other natural resources.
- If the proposed increase extends beyond the banks of the main channel and goes off the owner's property, then you must also send by certified mail the "Affected Property Owner Statements" to all upstream property owners impacted by the proposed increase. Verification that the letters were sent out by certified mail must be provided to EGLE.

A copy of EGLE discharge or discharge approval letter.

Requesting a Flood Discharge

Part 31 of the NREPA addresses flooding up to and including the 100-year (one percent annual chance) flood. The Hydrologic Studies and Dam Safety Unit (HSDSU) of the Water Resources Division calculates flood and low flow discharges and conducts other types of hydrologic analyses in support of EGLE's water-related programs.

You can request flood discharges by going to www.michigan.gov/hydrology and clicking "Request a flood or low flow discharge" or going to https://www.egle.state.mi.us/flow/ and clicking "Discharge Request Form."

Discharge values are only valid for the specific location and are valid for one year after the date the response was sent.

In areas with a detailed FEMA FIS, the discharge from the FIS is typically used and can be verified by the HSDSU.

If you have additional data that may be helpful in updating a discharge, contact the HSDSU. The engineer reviewing the hydraulic model will not be able to approve a discharge that differs from the HSDSU values.

If you calculate your own discharge, it must be validated by the HSDSU prior to submitting the model and application. If you have questions about requesting a flood discharge, you can contact the HSDSU at https://www.michigan.gov/egle/0,9429,7-135-3313_3684_3724-168812--,00.html.

Damage Assessment Guidelines

Proposed projects which cause an increase in flood stage (0.005 feet or greater) or change in the direction of flow that is not confined entirely within the applicant's property, require the following additional information to be submitted to EGLE. Submittal of this information does not guarantee that a permit can be issued.

- Property location map and a list of all property owners located within the area affected by the increase in flood stage.
- A map showing the existing and proposed floodplain and all structures within and near the affected area. For each structure, include the lowest ground elevation adjacent to the building (including deck stairs or supports), the lowest floor elevation (including basement), and the lowest sill elevation of a window or door of all structures located within the affected area.
- A written damage assessment certification from a licensed engineer indicating that the increase caused by the project will not cause a harmful interference and that the increase will not affect any insurable structures.
- Notification shall be sent by certified mail to the affected property owners indicating the extent of additional flooding and advising them to return the form to EGLE within 10 days.
- Copies of the letter(s) sent to the affected property owners and the certified mail receipts must be submitted to EGLE.
- Photographs of the affected properties and floodplain areas.

Sample Damage Assessment Certification

{Project Name}
{Stream Name}
{Town, Range, Section}
{Community}
{County}

“I, {Certifying Engineers Name & P.E. #}, do hereby certify that I have inspected the upstream adjoining properties and find that the reduction in hydraulic capacity and resulting {____} foot increase to upstream flood stages or diversion of flow will not cause a harmful interference or damage to adjacent structures or crop lands. Harmful interference is defined as an increased stage or change in the discharge or direction of flow that causes or is likely to cause any of the following: damage to property; a threat to life; a threat of personal injury; pollution, impairment, or destruction of water or other natural resources.”

Provide an explanation as to why the increase or change in flow direction is not a harmful interference.

(Affected Property Owner Statements must be sent to all property owners impacted by the proposed flood stage increase.)

Sample Affected Property Owner Statement

Date:
Department of Environment, Great Lakes, and Energy
{District Floodplain Engineer Address}

Dear :

SUBJECT: File {File Number}, Project Name, Stream Name

I/we (circle one) have been informed by the {*Applicant/Agent*} of a potential increased flood risk on my property. The increased risk would be caused by {describe project}. This project will cause an additional increase in the floodplain elevation at the upstream limits of the applicant's property of {___} feet (elevation = {_____}) over existing floodplain conditions.

I understand that this increased floodplain elevation could cause flooding on my property during a {100-year} flood which has a {one percent chance} of occurring or being exceeded in any given year. I also understand that the proposed structure could increase flooding on my property during lesser flood frequencies.

It is my opinion that this project will/will not (circle one) cause any of the following to my property: a) damage to property, b) threat to life, c) a threat to personal injury, d) pollution, impairment, or destruction of water or other natural resources.

I can/cannot (circle one) recall any past flooding which has caused flood damage to my property. I can/cannot (circle one) recall that water has overtopped the existing road grade at the bridge/culvert location. I have the following additional comments:
_____
_____
_____

Should additional information be required of me, I can be reached by email {_____} or telephone {telephone number}.

Sincerely,

{Property Owner(s) Signature(s)}
{Address}
{Phone}
{Property Tax ID}

(Form must be returned to EGLE within 10 days)

Sample Affected Property Owner Statement
(Transportation Version)

Date:
Department of Environment, Great Lakes, and Energy
Water Resources Division
Transportation and Flood Hazard Unit
PO Box 30458
Lansing, Michigan 48909-7958

Dear :

SUBJECT: File {File Number}, Project Name, Stream Name

I/we (circle one) have been informed by representatives of the _____County Road Commission of a potential increased flood risk on my property. The increased risk would be caused by replacing the existing ____ ft. span by ____ ft. rise (structure type) at the _____ Road crossing of _____Creek with a _____ ft. span by _____ ft. rise (structure type). Installation of this structure will cause an additional increase in the floodplain elevation at the upstream limits of the road right-of-way of _____ feet (elevation =_____) over existing floodplain conditions.

I understand that this increased floodplain elevation could cause flooding on my property during a {100-year} flood which has a {one percent chance} of occurring or being exceeded in any given year. I also understand that the proposed structure could increase flooding on my property during lesser flood frequencies.

It is my opinion that this project will/will not (circle one) cause any of the following to my property: a) damage to property, b) threat to life, c) a threat to personal injury, d) pollution, impairment, or destruction of water or other natural resources.

I can/cannot (circle one) recall any past flooding which has caused flood damage to my property. I can/cannot (circle one) recall that water has overtopped the existing road grade at the bridge/culvert location. Should additional information be required of me, I can be reached by writing or telephone.

Sincerely,

Property Owner(s) Signature(s)
Address
Phone
Property Tax ID

(Form must be returned to EGLE within 10 days)

References and Resources

EGLE Floodplain Management Websites:
www.michigan.gov/egletransportationreview
or
www.michigan.gov/floodplainmanagement

FEMA's Map Service Center -- 877-FEMA-MAP
msc.fema.gov

FEMA Engineering Library – to obtain model data for published flood studies
(The link provided was broken and has been removed)

Numerical Hydraulic Models Meeting the Minimum Requirement of the National Flood Insurance Program
(The link provided was broken and has been removed)

The Hydrologic Engineering Center
https://www.hec.usace.army.mil/

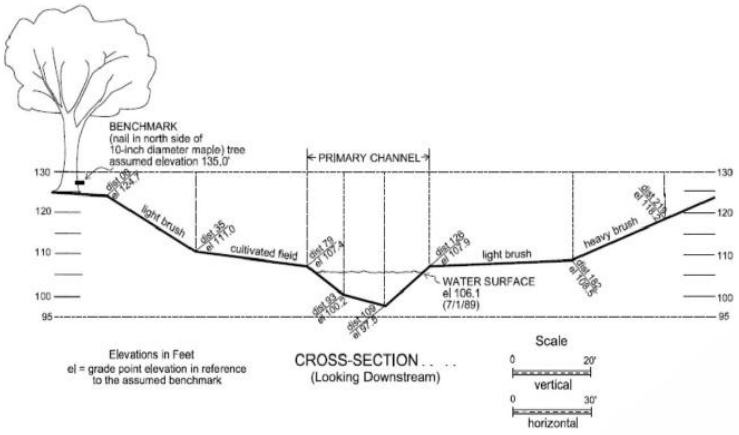
U.S. Department of Transportation Federal Highway Administration Hydraulics
www.fhwa.dot.gov/engineering/hydraulics/

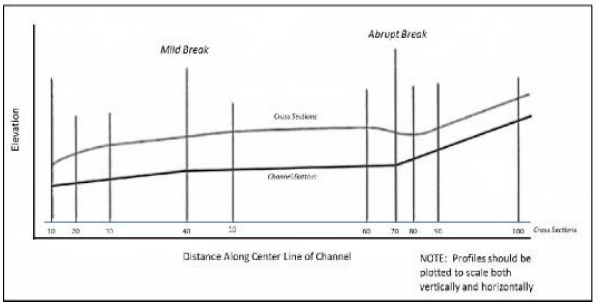
Chow, V. T., Open Channel Hydraulics, McGraw-Hill, Inc., New York, 1959 Mays, Larry W., Hydraulic Design Handbook, McGraw-Hill, Inc., New York, 1999

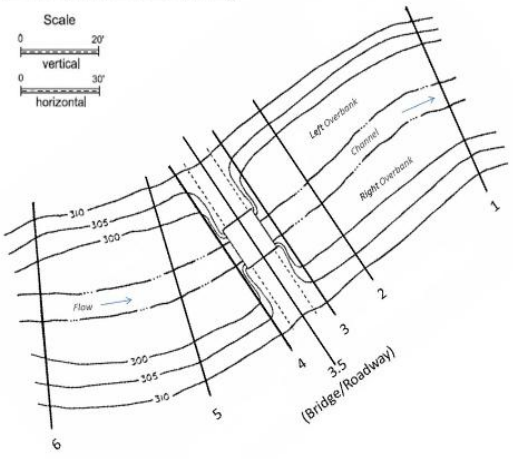
Michigan Department of Environment, Great Lakes, and Energy Hydraulic Report Guidelines

Cross-Section Guidelines

Revised May 2019







Cross-Sections

The computation of water surface profiles requires cross-sections at representative locations throughout the river reach. Cross-sections provided as part of a hydraulic report should be generated from surveyed data. A printout from a hydraulic modeling program is not sufficient.

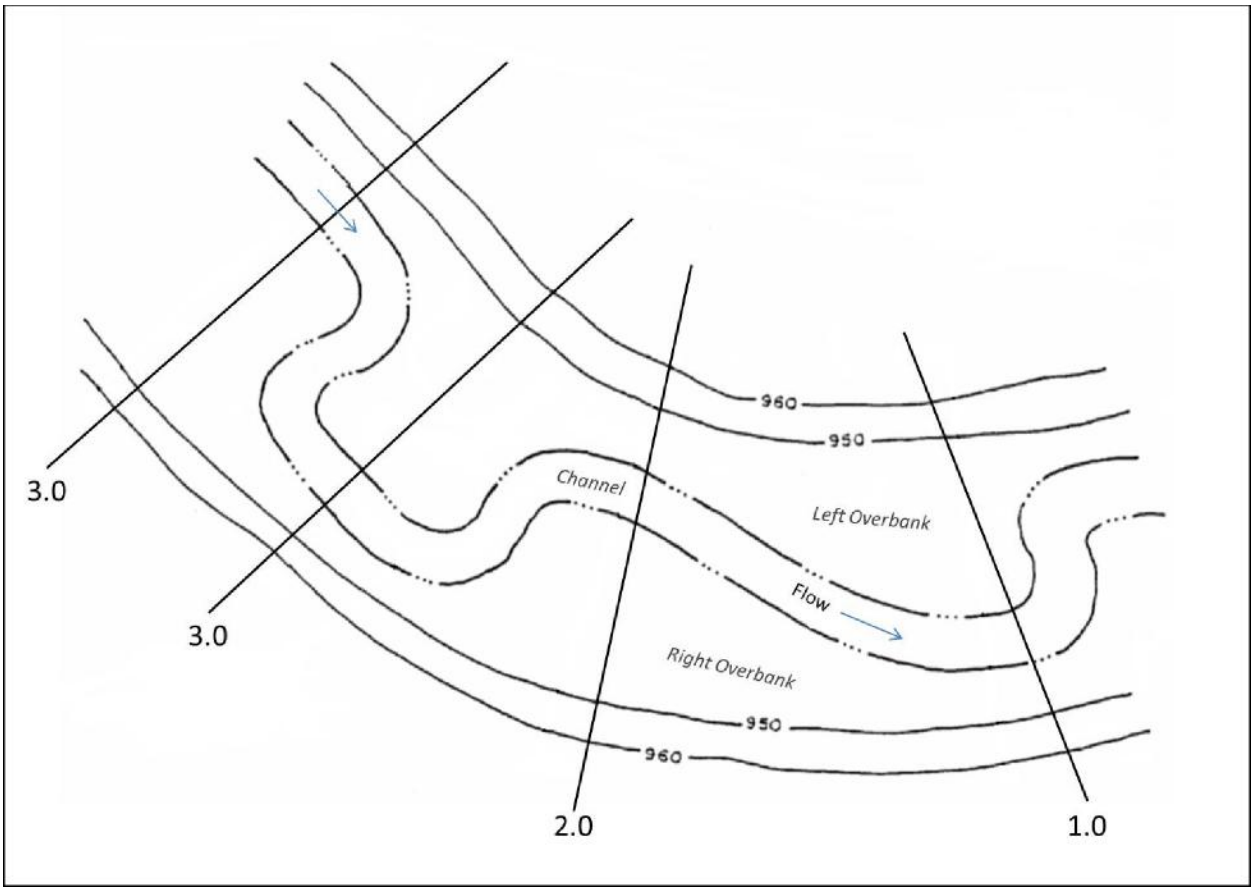
LIDAR data is generally acceptable data for creating cross-sections. The source of elevation data should be discussed in the report.

General Requirements

Cross-section stations should increase from downstream to upstream.

Each cross-section should be located on a topographic map of sufficient detail in order that the channel and overbank distances between sections can be measured accurately.

Cross-sections should be taken perpendicular to the direction of the estimated center of mass of the flood flow. This direction, in some instances, may differ materially from that of the normal flow in the channel. Every effort should be made to obtain cross-sections that accurately represent the river geometry at all stages.

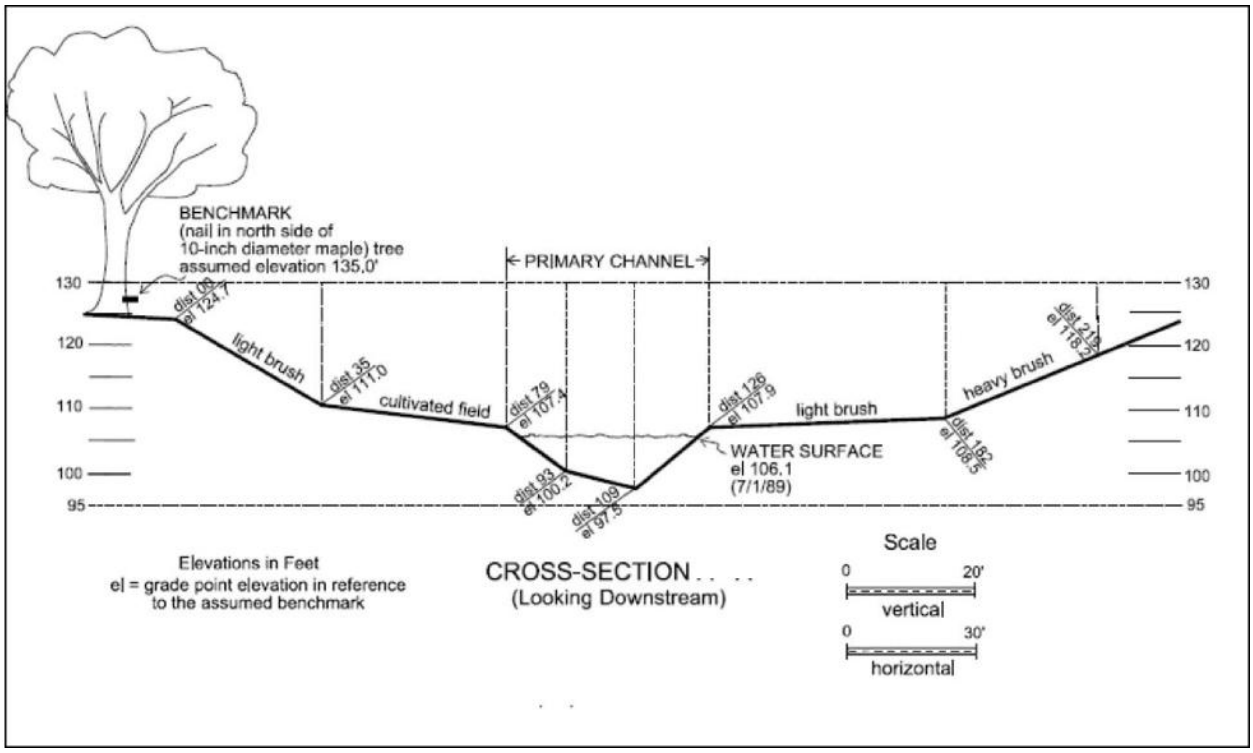


Cross-Sections

Cross-sections may not be uniform across the valley due to elevation or other geographic constraints. Bent or “dog leg” cross-sections may be appropriate. Cross-sections should not intersect.

Cross-sections must fully define transitional elements of a stream and floodplain such as the cross-sectional area increasing or decreasing, channel or overbank roughness changes, or marked breaks in bottom slope.

Each cross-section should be plotted at a reasonable scale with the left and right corresponding to that when viewed in the direction of flow (looking downstream). For each plotted point, the distance measured from a reference point on the left, and elevation should be shown. The water surface elevation, date taken, and cross-section station number label should be included on each of the plotted cross-sections.



A profile of the channel bottom and water surface should be plotted from the cross-section data. The plotted distance between cross-sections is measured along the main channel during normal flow.

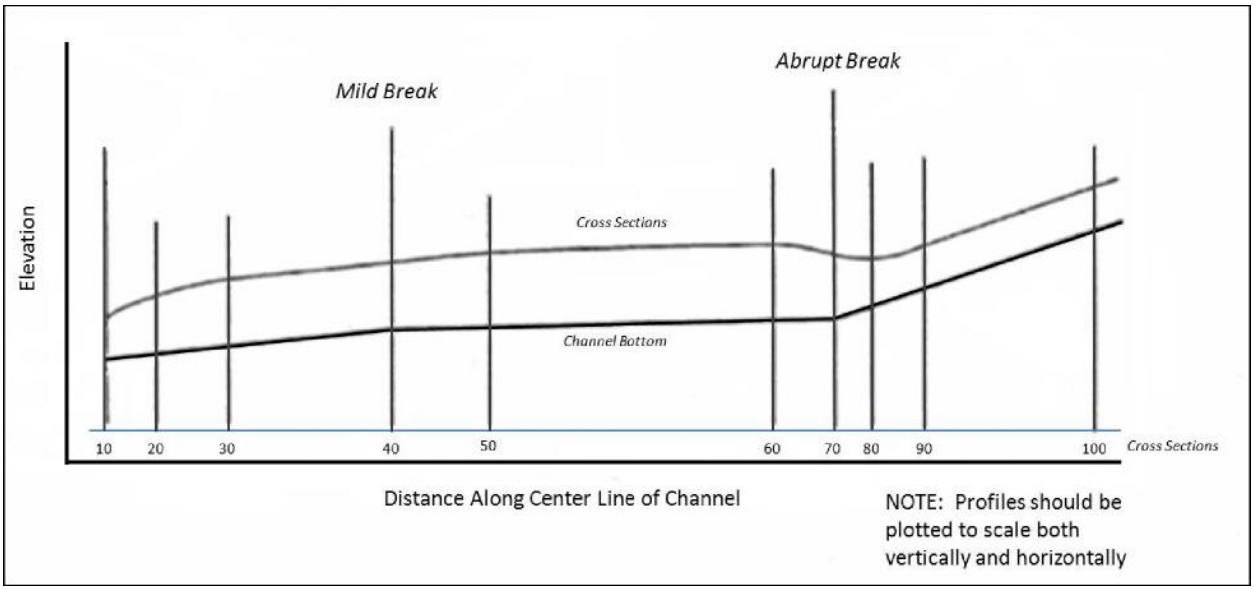
Cross-Sections

Cross-Section Location and Spacing

Downstream - Cross-sections must start sufficiently downstream of the project or study area. The downstream cross-sections should typically be on the downstream side of any bridges. If normal depth is used as a boundary condition, the downstream cross-sections should be a minimum of 500 feet downstream of the project area.

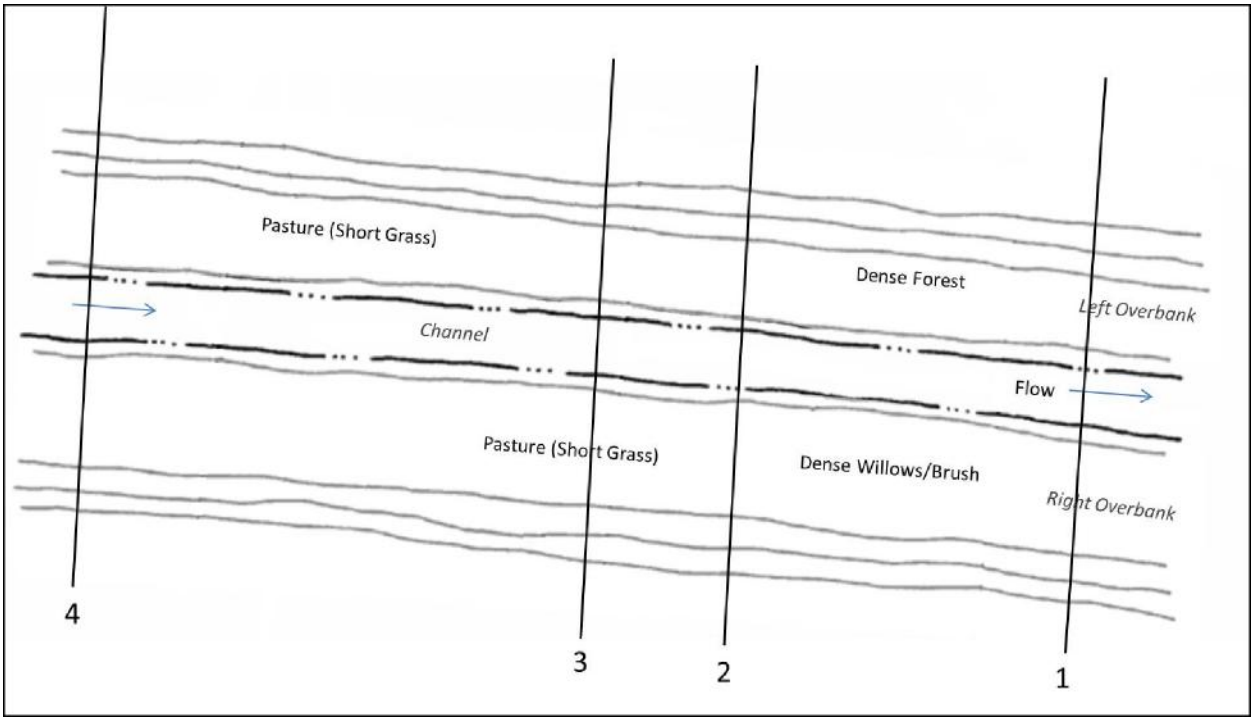
Upstream - For cross-sections upstream of the project, locate upstream cross-section(s) at any property boundaries and any city, township, county boundaries. The cross-sections should extend far enough upstream so that any increases between existing and proposed conditions dissipate to zero.

The distance between cross-sections varies based on the stream slope, the floodplain width, and the uniformity of the channel. In general, cross-section spacing of 500 feet is used when a river reach is fairly straight and uniform. Additional cross-sections are required when there are changes in the features of the watercourse. The number of cross-sections should be in proportion of the magnitude of the changes to the channel. The report or cross-section map should identify which cross-sections are interpolated vs. based on actual survey data.



- Bends and meanders.
- Changes in channel slope.
- Changes in channel or floodplain geometry, such as encroachments, expansions, or contractions.

- Abrupt changes in cross-section or profile occurs, such as at bridges, dams or other manmade or natural restrictions, a sufficient number of cross-sections should be used to describe the change.
- Changes in channel or overbank roughness.



Bridges and Culvert Cross-Sections

Generally, a minimum of six cross-sections are required to model a bridge or culvert. However, more cross-sections may be required to adequately represent site conditions in a model.

At a minimum, cross-sections should be located.

- At the upstream and downstream bridge faces (not in road ditch line or on road shoulder).
- At a location one bridge-span upstream.
- At a location four bridge-spans downstream.
- 100-feet beyond the above cross-sections both upstream and downstream.
- The cross-section should not show flow below the stream bottom.
- Depending on where the analysis starts and the boundary conditions, there should be a cross-section at least 500 feet downstream of the first bridge/culvert so that the model is stabile at the point where the bridge/culvert will be analyzed.