Fluvial Erosion Hazard Mitigation

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Road School 2019

SILVER JACKETS
Be Risk Aware!

BURKE

OCRA
Office of
COMMUNITY & RURAL AFFAIRS

WHAT IS A FLUVIAL EROSION HAZARD?

Bean Creek in Indianapolis, IN

WHAT IS A FLUVIAL EROSION HAZARD?

Sugar Creek in Crawfordsville, IN

WHAT IS A FLUVIAL EROSION HAZARD?

West Fork Whitewater River near Brookville, IN

WHAT IS A FLUVIAL EROSION HAZARD?

Fluvial Erosion Hazards are:

The suite of risks to structures, property, and infrastructure elements that are brought about by the natural processes of stream-bank erosion and stream-channel meandering

FEH CONCEPTS

Rivers are not static. They change:

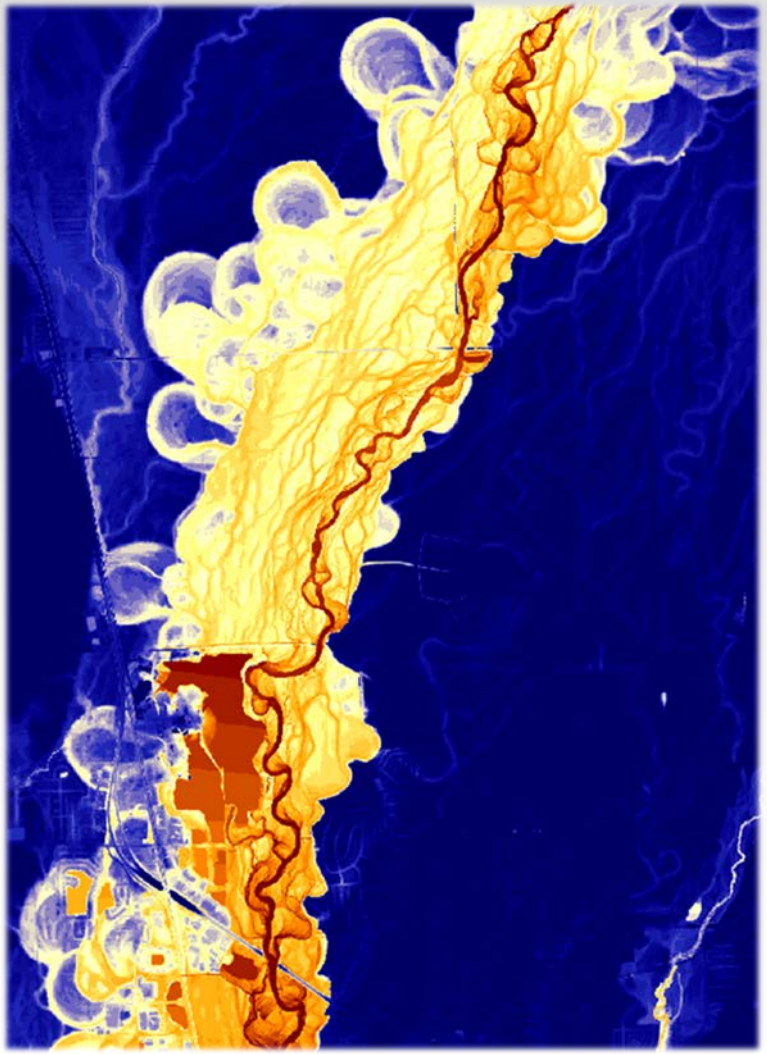
- Dimension (cross-section)

West Fork White River in Muncie, IN

FEH CONCEPTS

Rivers are not static. They change:

- Dimension(cross-section)
- Pattern (alignment from an aerial view)



Flatrock River near Columbus, IN

FEH CONCEPTS

Rivers are not static. They change:

- Dimension (cross-section)
- Pattern (alignment from an aerial view)
- Profile (bed elevation)

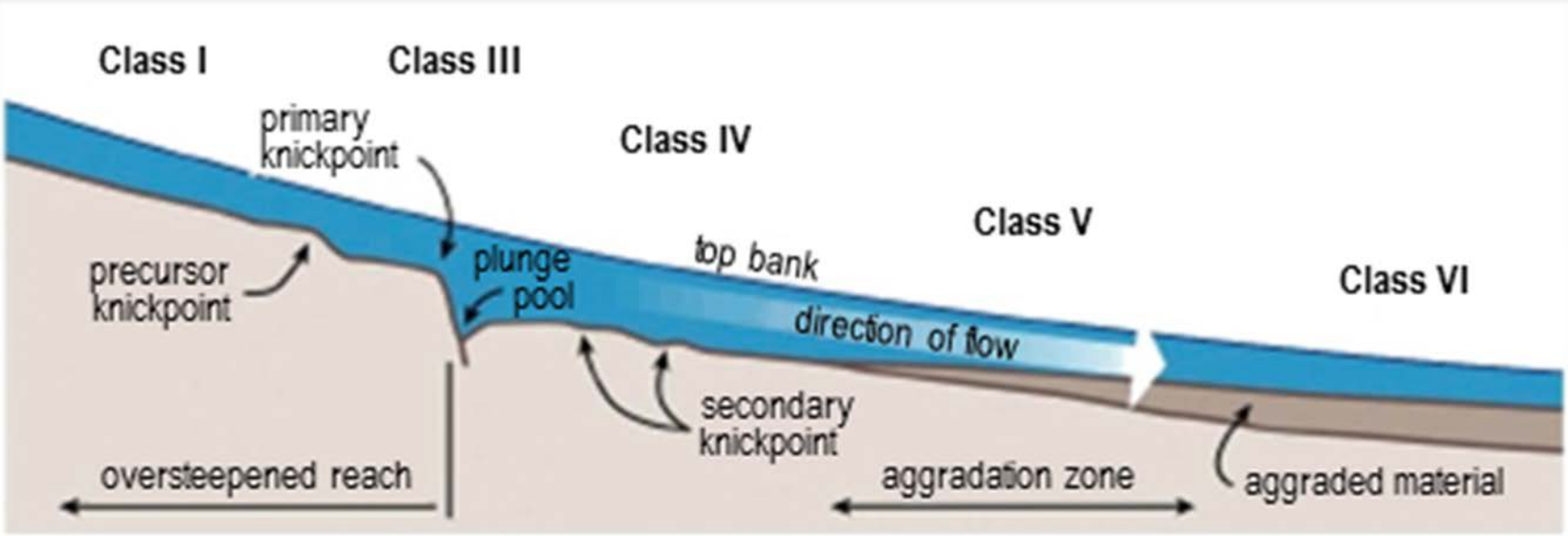


Image: Schumm et al, after USACE

FEH CONCEPTS

Stability is defined as a river or stream's ability in the present climate to transport the stream-flows and sediment of its watershed over time in such a manner that the channel maintains its dimension, pattern, and profile without either aggrading or degrading

(Rosgen, 1996, 2001).

- Fluvial erosion hazards can result from both stable and unstable rivers, though it is more common with unstable rivers.

FEH

INDIANA'S FLUVIAL EROSION HAZARD PROGRAM

INDIANA FEH PROGRAM

Federal and National Partners

FEMA

USGS science for a changing world

NOAA

National Weather Service

NRCS

USDA United States Department of Agriculture

Air National Guard

National Guard

U.S. Department of Housing and Urban Development

ASFPM

State, Local, and Educational Partners

Indiana Department of Homeland Security

Indiana Department of Transportation

Indiana Department of Natural Resources Division of Water

DNR Indiana Department of Natural Resources

IDEM Indiana Department of Environmental Management

Maumee River Basin Commission

OCRA Office of Community & Rural Affairs

Indiana Geographic Information Council

Purdue University

IUPUI

CEES

The Polis Center Indiana University-Purdue University Indianapolis

The Nature Conservancy Protecting nature. Preserving life.

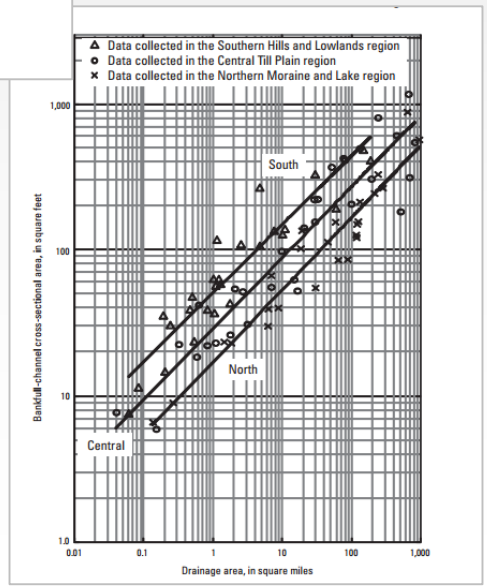
FEH

INDIANA'S FLUVIAL EROSION HAZARD PROGRAM

INDIANA FEH PROGRAM: PREVIOUS PHASES

- Phase I:

  Develop regionally-based channel dimensions for stable Indiana streams



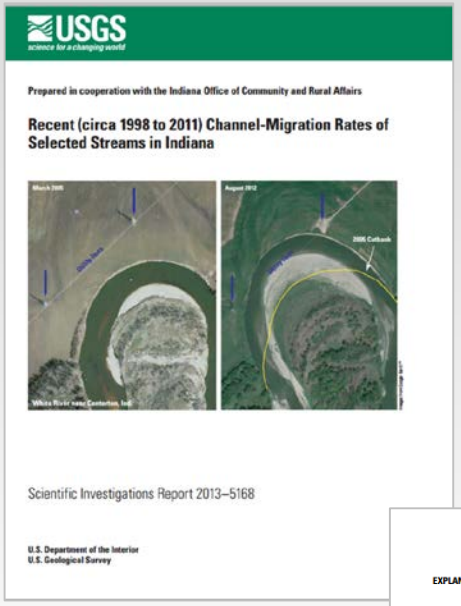
INDIANA FEH PROGRAM: PREVIOUS PHASES

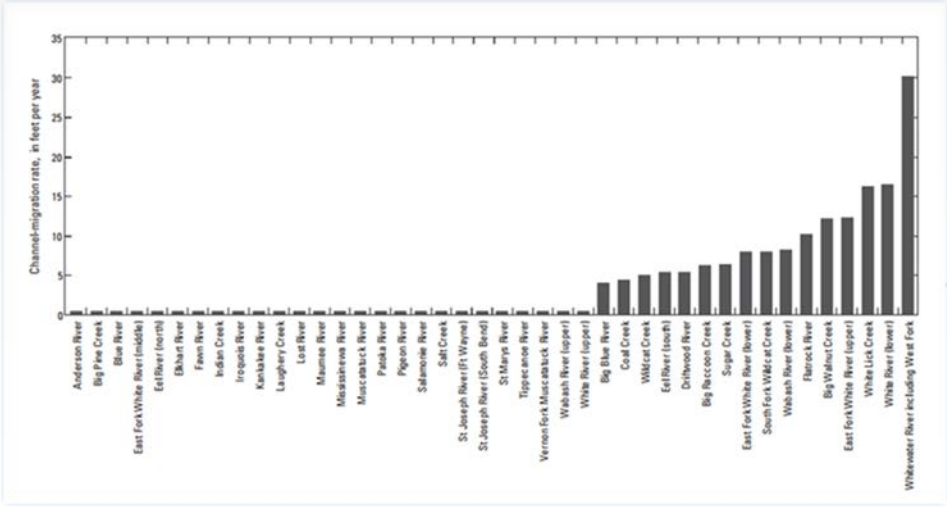
- Phase I:

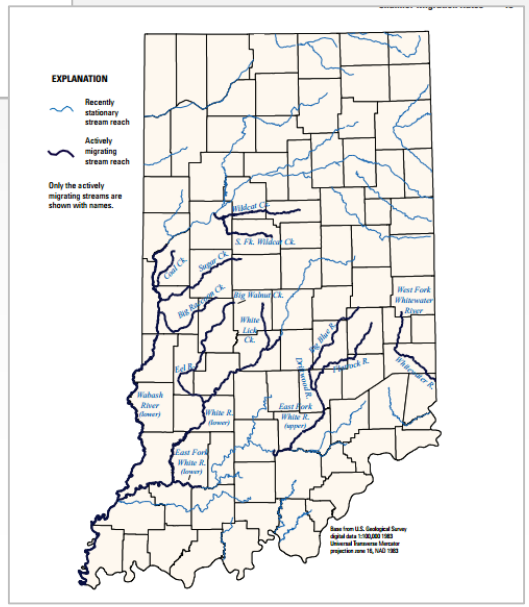
  Develop regionally-based channel dimensions for stable Indiana streams

- Phase II:

  Determine channel migration rates to identify mobile streams and establish statewide FEH corridors







FEH

INDIANA'S FLUVIAL EROSION HAZARD PROGRAM

INDIANA FEH PROGRAM: PREVIOUS PHASES

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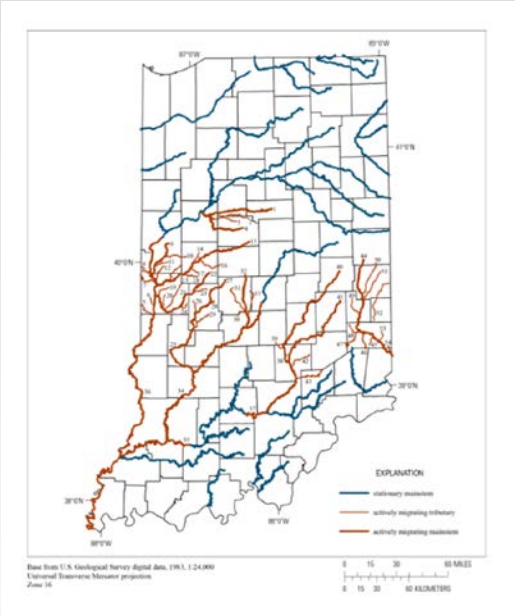
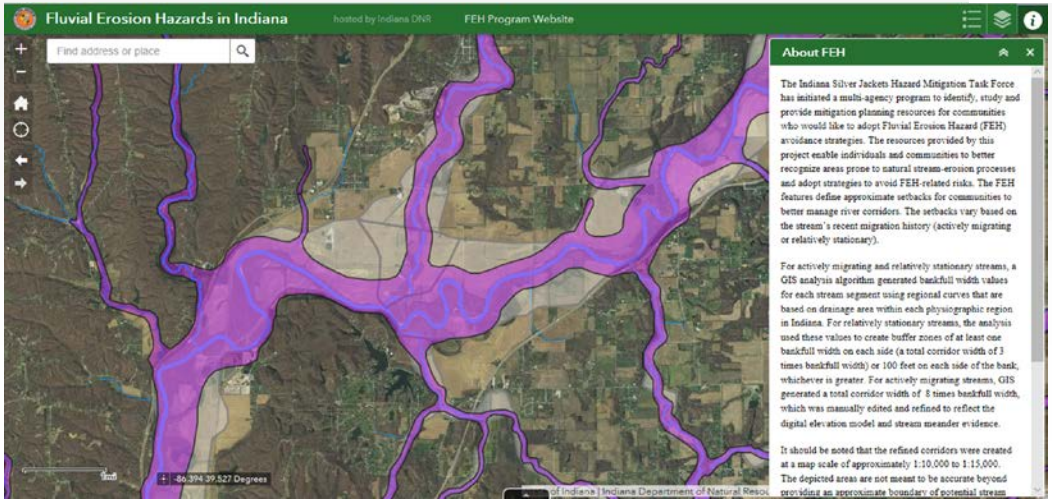




FEH

INDIANA'S FLUVIAL EROSION HAZARD PROGRAM

INDIANA FEH PROGRAM: PHASE III

- Phase I:

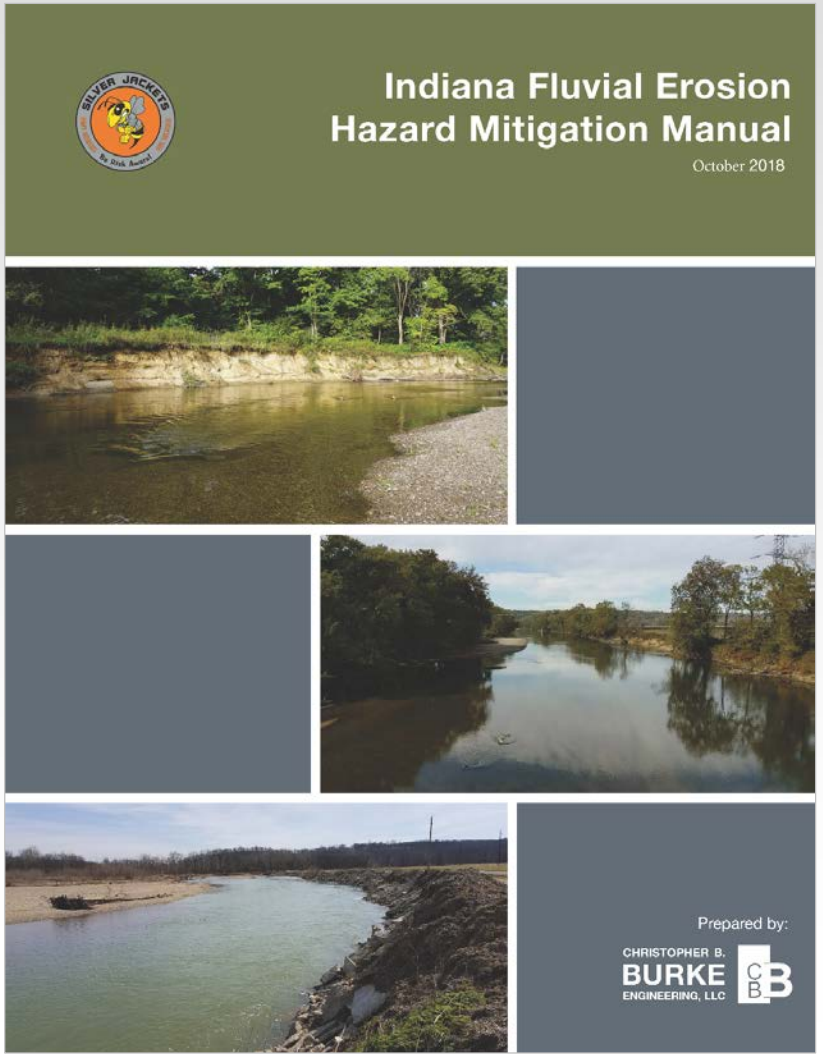
  Develop regionally-based channel dimensions for stable Indiana streams

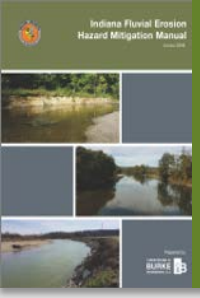
- Phase II:

  Determine channel migration rates to identify mobile streams and establish statewide FEH corridors

- Phase III:

  Develop a manual to provide guidance on how to address FEHs





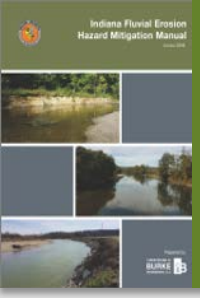
FEH MITIGATION MANUAL

- Purpose

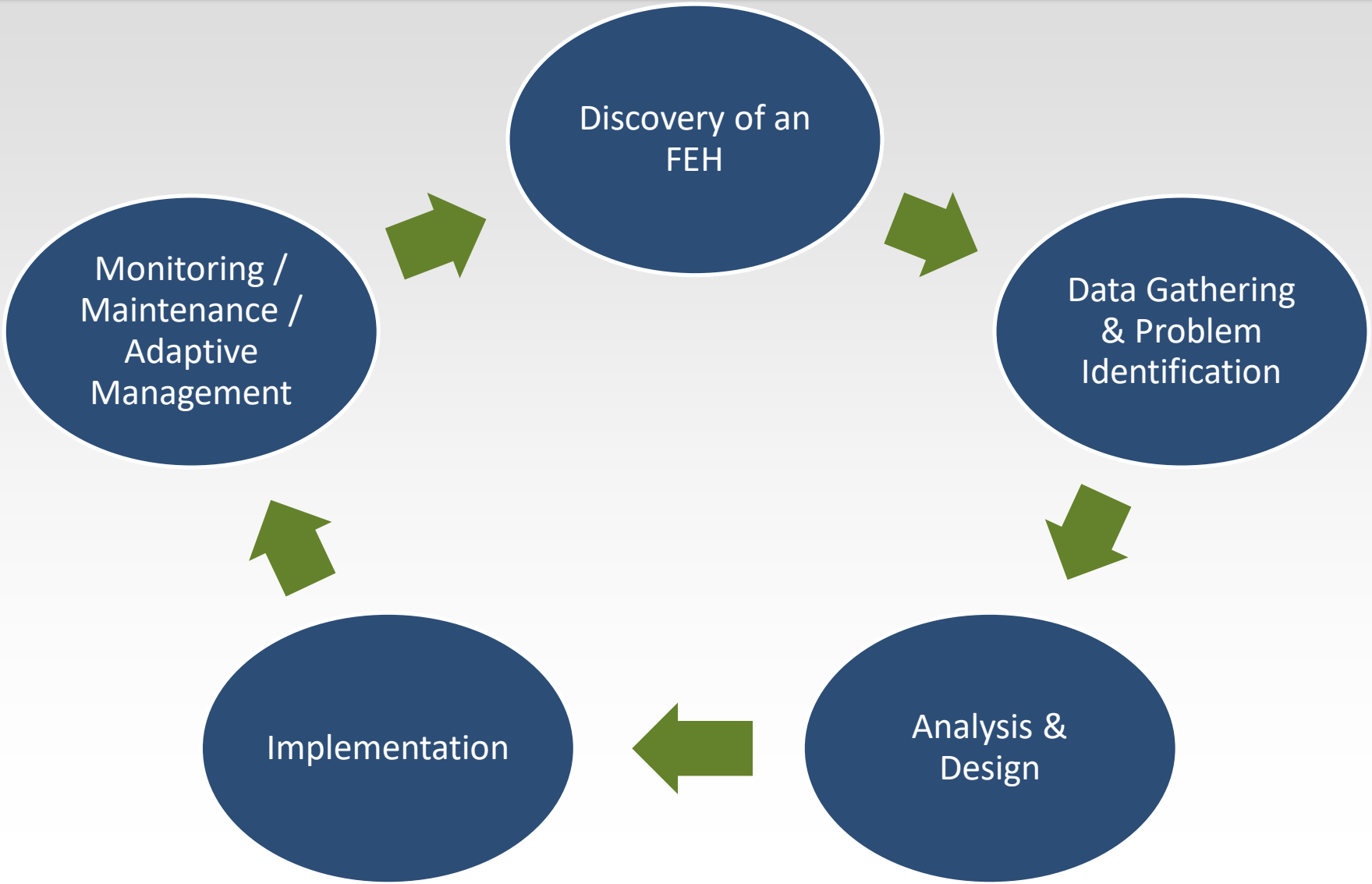
  Focus on how to best mitigate the fluvial erosion hazard in areas where avoidance is not feasible, acceptable, or is cost prohibitive, and how to evaluate best methods for protecting structures and infrastructure, while striving to minimize impacts on the stream system.

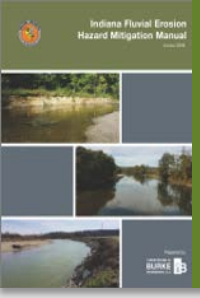
- Appropriate Use / Limitations

  This manual is directed to project engineers, technical professionals, and owners involved in the design and construction of fluvial erosion hazard mitigation projects, also referred to as bank stabilization or rehabilitation. The intent of this manual is to provide direction to experienced design professionals so that any modifications made to the stream maintain or improve the stability of the waterway and protect the interests of the owner. The majority of information given in this document is general and provides many of the technical principles used throughout the country. The designer must be a suitably educated and trained professional that has experience in this field to properly apply these guidelines to the specifics of the site and the needs of the owner.



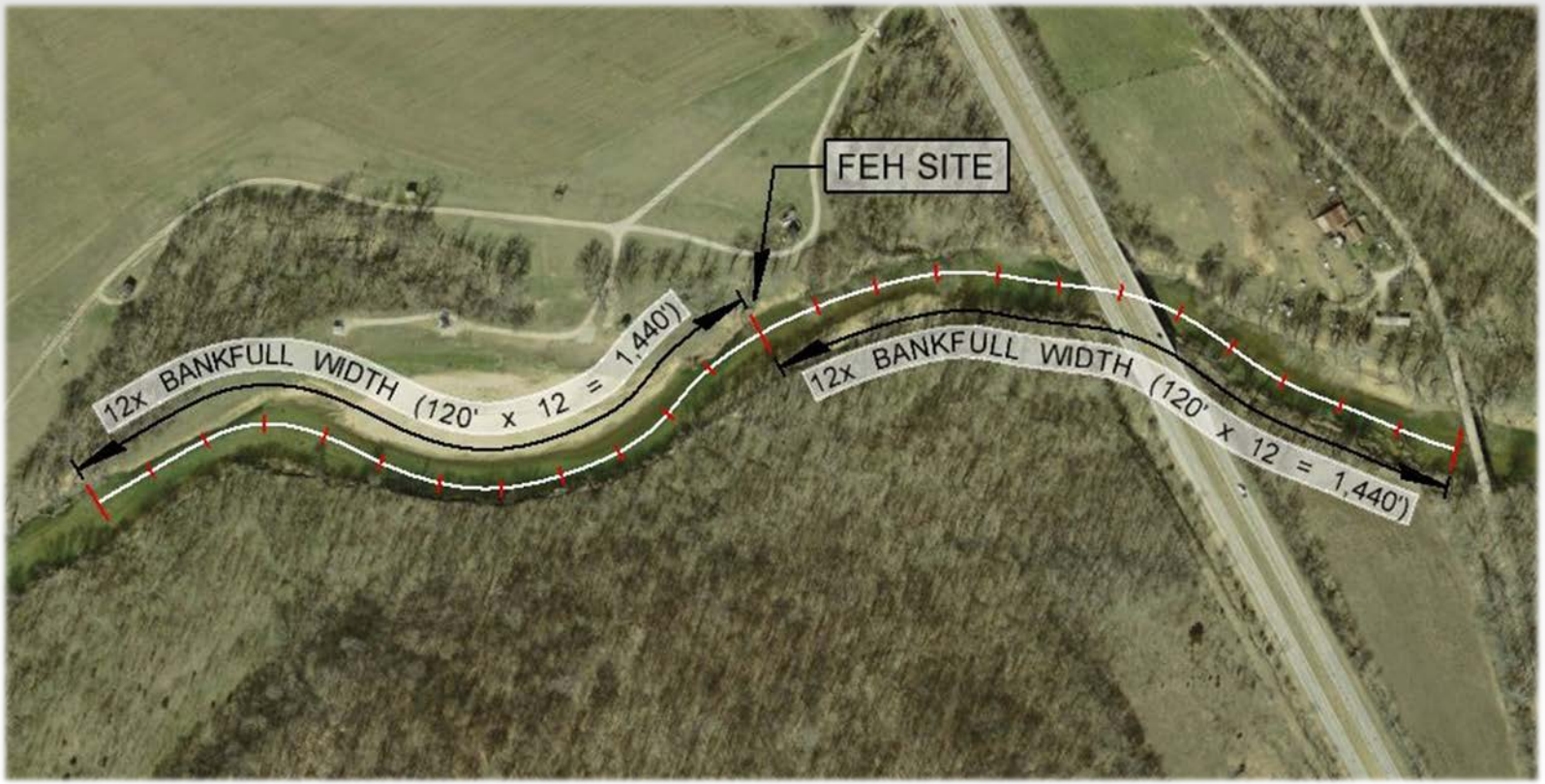
FEH MITIGATION MANUAL: OUTLINE / PROCESS

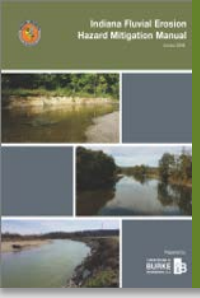




FEH MITIGATION MANUAL: DATA GATHERING

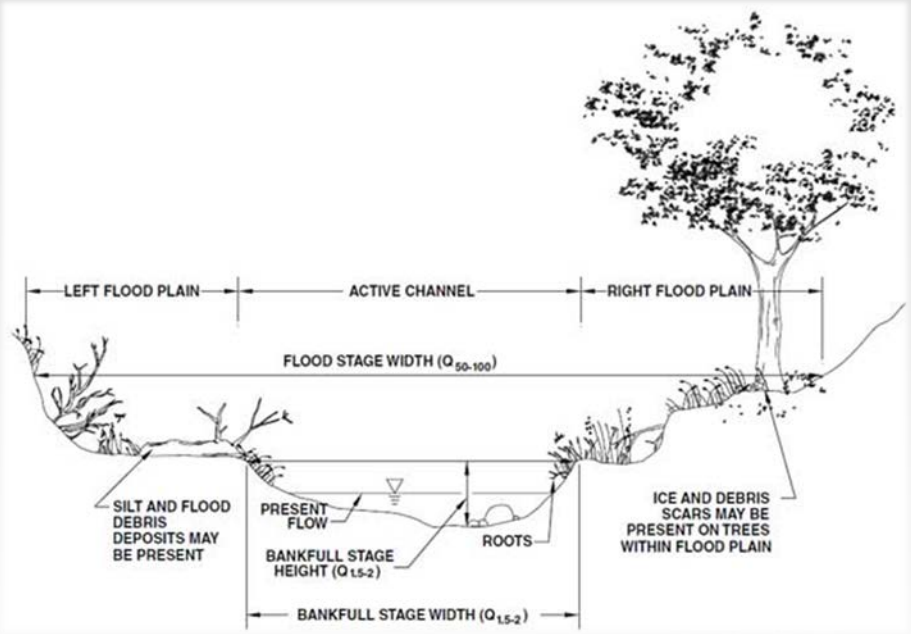
- Site Assessment
  - Establish assessment reach limits

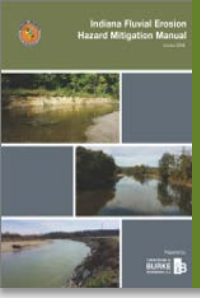




FEH MITIGATION MANUAL: DATA GATHERING

- Site Assessment
  - Establish assessment reach limits
  - Channel dimensions
  - Signs of erosion/deposition
  - Evaluate channel forming discharge & other flows
  - Document morphologic processes
  - Infrastructure & site constraints
  - Identify reach-scale stressors





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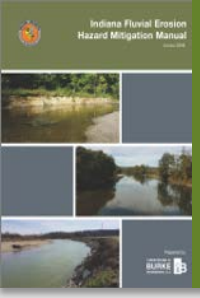
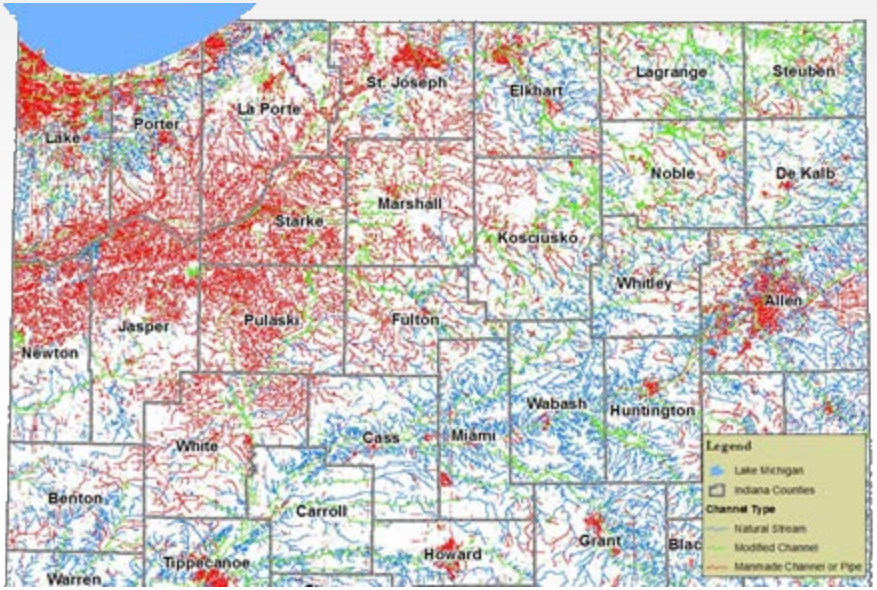
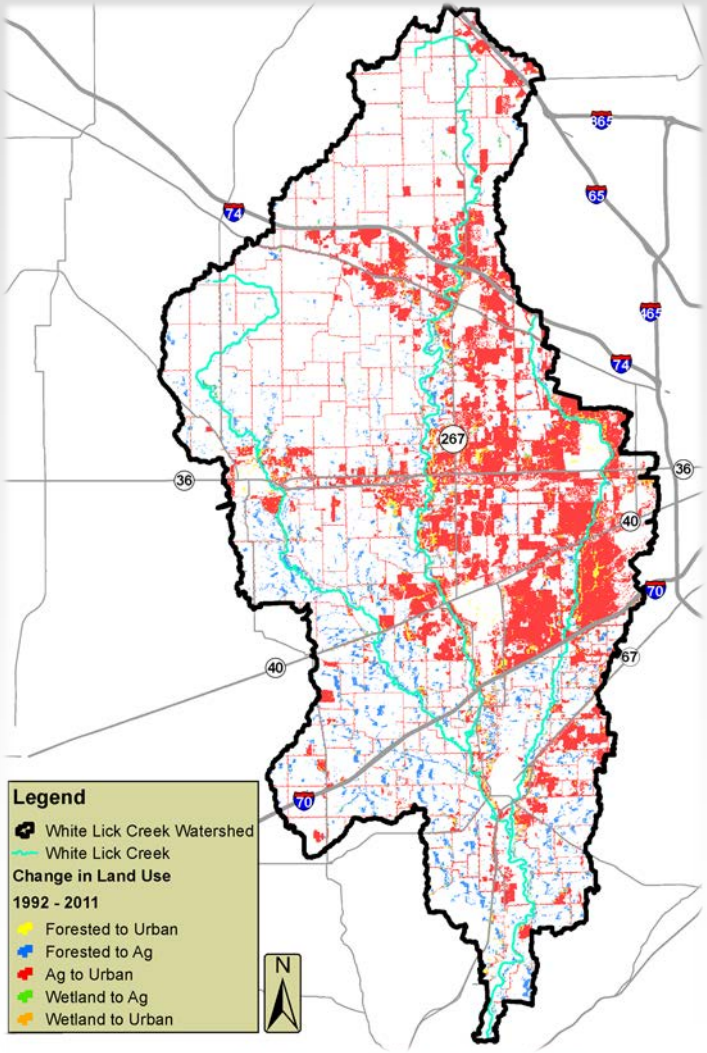
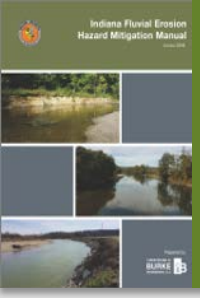


FEH MITIGATION MANUAL: DATA GATHERING

- Watershed Assessment
  - Land use analysis (composition & trends)
  - Rainfall analysis (trends)
  - Upstream drainage network analysis (composition & trends)
  - Streamflow Gage analysis (trends)







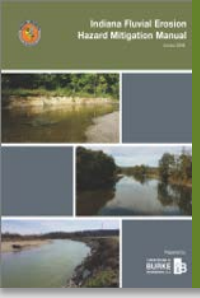
FEH MITIGATION MANUAL: DATA GATHERING

- Stakeholder Input
  - Federal, State, Local, & Project Team
  - Establish decision making process
  - Convey/acknowledge constraints and limitations based on site assessment

Photo courtesy: MakProSVC

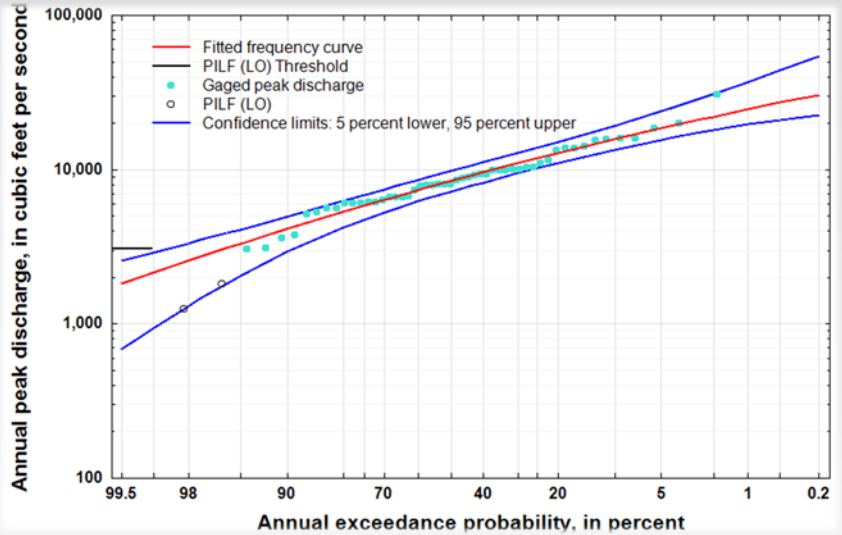
- Mitigation Objectives
  - Create list of stressors
  - List & prioritize desired stream functions
  - Evaluate social, environmental, and O&M factors
  - Identify additional information needs

Photo courtesy: EMH&T



FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Analysis Methods
  - Channel forming flows



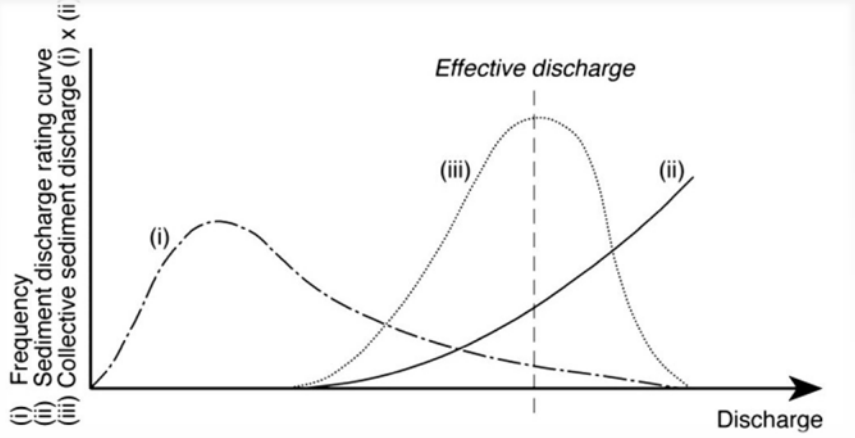
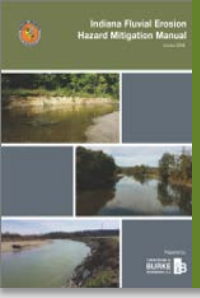
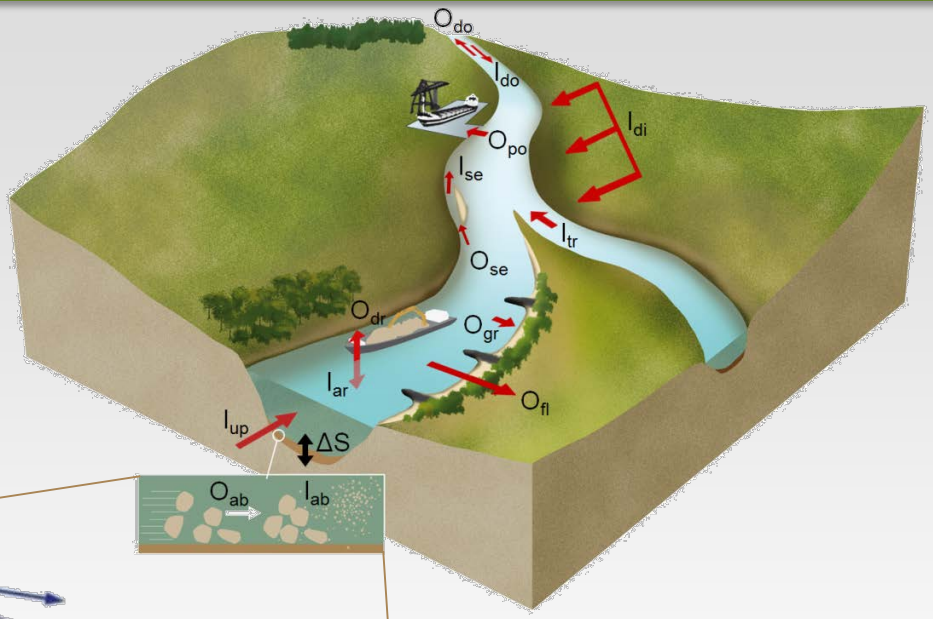


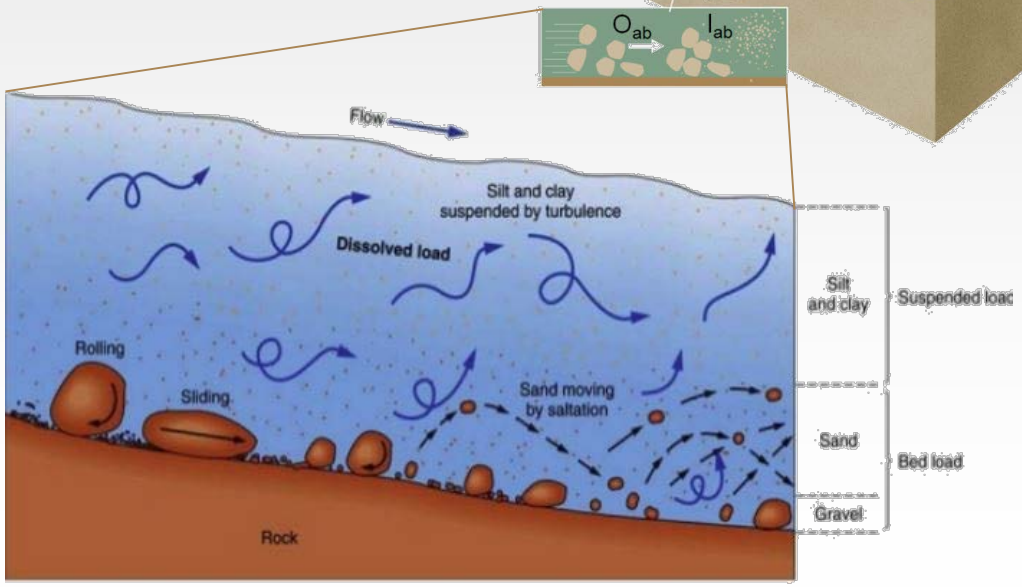
Image courtesy: Soar & Thorne, 2001



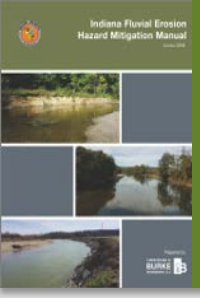
FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Analysis Methods
  - Channel forming flows
  - Sediment continuity





(Adapted from the International Commission for the Hydrology of the Rhine Basin [above]
Little Geological Consulting [below])



FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Analysis Methods
  - Channel forming flows
  - Sediment continuity
  - Stable channel geometry

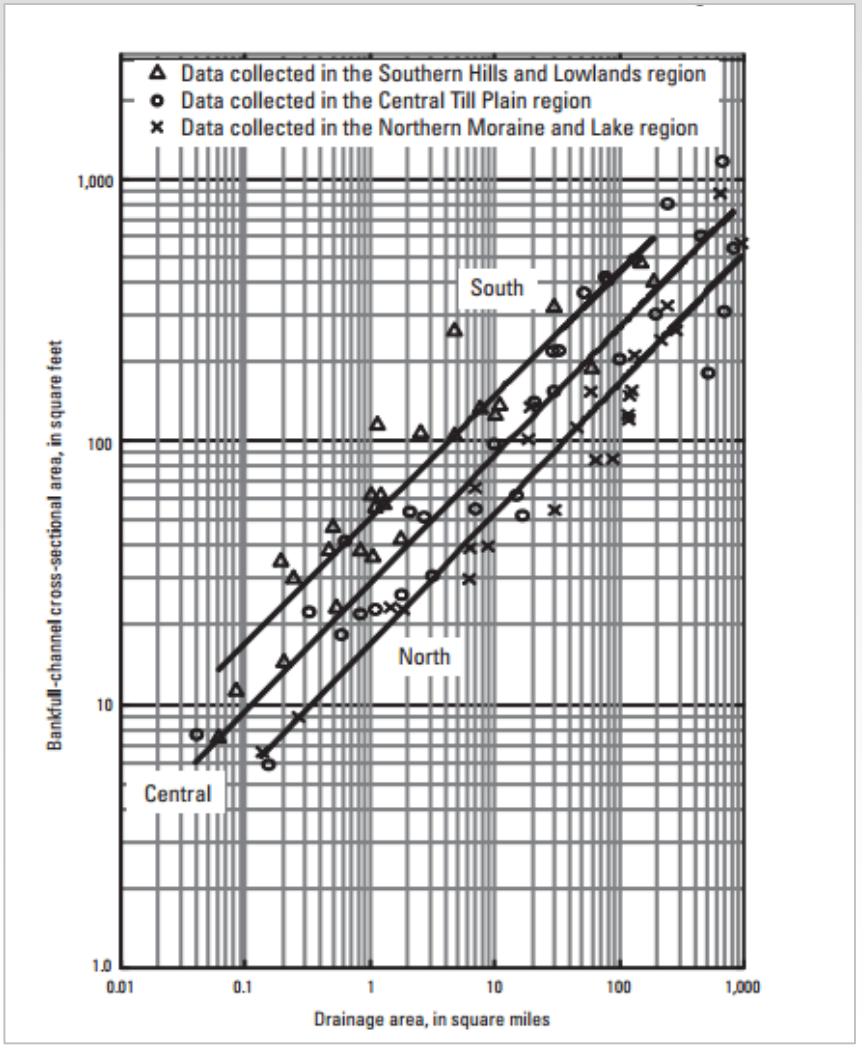
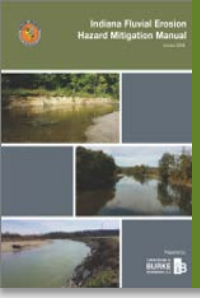


Image courtesy: USGS, 2013



FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Analysis Methods
  - Channel forming flows
  - Sediment continuity
  - Stable channel geometry
  - Scour

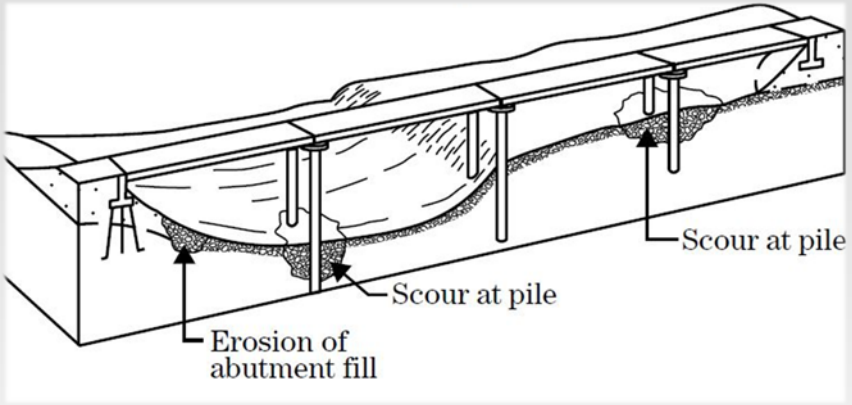
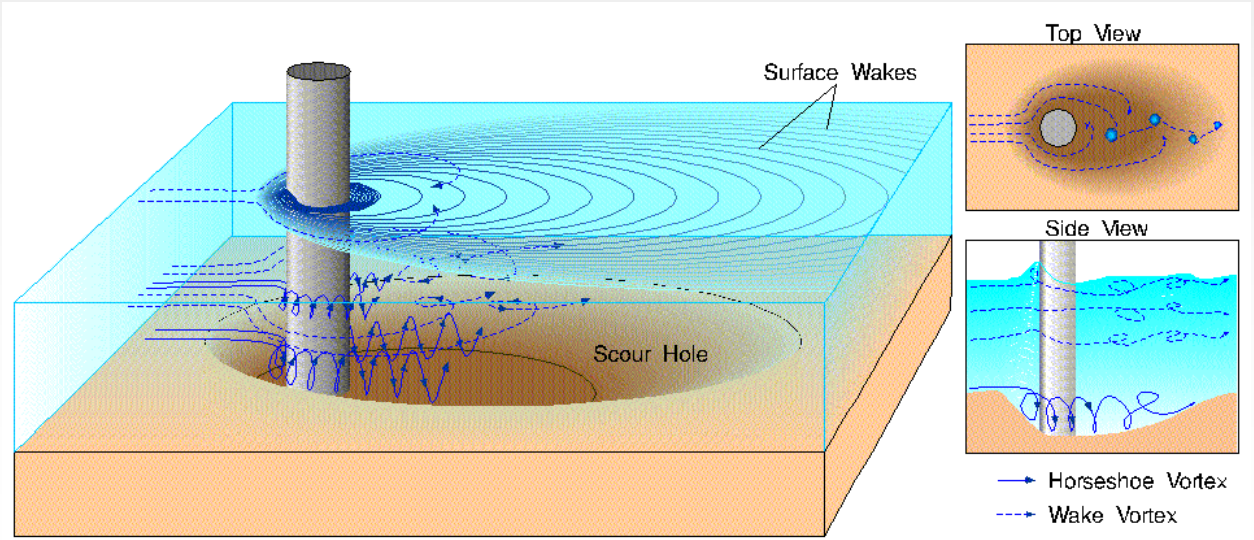


Image courtesy: USDA



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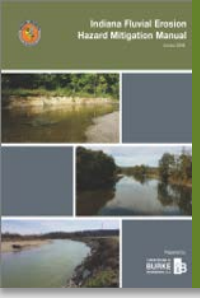
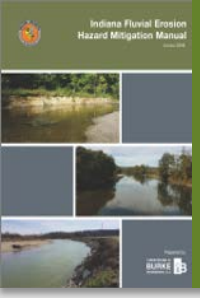


FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Analysis Methods
  - Channel forming flows
  - Sediment continuity
  - Stable channel geometry
  - Scour
  - Habitat quality & availability

Collection of Field Data for QHEI in White Lick

Invasive Species
(Top: Missouri Dept. of Conservation, 2017)
(Middle: Purdue Ext. Entomology, 2018)
(Bottom: Circle of Blue, 2016)



FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Passive River Management (Agricultural)
  - Land cover & tillage
  - Grazing
  - Soil compaction
  - Drainage
  - Nutrients

Extensive tile drainage

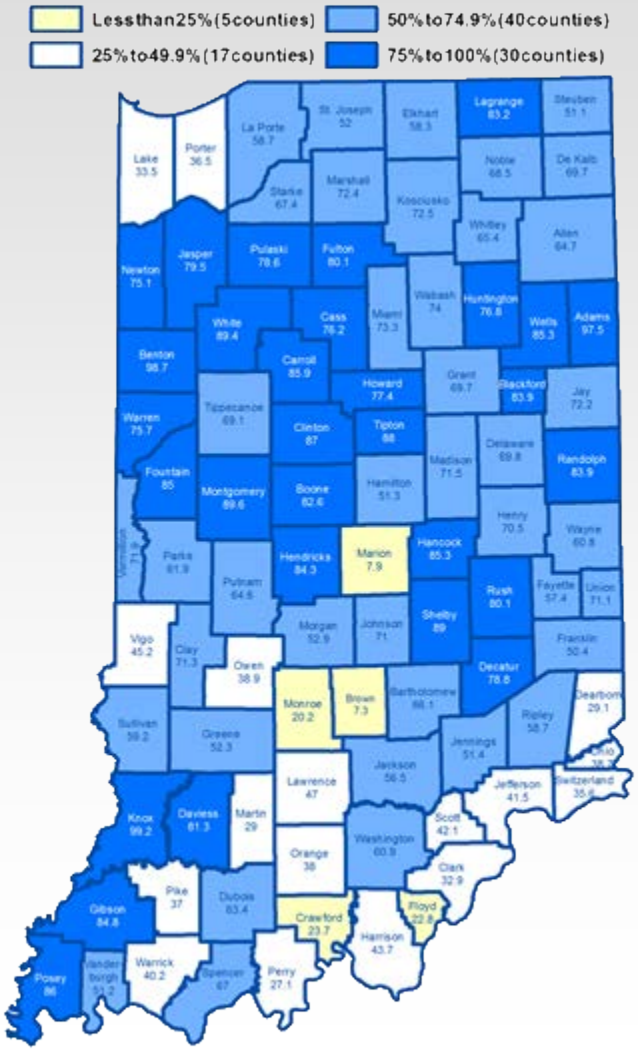
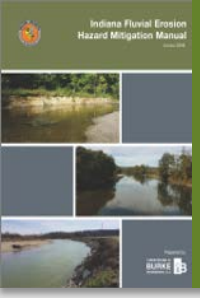


Image after USDA, 2012



FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Passive River Management (Urban)
  - Green infrastructure (including LID)
  - Pollutants of concern

Photo courtesy: AAES, 2015

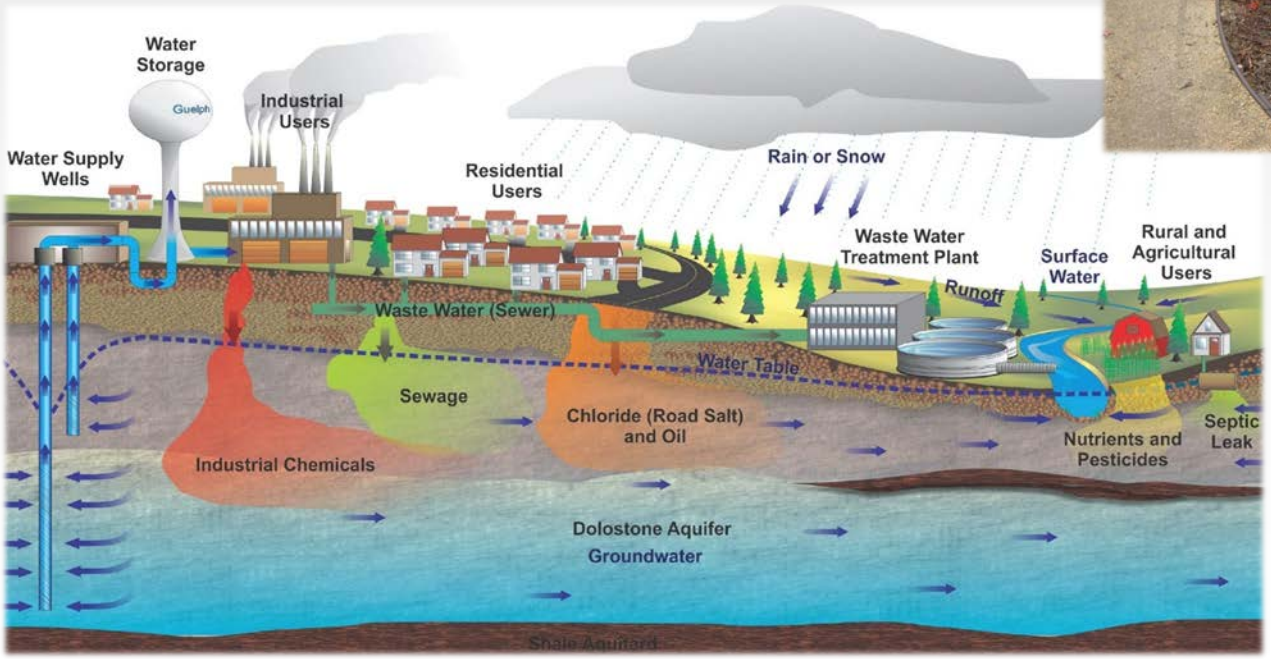
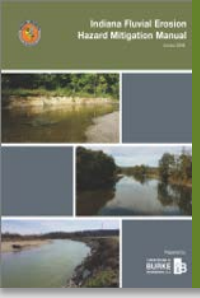


Photo courtesy: Institute for Groundwater Research



FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Active River Management
  - Vertical stability
    - Floodplain reattachment
    - Grade control structures
    - Bed armoring

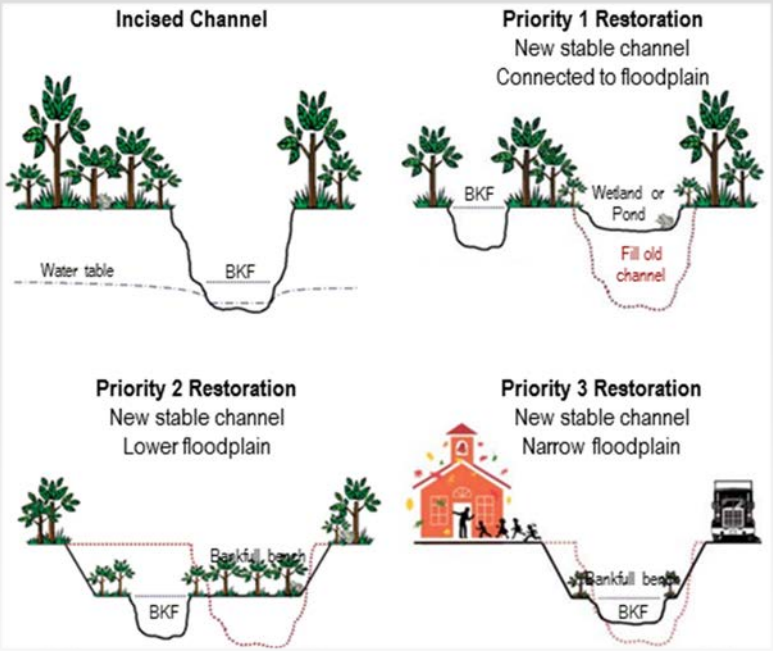
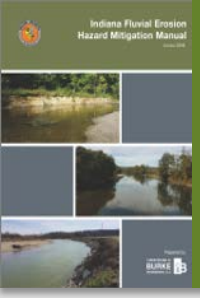


Image courtesy NCSU, 2017

Bean Creek in Indianapolis, IN

Photo courtesy USACE



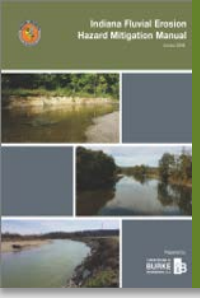
FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Active River Management
  - Lateral stability
    - Toe protection
    - Bank armoring
    - Flow redirection
    - Channel augmentation


Yellow River near Knox, IN

Armored bank along Wabash River in Vincennes, IN


Yellow River near Knox, IN

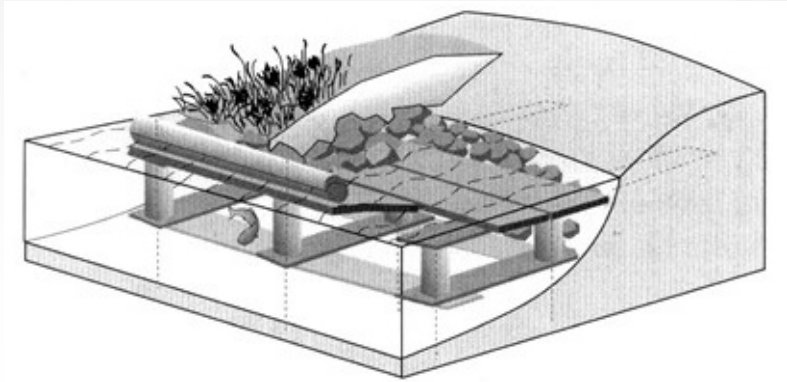


FEH MITIGATION MANUAL: ANALYSIS & DESIGN

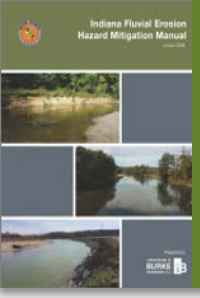
- Active River Management
  - Habitat
    - Water quality
    - Constructed habitat & habitat rejuvenation


Rain garden


Buffer strips

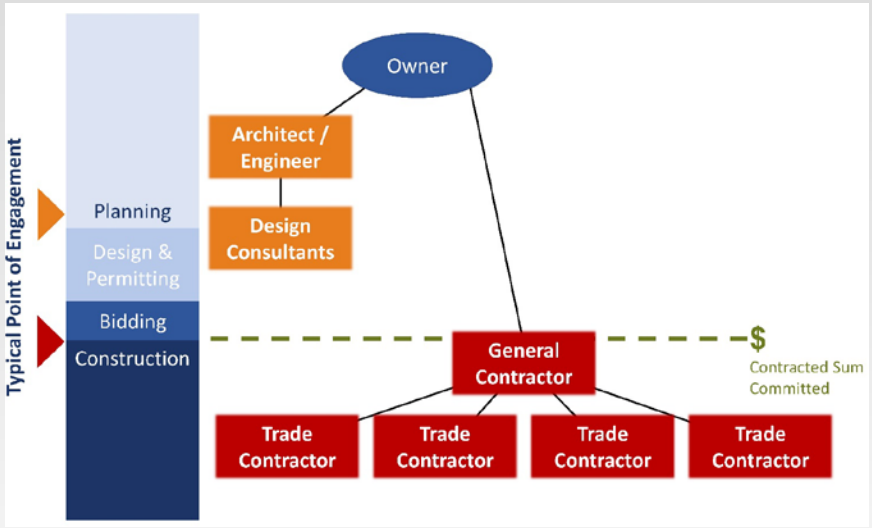

Lunker Structure
Image courtesy ESenSS, 2014

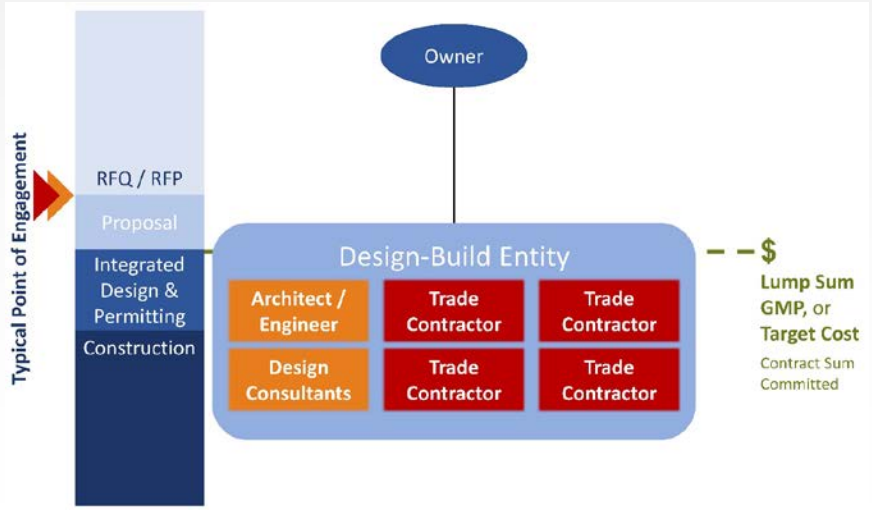

Sediment rejuvenation



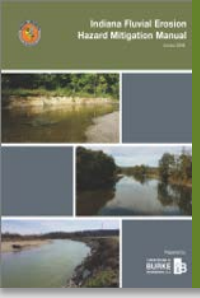
FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Project Implementation Considerations
  - Project Delivery
    - Design-Bid-Build
    - Design-Build





Images adapted from DBIA, 2015

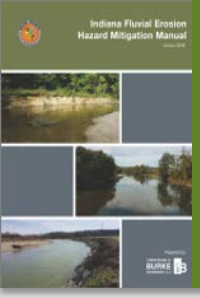


FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Project Implementation Considerations
  - Constructability & timing

Toe wood installation along Yellow River near Knox, IN

Poor initial establishment of vegetation due to timing along Yellow River near Knox, IN

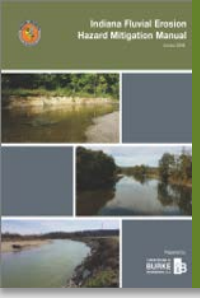


FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Project Implementation Considerations
  - Environmental impact

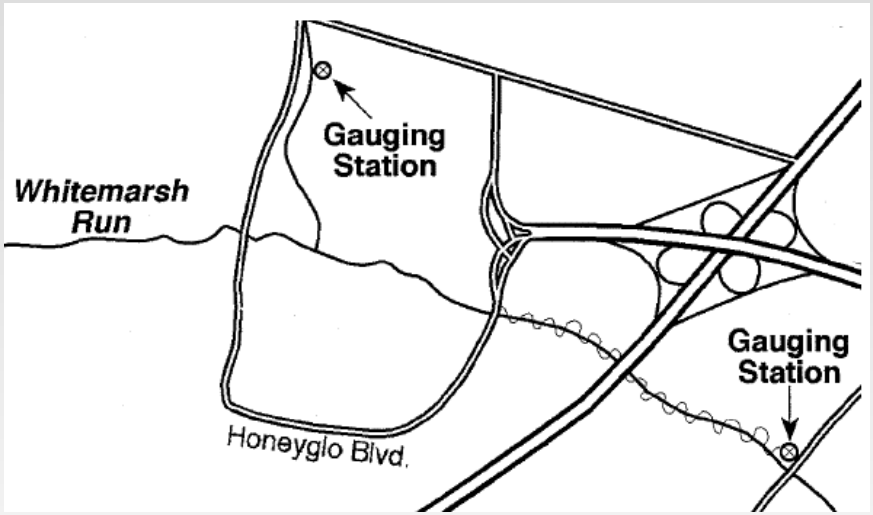
Native seeding over toe wood along Yellow River near Knox, IN

Photo courtesy of City of Golden Valley, 2018

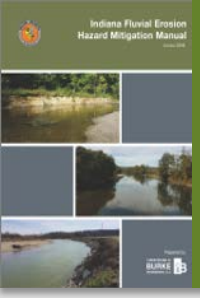


FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Project Implementation Considerations
  - Natural variability



Top: Sinuosity inconsistent with surrounding reaches, Soar and Thorne, 2001
Bottom: Project nearly indistinguishable from natural reaches, Google Earth, 2015

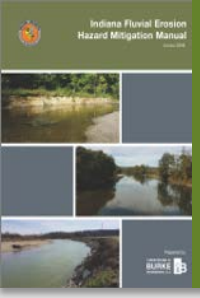


FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Project Implementation Considerations
  - Anticipated longevity
  - Maintenance

Robust materials protecting critical infrastructure in a flashy stream
Bean Creek in Indianapolis, IN

Lack of maintenance/management results in slope failure
White Lick Creek in Avon, IN



FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Project Implementation Considerations
  - Project cost
    - Delivery method
    - Alternative materials
    - Scope reduction
    - Prioritization of key project components

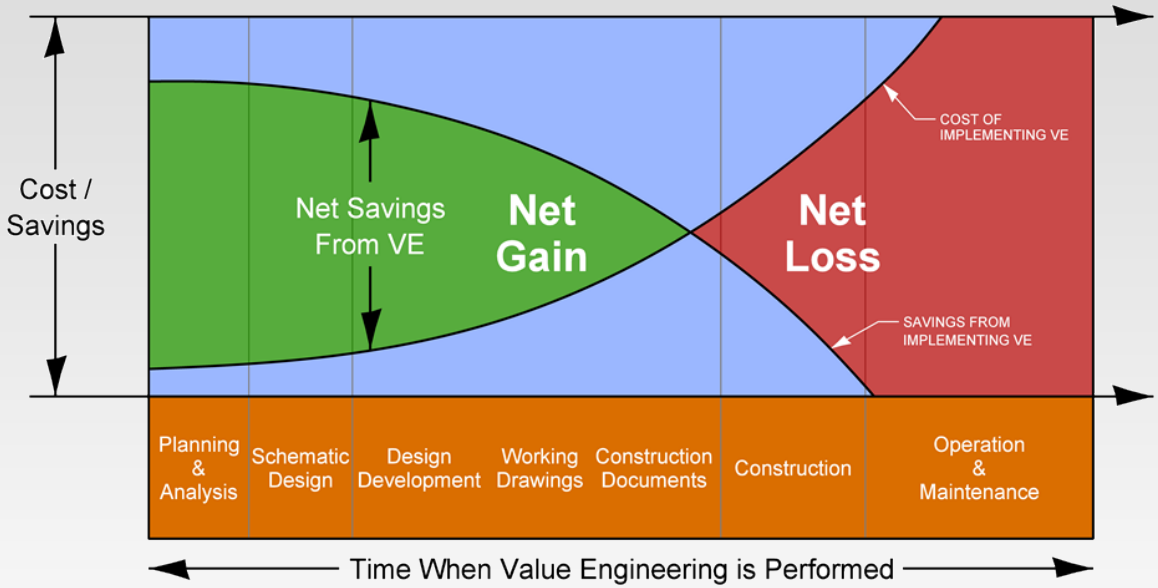
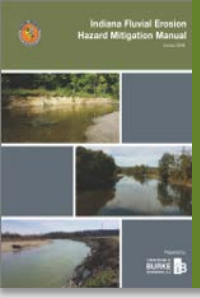


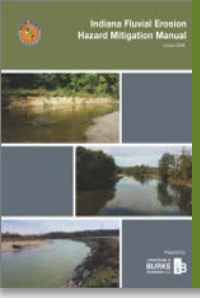
Image adapted from Whole Building Design Guide



FEH MITIGATION MANUAL: ANALYSIS & DESIGN

- Project Implementation Considerations
  - Performance evaluation
  - Selection of alternative
  - Develop design documents

Alternative Name, Treatment Type, or Other Project Metric	Cumulative Score (15)	ECONOMIC				SOCIAL					ENVIRONMENTAL				
		Capital Cost	Lifecycle O&M Cost	Shared Funding	Score (5)	Widespread Benefit (# of properties)	Reduce Flooding Drainage Problems	Benefit to Public Health & Safety	Benefit to Quality of Life	Score (5)	Level of Protection for Threatened Features	Impact to Adjacent Stream Reaches	Restore/ Protect Floodplain Function	Improve/ Protect Stream Habitat	Score (5)
	Weighting Factor=	0.45	0.20	0.35	1.00	0.25	0.25	0.25	0.25	1.00	0.40	0.30	0.20	0.10	1.00
	0=	> $10M	very high	none		0	none	none	none		added risk	significant (-)	no change	no change	
	1=	>$5M <$10M	high	100% Owner		1-10	limited	limited	limited		no change	minor (-)	limited	limited	
	2=	>$1M <$5M	mod-high	75% Owner		11-30	limited-mod	limited-mod	limited-mod		minimal	no change	limited-mod	limited-mod	
	3=	>$500K <$1M	moderate	50% Owner		31-100	moderate	moderate	moderate		moderate	minor (+)	moderate	moderate	
	4=	>$100K <$500K	low-mod	75% Other		101-300	mod-high	mod-high	mod-high		high	moderate (+)	mod-high	mod-high	
	5=	<$100K	low	100% Other		300+	high	high	high		robust	significant (+)	high	high	
Alternative 1 / Treatment 1	8	0	3	3	1.7	5	4	2	3	3.5	4	0	4	4	2.8
Alternative 2 / Treatment 2	10	3	3	4	3.4	5	5	0	3	3.3	5	1	3	1	3.0
Alternative 3 / Treatment 3	6	4	0	4	3.2	2	0	1	3	1.5	3	0	0	3	1.5

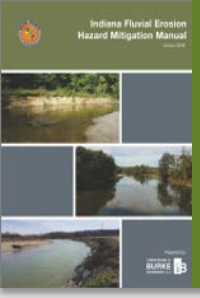


FEH MITIGATION MANUAL: IMPLEMENTATION

- Passive Measures
  - Programs Available
    - NRCS
    - TNC (and other non-governmental organizations)
    - Wetland and tree mitigation for regulatory permits
  - Duration & Deed Restriction
    - Required participation duration for voluntary programs varies
    - Mitigation for regulatory permits are typically in perpetuity

NRCS

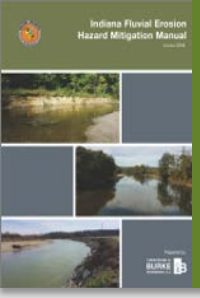
The Nature Conservancy
Protecting nature. Preserving life.™



FEH MITIGATION MANUAL: IMPLEMENTATION

- Active Measures
  - Funding
  - Regulatory permitting
  - Communication during construction

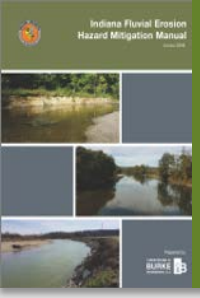
Pre-construction meetings and meetings about critical project elements are a key to successful implementation



FEH MITIGATION MANUAL: ADAPTIVE MANAGEMENT

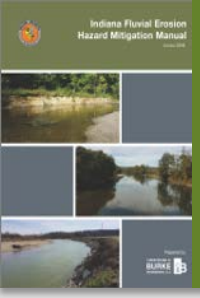
- Post-construction Activities
  - Mgmt Plan objectives & approach
    - Proper performance of in-stream structures and stabilization measures
    - Changes in channel morphology
    - Response by ecological/biological resources
  - Monitoring
    - Channel geometry
    - Channel materials
    - Water quality
    - Habitat & Flora/Fauna

FEH mitigation projects are generally most vulnerable immediately following construction, particularly when bio-engineering methods are used.



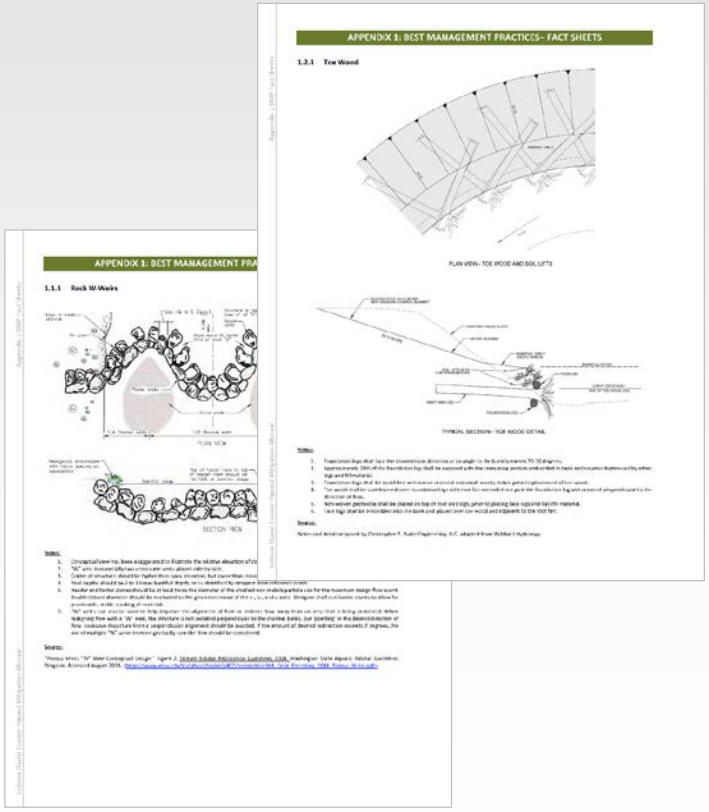
FEH MITIGATION MANUAL: ADAPTIVE MANAGEMENT

- Post-construction Activities
  - Maintenance
    - Correct settlement
    - Failed/inadequate vegetation
    - Repair minor erosion
  - Final Inspection & Termination
    - Confirm objectives are met and the project is self-sustaining
    - Nature-based vs. engineered solutions

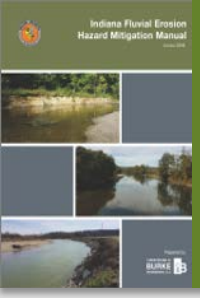


FEH MITIGATION MANUAL: APPENDIX INFORMATION

- BMP Fact Sheets

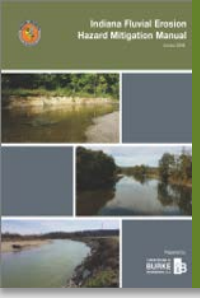


No.	Mitigation Measure	Primary Category	Secondary Category
1.1.1	Rock W-weirs	Grade Control Structures	Flow Redirection
1.1.2	Step-pools	Grade Control Structures	Floodplain Reattachment
1.1.3	Log drops and V-log drops	Grade Control Structures	Floodplain Reattachment
1.1.4	Newbury Riffle	Grade Control Structures	Bed Armoring
1.2.1	Toe wood	Toe Protection	Habitat Improvements
1.2.2	Rock-toe revetments	Toe Protection	
1.2.3	Interlocking concrete jacks	Toe Protection	
1.2.4	Boulder revetments	Toe Protection	Bank Armoring
1.3.1	Branch layering	Bank Armoring	
1.3.2	Natural fiber rolls	Bank Armoring	
1.3.3	Brush mattresses	Bank Armoring	Channel Augmentation
1.3.4	Gabion baskets	Bank Armoring	Toe Protection
1.3.5	Gabion mattresses	Bank Armoring	Bed Armoring
1.3.6	Live stakes	Bank Armoring	Habitat Improvements
1.3.7	Live fascines	Bank Armoring	Habitat Improvements
1.3.8	Live soil lifts	Bank Armoring	Channel Augmentation
1.3.9	Natural fiber matting / TRM / ECB	Bank Armoring	
1.3.10	Riprap bank armoring	Bank Armoring	
1.3.11	Articulating concrete blocks	Bank Armoring	
1.4.1	Rock cross-vanes	Flow Redirection	Grade Control Structures
1.4.2	J-hook vanes	Flow Redirection	Grade Control Structures
1.4.3	Rock vanes	Flow Redirection	
1.4.4	Log vanes	Flow Redirection	
1.5.1	Constructed riffle-pool series	Channel Augmentation	Habitat Improvements
1.5.2	Bank regrading/shaping	Channel Augmentation	Flow Redirection
1.5.3	Cut-off sills	Channel Augmentation	Floodplain Reattachment
1.5.4	Boulder clusters	Channel Augmentation	Habitat Improvements



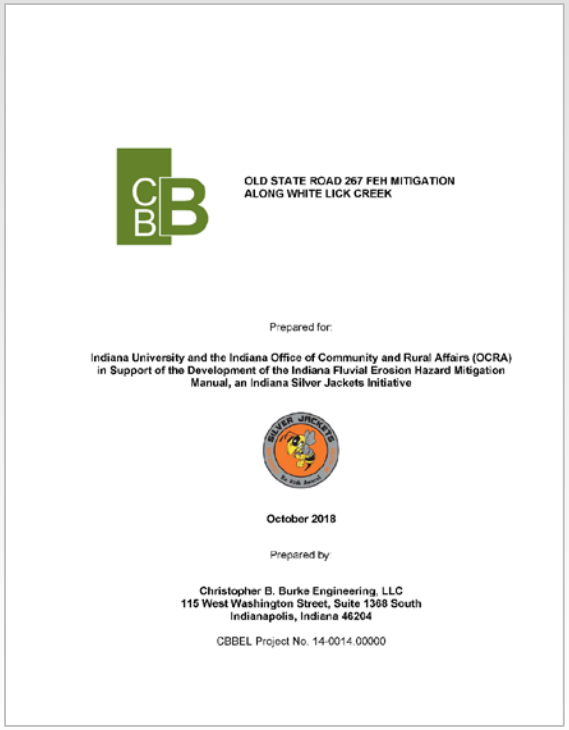
FEH MITIGATION MANUAL: APPENDIX INFORMATION

- FEH Mitigation Case Studies
  - Analysis
  - Design
  - Implementation



FEH MITIGATION MANUAL: EXAMPLE DOCUMENTS

- FEH Mitigation Study Example Reports



OLD STATE ROAD 267 FEH MITIGATION
ALONG WHITE LICK CREEK

Prepared for:

Indiana University and the Indiana Office of Community and Rural Affairs (OCRA)
in Support of the Development of the Indiana Fluvial Erosion Hazard Mitigation
Manual, an Indiana Silver Jackets Initiative

October 2018

Prepared by:

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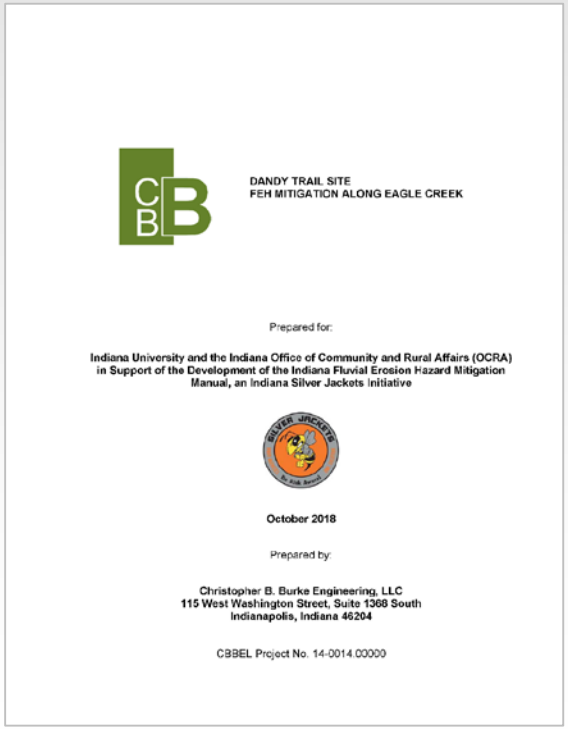
CBBEL Project No. 14-0014.00000



DANDY TRAIL SITE
FEH MITIGATION ALONG EAGLE CREEK

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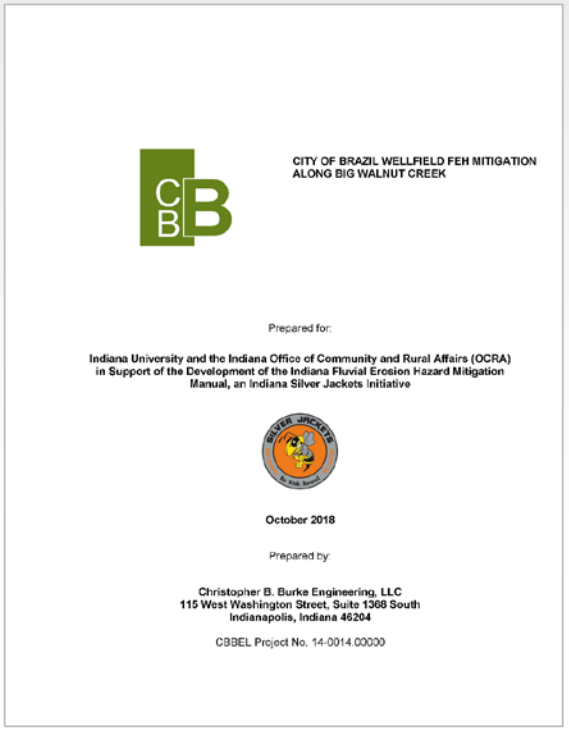

CITY OF BRAZIL WELLFIELD FEH MITIGATION
ALONG BIG WALNUT CREEK

Prepared for:

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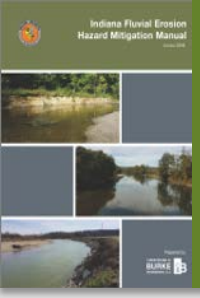

Indiana Fluvial Erosion Hazard Mitigation Manual

Available for download at:

http://feh.iupui.edu/resources/

Indiana Fluvial Erosion Hazard Mitigation Manual

Indiana Fluvial Erosion Hazard Mitigation Manual (FINAL)

Indiana Fluvial Erosion Hazard Mitigation Program: Big Walnut Creek Fluvial Erosion Hazard Assessment

Big Walnut Creek FEH Mitigation Assessment_Feb 2019

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