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Restoration of Urban Streams in the Midwest

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Streambank Stabilization Practices

Presentation Outline

- Principles of Streambank Stabilization Practices
- Stream Stabilization Efforts and Philosophies in Northeast Illinois
- Grade Stabilization, Armoring & Structural Practices*
- Vegetative Practices
- Project Example and Challenges
- Conclusions

* With a minor vegetative component

Principles of Fluvial Geomorphology

A View of Streambank Erosion

What exactly is "dynamic equilibrium"?

- Streams are inherently complex systems
- Relationships between a variety of variables result in the visible characteristics of a stream's bed and banks
- Changes in the "independent" variables that influence a stream result in changes in the "dependent" characteristics of the stream.
  - Independent Variables = Watershed Characteristics, e.g. discharge, soils, sediment load, climate, etc.
  - Dependent Variables = Stream Characteristics, e.g. channel slope, width, depth, pattern, etc.
- The more drastic the alteration to the independent variables, the more dramatic the visible changes in the dependent variables.
- As changes take place in the inputs to the stream, the stream alters itself through natural processes to accommodate for the new flow characteristics
- A stream is naturally working toward "dynamic equilibrium" as it erodes itself a new, more stable pattern due to changes in its watershed.
- A stream in dynamic equilibrium has reached a state of natural stability when it can convey it's flows and sediment load without significant erosion

Stream(bank) Stabilization and Riparian Restoration in Northeast Illinois

- Modifications to Stream Channel and Contributing Watershed
  - Agricultural Impacts
  - Urbanization

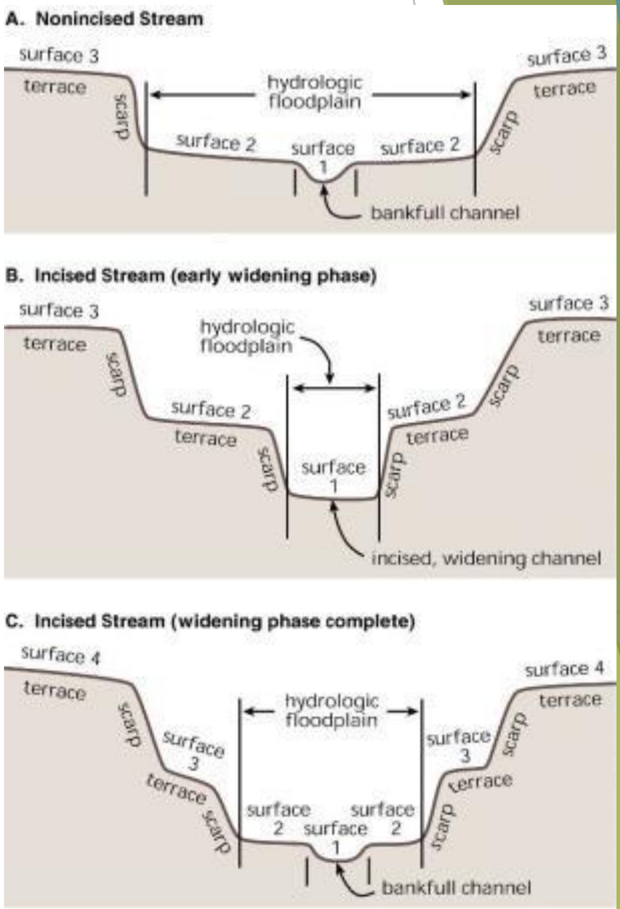


Fig. 1.24 – Terraces in (A) nonincised and (B and C) incised streams. Terraces are abandoned floodplains, formed through the interplay of incising and floodplain widening.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

- Incised Streams with Severe Bed Erosion and Downcutting
  - Signified by Head Cut Migration
  - Steep, nearly vertical banks
  - Disconnection from historic floodplain

Stream Stabilization and Riparian Restoration in Northeast Illinois

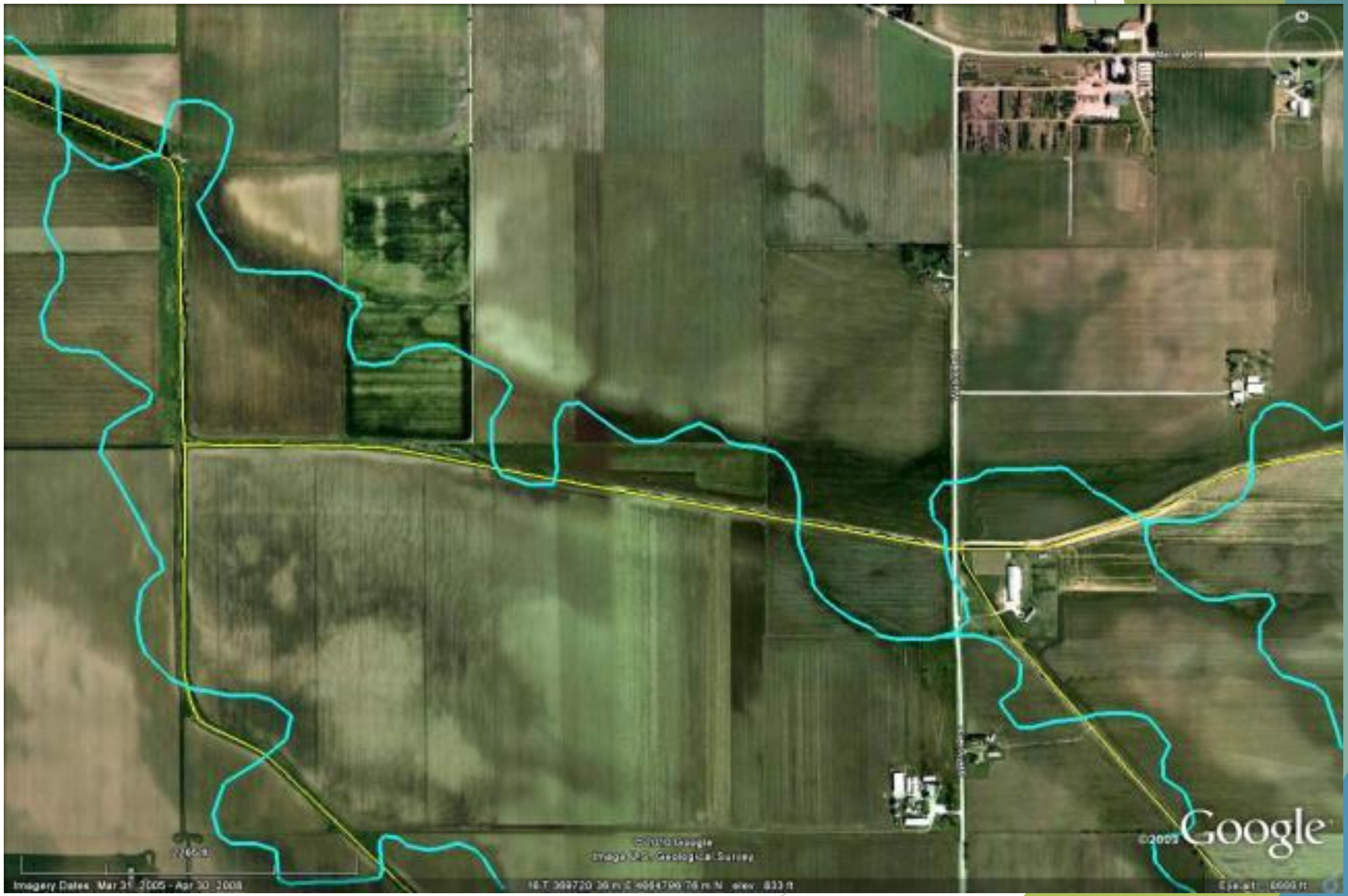
- Modifications to Stream Channel and Contributing Watershed

Agricultural Impacts

Stream Stabilization and Riparian Restoration in Northeast Illinois

- Modifications to Stream Channel and Contributing Watershed

Agricultural Impacts



Stream Stabilization and Riparian Restoration in Northeast Illinois

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Agricultural Impacts

Stream Stabilization and Riparian Restoration in Northeast Illinois

- Modifications to Stream Channel and Contributing Watershed

Urbanization

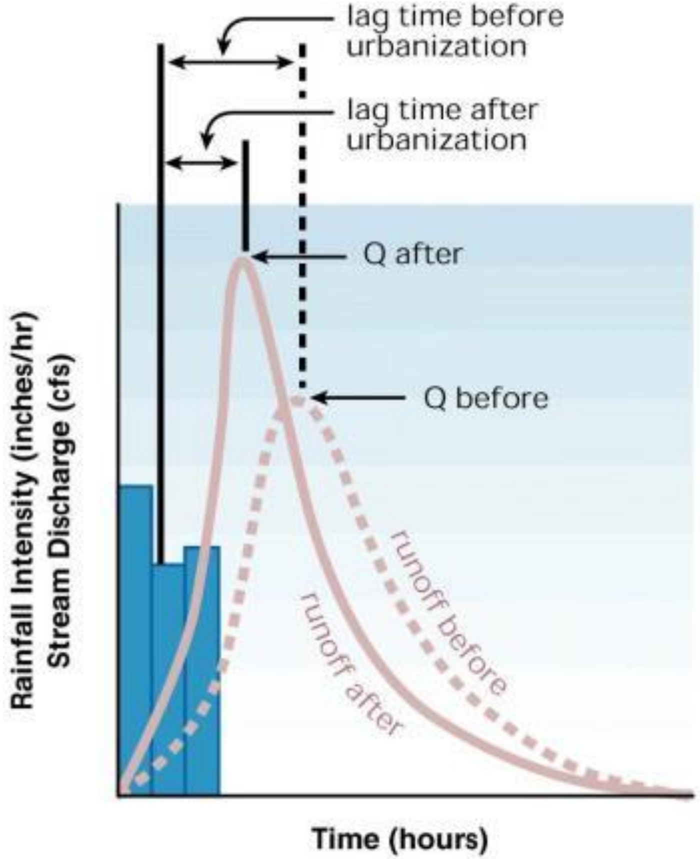

Fig. 1.15 -- A comparison of hydrographs before and after urbanization. The discharge curve is higher and steeper for urban streams than for natural streams.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Stream Stabilization and Riparian Restoration in Northeast Illinois

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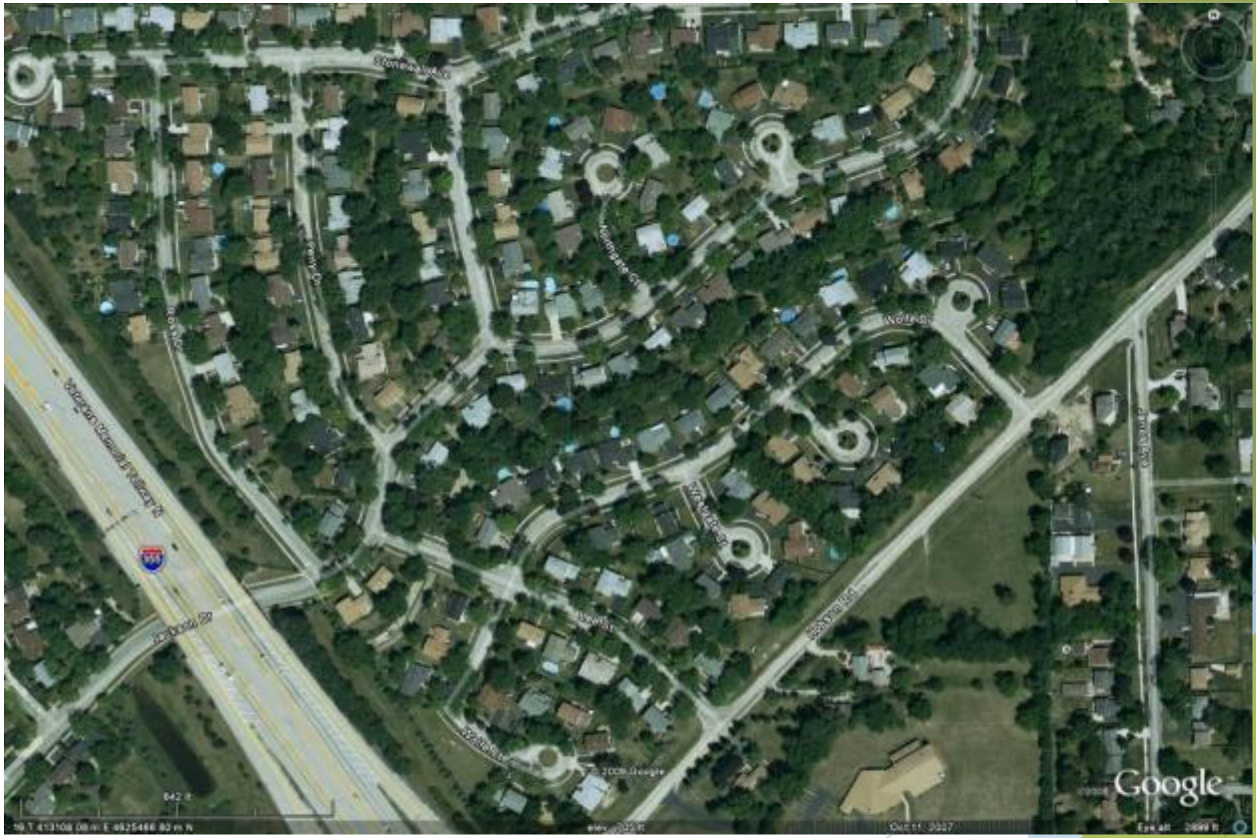


Stream Stabilization and Riparian Restoration in Northeast Illinois

- Modifications to Stream Channel and Contributing Watershed

Urbanization

Stream Stabilization and Riparian Restoration in Northeast Illinois

- Modifications to Stream Channel and Contributing Watershed

Urbanization

Stream Stabilization and Riparian Restoration in Northeast Illinois

Strategies to Address Incised Streams

1. Reconnect stream with historic floodplain
2. Recreate new floodplain between historic floodplain and the elevation of the incised streambed
3. Modify existing channel type and dimensions at existing streambed
4. Stabilize banks in place

What exactly are we attempting to “treat”?

Stream Stabilization Practices

A practice that misses the overall picture of stream dynamics is destined for failure

- Bed Stabilization Vs. Bank Stabilization
- What about the riparian corridor?
- Vegetative Regimes?

What is happening to our stream and our stabilization practices?

Bank Stabilization Practices

A practice that misses the overall picture of stream dynamics is destined for failure

- Bed Stabilization Vs. Bank Stabilization
- What about the riparian corridor?
- Vegetative Regimes?

Are we counting on vegetation here to stabilize the banks?

Did we constrict our channel?

Stream Stabilization Practices

Selected Projects Highlight Common Issues in Stream Restoration

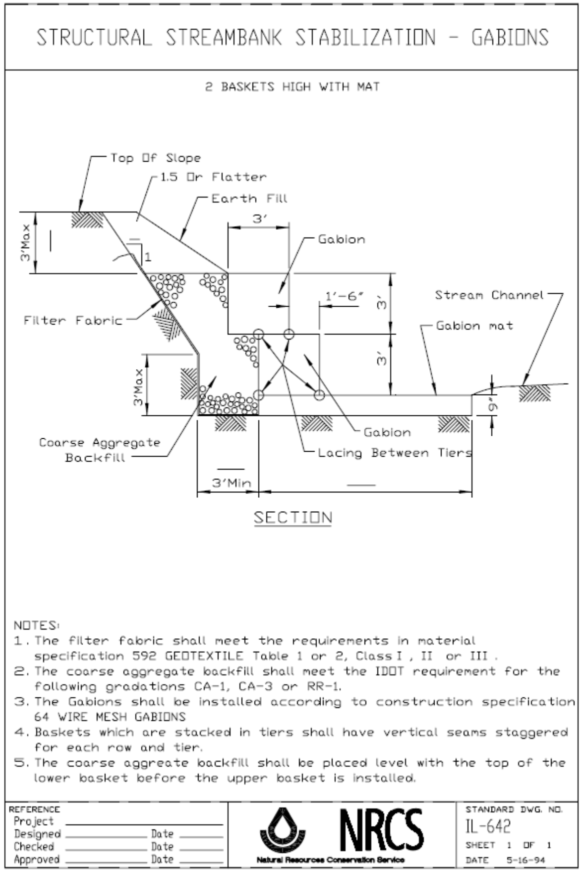
- "Debate" on applicability of hard armoring versus soft armoring (bioengineering) practices for stream restoration in Chicago Region
  - Many permitting authorities have been pushing "soft" approaches over the last decade
  - Rip rap viewed as "unnatural" and vegetation alone is used for permanent stabilization
- Stream channelization and urbanization of watersheds have presented visible bank erosion, but typically stream restoration and stabilization practices have been designed "property line to property line"
- How do you reach "dynamic equilibrium" within watersheds that by their construction are not geomorphically "dynamic"?

Grade Stabilization, Armoring, & Structural Practices

- Gabions, Rip Rap, and Other Bank Protection and Armoring Used to Hold Stream Banks in Place
- Grade Control Structures, Riffle Construction, and Step Pools Constructed to hold stream bed and stream profile in place or raise elevation of streamflow to compensate for lost stream length

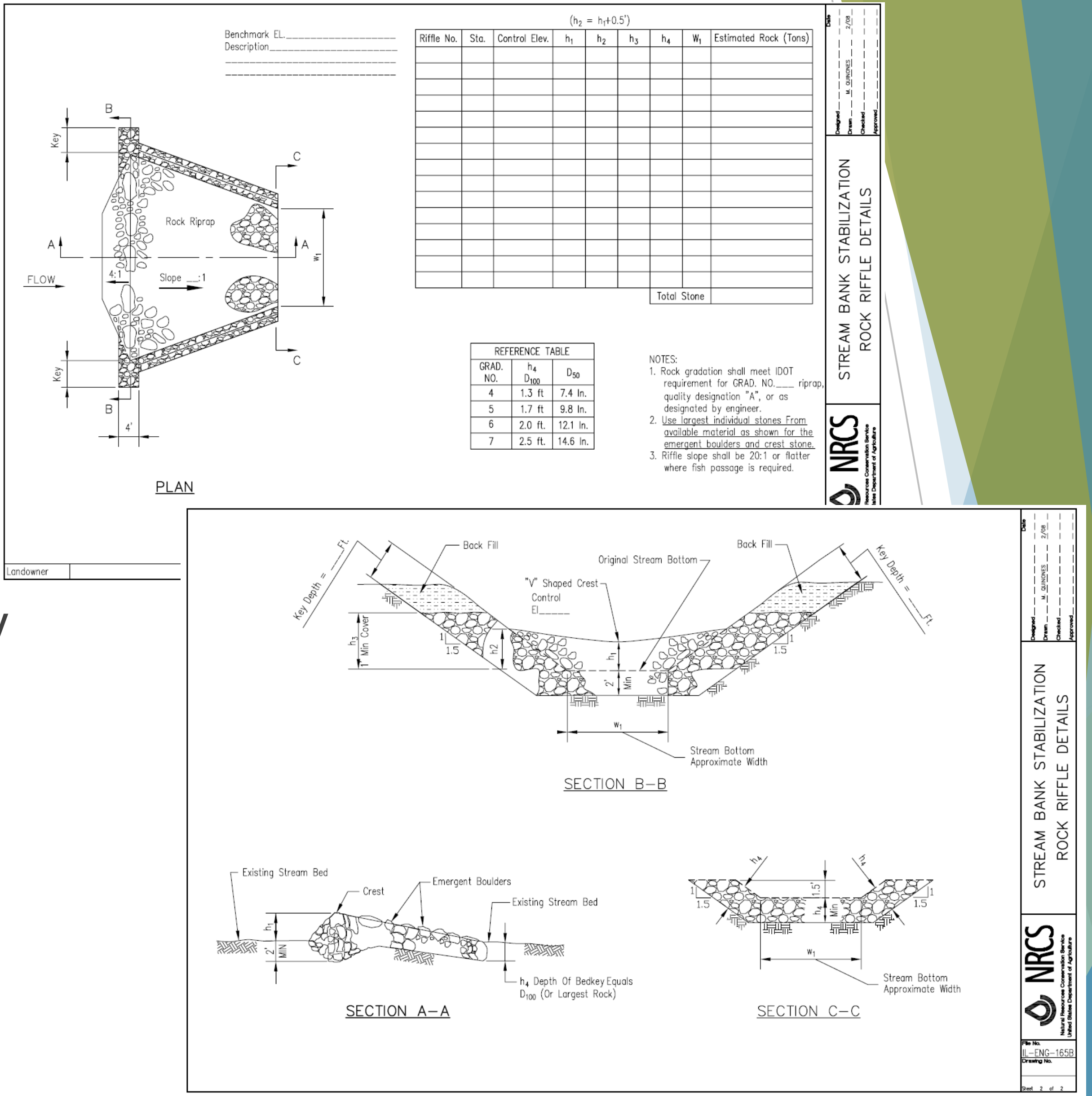
Grade Stabilization, Armoring, & Structural Practices

- Gabions, Rip Rap, and Other Bank Protection and Armoring Used to Hold Stream Banks in Place – ASSUMES STABLE STREAMBED!!!



Artificial Stream Riffles

- Purpose of Practice:
  - Provide grade control
  - Stream structure
  - Provides additional habitat
  - Control energy within treatment reach



Structural Grade Stabilization

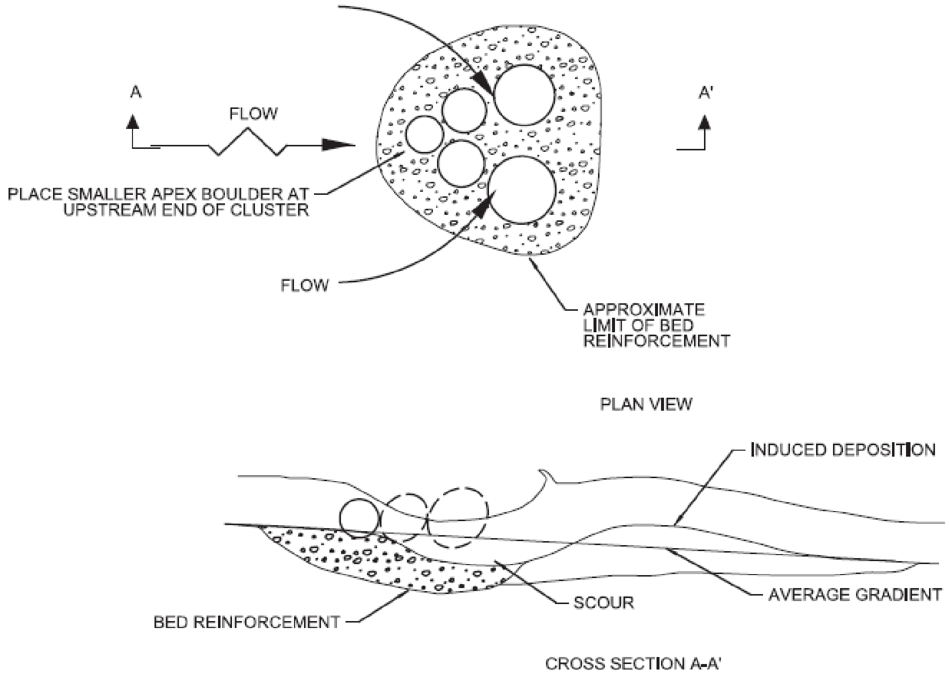
- Rock Riffles

Structural Grade Stabilization

- Rock Riffles

Structural Stabilization

- Boulder Clusters
  - Provide habitat and stabilization
  - Bed Roughening



Structural Stabilization

- Boulder Clusters

Structural Stabilization

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Structural Stabilization

- Boulder Clusters

Structural Stabilization

- Boulder Clusters

Vegetative Streambank Restoration

- Relies primarily on vegetation alone to stabilize banks on the long term
- May be utilize with bioengineering practices and temporary erosion control practices to establish vegetation
- Selection of species, establishment methods, and maintenance is critical to success of project

Vegetative Bank Stabilization

Keys to Successful Efforts

- Utilize manufacturers' data and design software to select appropriate blanket for soil and slope conditions
- Stabilization efforts should take into account drainage inputs from off-site and conditions of existing resource
- Select appropriate vegetation based on hydrology and sunlight regime

Vegetative Bank Stabilization

- Riparian Clearing
  - Removal of overgrowth of woody invasive species
  - Allows sunlight to penetrate the canopy to promote native vegetation
  - Requires significant planting and maintenance efforts

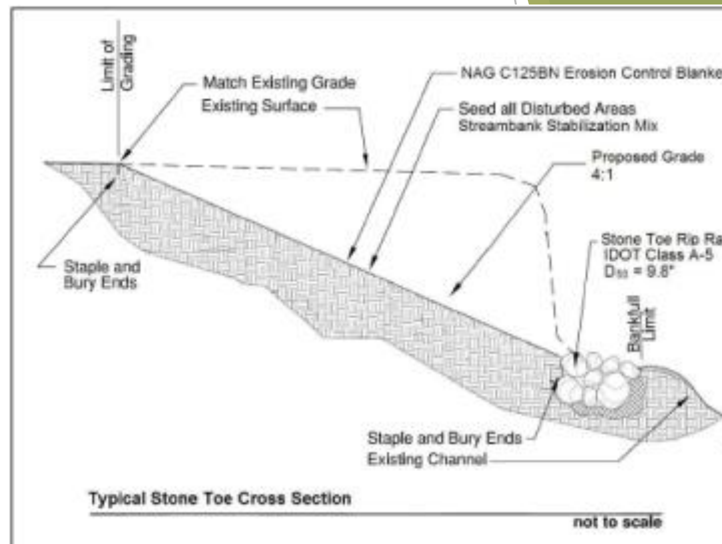
Site Photos Prior to Clearing

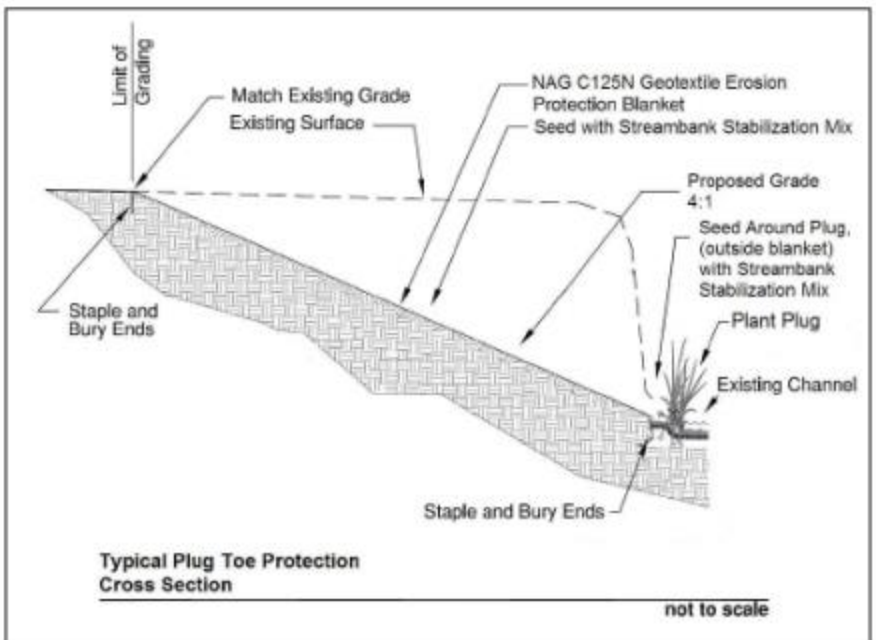
Vegetative Bank Stabilization

After Clearing

Vegetative Bank Stabilization

- Bank Reshaping
  - Expand cross sectional area to reduce velocity





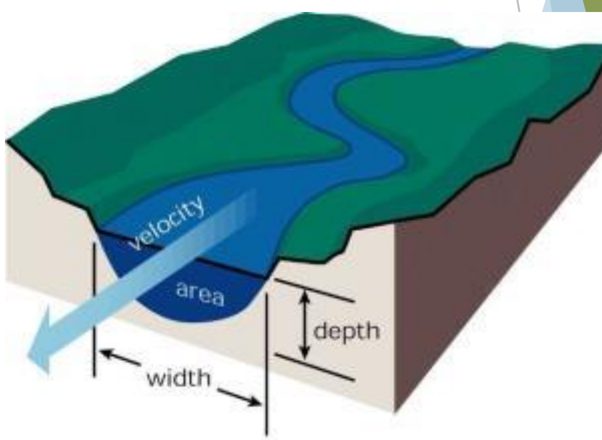


Fig. 1.18 – Channel discharge. Discharge is a product of area times velocity.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Vegetative Bank Stabilization

- Bank Reshaping

Vegetative Bank Stabilization

- Bank Reshaping

Vegetative Bank Stabilization

- Bank Grading Comparison
  - Before

Vegetative Bank Stabilization

- Bank Grading Comparison
  - After

Vegetative Bank Stabilization

- Establish native vegetation
- Open streambanks to sunlight
- Removal of woody invasives throughout riparian corridor
- REQUIRES ONGOING MAINTENANCE!!!!!

Combined Structural & Vegetative Stabilization Techniques

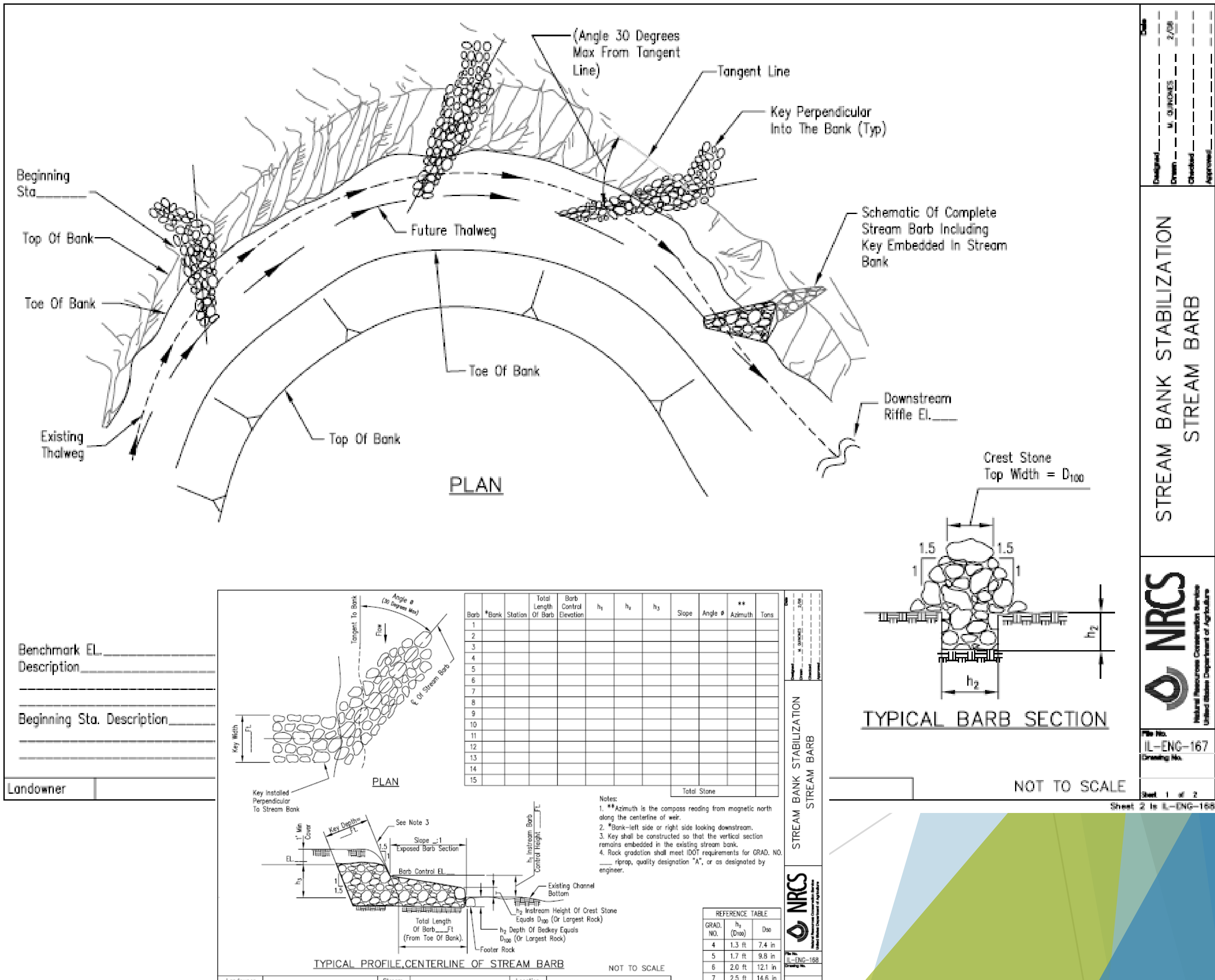
- Some Practices Include:
  - Stream Barbs/Bendway Weirs
  - Rootwad Revetments
  - Longitudinal Peak Stone Toe Protection

Combined Structural & Vegetative Stabilization Techniques

- Blend of Hard Armoring and Vegetative Practices
- Most structural practices rely on dissipating energy and reducing velocity in streamflow rather than diverting or redirecting it further downstream
- Design relies on structural measures to control thalweg and reduce energy and sheer stress at banks to promote deposition and vegetation development
- Extension of stabilization techniques outside of banks into the riparian zone improves long term stabilization and restoration efforts

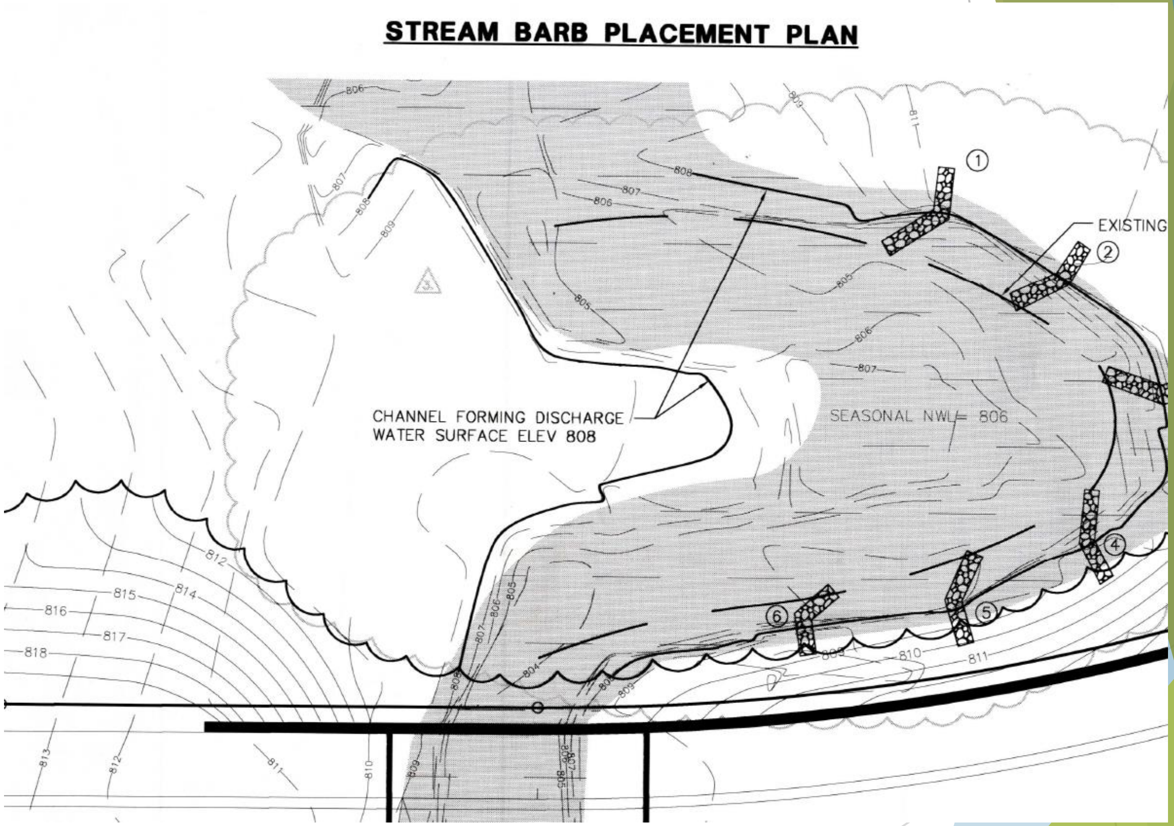
Stream Barbs / Bendway Weirs

- Purpose of Practice:
  - Control Meander Migration
  - Center Thalweg
  - Reduce Energy at bank
  - Control Energy within treatment reach



Stream Barbs / Bendway Weirs

- Keys to Practice Installation:
  - Stone Sizing per Spec
  - Key into bank
  - Use of crest stone and anchor
  - Proper upstream angle per plan



Stream Barbs / Bendway Weirs

Stream Barbs / Bendway Weirs

Base Flow Conditions

Stream Barbs / Bendway Weirs

Approximate Bankfull

Rootwad Revetment

- Purpose of Practice:
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  - Center Thalweg
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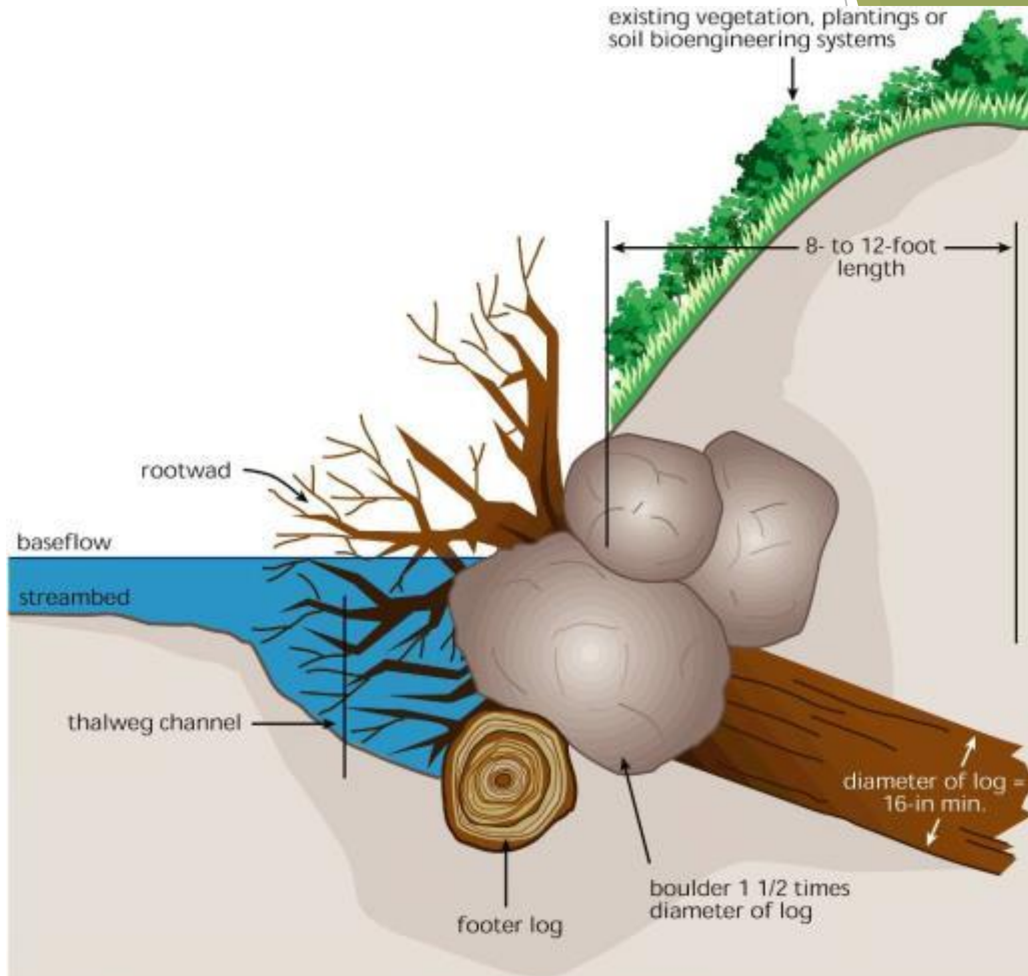


Source: Chapter 16 Engineering Handbook, USDA-NRCS, 1997.

Fig. 8.42 -- Revetment systems. Details of rootwad and boulder technique.
In Stream Corridor Restoration: Principles, Processes, and Practices, 10/98.
Interagency Stream Restoration Working Group (FISRWG)(15 Federal agencies of the US).

Rootwad Revetment

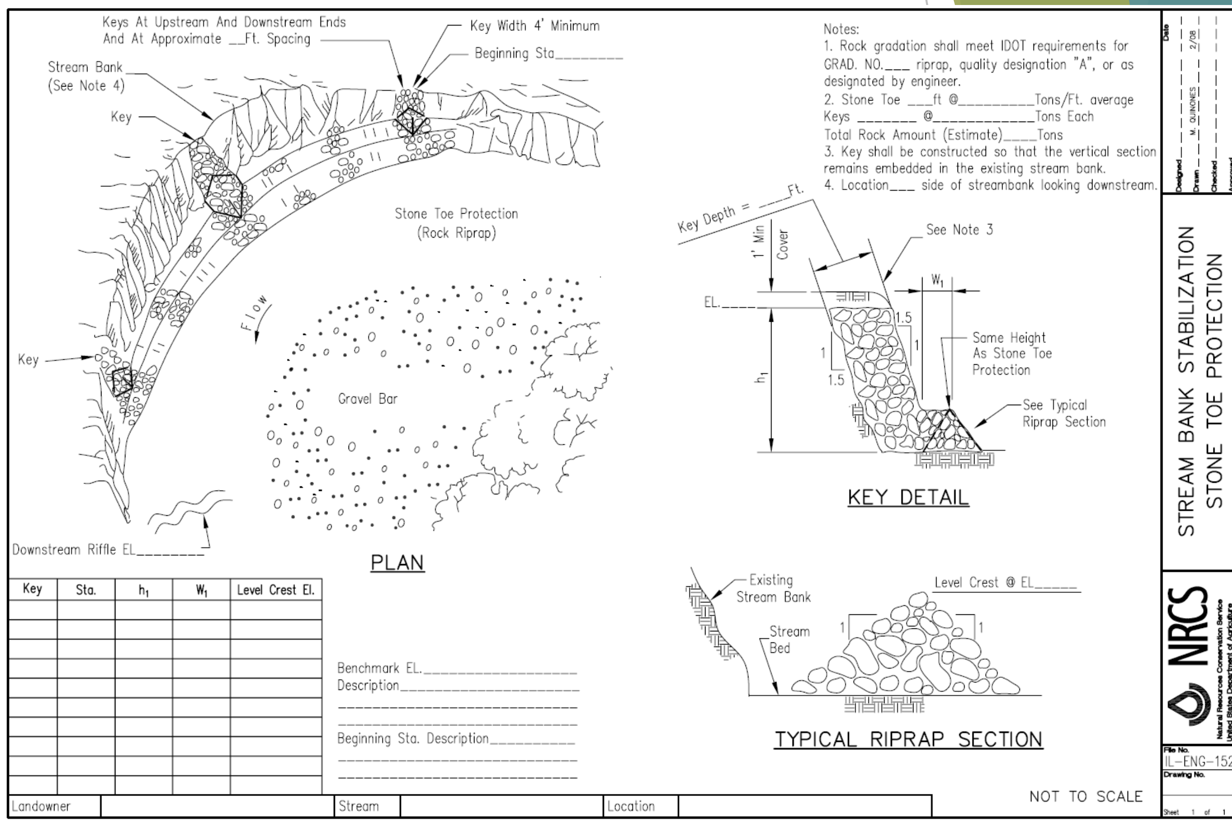
- Purpose of Practice:
  - Control Meander Migration
  - Center Thalweg
  - Reduce Energy at bank
  - Control Energy within treatment reach

Natural Channel Design Implementation

- Rootwad Revetments – Woody Debris Clusters

Longitudinal Peak Stone Toe Protection

- Purpose of Practice:
  - Control Meander Migration
  - Narrow channel slightly
  - Allow bank to slough or deposition to occur behind structure and revegetate
  - Control Energy within treatment reach



Longitudinal Peak Stone Toe Protection

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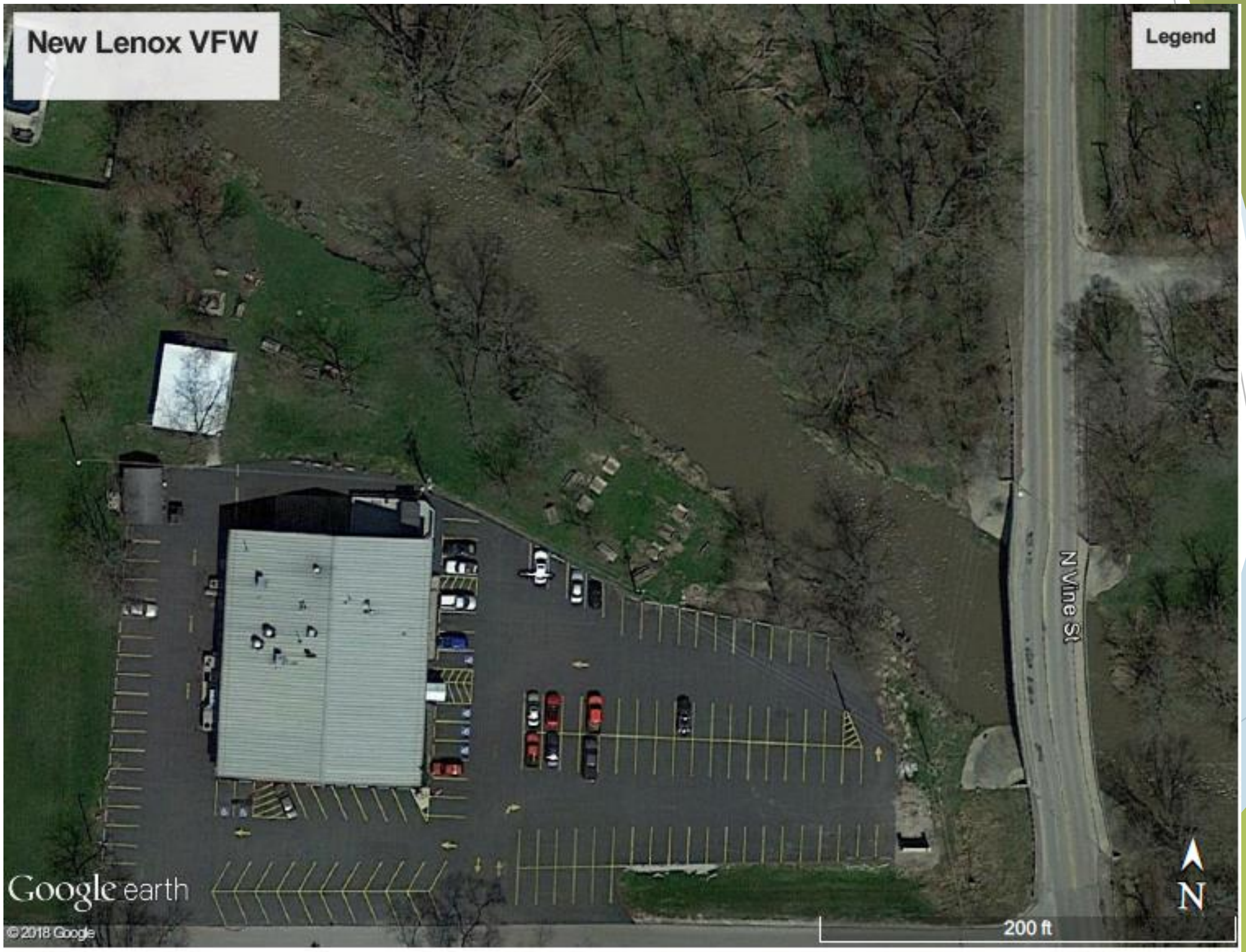
Project Example and Challenges



Project Example and Challenges

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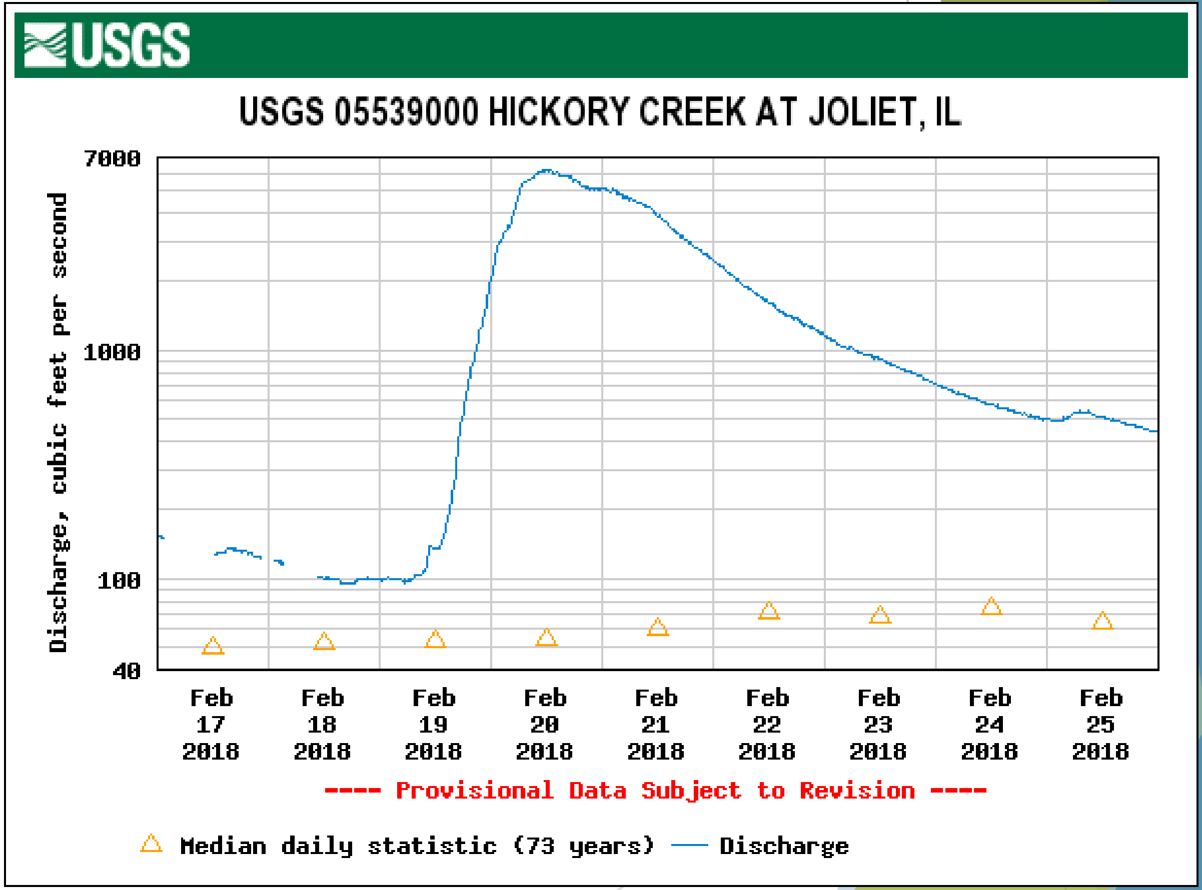
Project Example and Challenges

Challenges

- Perfect Timing
  - February 19th-20th Storm
  - Approximately 6.5” of rain in 20 hours
  - 15-18” Snowpack
  - Frozen Ground



Challenges

https://youtu.be/mFlNd7FIGck

Challenges

- Post Flood Conditions

Challenges

- Post Flood Conditions

Challenges

- Post Flood Conditions

Challenges

- Post Flood Conditions

Challenges

- Proof of Concept

Challenges

- Proof of Concept

Challenges

- Proof of Concept

Conclusions

- Design and construction of streambank stabilization practices must take into account upstream and downstream conditions from the "treated" stream segment
- Practices may work well in some conditions but may not work well in others
- Experienced, interdisciplinary design and construction teams are necessary to ensure a successful project
- While ascetics of practices is important, it is of minor importance to the overall success of the project
- Hard and soft armoring of streambanks must be carefully selected based on the dynamics of the project
- Practices must suit observed and modeled conditions, don't select practices and then work backwards

Conclusions

- Take into account the longevity of the treatment options
  - If vegetation is my "final" stabilization practice, ensure that the selected plant mix suits the hydrology and sunlight regime of the project area
- Understand the project goals during design and construction
- Communication and coordination is critical to success of the project

Questions?

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