Understanding and Controlling Shoreline Erosion

on Reservoirs with fine grain, cohesive shoreline soils

Some aspects of this presentation may not apply to reservoirs located at latitudes South of 35° N

Presented by: Shoreline Metrics, LLC
Hank Sutton, Senior Engineering Technician

Lake Rip Rap, Inc. - Macoupin Boat Works - Shoreline Metrics, LLC

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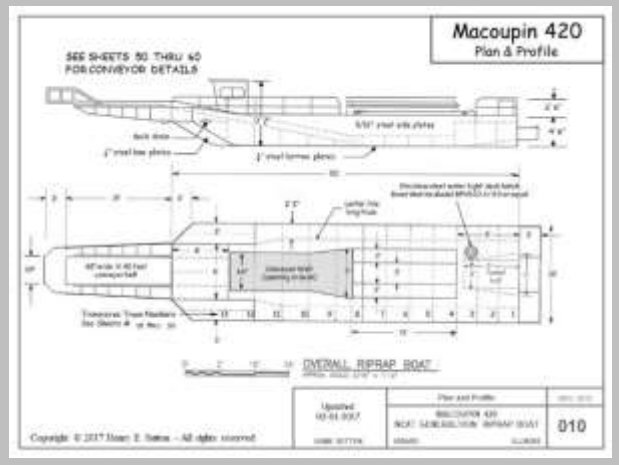
Hank Sutton
Senior Engineering Technician
trained at the University of Illinois, Champaign.

Hank is a Shoreline Erosion Control Specialist and owner of Shoreline Metrics, LLC. He was the founder and President of Lake Rip Rap, Inc. and Macoupin Boat Works in charge of design and production of steel mechanical riprap boats, the largest being 75 feet over all length with super shallow draft of 20" and a gross weight of 77 tons. Using Macoupin Mechanical Boats, his company has constructed shoreline erosion control structures along more than 200,000 lineal feet of shoreline on 42 midwestern bodies of water, primarily in Illinois (over a quarter of a million tons of riprap have been placed by Macoupin Boats). Hank has been a member of the Illinois Lake Management Association since 1987 and was presented the Lake Guardian Award by the Association in 2012.



Prior to his work as a boat builder and marine contractor, Hank was employed by IDOT and served as a survey party chief for construction of Interstate Highway Mainline, Interchanges and Bridges. Later in his highway career, Hank was an IDOT Certified Aggregate Inspector, for 22 years, which included gradation and quality sampling and testing of crushed stone, sand, gravel and stone riprap. His last 6 years with IDOT, Hank served as District 6 Bureau of Materials, Physical Test Supervisor. A former member of the Sunset Lake Association Board and present board member of the Otter Lake Water Commission, Hank has over 50 years of engineering experience.

Macoupin Boat Works

In the past 25 years, Macoupin Mechanical Boats
have placed over 250,000 tons of riprap along remote reservoir shorelines.

Illinois Lake Management Association - member since 1987

Lake Rip Rap, Inc.
&
Macoupin Boat Works
have re-organized as

Shoreline Metrics, LLC

We are no longer building Macoupin Riprap Boats or bidding riprap construction projects, but now offer technical services related to shoreline erosion control.

Understanding and Controlling Shoreline Erosion on Reservoirs with fine grain, cohesive shoreline soils

Issues Addressed in this Presentation

- Reorganization of Lake Rip Rap, Inc./Macoupin Boats to Shoreline Metrics, LLC
- Geomorphology of Reservoir Shorelines as influenced by physical and meteorological processes
- The Destructive Power of Freeze-Thaw Stresses - Seasonality of Shoreline Erosion
- Affordable Living Shoreline using Standard Off-shore Breakwater and Naturally Colonized Littoral Zone with No Environmental Damage to the Terrestrial Habitat
- Managing Breakwater Subsidence with Non-woven Filter Fabric
- Down Trees Provide a Desirable Element to the Developing Littoral Habitat
- Riprap Durability Based on Department of Transportation Laboratory Test Results
- Over Designing, an Engineering Failure of Cost-Effectiveness
- Why Banks Recede at Similar Rates Regardless of Prevailing Wind Direction
- Living Shoreline Development, Ref: Thesis by John Severson, (now PhD), SIU Carbondale
- Recreational Boating and Horsepower Limits Relative to Shoreline Erosion
- Cheating in the No Wake Zone
- Affordability of Bioengineering and Supplemental Planting of the Littoral Zone
- Project Planning - Littoral Slope Topographic Survey, Construction Inspection, Project Documentation for Material Budgeting, Required Submittals and Weighted Average Water Haul Distance Determination

The cost effectiveness, durability and longevity of shoreline stabilization projects can be optimized by following a few simple, but essential, procedures.

Setting priorities - quick and easy

The work area should be within 3 miles of a stagging area, with a weighted average water haul distance of 1 ½ miles or less. If the work area must exceed these distances, consider an additional stagging area. Cruising time is expensive.

Preliminary littoral cross sections

Spot check littoral slope gradient vs. bank height. A low littoral slope gradient with a high bank defines severity. Do not limit the spot checks to visually high banks only. Record lat/long locations, estimated bank heights and measured littoral slope gradients.

Refine littoral slope surveys of severe erosion based on preliminary spot checks - develop the short list

Determine appropriate cross section spacing. Estimate approximate bank heights using a range pole or leveling rod. Use the water level for the bench mark adjusted to full pool elevation. Record water depth at the bank, 10 feet out and 20 feet out to determine littoral slope gradient. Measure the reach length at the proposed center line of the breakwater. Record information and photograph the bank along the selected reaches.

Select probable reaches for stabilization

After evaluation of raw data, make final selections for stabilization with provisions for flexibility based on unit price bids.

Develop typical section based on the Illinois Standard Breakwater

Riprap quantities will vary as the littoral slope varies, but keep the number of typical sections to a minimum within reason, relying on sound engineering judgement.

Job site inspection of delivered materials

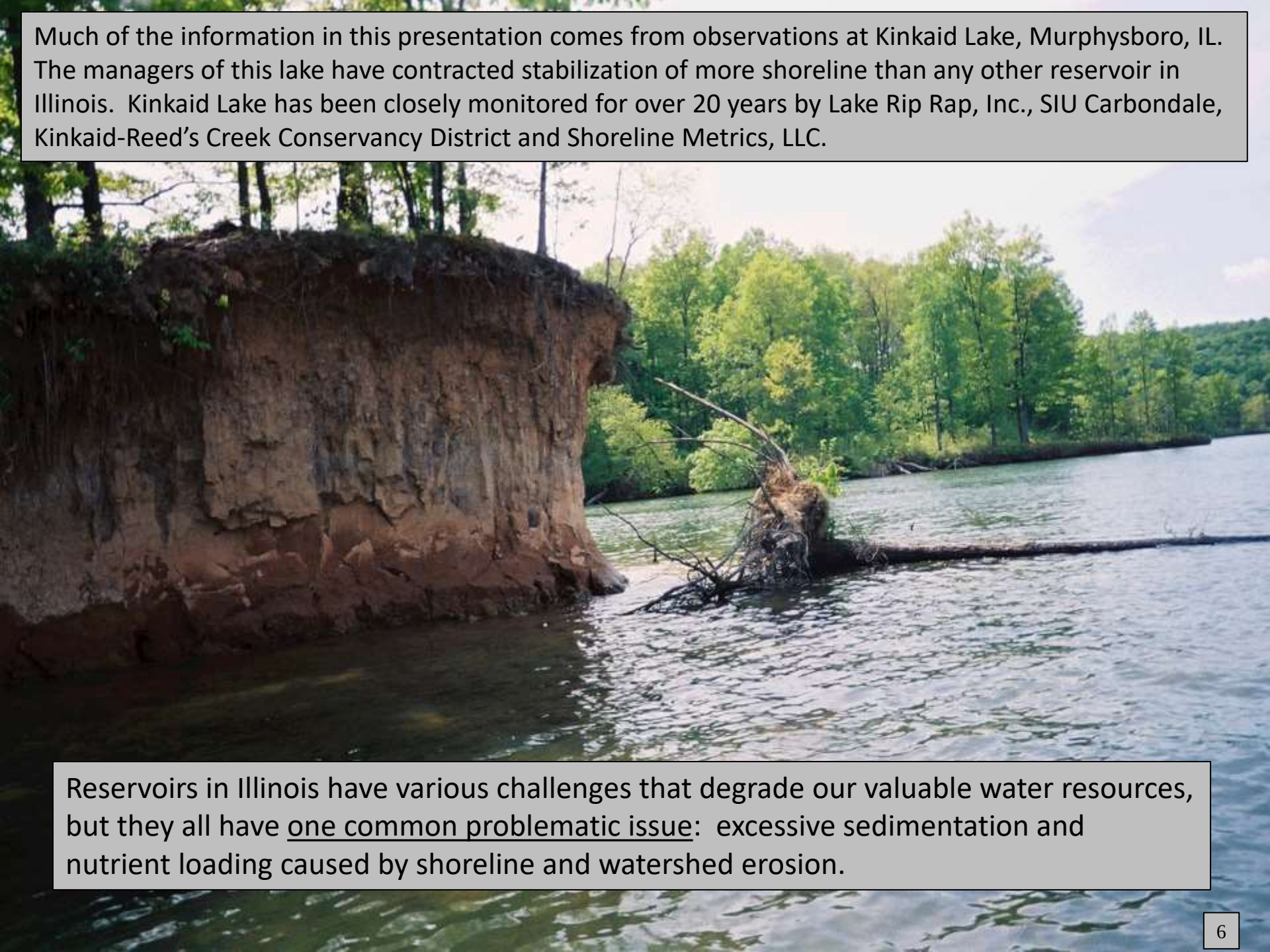
All materials delivered by the supplier must state a description of the materials to compared to the IDOT Standard Specifications. (a link to IDOT specifications is provided later in this presentation)

The two main materials delivered will be non-woven filter fabric for use with riprap and stone riprap. The filter fabric must be delivered dry with wrapping in good condition and must be protected from weather and sunlight until placed. The riprap job site visual inspection procedure using Key Stones is described later in this presentation.

Construction observation and material budgeting is essential

A technician experienced in shoreline erosion control must be on site to ensure proper fabric placement and proposed lines and grade.

Much of the information in this presentation comes from observations at Kinkaid Lake, Murphysboro, IL. The managers of this lake have contracted stabilization of more shoreline than any other reservoir in Illinois. Kinkaid Lake has been closely monitored for over 20 years by Lake Rip Rap, Inc., SIU Carbondale, Kinkaid-Reed's Creek Conservancy District and Shoreline Metrics, LLC.



Reservoirs in Illinois have various challenges that degrade our valuable water resources, but they all have <u>one common problematic issue</u>: excessive sedimentation and nutrient loading caused by shoreline and watershed erosion.

Most severe shoreline erosion of an Illinois reservoir
Banks up to 40 feet high
Short Fetches: 2 miles or less
Receding more than 1 foot per year
172 miles of shoreline

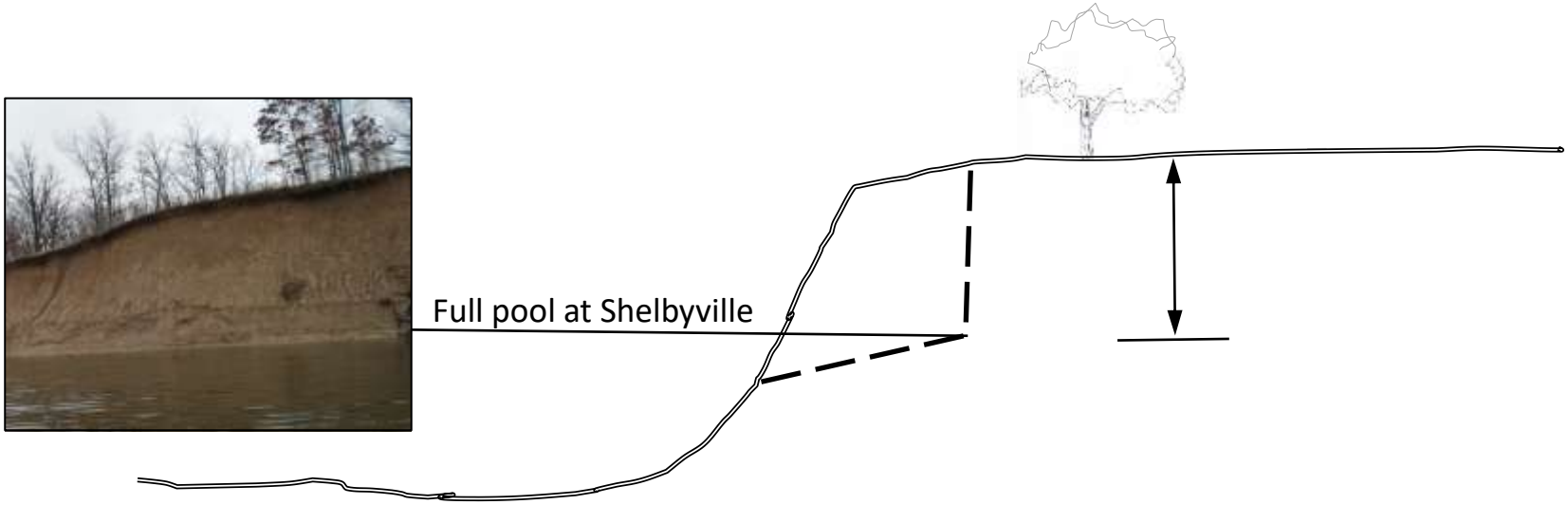
Lake Shelbyville

39°27’00”N 88°44’00”W

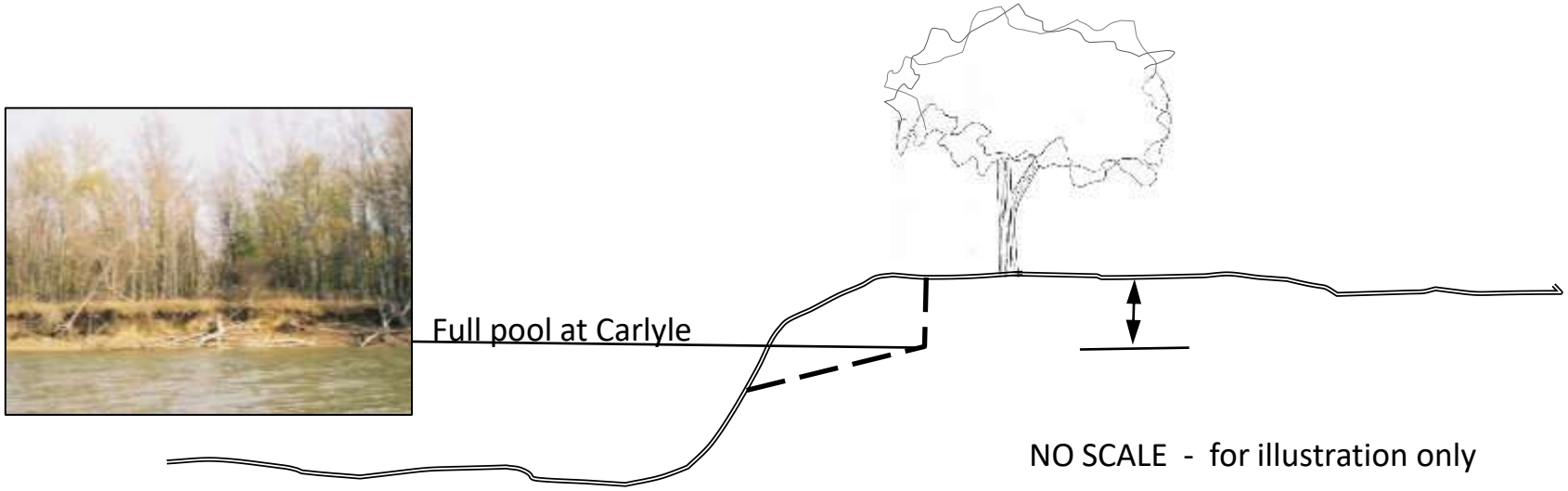
50 years later

Carlyle Lake, the longest fetch on an Illinois Reservoir

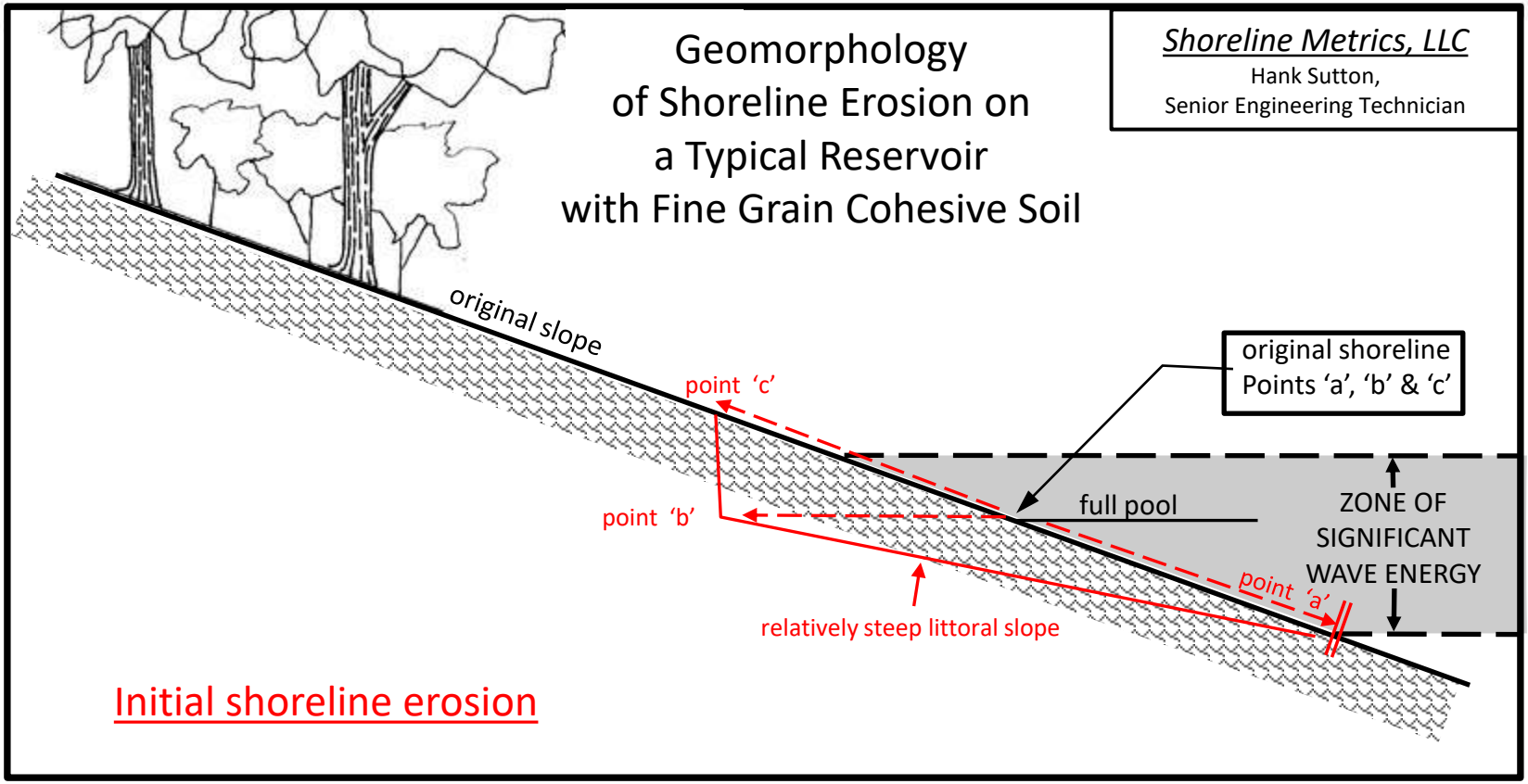
Why is shoreline erosion more severe at Lake Shelbyville than Carlyle Lake?



Carlyle Lake has longer fetches and therefore more wind driven wave energy, but the bank height will never reach that of Shelbyville, where the surrounding terrain is much higher.



Wind driven waves at Rend Lake
4 mile fetch

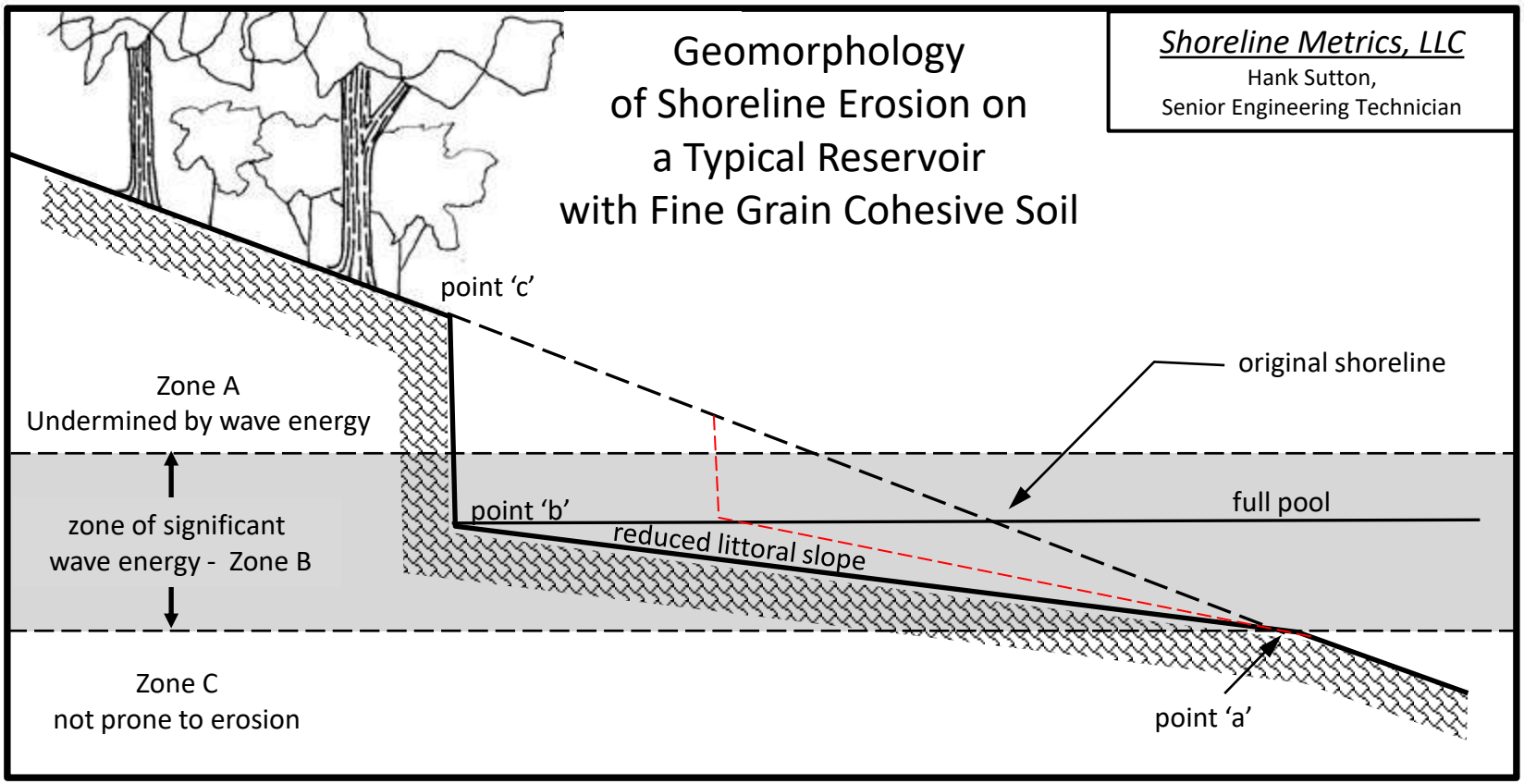


As shoreline erosion begins

Point 'a' moves down the original slope until it reaches the lower limit of significant wave energy, where it remans indefinitely.

Point 'b' moves inland at full pool elevation.

Point 'c' moves up the original slope maintaining an approximate location above point 'b'.

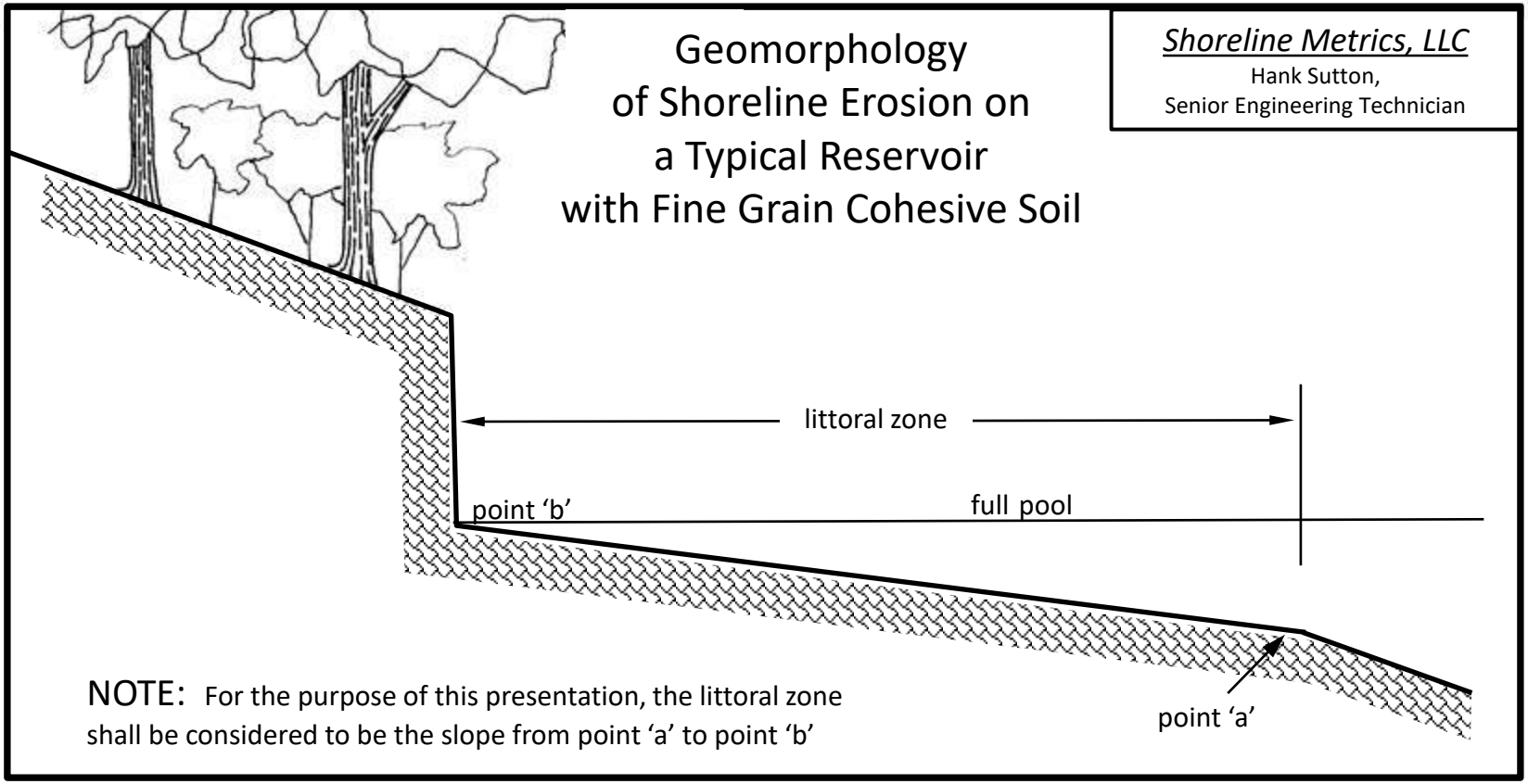


As shoreline erosion continues

Notice that Point 'a' remains indefinitely at the intersection of the littoral slope and the lower limit of the Zone of Significant Wave Energy.

Points 'b' and 'c' continue on their projected trajectories.

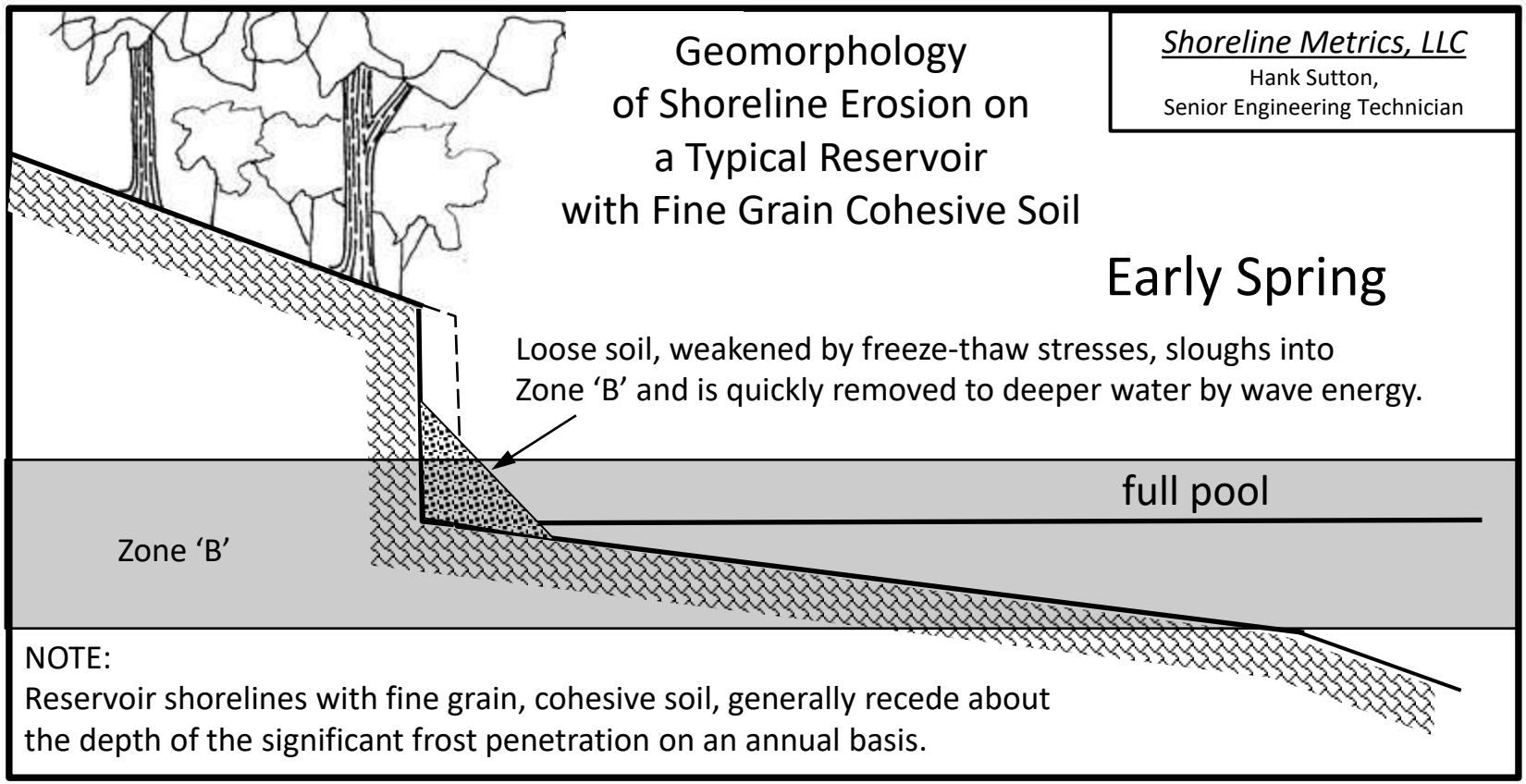
Also notice that, as the bank recedes, the littoral slope becomes less steep. (more on this later)



Shoreline erosion occurs when the wave energy exceeds the cohesive strength of the soil, but the cohesive strength of the soil is not constant throughout the year.

The soil strength is greatly reduced every winter due to freeze-thaw stresses as ice crystals form in the voids and reduce the cohesion and particle interlock of the soil, therefore, shoreline erosion is at it's peak just after the Spring thaw.

The severity of freeze-thaw stresses is determined by: Depth of frost penetration, soil moisture content, number of freeze-thaw cycles, physical characteristics of the soil.



This weakened fine grain cohesive soil commonly has a consistency similar to loose sand.

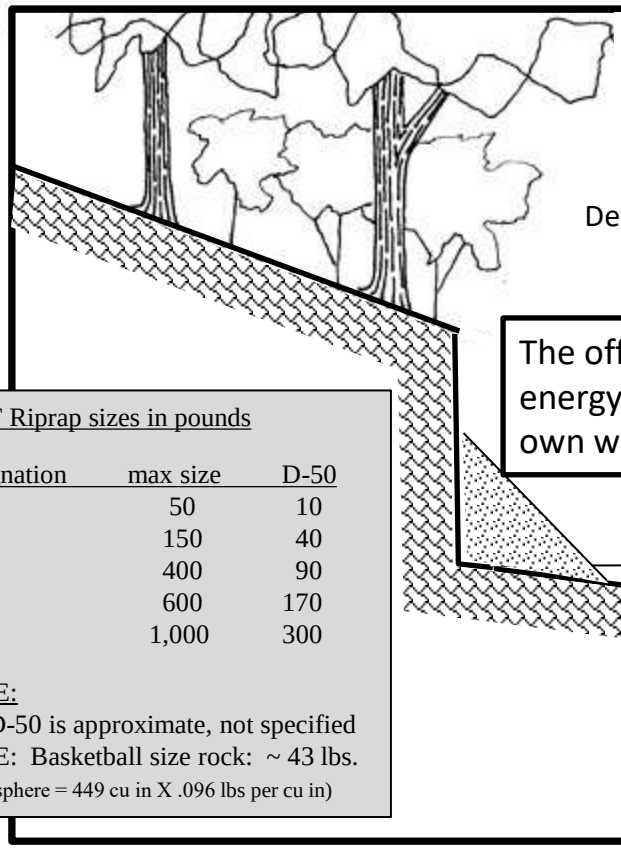
It is also very common for sloughing to occur intermittently during the winter between freeze-thaw cycles. In those cases, the sloughing and bank recession is not as noticeable.

Annual bank recession will vary as winter conditions differ from year to year, with the preponderance of erosion occurring in Early Spring.

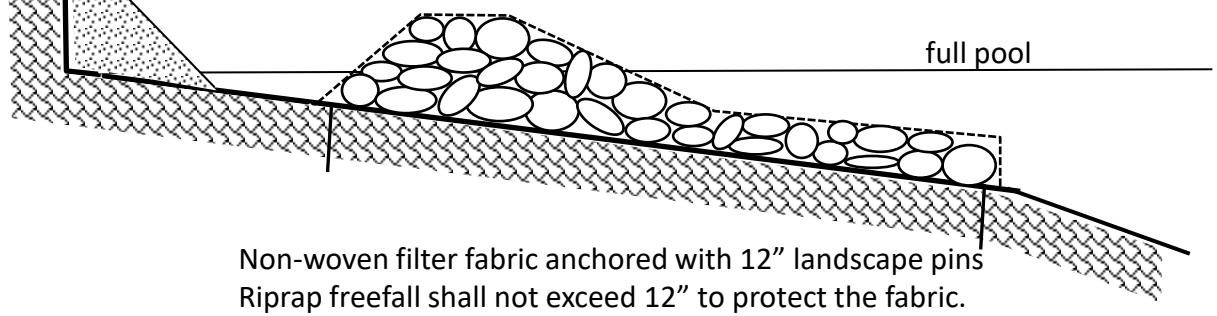
Illinois Standard Off-shore Breakwater on non-woven filter fabric

Developed by: Hank Sutton, Shoreline Metrics, LLC.
and Scott Martin, NRCS

Shoreline Metrics, LLC
Hank Sutton,
Senior Engineering Technician



The off-shore Breakwater isolates the frost weakened soil from wave energy, the weakened soil consolidates during the summer under its own weight then Natural Shoreline Plant Colonization begins.



Non-woven filter fabric anchored with 12” landscape pins
Riprap freefall shall not exceed 12” to protect the fabric.

IDOT Riprap sizes in pounds

Designation	max size	D-50
RR-3	50	10
RR-4	150	40
RR-5	400	90
RR-6	600	170
RR-7	1,000	300

NOTE:
The D-50 is approximate, not specified
NOTE: Basketball size rock: ~ 43 lbs.
(9 ½” sphere = 449 cu in X .096 lbs per cu in)

The Process of Natural Shoreline Plant Colonization

Last year's plants coming out of dormancy.

Frost weakened soil and emerging plants removed by wave energy in a couple of weeks, with no storm event.

In Spring and Summer a small number of plants sprout along the eroding shoreline, put down roots, become dormant in Fall and survive through the Winter. In late Winter and early Spring the frost weakened soil is removed to deeper water, including the emerging plants, roots and all. If the shoreline is not isolated from wave energy, this process is an ongoing annual event, resulting in continuous shoreline recession, excessive sedimentation and nutrient loading.

After the shoreline is stabilized with an off-shore breakwater, the fledgling plants thrive and mature from year to year in the low energy environment behind the breakwater.

The breakwater is designed to dissipate most of the wave energy, most of the time. In the event of occasional high water and overtopping of the breakwater, the plants dissipate wave energy, protecting the bank. The root system of the naturally colonized plants also contribute to stability by reinforcing the soil. In the event of occasional low water the stone apron protects the toe of the breakwater.

No excavation, No seeding or planting required, No heavy equipment on the bank and No environmental damage of the terrestrial habitat.

Shoreline Metrics, LLC
Hank Sutton (217) 899-9706

The Process of Natural Shoreline Plant Colonization

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Last year's plants coming out of dormancy.

Frost weakened soil and emerging plants removed by wave energy in a couple of weeks, with no storm event.

Before stabilization

8 years After Stabilization

Different Location than above

Shoreline Metrics, LLC
Hank Sutton (217) 899-9706

Standard off-shore Breakwater water level 24” above full pool.

It is not necessary for the top of the structure to be built to an elevation that totally eliminates overtopping.

Although the riprap structure is submerged, it will still dissipate some of the wave energy and the naturally colonized vegetation will dissipate the rest of the energy.

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STANDARD OFF-SHORE BREAKWATER

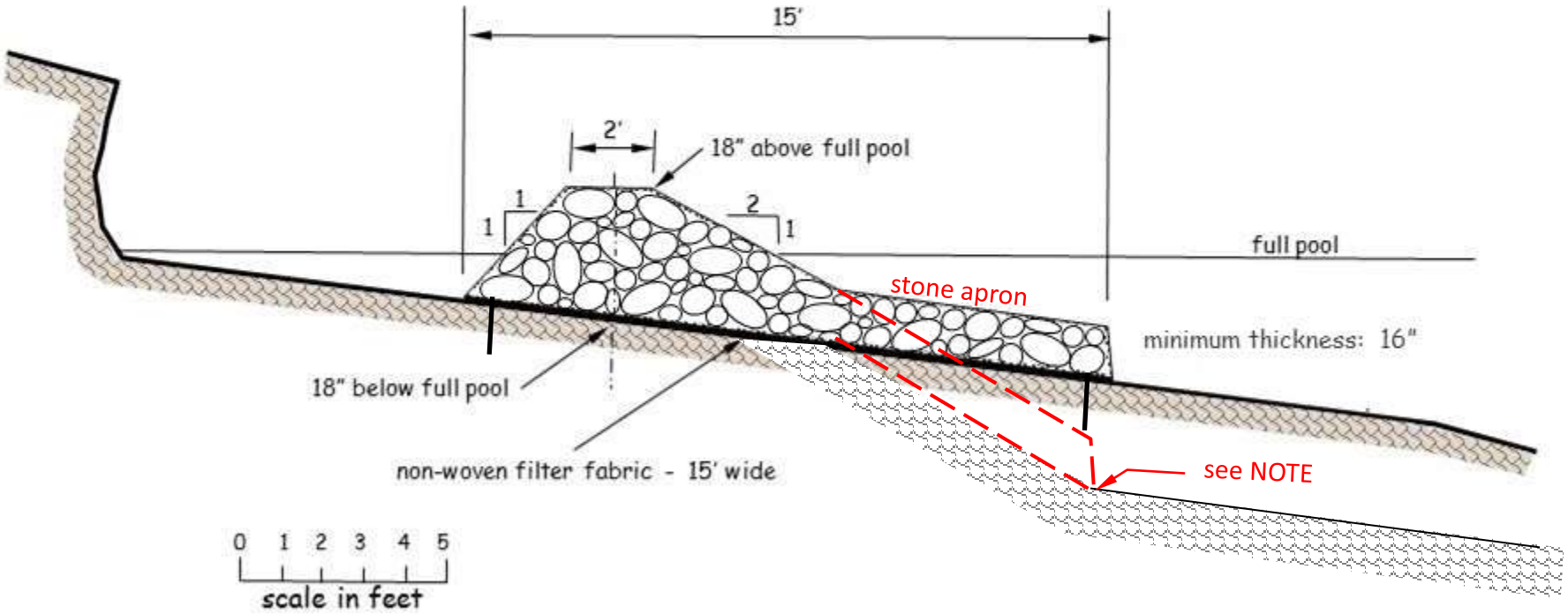
TYPICAL SECTION

Stone Riprap ('A' Quality)
Non-woven Filter Fabric (6 - 8 ounce/ sq. yd.)*
Reference: Illinois DOT Standard Specifications
For Road and Bridge Construction
Sections 1005 & 1080

Dimensions for RR-4

Function of the stone apron

NOTE: In the rare event of low water for an extended period of time, the apron is designed to protect the breakwater to a lower elevation and still retain the desired 2h :1v surface slope.



* Non-woven filter fabric requirements vary with specified riprap size.

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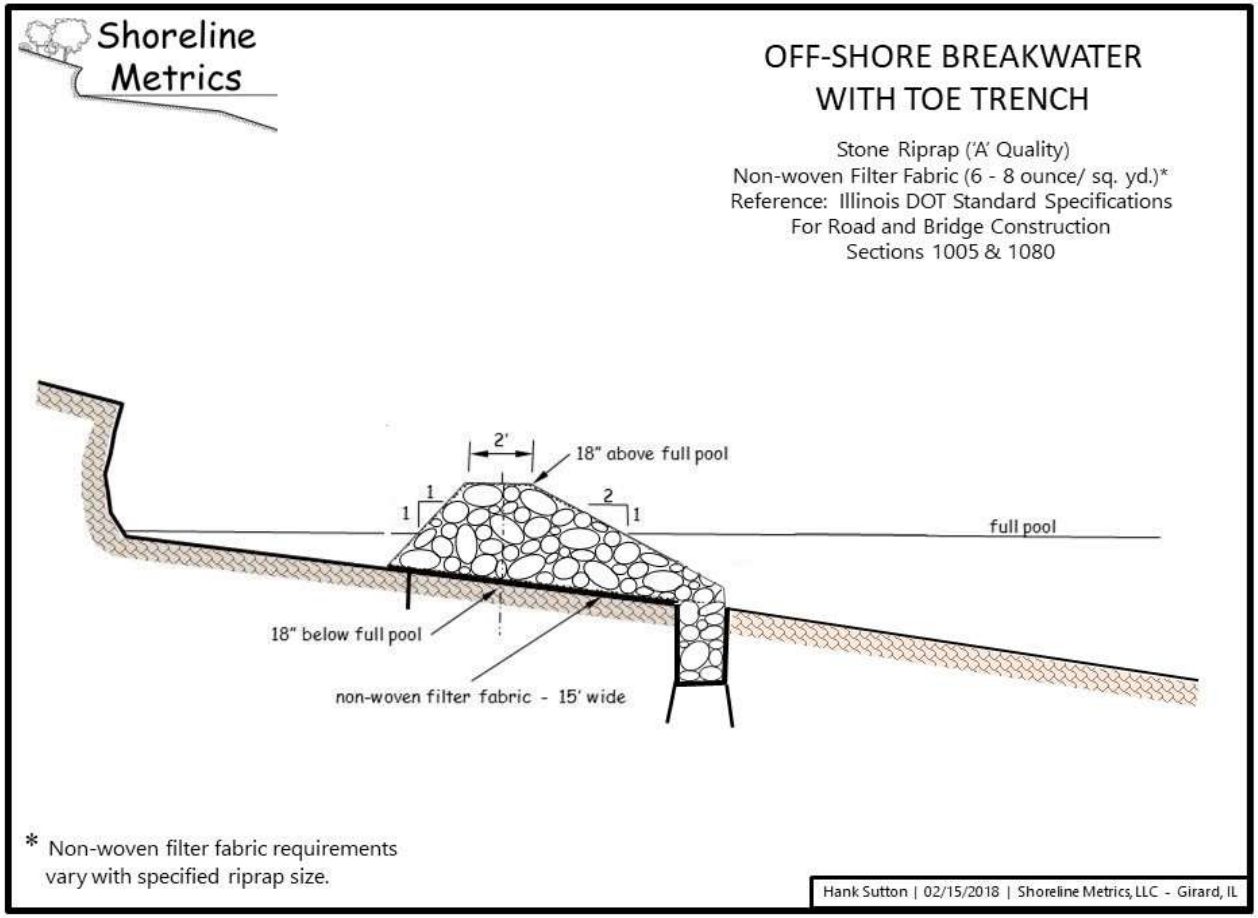


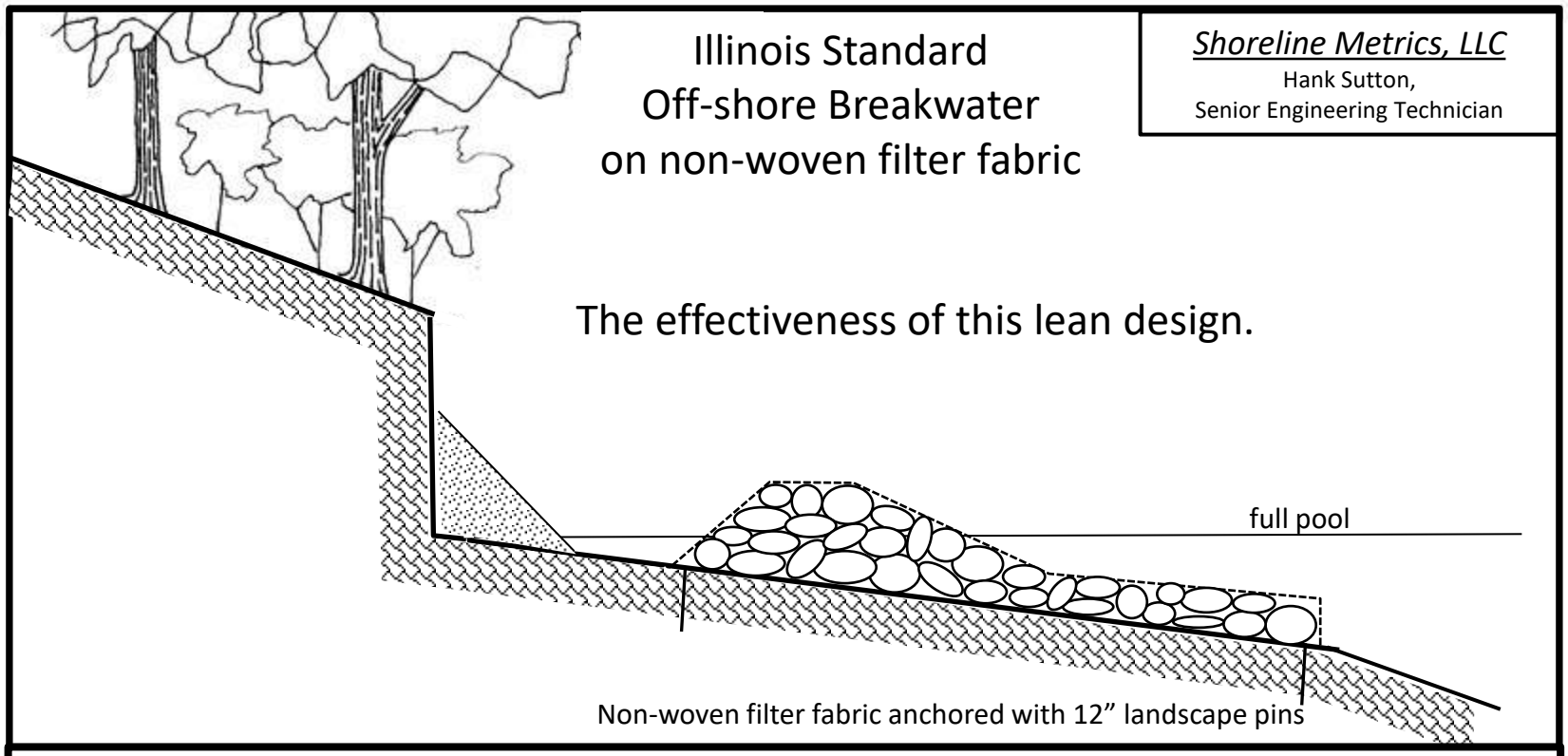
The apron is an improved design that replaces the toe trench.

The problem with the toe trench is that it was difficult to accurately excavate the trench under water and added significant cost to the work. Before non-woven filter fabric was developed, stone bedding was used under riprap. Stone Bedding remains in IDOT Specifications, under Section 1005, RR-1 and RR-2.

After the advent of filter fabric, it was difficult to line the trench with fabric and secure it in the trench until the riprap was placed because filter fabric floats. It was not unusual for the fabric to be wadded up and ineffective.

Ref: Hank Sutton's experience while working for the Illinois Department of Transportation (1965 construction inspection)

Non-standard Design with
no fabric and no apron to protect the toe



NOTE: This design is deliberately lean to optimize cost-effectiveness. The intent is to effectively dissipate wave energy without over designing. This lean design has been in use for over 20 years with no significant failures. If, by chance, the structure needs maintenance, small additional quantities of riprap can simply be applied to restore the original lines and grade of the localized failures. High quality riprap (IDOT quality designation ‘A’) is virtually impervious to weathering.

In a nut shell, this design has proven to be the most affordable method of shoreline erosion control where the shoreline is made up of fine grain, cohesive soil and it sets the stage for a naturally colonized living shoreline. “Bioengineered” shoreline remediation (with a little help from the existing seed bank)

Various features of this design will be addressed throughout this presentation.

Riprap, Specific Details that Ensure Performance

Riprap must have three characteristics to be effective for shoreline erosion control. First, it must be of sufficient quality to prevent deterioration in a saturated freeze/thaw environment, second, it must have enough mass to resist movement by the existing wave energy and third, it should have +/- 40% voids to effectively dissipate wave energy. If the voids are full of fines, the energy will be reflected instead of being dissipated. Wave energy impacting immobile rough fractured stones, energy continual reflected and redirected within the void matrix and pressure spikes in the voids convert kinetic energy to heat energy with negligible macro-reflection of the wave energy.

IDOT uses the sodium sulphate soundness test (ASTM C-88 modified) to ensure quality, after 5 cycles of saturating and drying to grow salt crystals which simulate the repeated formation of ice crystals within the micro-partings of friable materials, the loss shall not exceed 15%. IDOT specifies quarried stone with a minimum Specific Gravity (SpG) of 2.45 to meet the mass needed for the application. Also included are specifications to limit flat elongated particles that can "sail" in the presents of wave energy. Field stones and boulders are not allowed because of the reduced potential for beneficial particle interlock, unknown quality and other factors.

All gradations produced shall be well graded (not skip graded) from the specified top-size particles to the smallest particles. Shoreline Metrics, LLC recommends 2 additional key-stones per RR size, of intermediate weights to ensure that the material is well graded. Example of additional key-stones for RR-4: specified key-stones : 150 lbs, 40 lbs, 1 lb - intermediate key-stones: 90 lbs & 20 lbs.

Each IDOT size designation of riprap has a required Particle Size Distribution (gradation) to provide the desired mass and void matrix. For riprap gradation acceptance: see IDOT Policy Memorandum No. 14-08.2 Revised July 24, 2018 which calls for visual inspection based on weighed key-stones (not to be confused with masonry keystones) for various sizes stated in Standard Specs. Art. 1005.01.

Riprap Size	Keystone #1 (lbs. +/- 10%)	Keystone #2 (lbs. +/- 10%)	Keystone #3 (lbs. +/- 10%)
RR-3	50	10	1
RR-4	150	40	1
RR-5	400	90	3
RR-6	600	170	6
RR-7	1000	300	12

Riprap, Specific Details that Ensure Performance

Continued

Each scale ticket must state the size and the quality designation, this is the producer's certification.

IDOT Specifications for riprap: Article 1005 page 759 Non-woven filter fabric: Article 1080.03 page 1000

Link to IDOT Specifications: https://idot.illinois.gov/Assets/uploads/files/Doing-Business/Manuals-Guides-&-

Link to Illinois Quarries: c584.pdf (illinois.edu) Investigate possible sources in nearby States when the project is near the Illinois border

Shipments should come from IDOT approved stock. If you suspect a problem with the gradation, contact the supplier first. If not resolved, contact the IDOT District Office, District Bureau of Materials. Unlike other aggregates, it is difficult for the quarry to consistently produce riprap without significant variations.

Acceptance Procedure for Riprap Gradation: IDOT Policy Memorandum No. 14-08.2 Revised July 24, 2018

Riprap in place - weight per cubic foot

"A" quality limestone commonly has a SpG of 2.60 or about 162 pounds per solid cubic foot. Riprap generally has 40% voids, regardless of the size designation.

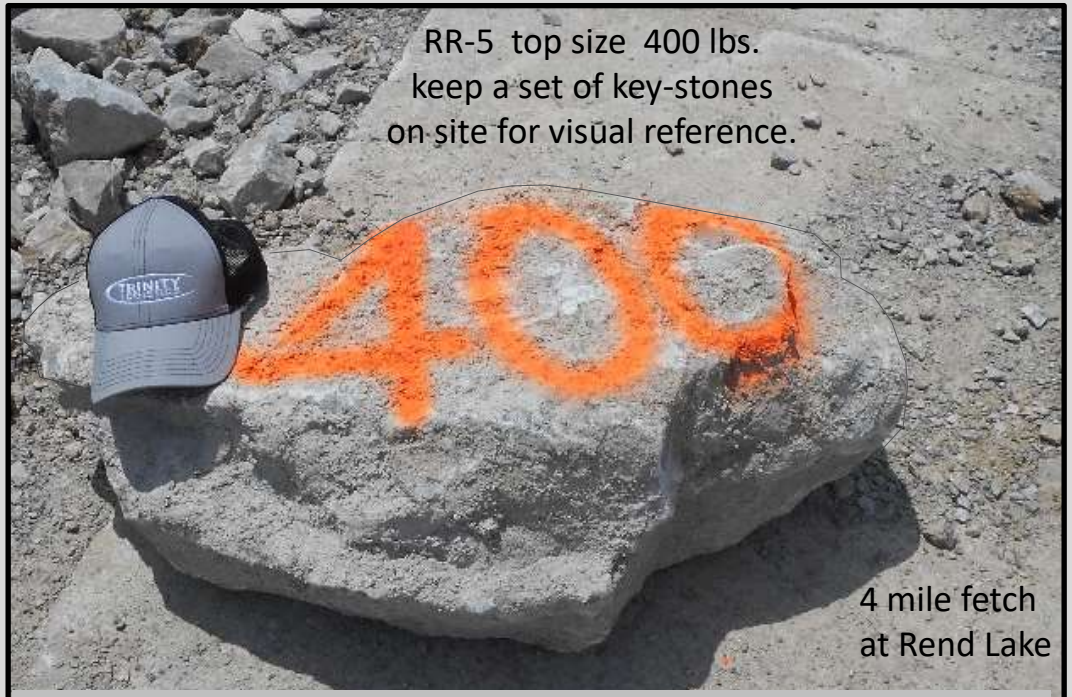
Therefore, for estimating purposes, riprap in place use 100 pounds per cubic foot.

Limestone weight per cubic volume

50 pound stone	=	8" cube
150 pound stone	=	12' cube
400 pound stone	=	16" cube
600 pound stone	=	18" cube
1000 pound stone	=	22" cube

Minimum thickness, riprap in place

RR-3	8 inches
RR-4	16 inches
RR-5	22 inches
RR-6	26 inches
RR-7	30 inches



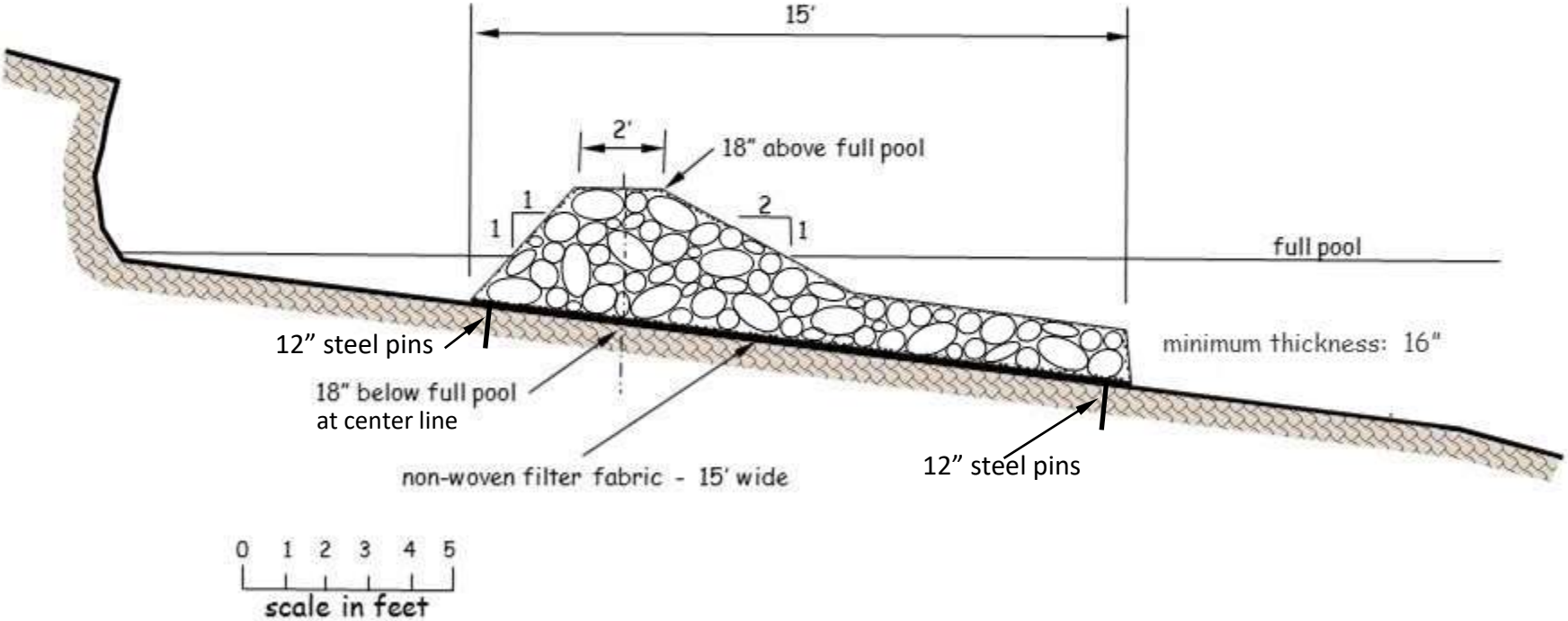
Shoreline Metrics recommended key-stones, in pounds for RR-5:
400 250 90 40 3 (the 250 and 40 ensures well graded material)

Shoreline Metrics

ILLINOIS STANDARD BREAKWATER
Typical Section

RR-4 on 12% littoral slope shown here

NOTE: For littoral slopes steeper than 17%, modifications of the Standard Breakwater should be considered. See Special Provisions for steeper littoral slopes, page 112.



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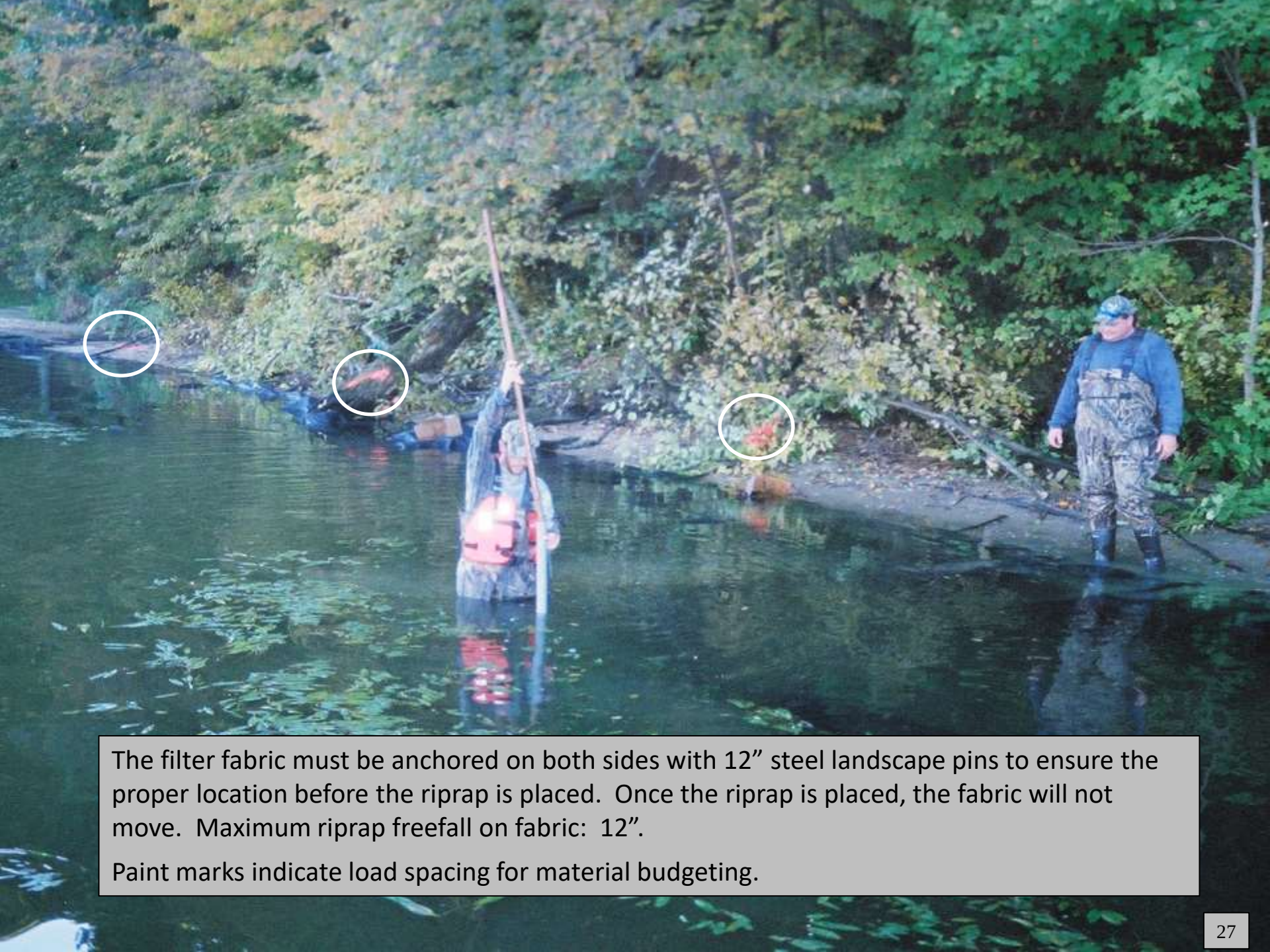


The filter fabric must be anchored on both sides with 12” steel landscape pins to ensure the proper location before the riprap is placed. Once the riprap is placed, the fabric will not move. Maximum riprap freefall on fabric: 12”.

Paint marks indicate load spacing for material budgeting.

Lake Rip Rap, Inc.

Placing fabric around down trees

Drape fabric loosely over the log, then cut the fabric along the top of the log.

Lake Rip Rap, Inc.

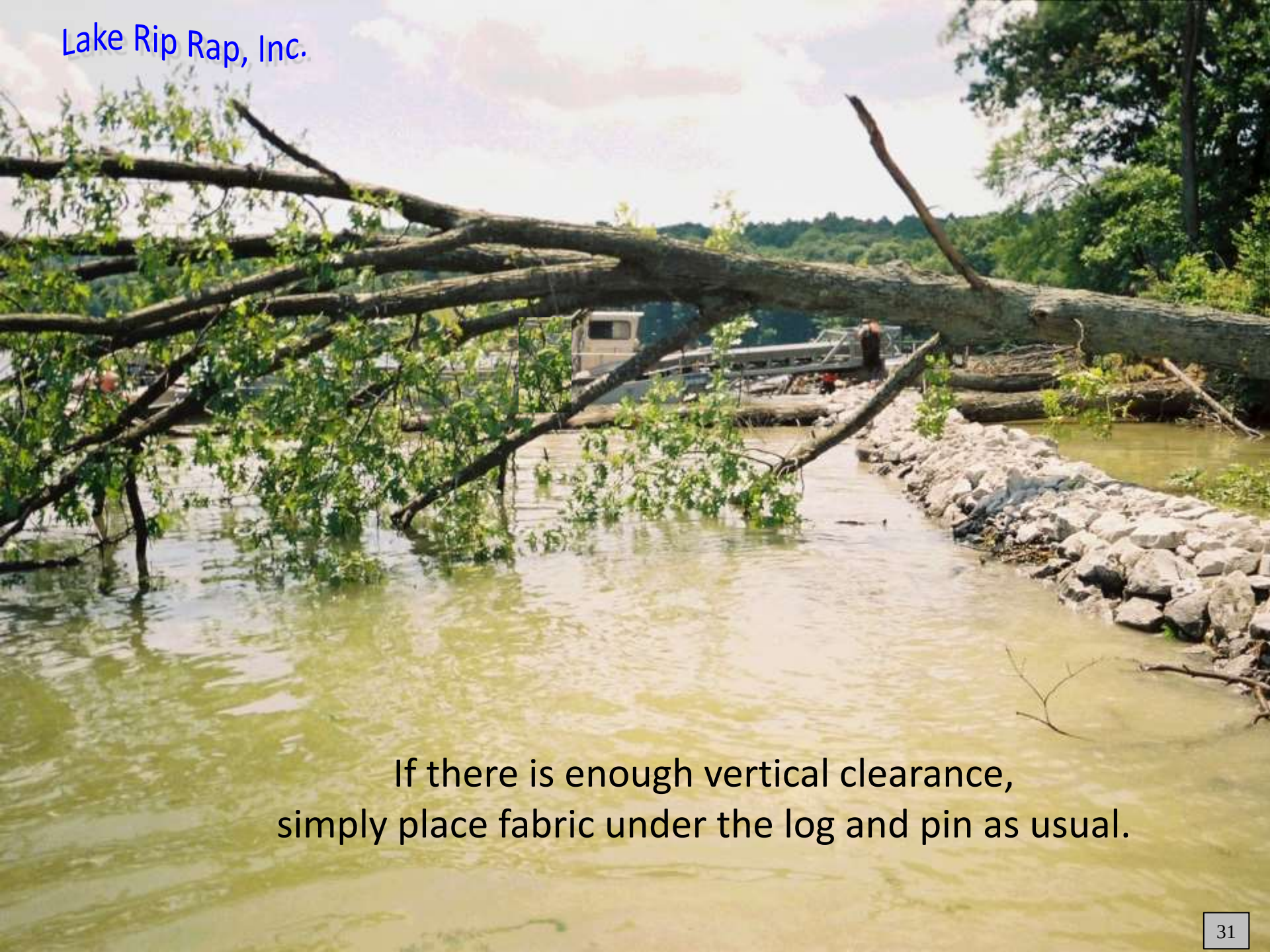
Placing fabric around down trees

Lap and pin the fabric under the log from both sides.

Lake Rip Rap, Inc.

Placing fabric around down trees

Place riprap over the log. Although the log will last a long time, we have started placing additional riprap on top of logs to replace the volume of the log as it decays.



If there is enough vertical clearance,
simply place fabric under the log and pin as usual.

Lake Rip Rap, Inc.

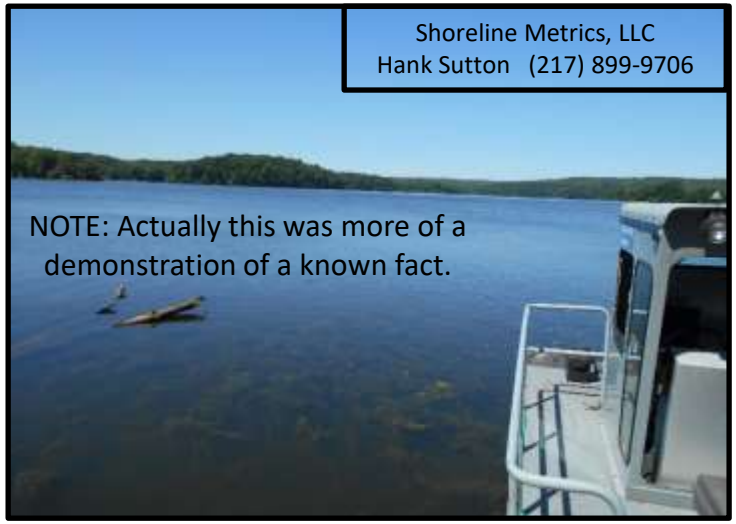
Working around down trees can be a challenge, but, biologists agree that down trees provide a desirable element to the developing shoreline habitat and the cost of removing them can be avoided.

Engineers loathe failures, and rightfully so. But, keep in mind that over-designing is a failure of cost-effectiveness. It is not a failure if it is stated at the outset that when designing shoreline stabilization projects, the goal is to marginally dissipate most of the wave energy, most of the time. Localized subsidence issues that develop over a number of years can be tolerated and can be rectified by simply adding larger riprap to re-establish the original lines and grade or by using the same size riprap but reducing the maximum surface slope of the structure to a 3h:1v.
Expecting, accepting and repairing localized subsidence issues will result in a significant overall savings.
An experiment was conducted at Kinkaid Lake, funded and conducted by Lake Rip Rap, Inc, where undersize "RR-3" was used facing the longest fetch on the lake, with a 3h:1v riprap surface slope, it remains fully effective after 20 years. (37°47'51"N 89°25'31"W see photos next slide)

On a large project, if there are no localized subsidence issues facing the longest fetches, it is possible that the entire project was over-designed.

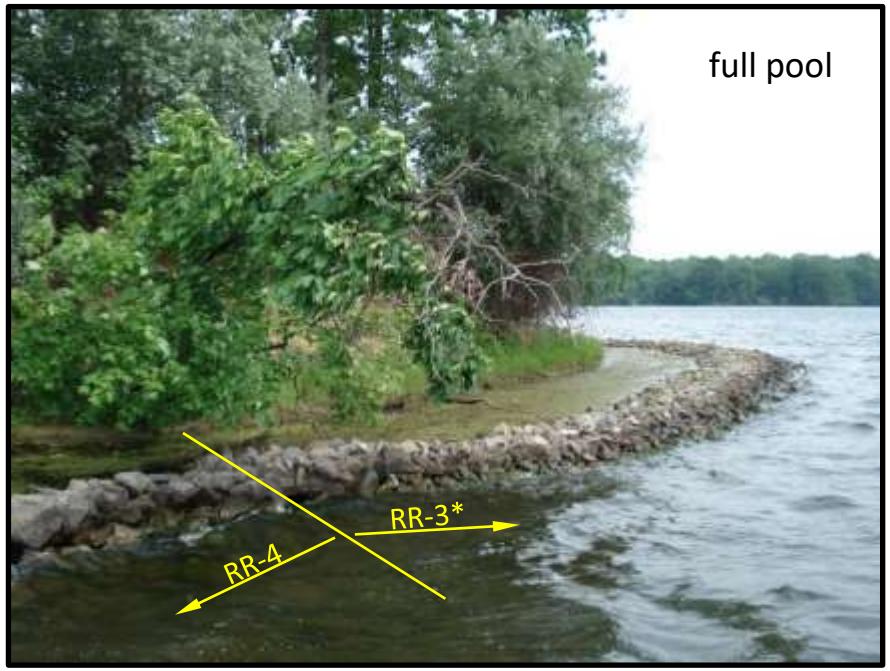
On the largest reservoirs in Illinois, (Carlyle, Rend, Shelbyville, Crab Orchard or Clinton) more than one design may be appropriate. It would be wise for the project designer to visit other reservoirs with similar fetches to see what has worked over a period of time. Utilizing various sizes of riprap on a project may create some logistical challenges if the staging area is tight. If the project is spread out over several miles, consider multiple staging areas to reduce cruising. The contractor's cruising mileage/ time is expensive and multiple staging areas have proven to be cost-effective.

* This material was not shipped from IDOT approved RR-3 stock, it is significantly smaller than RR-3, but this is what was available.



Experiment at Kinkaid Lake (37°47'51"N 89°25'31"W)
Under size riprap with a reduced surface slope (3h:1v)

Hypothesis: A reduced surface slope increases the stability of a riprap structure to withstand wave energy.



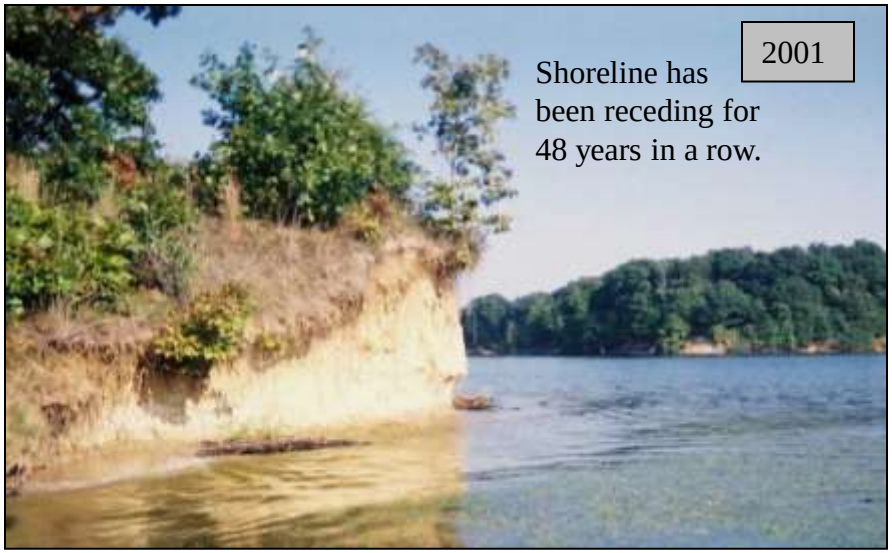
Large quantities of brush may need to be cut to accommodate construction.

Brush can be physically removed from the site. Brush could also be chipped and blown into the woods or smaller amounts can simply be placed behind the breakwater, either may be a cost-effective option to physical removal.

Lake Rip Rap, Inc.

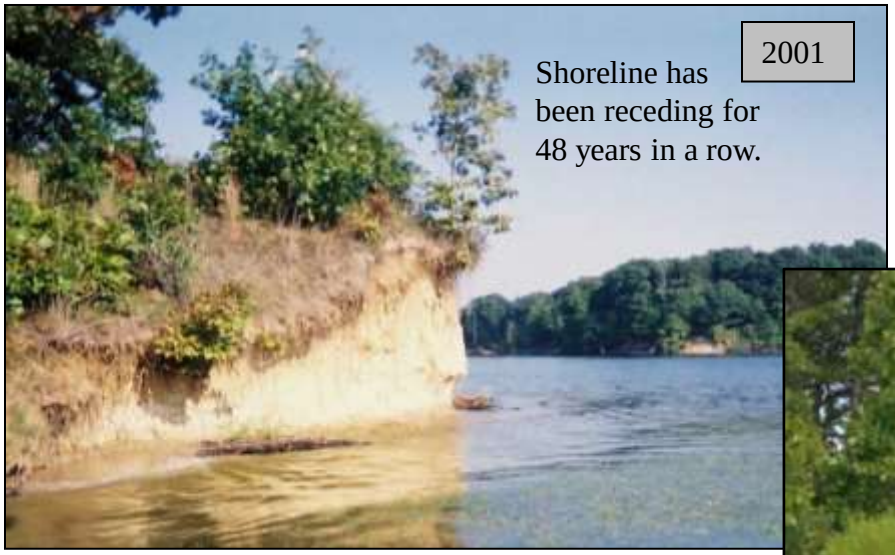
Natural Shoreline Healing at Gillespie New Lake.

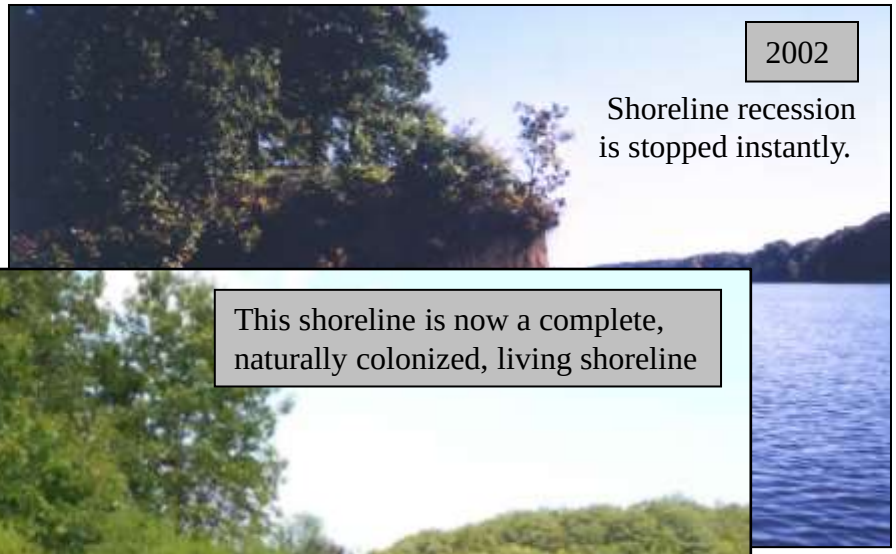
Shoreline Metrics

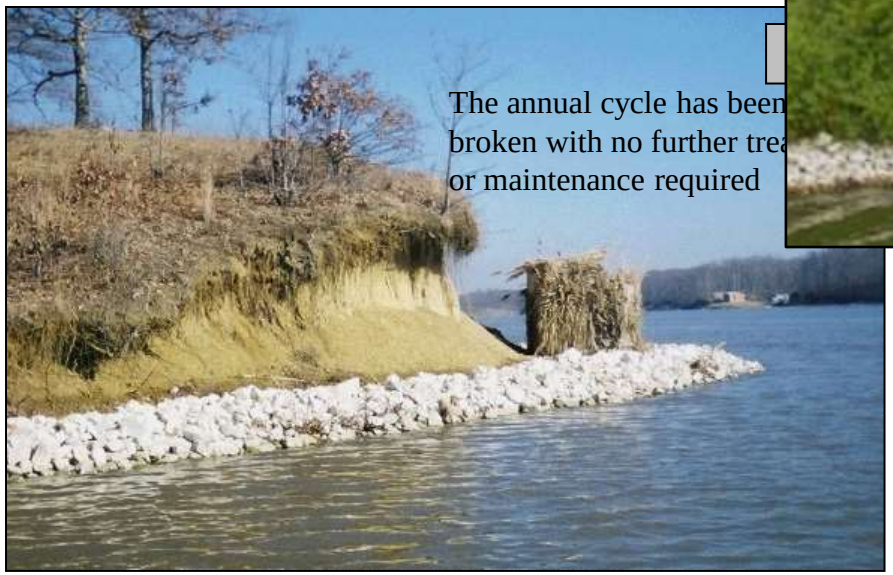


Natural Shoreline Healing at Gillespie New Lake.

Shoreline Metrics







Lake Rip Rap, Inc.

Notice sediment plume with relatively calm water, before stabilization.

Natural Plant Colonization

No excavation, no equipment on the bank and no seeding or planting required.

Lake Rip Rap, Inc.

Natural Plant Colonization

No excavation, no equipment on the bank and no seeding or planting required.

Lake Rip Rap, Inc.

Natural Plant Colonization

No excavation, no equipment on the bank
and no seeding or planting required.

Natural Shoreline Plant Colonization:

After the flora species in the seed bank have naturally colonized the stabilized littoral zone fauna species will naturally colonize the newly developed habitat.

Charleston Side Channel Reservoir, Charleston, Illinois

Some have the opinion that a shoreline protected by riprap is undesirable, unsightly and looks unnatural.

Bioengineered Shorelines will be discussed later in this presentation.

It is unrealistic to expect to see the idyllic littoral habitat of a pristine glacial lake on a midwestern reservoir.


evetment
e, Illinois


Natural Shoreline
Kinkaid Lake, Murphysboro, Illinois

Continue

<u>Properly applied, riprap on filter fabric:</u>

1. *positively* stops wave induced shoreline erosion & bank recession
2. reduces sedimentation & reduces nutrients which improves water quality
3. provides interstitial habitat & enhances the food chain
4. does not reflect wave energy
5. does not impede wildlife access
6. is not compromised by common fluctuations of the water level
7. is the most cost-effective method of shoreline restoration
8. provides stable conditions for natural healing and re-vegetation of the littoral slope

The next three slides are presented with permission of:

Jack Nawrot, Senior Scientist
Cooperative Wildlife Research Laboratory
Southern Illinois University, Carbondale

John P. Severson, now PhD

WETLAND HABITAT ENHANCEMENT AND SHORELINE STABILIZATION USING RIPRAP BREAKWATERS ON KINKAID LAKE IN SOUTHERN ILLINOIS

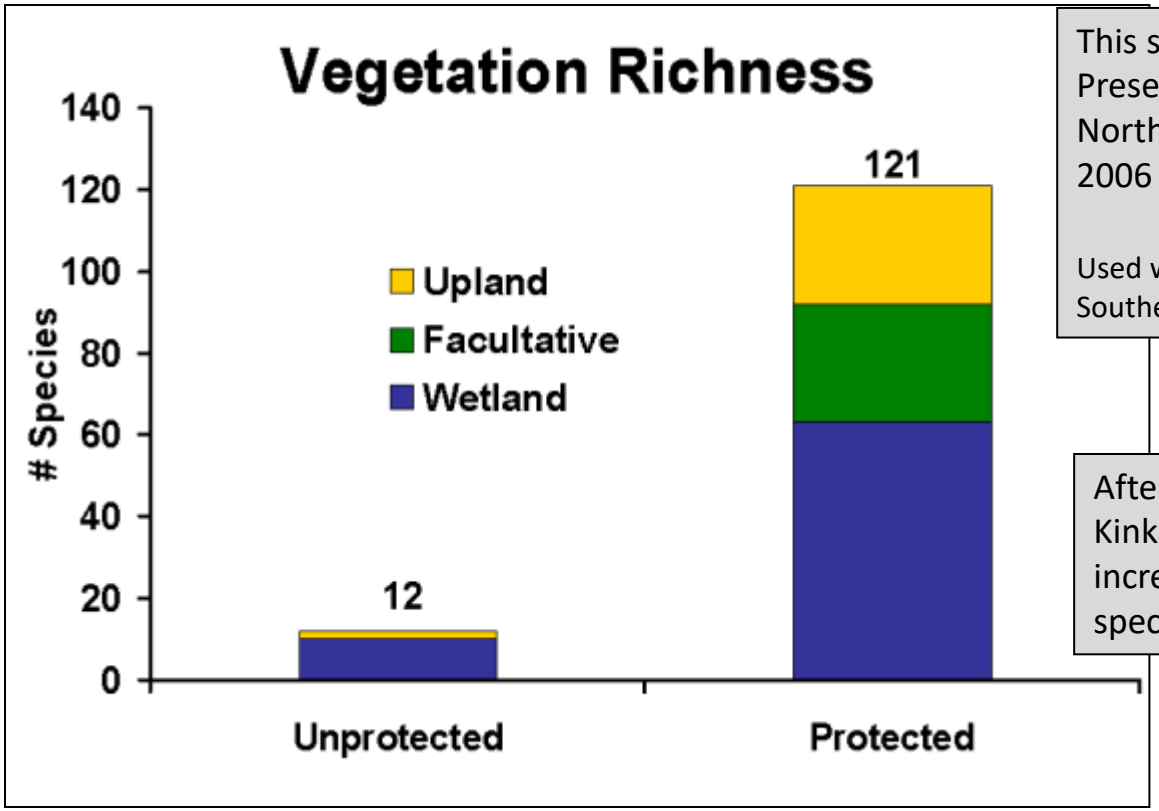
by
John P. Severson
B.S., University of Wisconsin – Stevens Point, 2004

A Thesis

Submitted in Partial Fulfillment of the Requirements for the

Master of Science Degree
Department of Zoology
in the Graduate School
Southern Illinois University Carbondale
December 2007

WETLAND HABITAT ENHANCEMENT AND SHORELINE STABILIZATION USING RIPRAP BREAKWATERS ON KINKAID LAKE IN SOUTHERN ILLINOIS J. Severson, Graduate Research Assistant, J. Nawrot, Senior Scientist, Cooperative Wildlife Laboratory, Southern Illinois University, Carbondale, Illinois (618) 536-7766 – D. Fligor, Manager, Kinkaid-Reeds Creed Conservancy District, Murphysboro, IL



This slide is from John Severson's (now PhD) Presentation delivered to the:
North America Lake Management Society's 2006 Annual Symposium, Indianapolis, Indiana

Used with permission: Jack Nawrot, Senior Scientist Southern Illinois University, Cooperative Wildlife Laboratory

After 6 years of natural shoreline healing, at Kinkaid Lake, the number of flora species increased 10 fold and the number of fauna species increased exponentially.

Natural Shoreline Healing:
Kinkaid Lake, Murphysboro, Illinois

Invertebrate Samples

- Hester-Dendy and Limestone Tile
  - Mayflies
  - Damselflies
  - Dragonflies
  - Chironomids
  - Amphipods
  - Crawfish

Fauna species identified
6 years after shoreline stabilization

Reptiles and Amphibians

- Surveyed with coverboards
- Observational data
- 12 herpetofauna spp.
  - 3 snakes
  - 3 lizards
  - 3 frogs
  - 1 toad
  - 2 turtles
  - 1 IDNR Conservation Priority Species
    Ornate Box Turtle

Mammals Observed

- Coyote, Fox, Deer, Mink (tracks)
- Raccoon (observed feeding)
- Beaver (lodge, dens, runs, and feeding)
- Muskrat
- Chipmunk
- Unidentified Rodents

Other slides from John Severson's Presentation

North America Lake Management Society's
2006 Annual Symposium, Indianapolis, Indiana

Used with permission: Jack Nawrot, Senior Scientist
Southern Illinois University, Cooperative Wildlife Laboratory

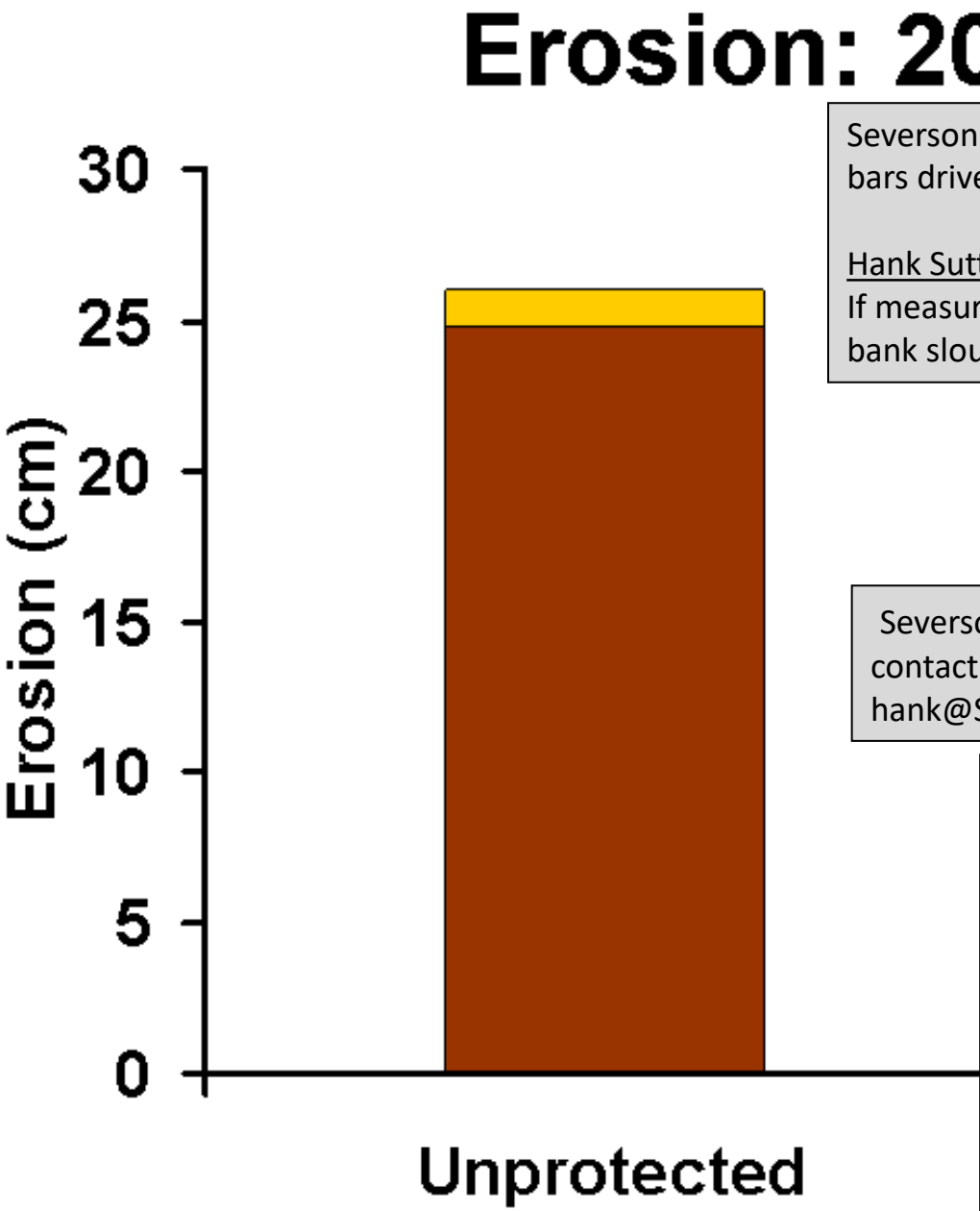
Birds Observed

- Wood Duck (broods)
- Canada Goose (broods, feeding)
- Great Blue and Green Heron (feeding)
- Mallard and Coot
- Turkey Vulture
- Goldfinch, Grackle, Swallow, Kingbird, Warbler

Fish Observed

- Largemouth Bass
- Bluegill
- Catfish
- Bullhead
- Mosquito Fish
- Topminnow
- 2 species new to Kinkaid
  - Tadpole Madtom
  - Cypress Darter
  - Fantail Darter

Does 95% of shoreline erosion occur in Early Spring



Severson acquired bank recession measurements with re-bars driven horizontally into the bank.

<u>Hank Sutton's opinion based on observations:</u>
If measurements had been taken monthly, it is likely that the bank sloughing after ice-out, would have been detected.

Severson's full thesis is available in digital form
contact Hank Sutton (217) 899-9706
hank@ShorelineMetrics.com

The destructive power of freeze-thaw stresses

Early Spring
actual erosion event

Kinkaid Lake, Murphysboro, Illinois

The destructive power of freeze-thaw stresses

Early Spring
actual erosion event

Kinkaid Lake, Murphysboro, Illinois

The destructive power of freeze-thaw stresses

Shoreline Metrics

Kinkaid Lake, Murphysboro, Illinois

You have just witnessed 95% of the annual shoreline erosion at this location.

Shoreline erosion occurs primarily in Early Spring

Bank slough - March 11, 2014 - Clinton Lake - Clinton, Illinois

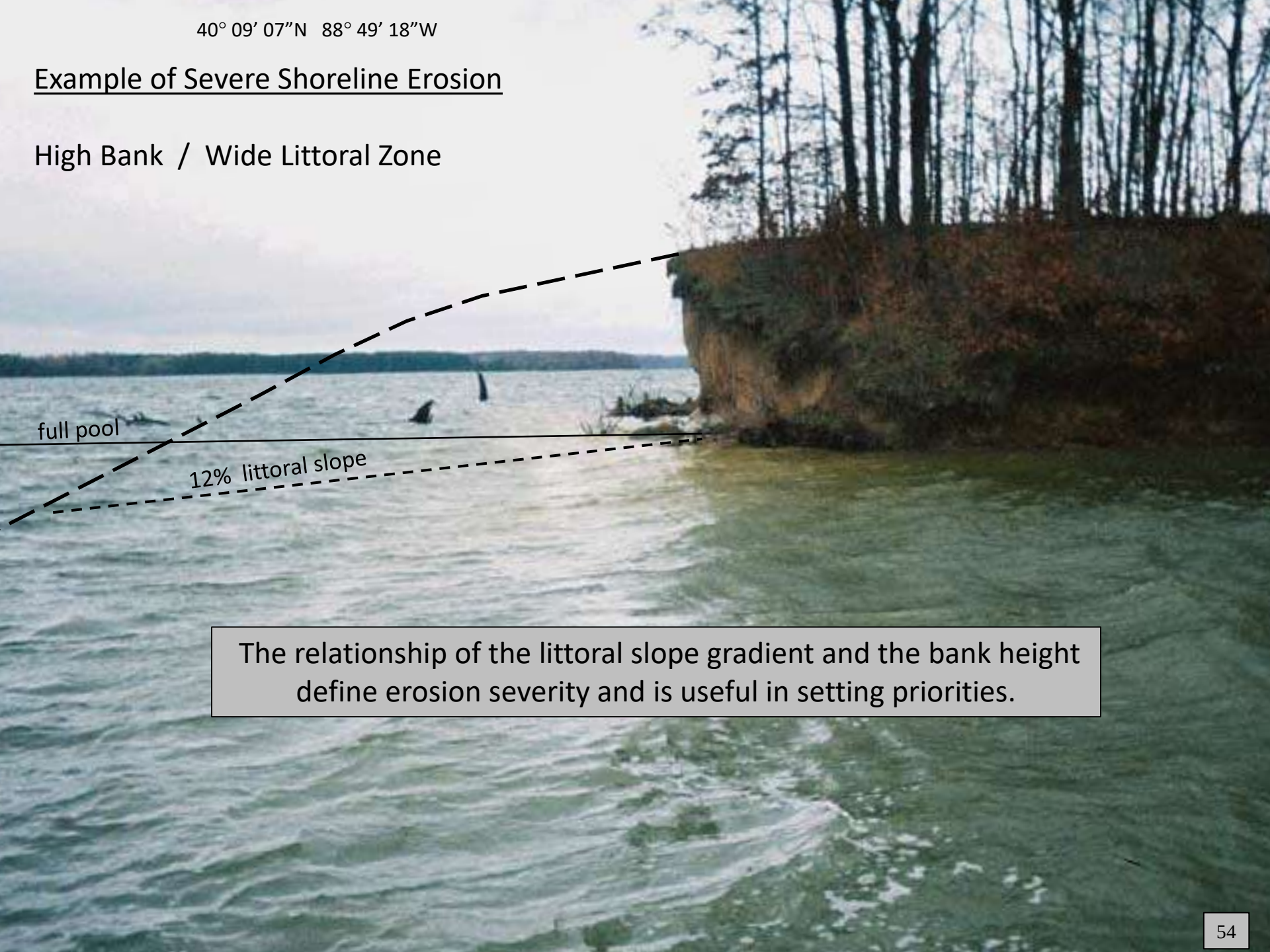
<u>Conclusion</u>

As we have observed, soil weakened by freeze thaw stresses, sloughs off the bank in early Spring and is quickly removed to deeper water by wind driven wave energy, where it remains indefinitely as unconsolidated sediment.

40° 09’ 07”N 88° 49’ 18”W

Example of Severe Shoreline Erosion

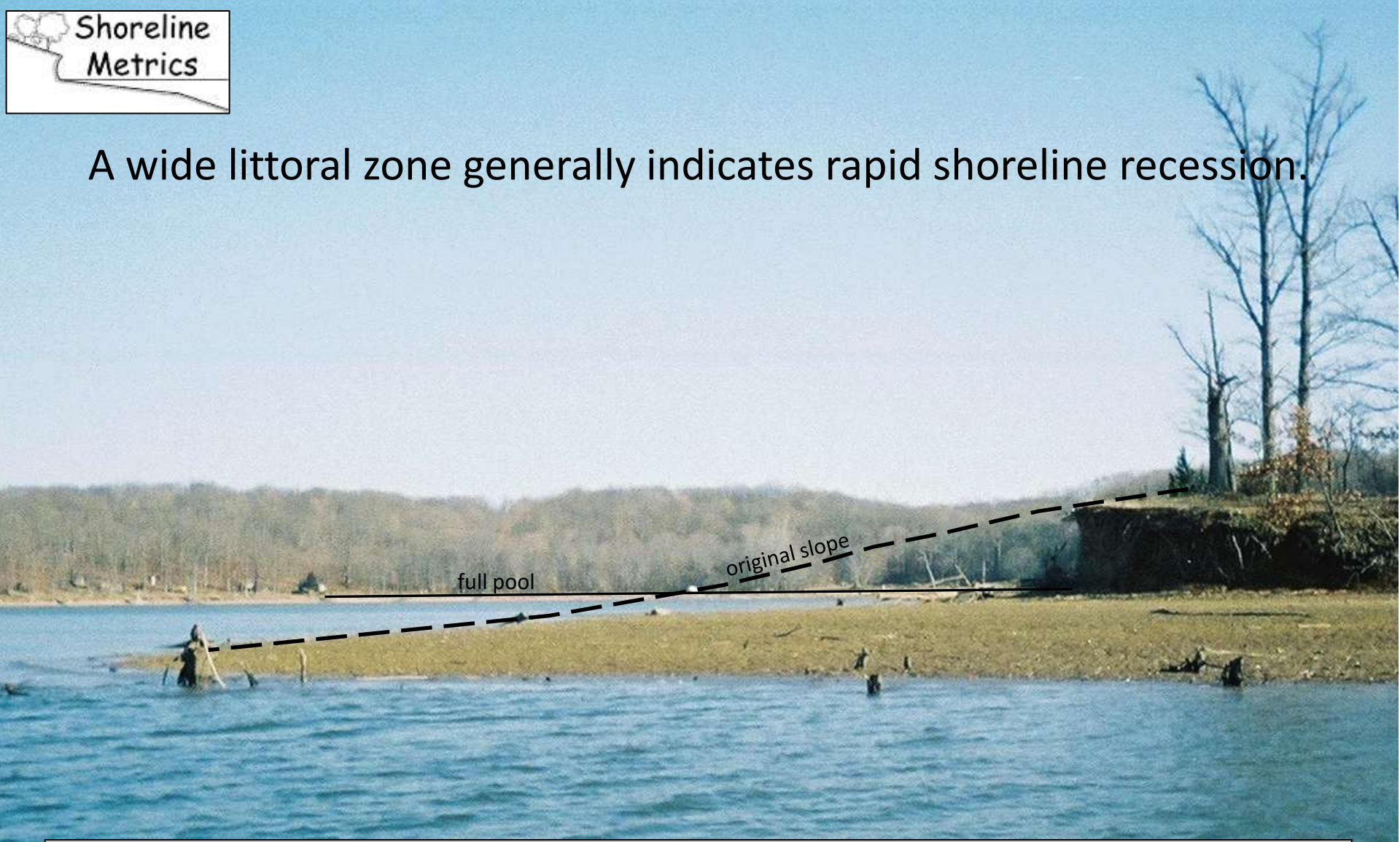
High Bank / Wide Littoral Zone



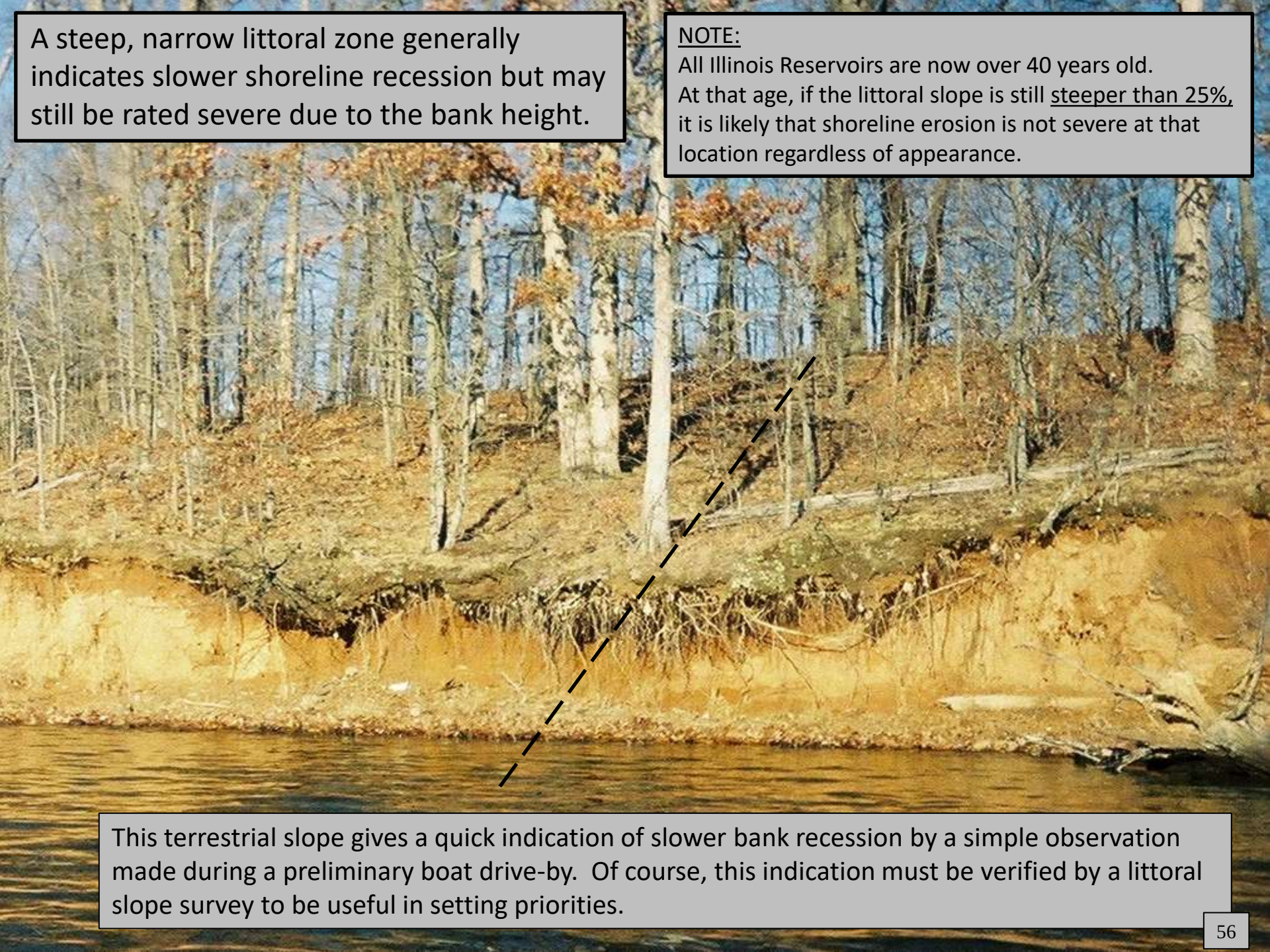
The relationship of the littoral slope gradient and the bank height define erosion severity and is useful in setting priorities.

Shoreline Metrics

A wide littoral zone generally indicates rapid shoreline recession.



If the terrestrial slope is visually extended, the location of point “a” can be approximated, giving a quick indication of the rate of bank recession. Compare this original terrestrial slope to the obvious terrestrial slope in the next slide.



A steep, narrow littoral zone generally indicates slower shoreline recession but may still be rated severe due to the bank height.

NOTE:
All Illinois Reservoirs are now over 40 years old.
At that age, if the littoral slope is still steeper than 25%, it is likely that shoreline erosion is not severe at that location regardless of appearance.

This terrestrial slope gives a quick indication of slower bank recession by a simple observation made during a preliminary boat drive-by. Of course, this indication must be verified by a littoral slope survey to be useful in setting priorities.

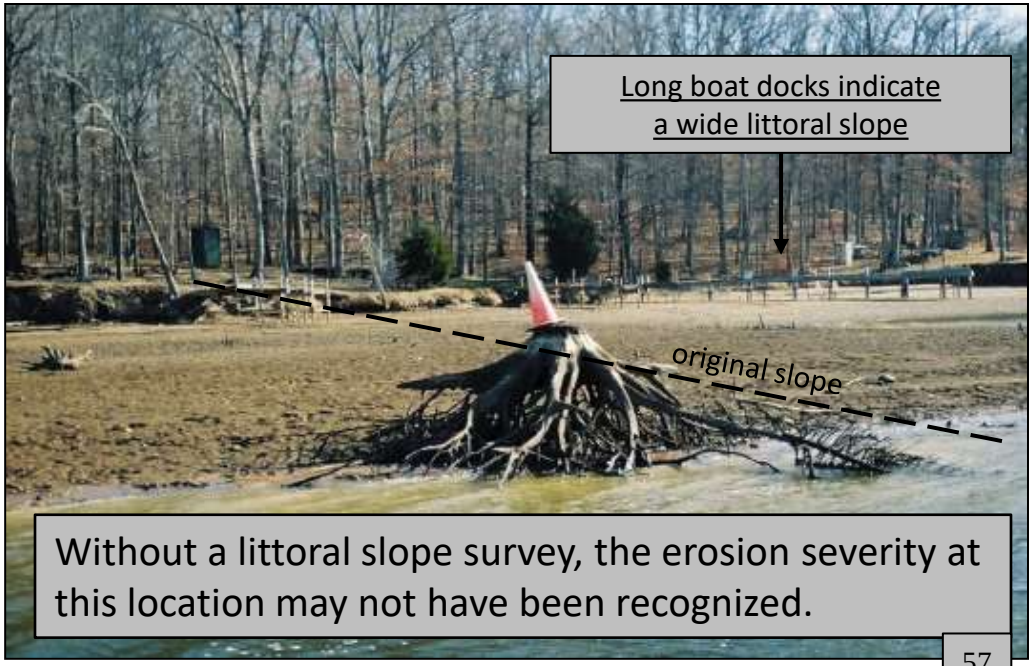
Shoreline Metrics

Lake Lou Yaeger
39°12’27”N 89°36’18”W

Macoupin 415 was rigged for shallow bow draft to gain access to the bank on this 1 ½% littoral slope.

Height of Bank: 6 feet
bank recession: > 200 feet
Littoral slope: 1 ½ %

Total soil lost to erosion: > **600 cubic feet**
(per lineal foot of shoreline)

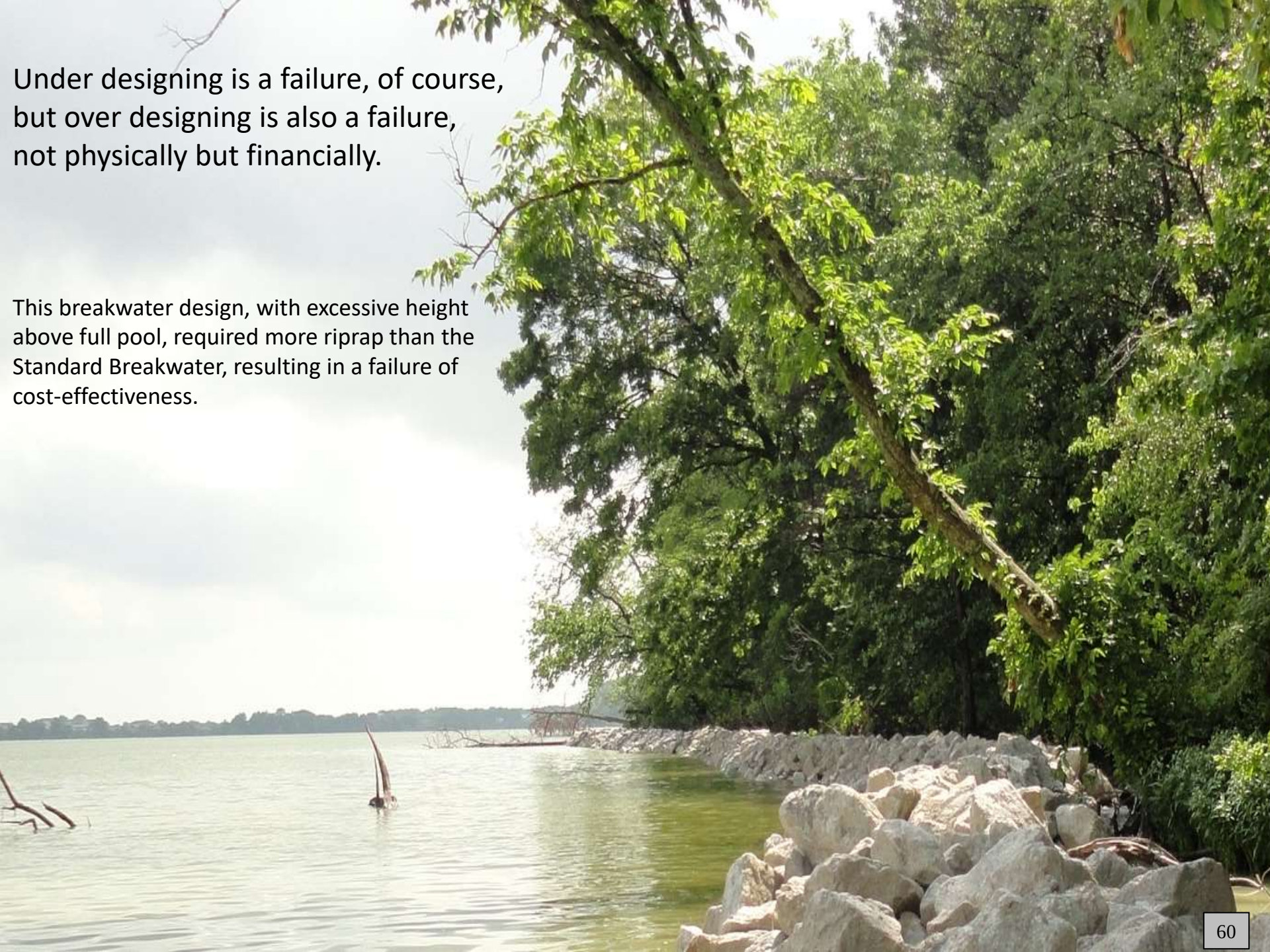


Under designed revetment

The root collar of this stump delineates the original slope.

Note: This failing riprap revetment was under designed and filter fabric was not utilized.


Newly built, under designed
revetment, sure to fail with
no long-term value at all.

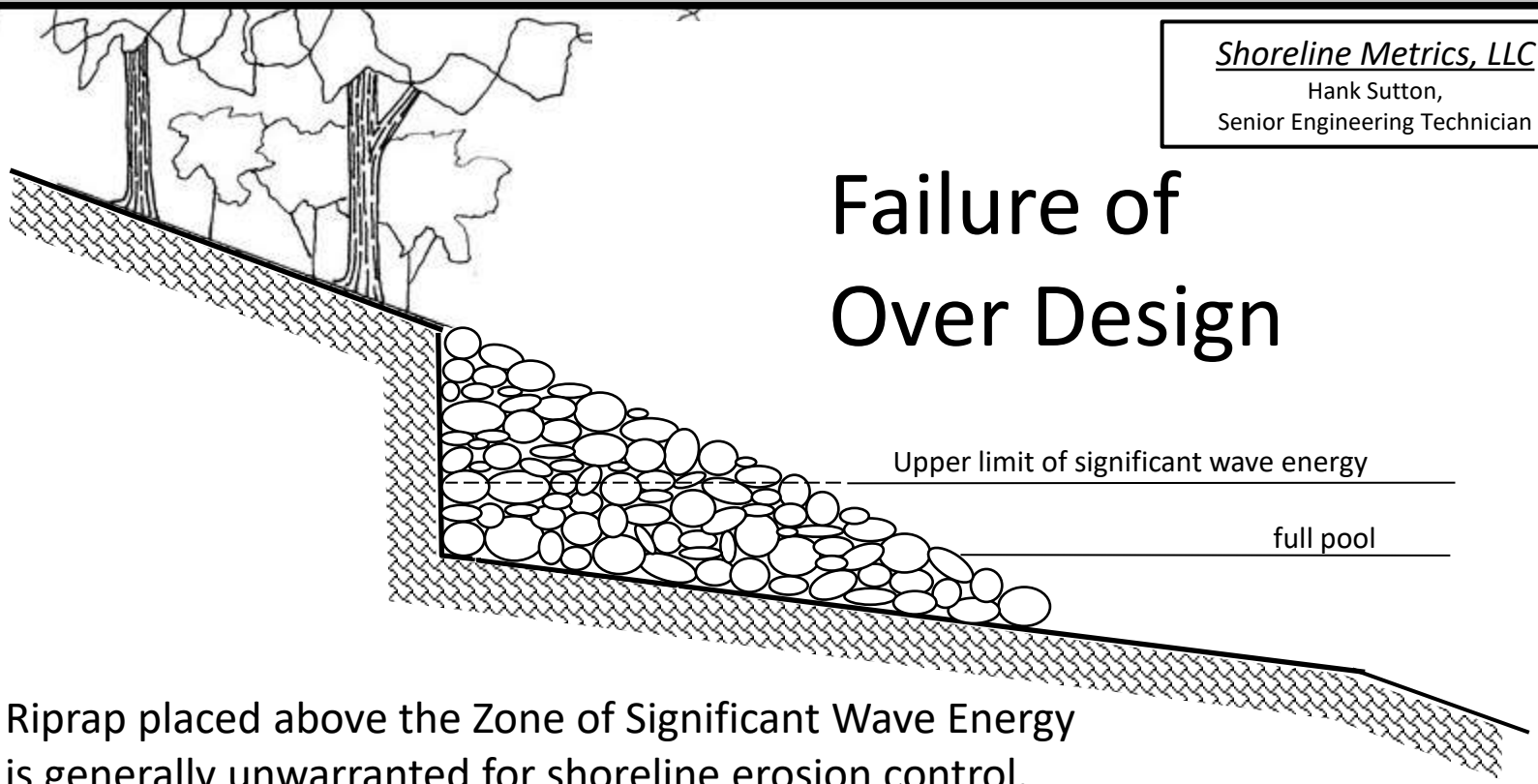


Under designing is a failure, of course, but over designing is also a failure, not physically but financially.

This breakwater design, with excessive height above full pool, required more riprap than the Standard Breakwater, resulting in a failure of cost-effectiveness.

Shoreline Metrics, LLC
Hank Sutton,
Senior Engineering Technician

Failure of Over Design



Riprap placed above the Zone of Significant Wave Energy is generally unwarranted for shoreline erosion control.

More about cost-effectiveness and overtopping of the Standard Breakwater.

39° 25’ 13”N 87° 48’ 1827”W

Mill Creek Park Lake, Marshall, Illinois

A turbid high water event occurred in 2008 and remained up to 6 feet above full pool for several weeks. The naturally colonized vegetation in the littoral zone was destroyed for lack of sunlight, but the breakwater remained intact and continued to isolate the bank from wave energy. By 2010 the littoral zone was starting to be naturally colonized again by aquatic vegetation with no repairs required.

More about cost-effectiveness and overtopping of the Standard Breakwater.

39° 25’ 13”N 87° 48’ 1827”W

Does the East bank and West bank of a reservoir have essentially the same rate of shoreline recession regardless of prevailing wind direction?

The East bank, of Illinois reservoirs, receives more wave energy than the West bank. However….

Prevailing Wind

North

Lake Shelbyville

West Bank

East Bank

Does the East bank and West bank of a reservoir have essentially the same rate of shoreline recession regardless of prevailing wind direction?

The East bank, of our local reservoirs, receives more wave energy than the West bank. However….

Prevailing Wind →

North ↑

Coffeen Lake
at low water

West Bank

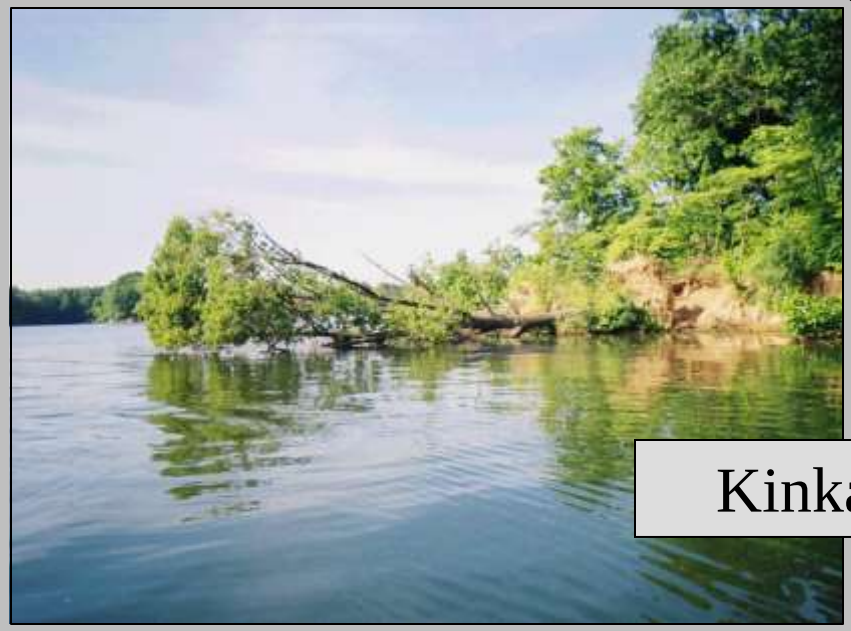
East Bank

Does the East bank and West bank of a reservoir have essentially the same rate of shoreline recession regardless of prevailing wind direction?

The East bank, of our local reservoirs, receives more wave energy than the West bank. However….

Prevailing Wind →

North ↑



Kinkaid Lake

West Bank

East Bank

So… why does the West bank erode as fast as the East bank ?

<u>Conclusion</u>

The soil is so severely weakened by frost that both banks recede at a similar rate, regardless of the difference in wave energy.

Note: The fetch in small coves is extremely short and very little wave energy is generated within the cove, therefore, shoreline erosion in small coves may be insignificant, even after the Spring thaw. Wave energy that enters the small cove from open water runs mostly parallel to the shoreline without making direct impact upon the shoreline (small angle of incidence).
Actually, it is common for small coves to be experiencing accretion by sediment laden inflow from a small intermittent stream.

(The method of fetch determination using the length of open water and the angle of incidence is not discussed in this presentation, for more information contact the US Army Corps of Engineers, Research and Development Center, Vicksburg, Mississippi)

Are recreational boating & horsepower limits relevant issues of shoreline erosion?

Are recreational boating & horsepower limits relevant issues of shoreline erosion?

Cedar Lake
10 Horsepower Limit

Kinkaid Lake
No limit of Horsepower

Are recreational boating & horsepower limits relevant issues of shoreline erosion?

Cedar Lake
10 Horsepower Limit

Cedar Lake and Kinkaid Lake are located 10 miles apart & have similar soils, are similar in size, and have similar weather patterns, with….

similar shoreline erosion,
regardless of horsepower limits.

Kinkaid Lake
No limit of Horsepower

NOTE: Both of these lakes have implemented multi-year shoreline stabilization projects, totaling over 75,000 lineal feet of shoreline.

With the placement of 90,000 tons of riprap.

Total cruising distance: nearly 10,000 miles.

Lake Rip Rap, Inc.

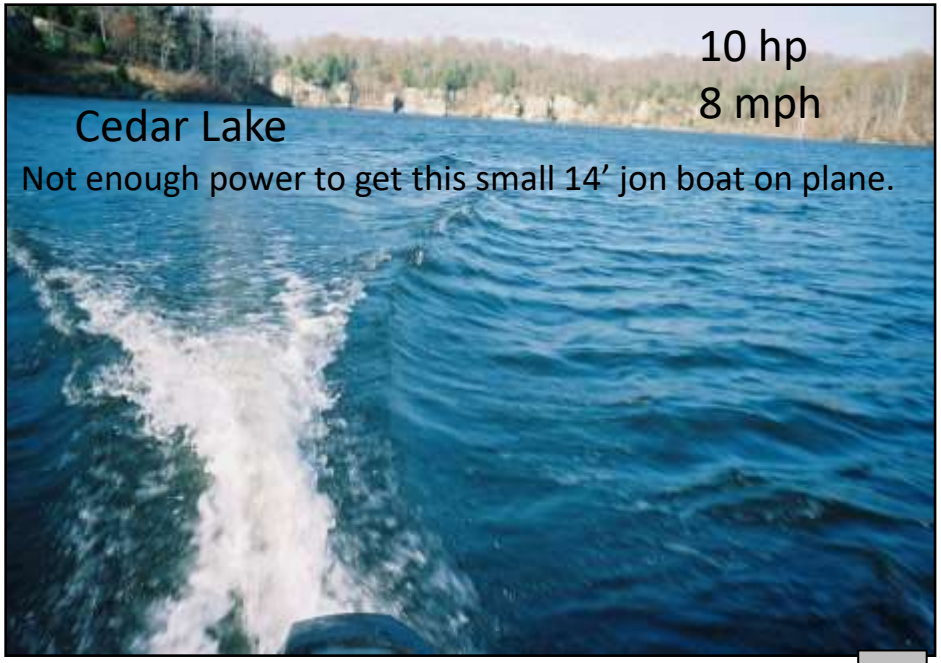
Are recreational boating & horsepower limits relevant issues of shoreline erosion?

Boats do indeed produce wave energy and may contribute, to some extent, to shoreline erosion if the shoreline is not stabilized.

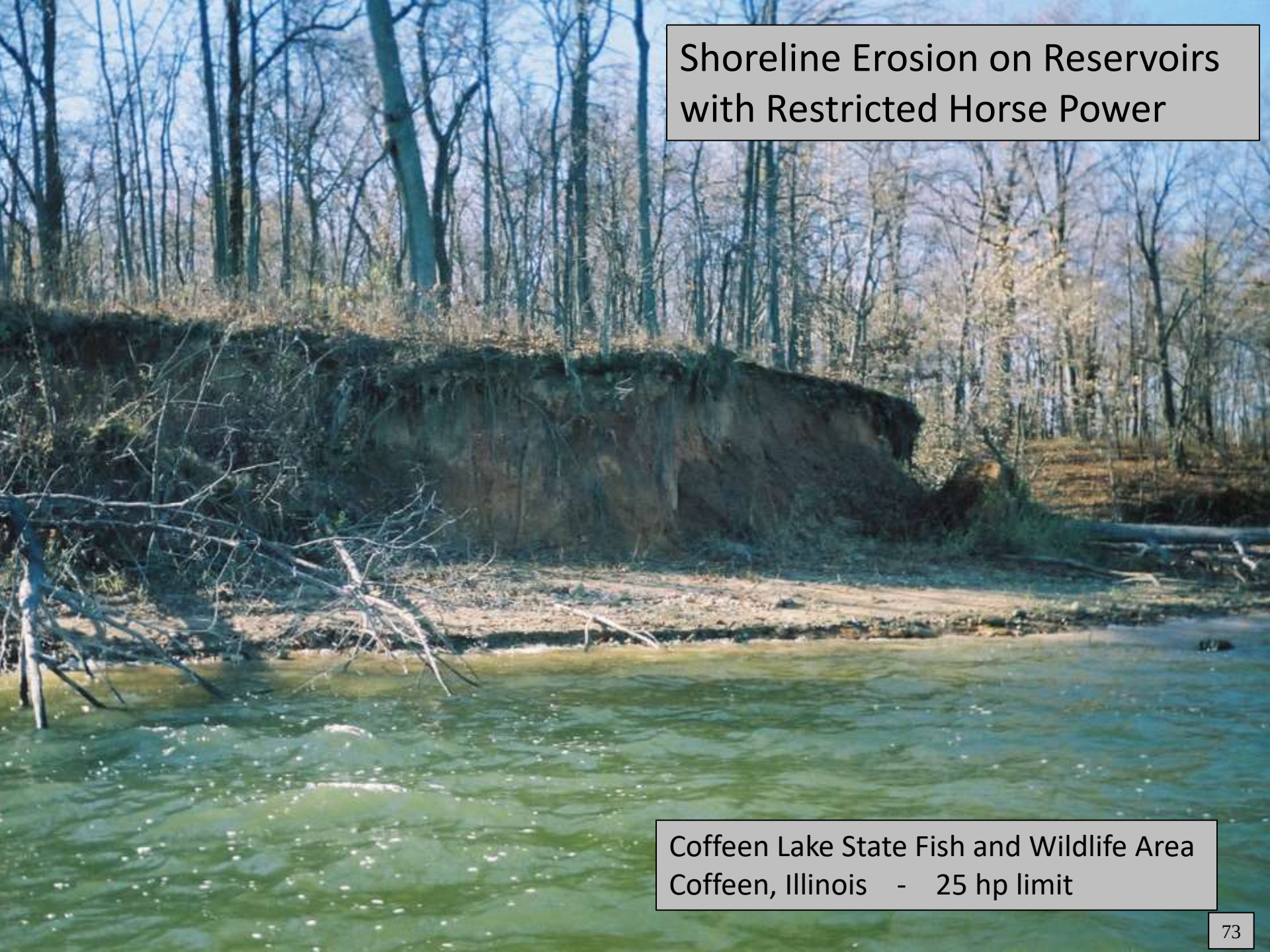
However, restricting horsepower may not greatly reduce the rate of shoreline erosion, if at all.

If boating is completely eliminated, shorelines consisting of cohesive soil will continue to erode due to frost action and wind generated waves. Every Illinois reservoir experiences hundreds of thousands of wind driven waves every year.

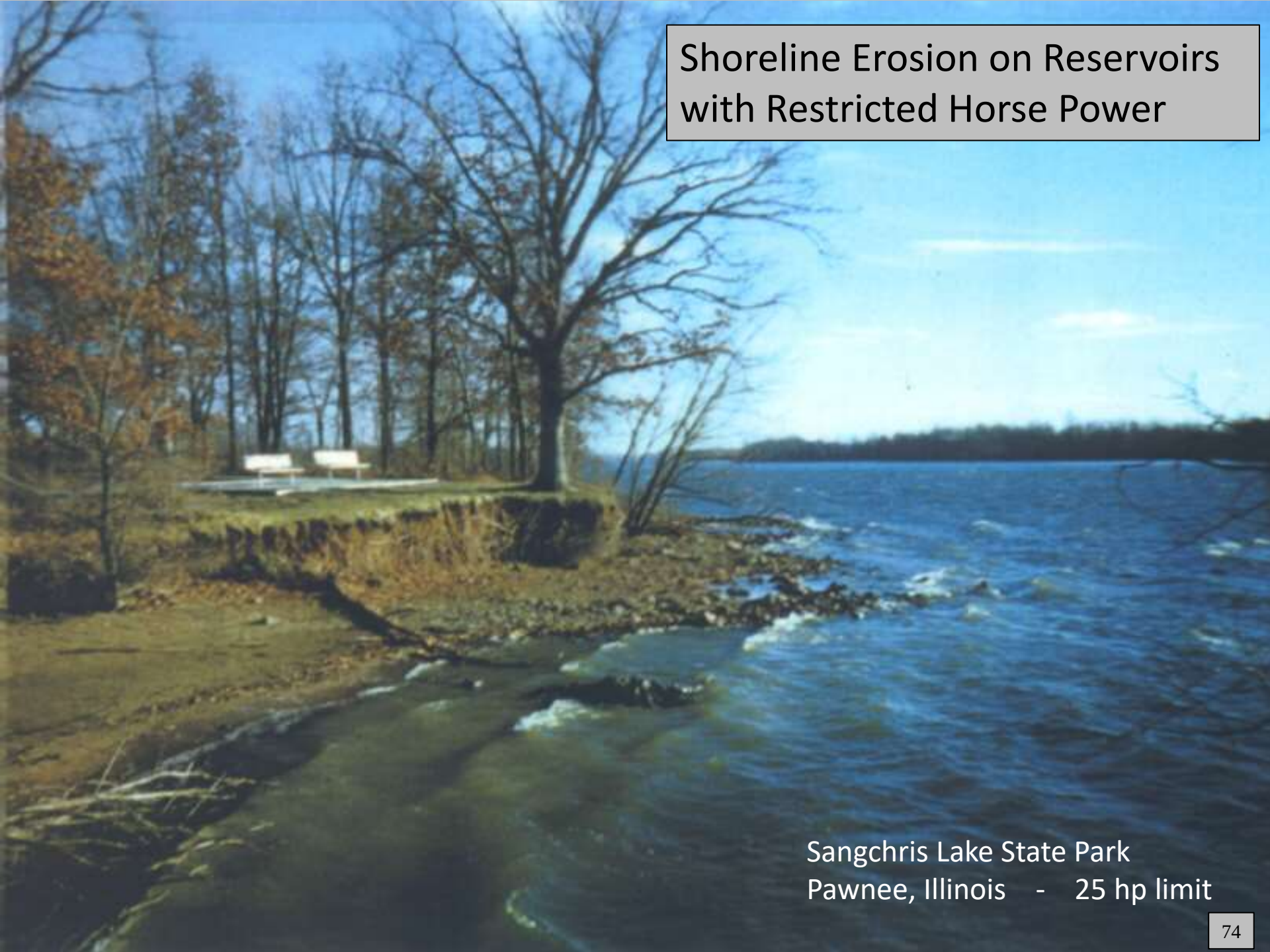
Another point to consider: Most of the erosion occurs immediately after ice out, before the boating season is fully underway.



The Following Slides Illustrate Severe Shoreline Erosion on Reservoirs with Restricted Horse Power


Shoreline Erosion on Reservoirs with Restricted Horse Power
Coffeen Lake State Fish and Wildlife Area
Coffeen, Illinois - 25 hp limit

Shoreline Erosion on Reservoirs with Restricted Horse Power

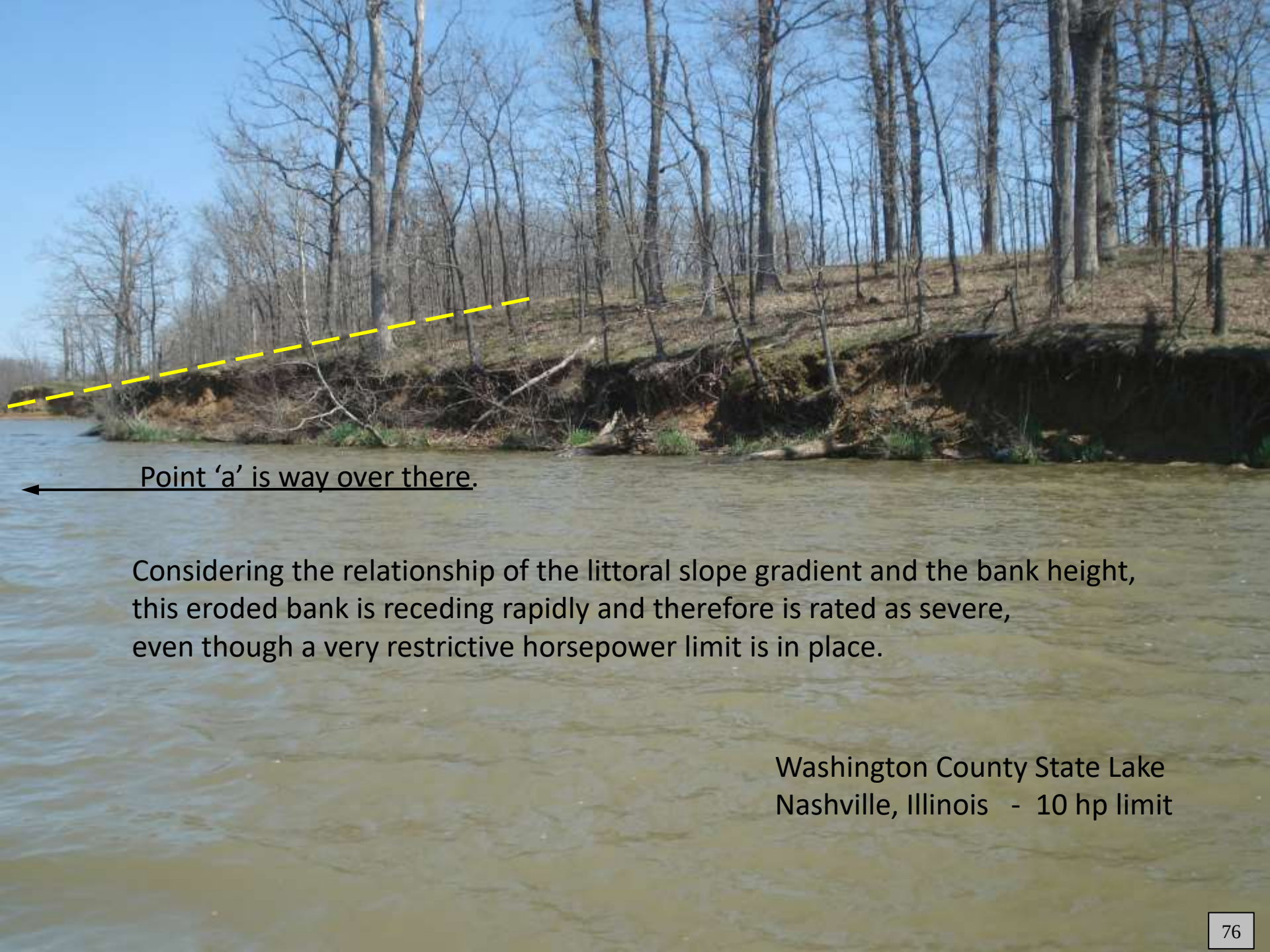


Sangchris Lake State Park
Pawnee, Illinois - 25 hp limit

Shoreline Erosion on Reservoirs with Restricted Horse Power

Evergreen Lake
Kappa, IL 10 hp limit

Photo Credit: Wayne Kinney
Midwest Streams, Inc.



Considering the relationship of the littoral slope gradient and the bank height, this eroded bank is receding rapidly and therefore is rated as severe, even though a very restrictive horsepower limit is in place.

Washington County State Lake
Nashville, Illinois - 10 hp limit


Shoreline Erosion on Reservoirs
with Restricted Horse Power
Cedar Lake, Carbondale, Illinois
10 hp limit

Shoreline Erosion on Reservoirs with Restricted Horse Power

Cedar Lake, Carbondale, Illinois
10 hp limit

Are recreational boating & horsepower limits relevant issues of shoreline erosion?

<u>There may be other reasons to limit horsepower:</u>

- Safety on smaller lakes (it is easier to enforce horsepower limits than speed limits)
- Calmer water for kayaks, canoes and fishermen
- High power boats can <u>resuspend nutrient rich sediments</u> in shallow water (it would be prudent for areas of shallow water to be posted “No Wake” and they generally are in Illinois)

No Wake Zones parallel to the shore may be helpful in protecting docks and docked boats.

Are recreational boating & horsepower limits relevant issues of shoreline erosion?

This small 173 acre residential lake has the entire shoreline stabilized with well maintained riprap revetments and has no significant shoreline erosion after 65 years.

Sunset Lake has a 50 hp limit to control speed for safety with "No Wake" before noon to accommodate fishermen and kayaks.

A perfect balance for recreation: fishing and kayaks in the morning and tubing in the afternoon.

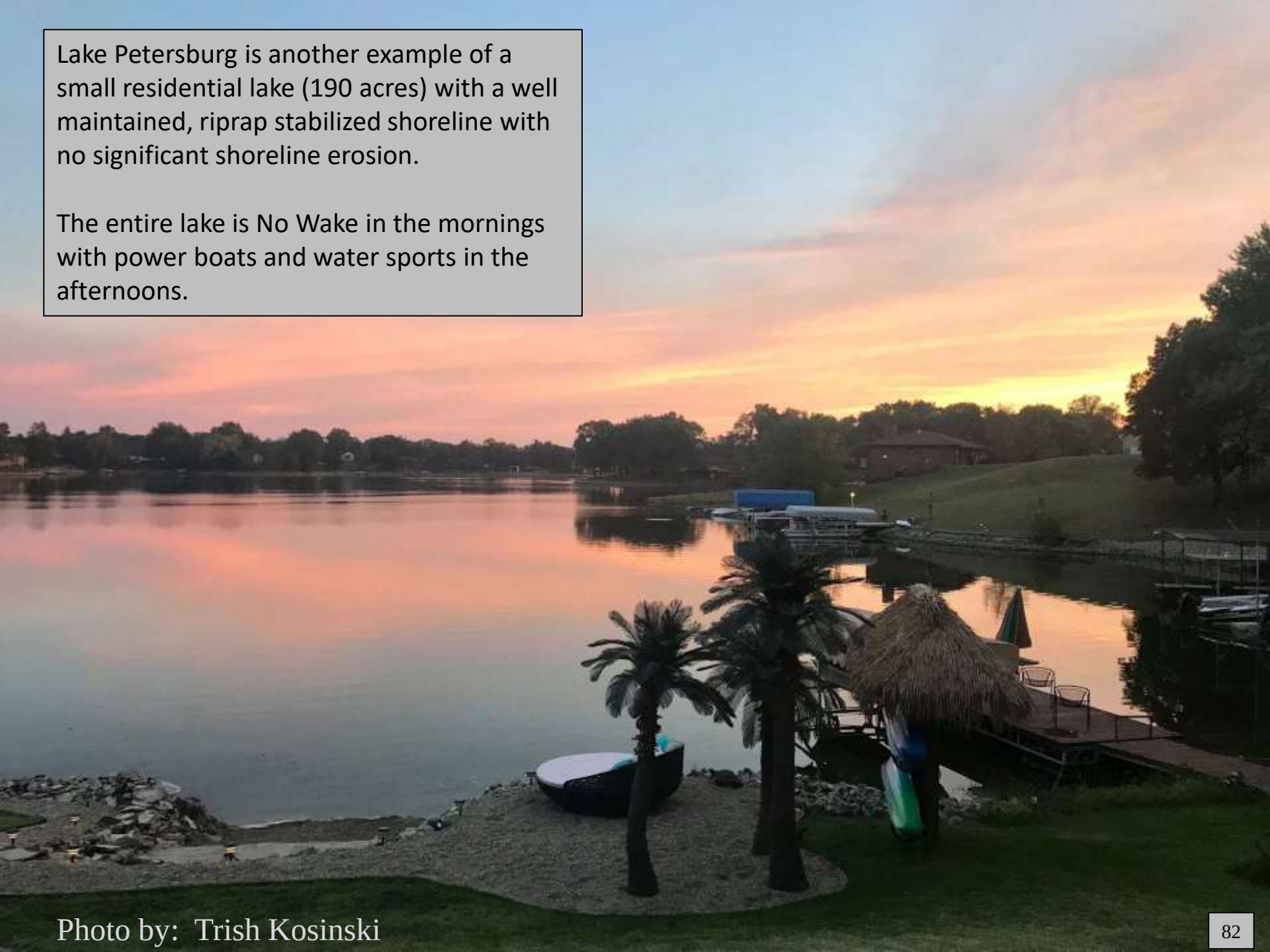
Are recreational boating & horsepower limits relevant issues of shoreline erosion?

Shoreline Maintenance at Sunset Lake

(as discussed, very little maintenance is required for Standard riprap designs, this location required additional riprap placement because of a deficient original design)

Captain in Charge (Boat Driver):

Steve Kolsto - 2004 ILMA Lake Guardian
(Our Departed Friend of ILMA)

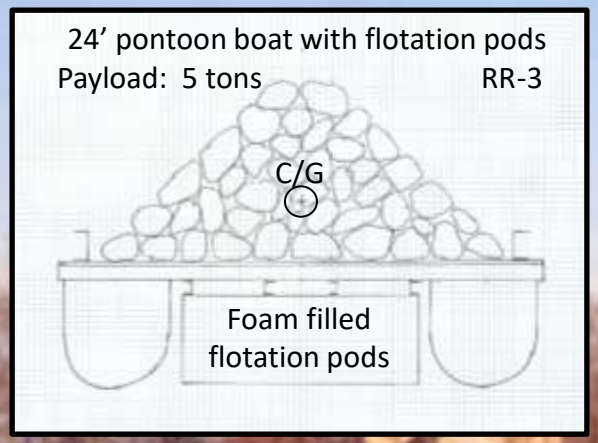


Lake Petersburg is another example of a small residential lake (190 acres) with a well maintained, riprap stabilized shoreline with no significant shoreline erosion.

The entire lake is No Wake in the mornings with power boats and water sports in the afternoons.

Photo by: Trish Kosinski

Are recreational boating & horsepower limits relevant issues of shoreline erosion?



Lake Catatoga (60 acres) - Carlinville, Illinois

Low tech DIY shoreline stabilization on a small lake

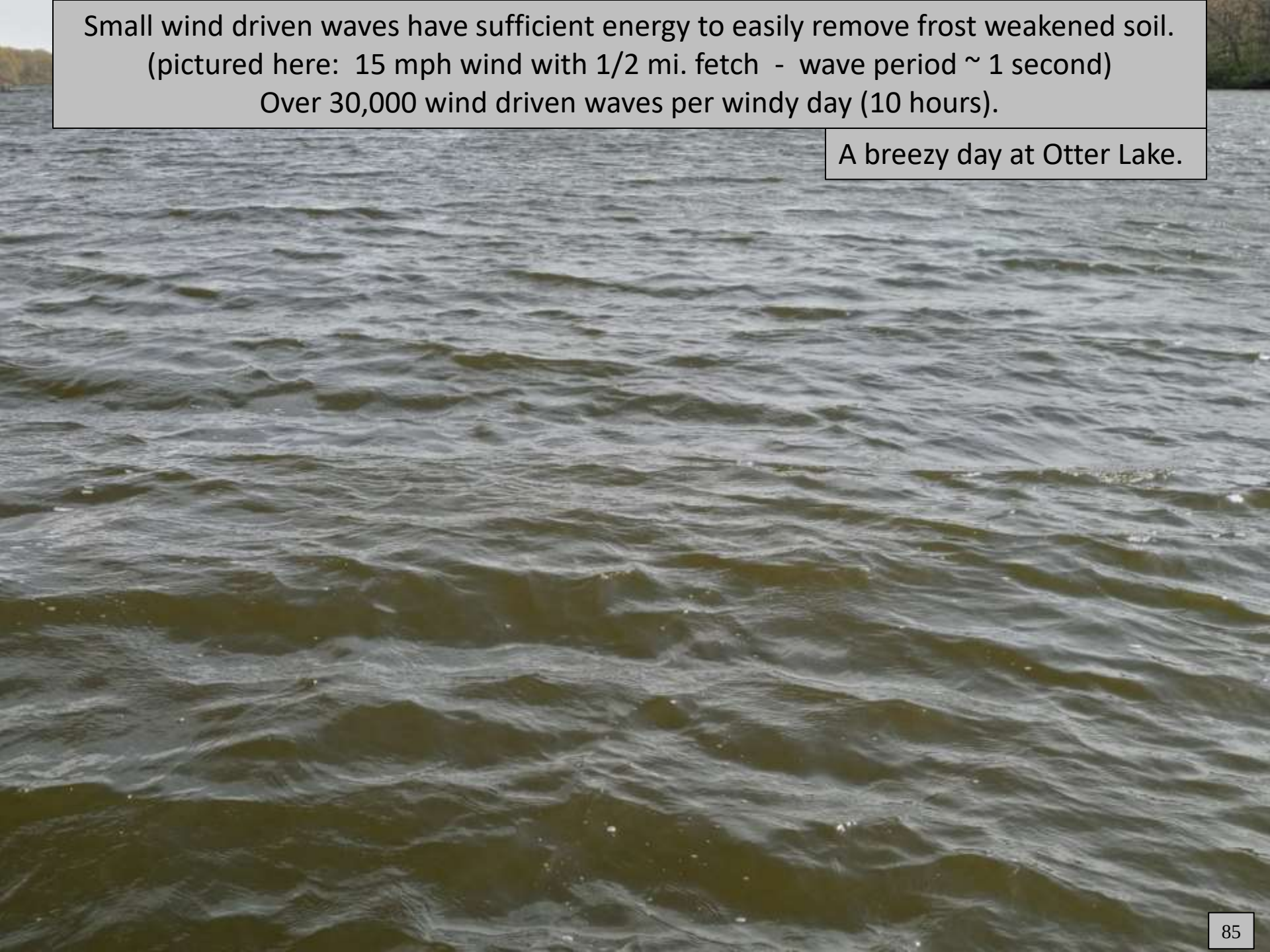
Payload of this boat: 5 tons
24' with U shaped pontoons

This boat is obviously fully loaded. But the vertical C/G is low and it is completely stable on this small lake.

Are recreational boating & horsepower limits relevant issues of shoreline erosion?

Carlyle Lake in early April. The frost weakened soil has been transported to deeper water. Boat generated waves and wind driven waves together are not likely to overcome the cohesive strength of this newly exposed tight clay soil…. but frost will, again next Winter.

Small wind driven waves have sufficient energy to easily remove frost weakened soil.
(pictured here: 15 mph wind with 1/2 mi. fetch - wave period ~ 1 second)
Over 30,000 wind driven waves per windy day (10 hours).



A breezy day at Otter Lake.

Illinois reservoirs experience hundreds of thousands of wind driven waves every year.

Otter Lake has stabilized over 35,000 lineal feet of shoreline in an on-going multi-year program using their own Macoupin Riprap Boat with inhouse labor.

Are recreational boating & horsepower limits relevant issues of shoreline erosion?

Conclusion

Shorelines weakened by freeze/ thaw will erode and recede with or without recreational boating* or horsepower limits.

If reservoir shorelines are stabilized to withstand wind driven waves, recreational boating will not contribute to shoreline erosion.

*few reservoirs in Illinois have boats larger than 20' "bass boats" and ski boats (however wake boats can be a problematic issue)

Cheating in the No Wake Zone

It seems to be human nature for boaters to cheat in the No Wake Zone.

As speed increases beyond no wake speed, the bow, of a pleasure boat with a planing hull, comes up and the longitudinal Center of Buoyancy moves to aft, making the stern draft deeper.

With this deeper stern draft, the boat makes a larger wake until it transitions from displacement (no wake) to planing.

Conclusion: To be effective in reducing wave energy, the no wake zone must be diligently enforced.

ALWAYS

Specify IDOT Approved, "A" Quality Riprap, Shipped from Approved Stock

Low quality riprap is broken down by the stresses of freezing & thawing.

IDOT Spec. for riprap quality, Sodium Sulfate Soundness Loss after 5 cycles:
15% loss maximum

This 400 pound riprap (RR-5) was reduced to rubble in less than 15 years
Sodium Sulfate Soundness Loss by Laboratory Test: >20%

ALWAYS

Specify IDOT Approved, "A" Quality Riprap, Shipped from Approved Stock

Low quality riprap is broken down by the stresses of freezing & thawing.

Don't forget the filter fabric - very cheap and very effective

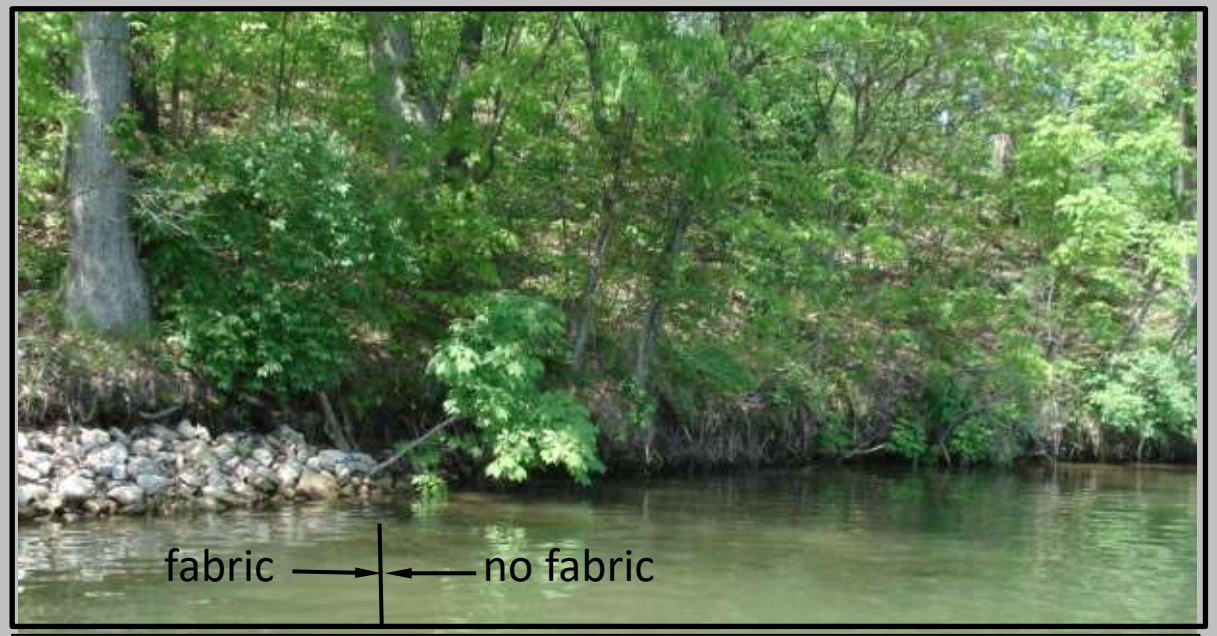
IDOT Spec. for riprap quality, Sodium Sulfate Soundness Loss after 5 cycles:
15% loss maximum

This 400 pound riprap (RR-5) was reduced to rubble in less than 15 years

Sodium Sulfate Soundness Loss by Laboratory Test: >20%

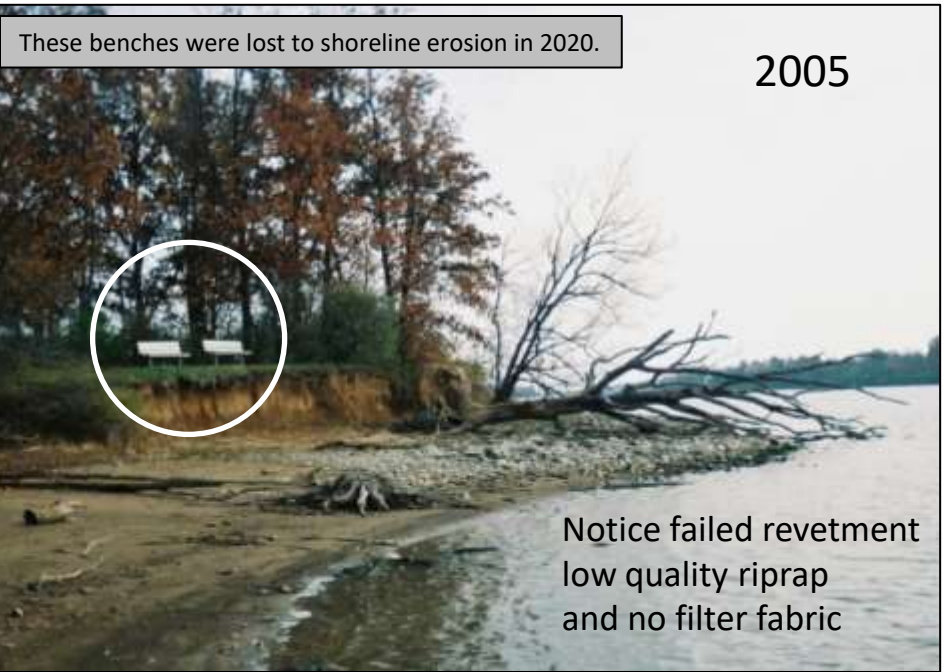
Shoreline Metrics

Filter Fabric reduces riprap subsidence, well worth the cost.



In the 1990's -
Local teenagers were hired to hand place riprap without adequate supervision.

At this location, the roll of fabric was buried under the riprap instead of being installed.



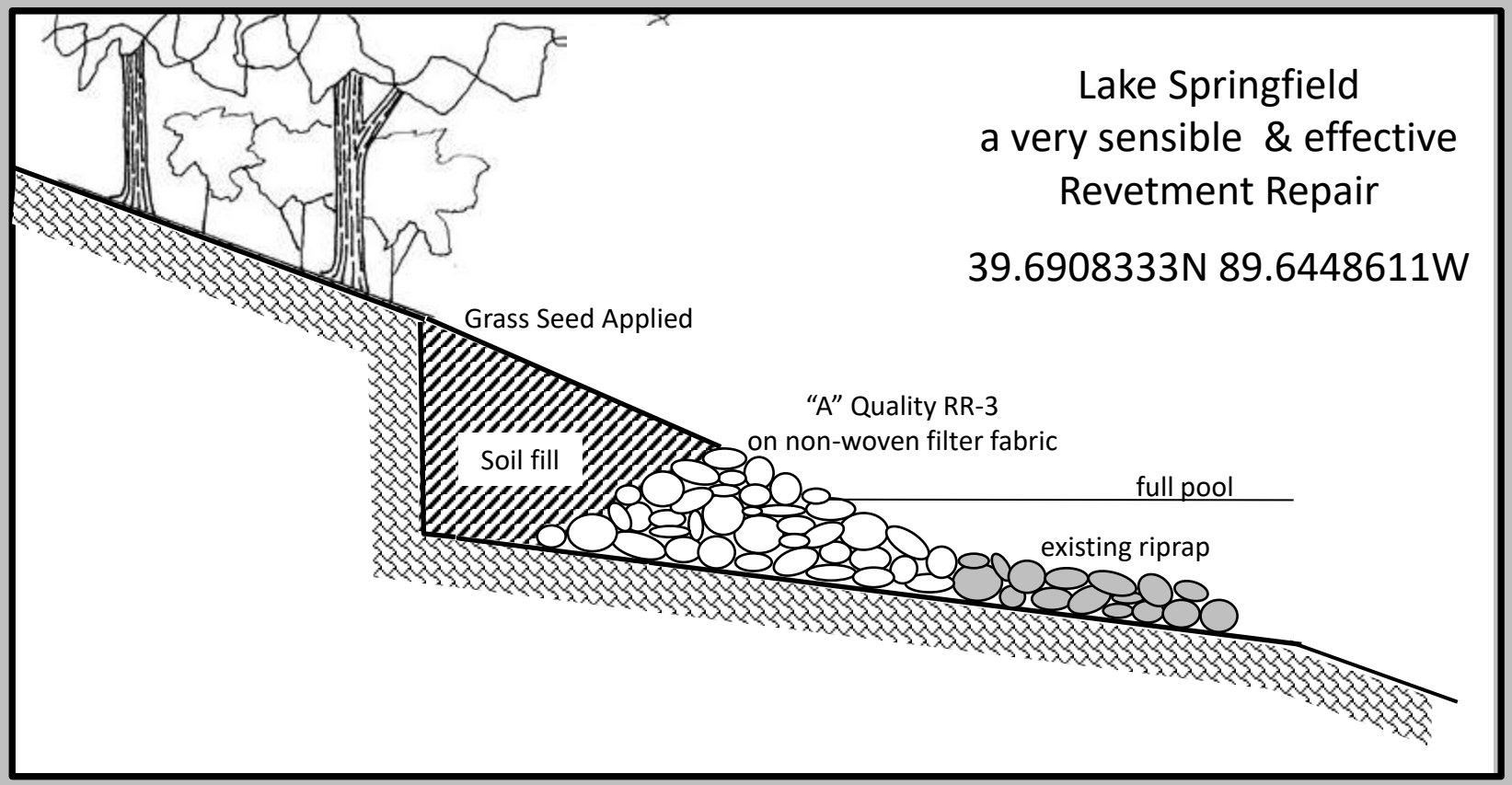
Lake Sangchris State Park (25 hp limit)

The shoreline has receded over a foot per year for the past 50 years.

This revetment was built in the late 1950's before filter fabric was available.
(Next slide shows the repair)

Lake Springfield
Revetment Failure & Repair

39.6908333N 89.6448611W


Lake Springfield
a very sensible & effective
Revetment Repair
39.6908333N 89.6448611W
Grass Seed Applied
"A" Quality RR-3
on non-woven filter fabric
Soil fill
full pool
existing riprap


After Repair March 2013 Full Pool

The Gold Standard Bioengineered Shoreline

Chicago Botanic Garden

This beautiful display was probably the most expensive shoreline stabilization project ever undertaken in the Midwest. Maintaining the plant diversity has also been an expensive challenge on an annual basis.

"It is well worth the money for educational display but not affordable for general use on larger projects."
Hank Sutton's opinion


Photo: Chicago Botanic Garden website

For this project, the U.S. Army Corps of Engineers Ecosystem Restoration Program provided $3,737,500 of the total project cost of $5,750,000.

The Gold Standard Bioengineered Shoreline

Morton Arboretum

The Morton Arboretum has another one of the most gorgeous shoreline displays in Illinois.

The educational displays at the Chicago Botanic Garden and the Morton Arboretum are two of the best anywhere.

Pape Island
Fox Lake, Illinois

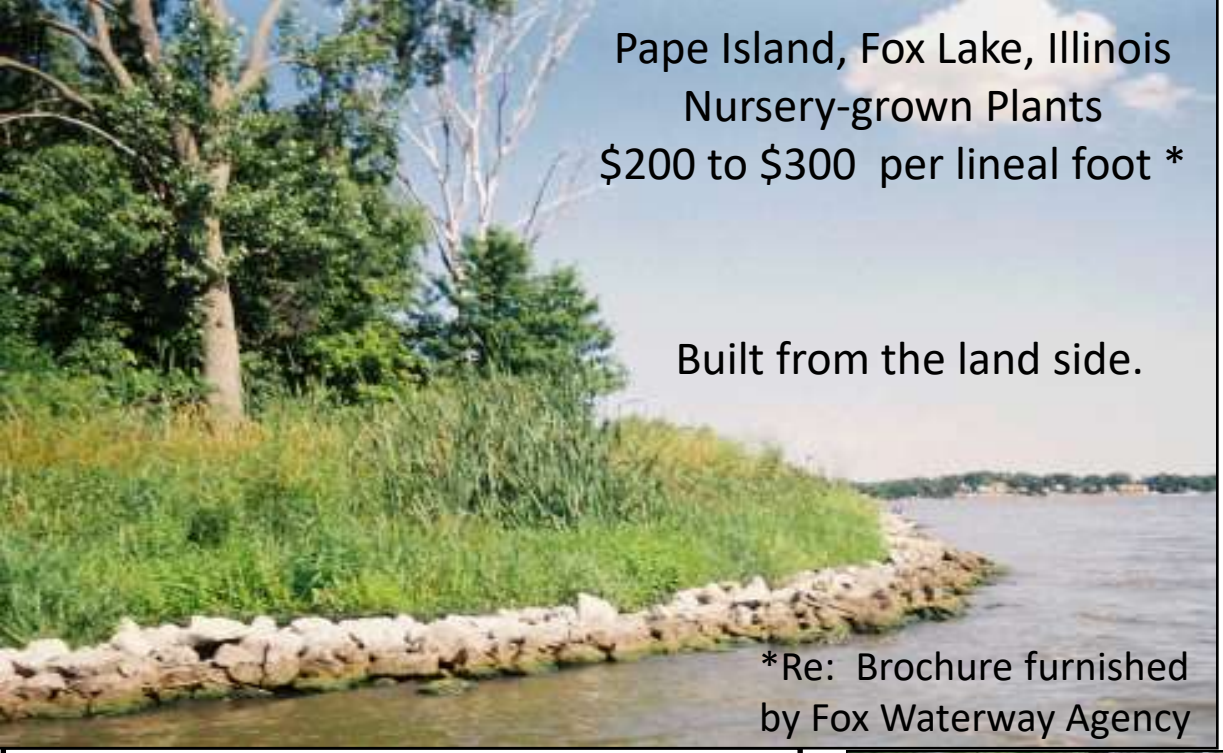
42°23’55”N 88°11’53”W

Bioengineered Shoreline
with no annual maintenance.

Much of the plant diversity has been lost to invasive plant species.

$200 to $300 per foot
Depending on design
(5 designs were used)

Compare Cost and Results of Constructed Living Shoreline



Lake Rip Rap, Inc.

Note: 2004 prices

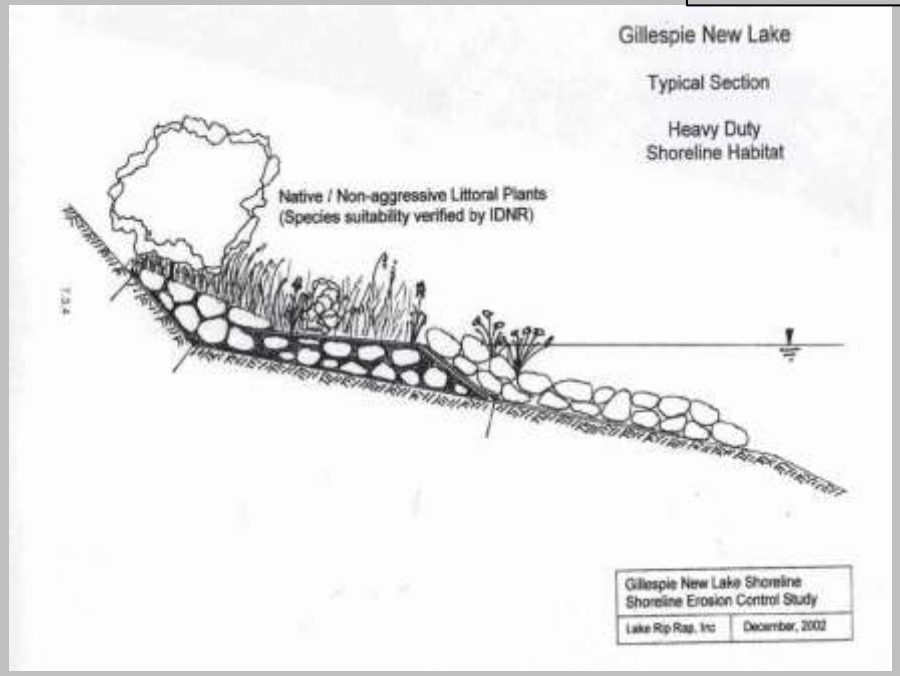
Built by Macoupin Boats.
Kinkaid Lake,
Murphysboro, Illinois

Using nursery-grown plants may offer more initial diversity but that diversity will be lost, if aggressive plant species exist near the site.

A natural plant community takes a few years to develop, but it is worth the wait and at less than one third the cost, this living shoreline is feasible for large remote projects.

Lean Bioengineered Shoreline Gillespie, Illinois

Gillespie New Lake Designed and built by Lake Rip Rap, Inc.



At less than $100 per lineal foot, this project was much cheaper than the projects at the Chicago Botanic Garden, the Morton Arboretum or Pape Island, but still not the most cost-effective living shoreline for use on a large scale. Over 20 years, much of the plant diversity has been lost to invasive and native species in the seed bank best suited to the local conditions.

Savings were realized on this project by working with the existing topography with no excavation or fill and seeding but no nursery grown plants.

Macoupin Boats

"Setting the stage for natural shoreline healing"

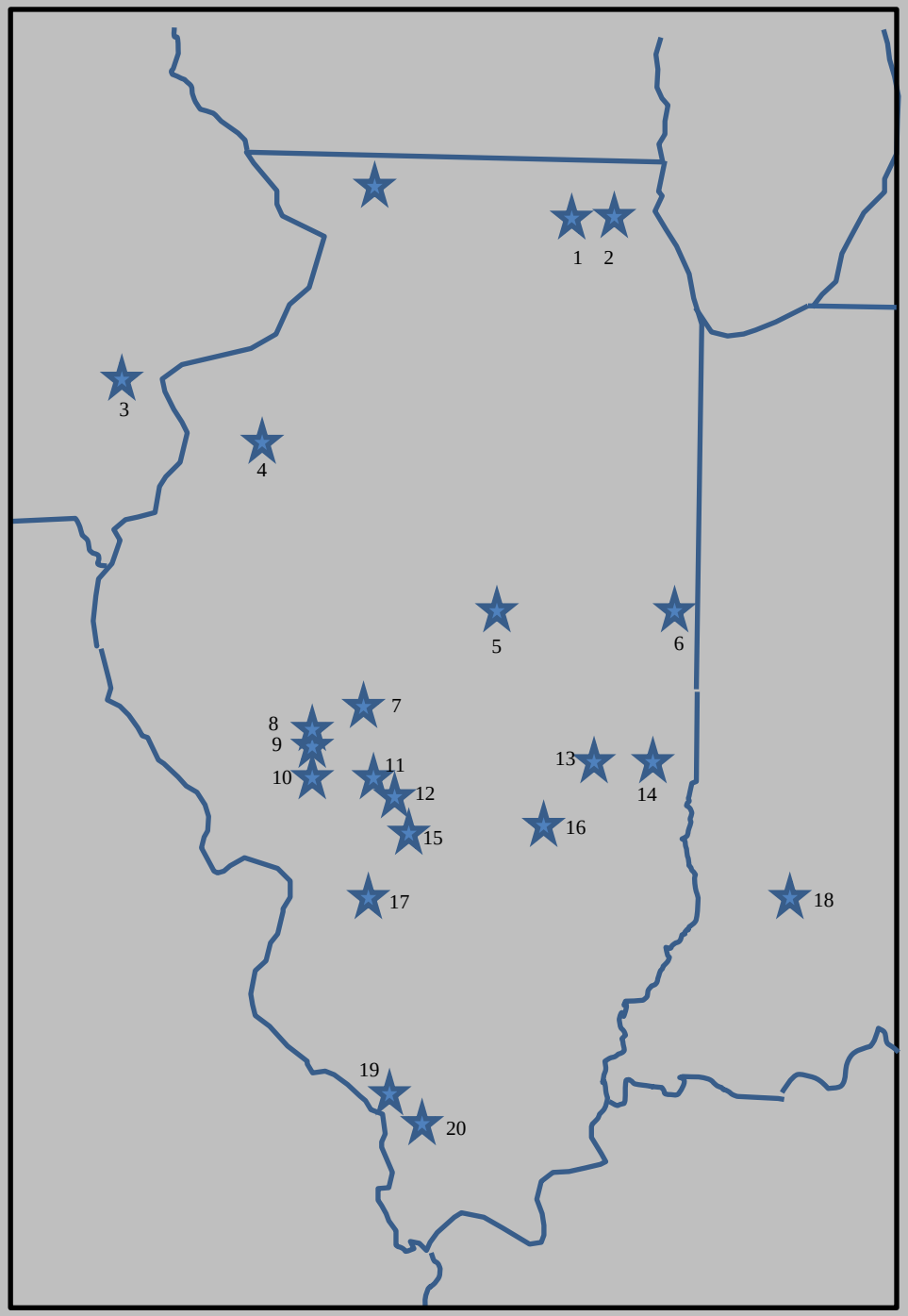
Illinois Reservoirs over 200 Surface Acres

Lakes Serviced by Macoupin Boats are Highlighted in Yellow.

www.MacoupinBoats.com www.LakeRiprap.com

Lake	Acres	Shoreline	Remarks	Owner
Carlyle	26,000	85		COE
Rend	18,900	162		COE
Shelbyville	11,000	250		COE
Crab Orchard	7,000	190	est.	US Fish & Wildlife
Clinton	4,900	130		Exelon Nuclear Power Plant
Springfield	4,200	110	est	City or Local Agency
Decatur	3,100	100	est	City or Local Agency
Kinkaid	2,750	90		City or Local Agency
Sangchris	2,320	120		Coal Fired Power Plant
Egypt	2,300	90		Coal Fired Power Plant
Baldwin (cooling tank)	2,020	8		Coal Fired Power Plant
Cedar	1,750	70	est	City or Local Agency
Newton	1,750	80	est	Coal Fired Power Plant
Lou Yaeger	1,300	70	est	City or Local Agency
Little Grassy	1,200	36		US Fish & Wildlife
Glenn Shoals	1,200	40	est	City or Local Agency
Taylorville	1,200	40	est	City or Local Agency
Coffeen	1,100	40	est	Power Plant
Mattoon	1,050	40	est	City or Local Agency
Vermilion	1,000	40	est	American Water Company
Centrailia Raccoon	970	40	est	City or Local Agency
Olney East Fork	934	40	est	City or Local Agency
Evergreen	886	40	est	City or Local Agency
Wonder	830	40	est	Property Owners Association
Mill Creek	811	39		City or Local Agency
Devils Kitchen	810	40	est	US Fish & Wildlife
Otter Lake	765	40		City or Local Agency
Gov. Bond	750	30	est	City or Local Agency
Vandalia	660	30	est	City or Local Agency
Carroll	636	30	est	Property Owners Association
Bloomington	635	30	est	City or Local Agency
Oak Run - Spoon	600	19		Property Owners Association
Sara	586	18	est	City or Local Agency
Highland Silver	550	18	est	City or Local Agency
Stephen Forbes	509	18		IDNR
Apple Canyon	480	12	est	Property Owners Association
Jacksonville	476	12	est	City or Local Agency
Holiday Shores	430	17	est	Property Owners Association
Charleston Side Channel	346	12	est	City or Local Agency
Holiday	328	12	est	Property Owners Association
Shabbona	318	12	est	IDNR
Washington County	248	12	est	IDNR
Pittsfield	241	12	est	City or Local Agency
Carlinville	233	12		City or Local Agency
Wildwood	220	12	est	Property Owners Association
Galena	220	7		Property Owners Association
Gillespie	207	7	est	City or Local Agency

Estimated Shoreline Miles (est.) are Indicated Under Remarks



The 20 largest living shoreline projects

built by Macoupin Boats
with no maintenance and no failures.

Lake Rip Rap, Inc.

1. Wonder Lake, Wonder Lake, IL
2. Grass Lake, Antioch, IL
3. Lake Odessa, Wapello, IA
4. Lake Story, Galesburg, IL
5. Clinton Lake, Clinton, IL
6. Vermilion Lake, Danville, IL
7. Lake Springfield, Springfield, IL
8. Otter Lake, Girard, IL
9. Lake Carlinville, Carlinville, IL
10. New Lake Gillespie, Gillespie, IL
11. Lake Lou Yaeger, Litchfield, IL
12. Lake Glenn Shoals, Hillsboro, IL
13. Charleston Side Channel, Charleston, IL
14. Mill Creek Lake, Marshall, IL
15. Gov. Bond Lake, Greenville, IL
16. Lake Sara, Effingham, IL
17. Highland Silver Lake, Highland, IL
18. West Boggs Park, Loogootee, IN
19. Kinkaid Lake, Murphysboro, IL
20. Cedar Lake, Carbondale, IL

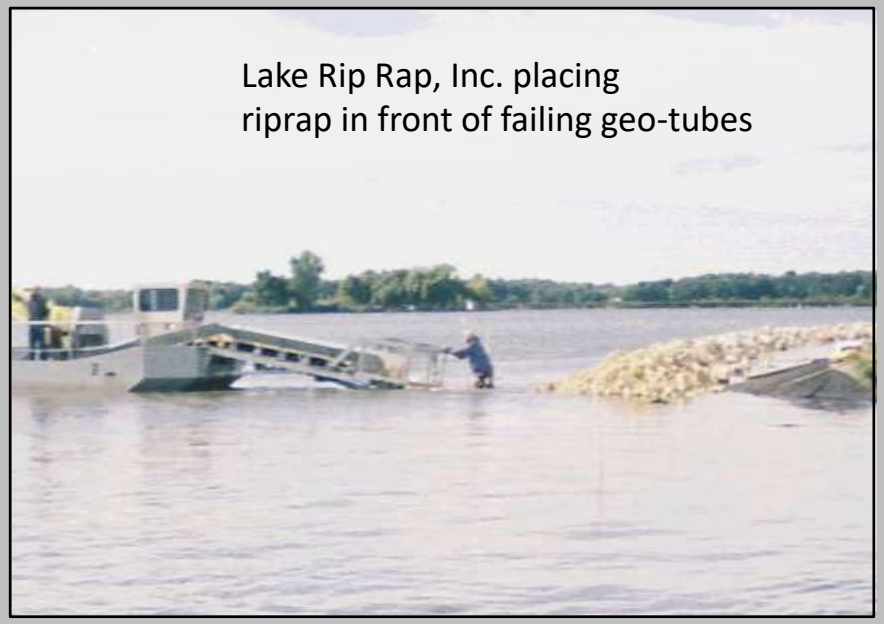
Standard offshore breakwater with naturally colonized littoral habitat "Affordable Lean Bioengineering"

This method does not offer great plant diversity, but is very affordable on a large scale and is extremely effective in wave energy dissipation. Even a monoculture is better than no vegetation at all.
(well over 150,000 feet installed on Illinois Reservoirs)

Initially there were only 12 shoreline plant species identified on this reservoir, 6 years after the breakwater was installed, there were 121 shoreline plant species identified plus numerous fauna species.

Ref: SIU Carbondale multi-year study by John Severson, (now Ph


Lake Rip Rap, Inc.
Living Shoreline
(Standard Breakwater with natural plant colonization)
after 8 years
same root
2001
2009
Notice the improved water clarity.



Grass Island, Fox Lake, Illinois

42°26’59”N 88°09’38”W

An emergency repair of the Grass Lake Geo-tube Island sets the stage for a lush shoreline habitat by natural propagation.

Two years later, Lake Rip Rap, Inc. was contracted to make similar repairs on an additional 2000 feet of the Geo-Tubes.

Shoreline Metrics

Shoreline Metrics

Sycamore

Sycamore

Giant bur reed

Rice cutgrass

American water willow

Creeping water primrose

37° 47’ 18”N 89° 26’ 44”W

Natural colonization with no supplemental seeding.

Notice the improved water clarity.

This littoral habitat is now teeming with life, both flora and fauna. (ref. Severson’s thesis)

I do not recommend supplemental seeding because, without cost prohibitive hand weeding, the diversity will most likely be lost to plants represented in the seed bank that are best suited to the existing conditions. *Hank Sutton*

2009

The most cost effective method of shoreline erosion control is a well engineered, multi-year project to construct offshore breakwaters, with a naturally colonized living shoreline.

Record Littoral Slope Topography of Selected Sites

Lake Sara's multi-year project stabilized over 30,000 lineal feet of shoreline.

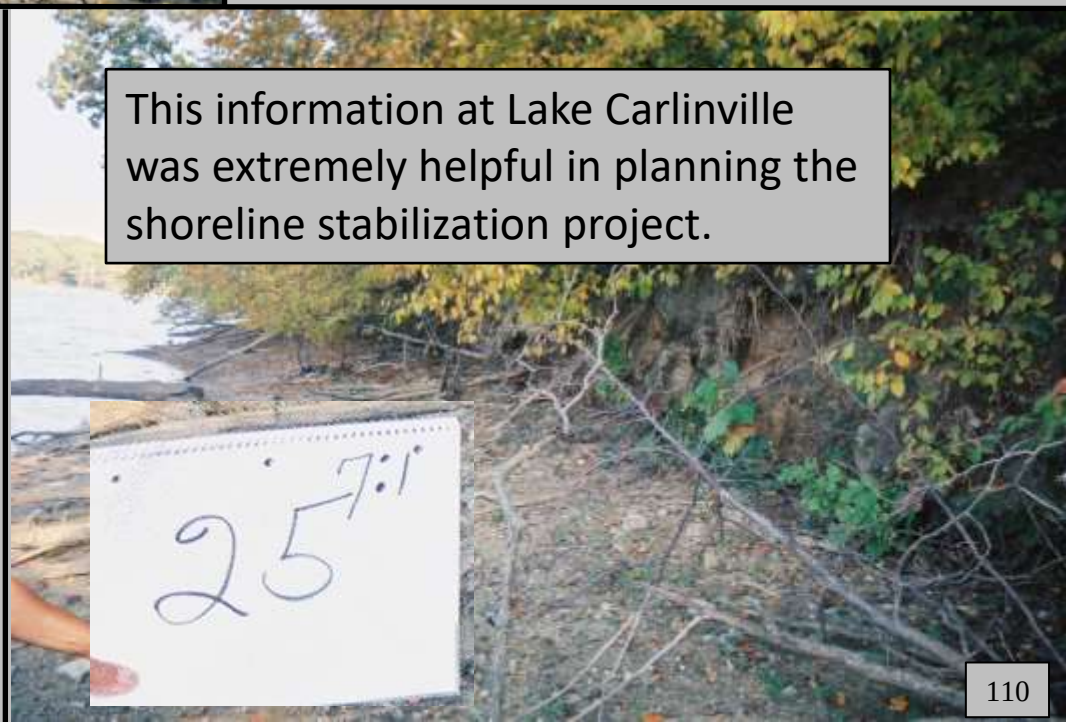
Lake Sara, Effingham, Illinois - Project Manager: Tom Ryan

Determine the littoral slope gradient - 1.5 feet of water at 10 feet from the bank and 3.0 feet of water at 20 feet from the bank = <u>15% littoral slope</u>


Lake Sara's multi-year project stabilized over 30,000 lineal feet of shoreline.
"A" Quality
RR-3 riprap on fabric

Anytime the water level is low, get out and take pictures. Record the location of each photo and the littoral slope gradient plus any other appropriate remarks.

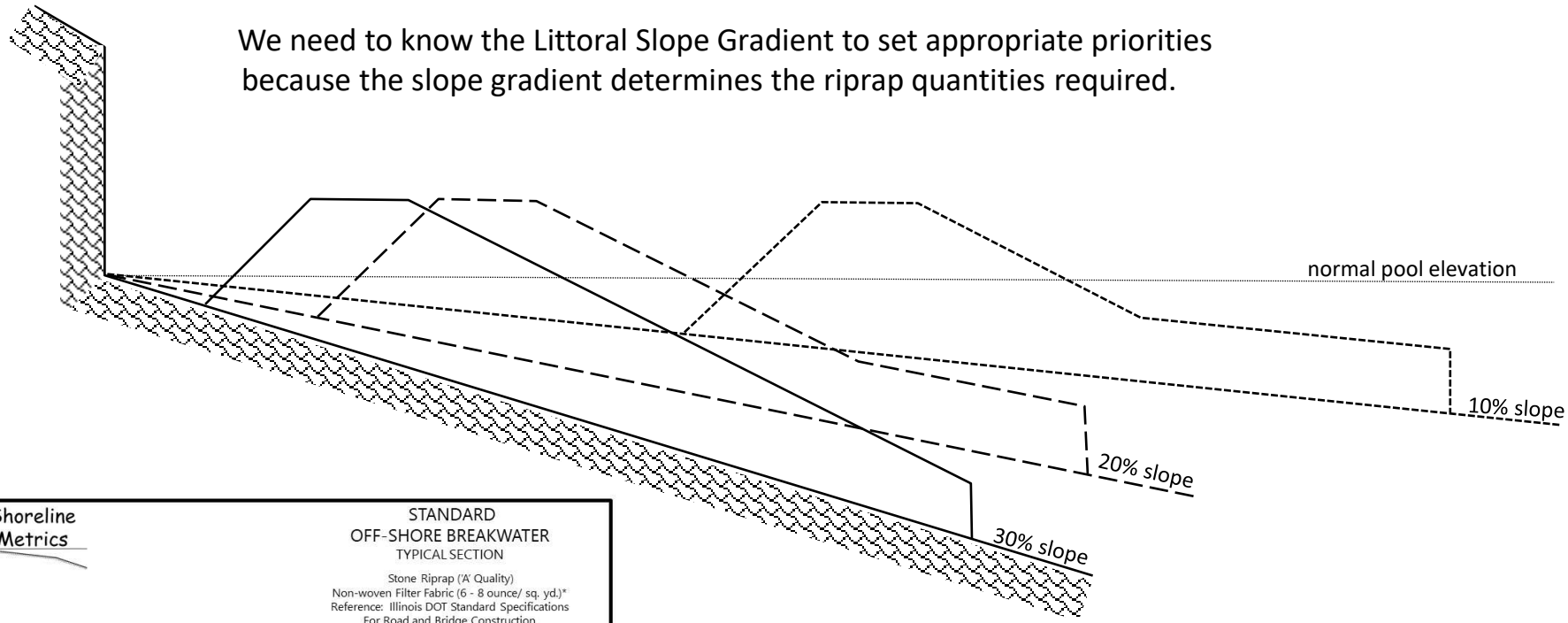
Also evaluate the condition of existing riprap structures while the water level is low.

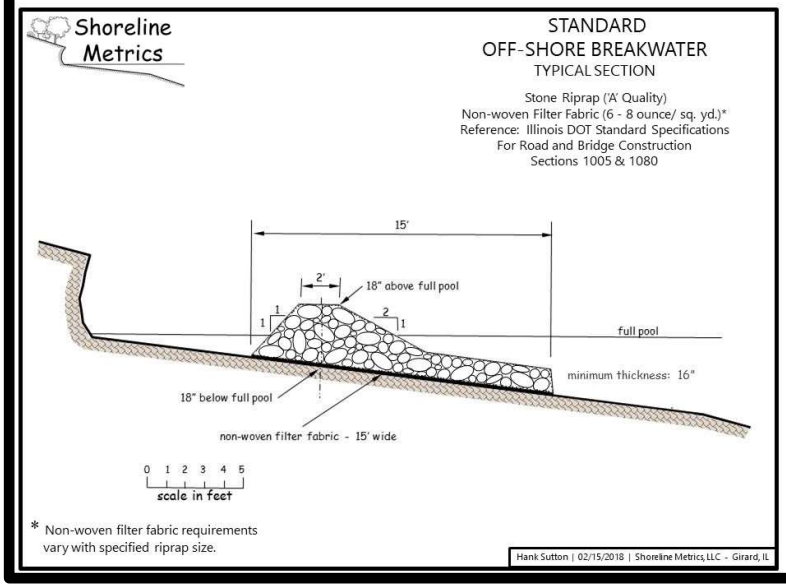


This information at Lake Carlinville was extremely helpful in planning the shoreline stabilization project.

Littoral Slope Gradient
vs:
Standard Breakwater End Area

We need to know the Littoral Slope Gradient to set appropriate priorities because the slope gradient determines the riprap quantities required.





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Hank Sutton 01-15-20

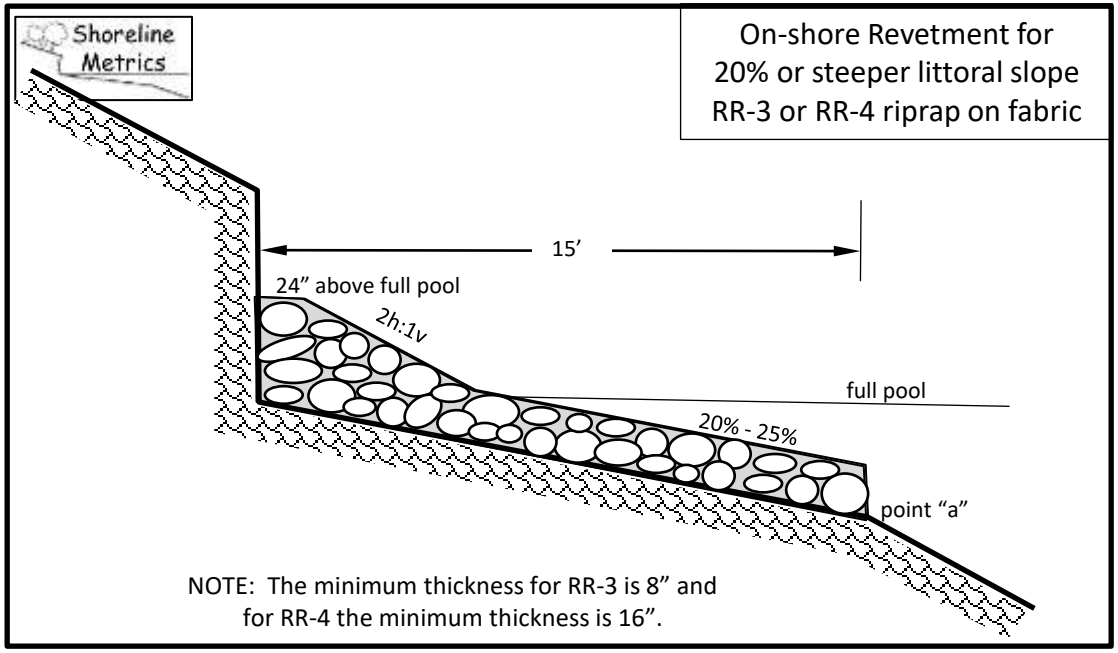
Special Provisions for Steeper Littoral Slopes

Steeper Littoral slopes require more material and the apron may extend beyond point "a"

Special Provision where the littoral slope is between 17% and 20% : The breakwater can be moved closer to the shore with the center line at 12" of water instead of 18". This move will offset the increase of riprap required and with the steeper slope, but the move will not reduce the effectiveness of the breakwater

Special Provision where the littoral slope is between 20% and 25%: As the littoral slope gets progressively narrow, there is not enough width for the Standard Breakwater therefore, the on-shore revetment as shown below will fit the topography but the opportunity for the beneficial natural plant colonization will not be possible, however, the shoreline will be stabilized.

Littoral slopes 25% or steeper: All of the reservoirs, over 200 acres, in Illinois are now over 40 years old. At that age, if the littoral slope has not been reduced to less than 25%, the shoreline erosion rating would be low and generally not warrant stabilization.



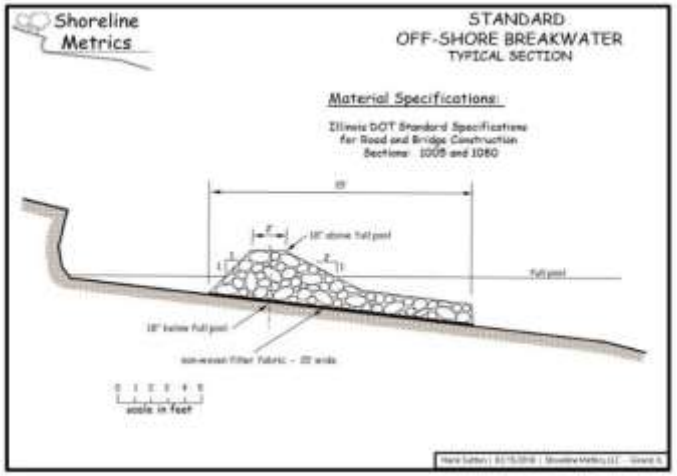
I have completed many projects where there was no littoral zone survey conducted prior to letting the contract.

These projects commonly resulted in issues of typical section revisions while under construction, inconsistency in required material quantities, illogical site selections and administrative complications. A thorough littoral zone survey completed by technicians experienced in shoreline erosion control, plus on-site observation while under construction, will eliminate these issues and ensure confidence in the cost-effectiveness of the project.

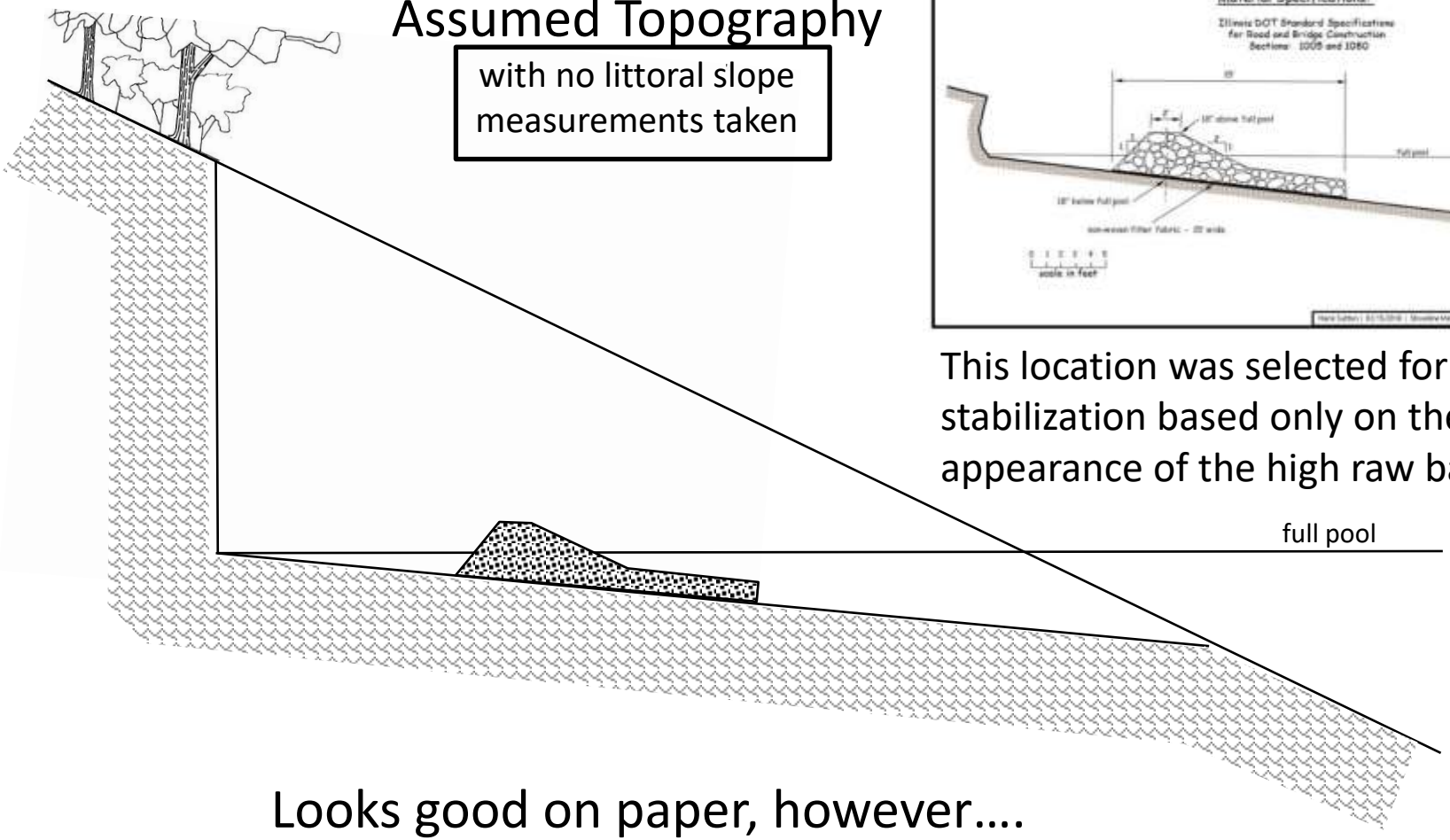
Shoreline Metrics, LLC
Hank Sutton (217) 899-9706

An example of Assumed Topography

with no littoral slope measurements taken



This location was selected for stabilization based only on the appearance of the high raw bank.



Looks good on paper, however….
(see next slide)

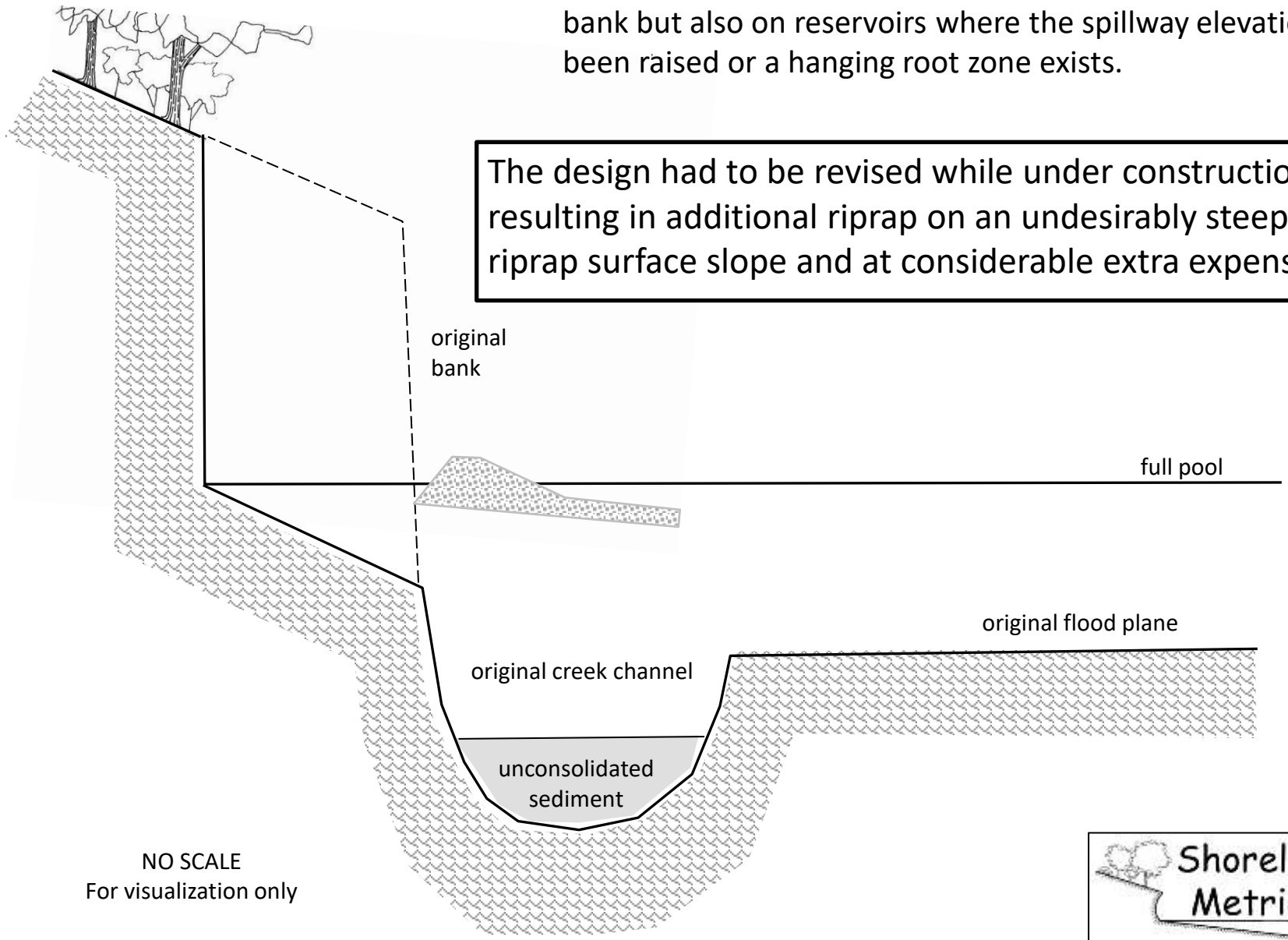
No Scale

Shoreline Metrics

Actual Littoral Cross Section

This issue of deep water near the shore has been observed not only because of a creek channel cutting into an existing bank but also on reservoirs where the spillway elevation has been raised or a hanging root zone exists.

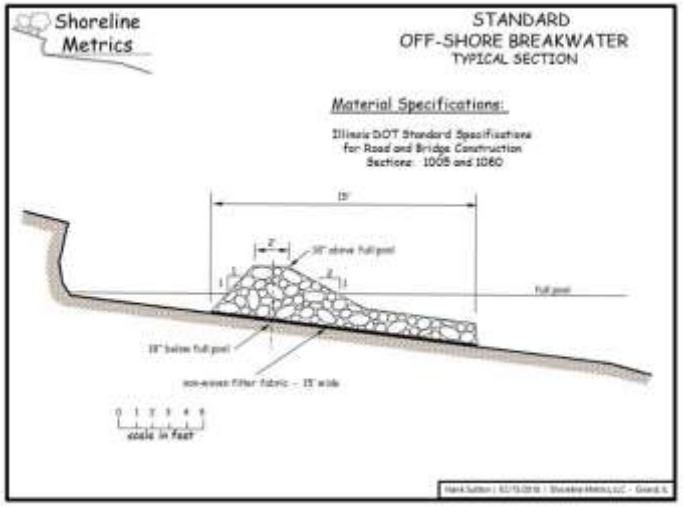
The design had to be revised while under construction resulting in additional riprap on an undesirably steep riprap surface slope and at considerable extra expense.

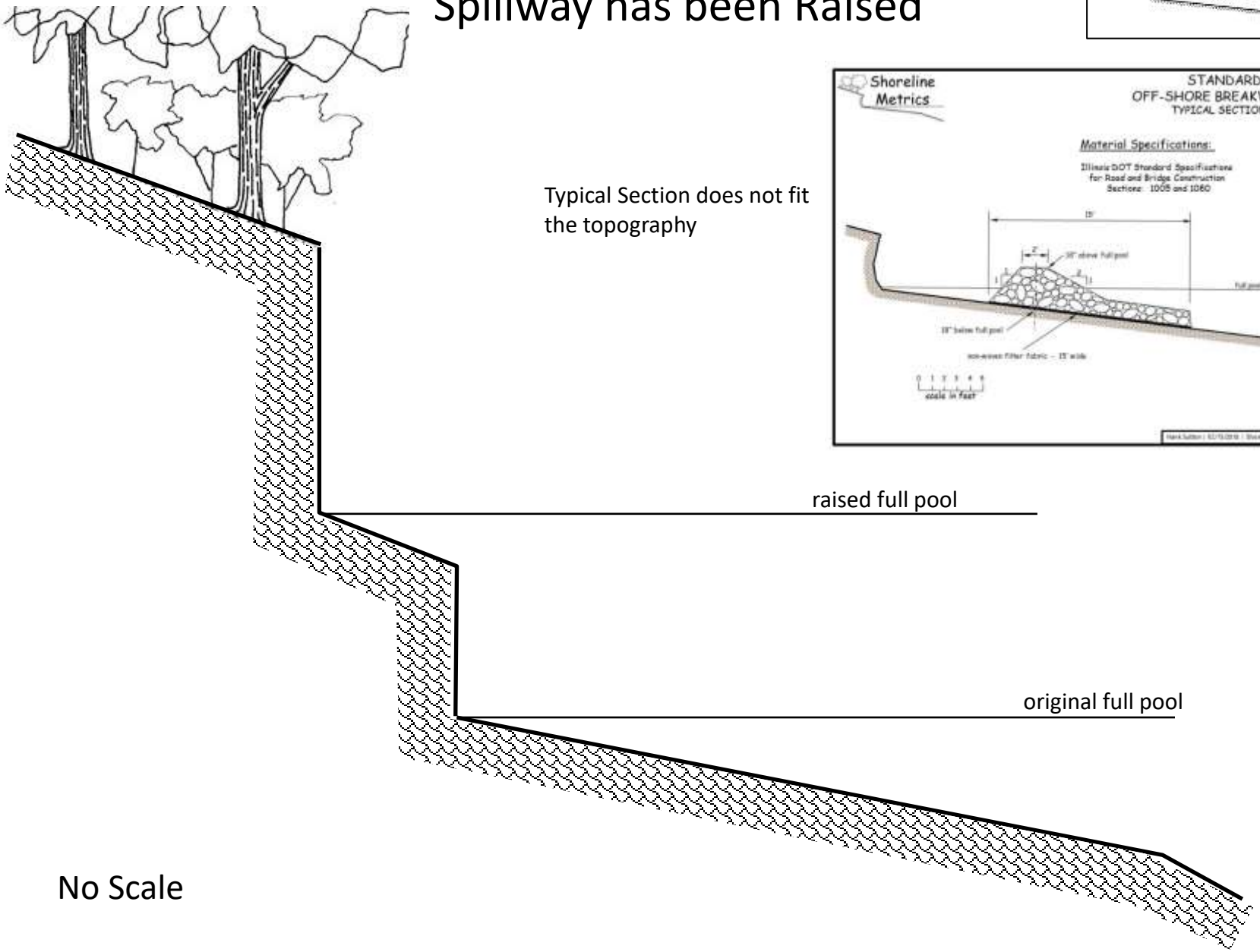


Shoreline Metrics

Geomorphology After Spillway has been Raised

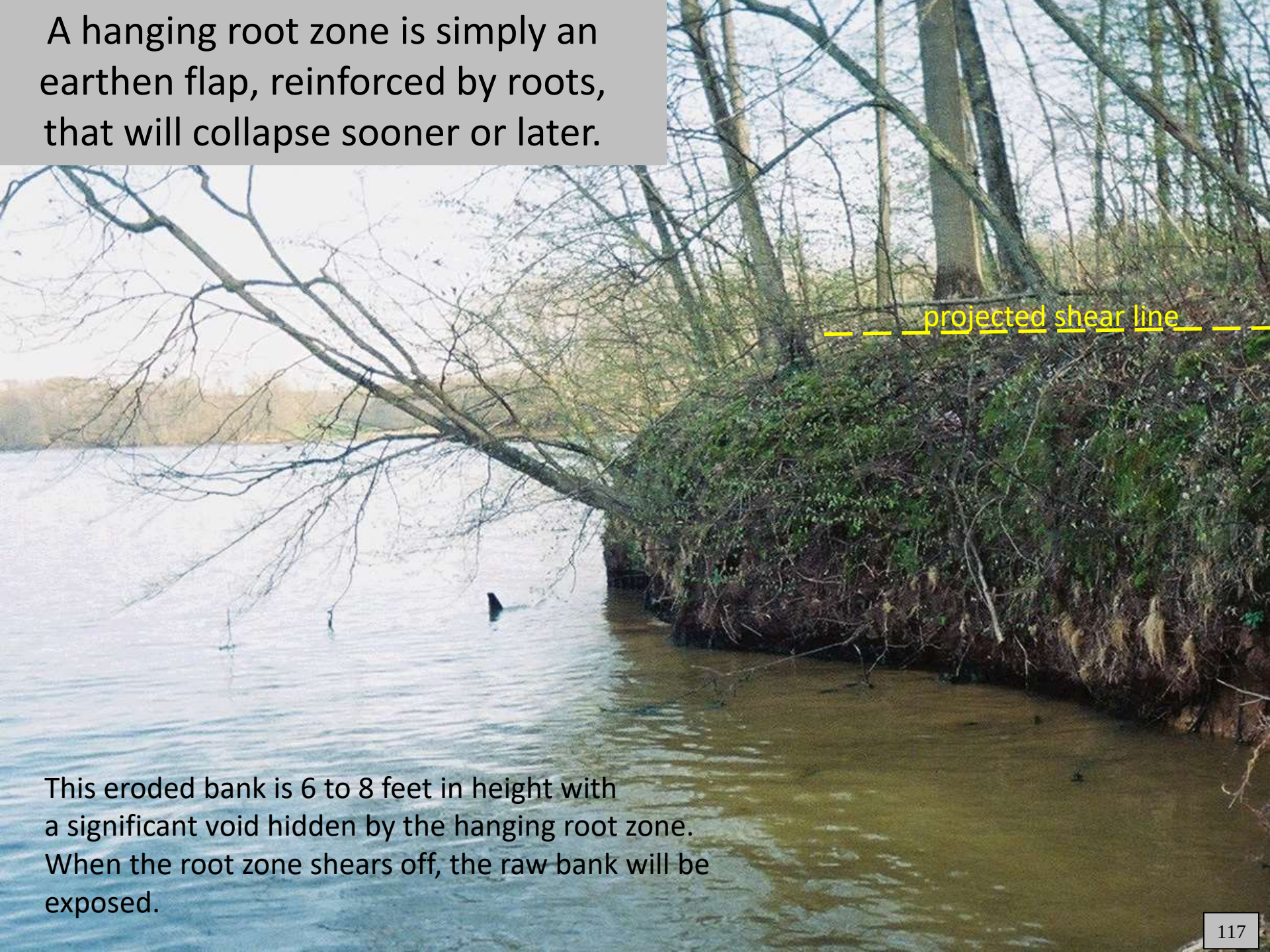
Typical Section does not fit the topography



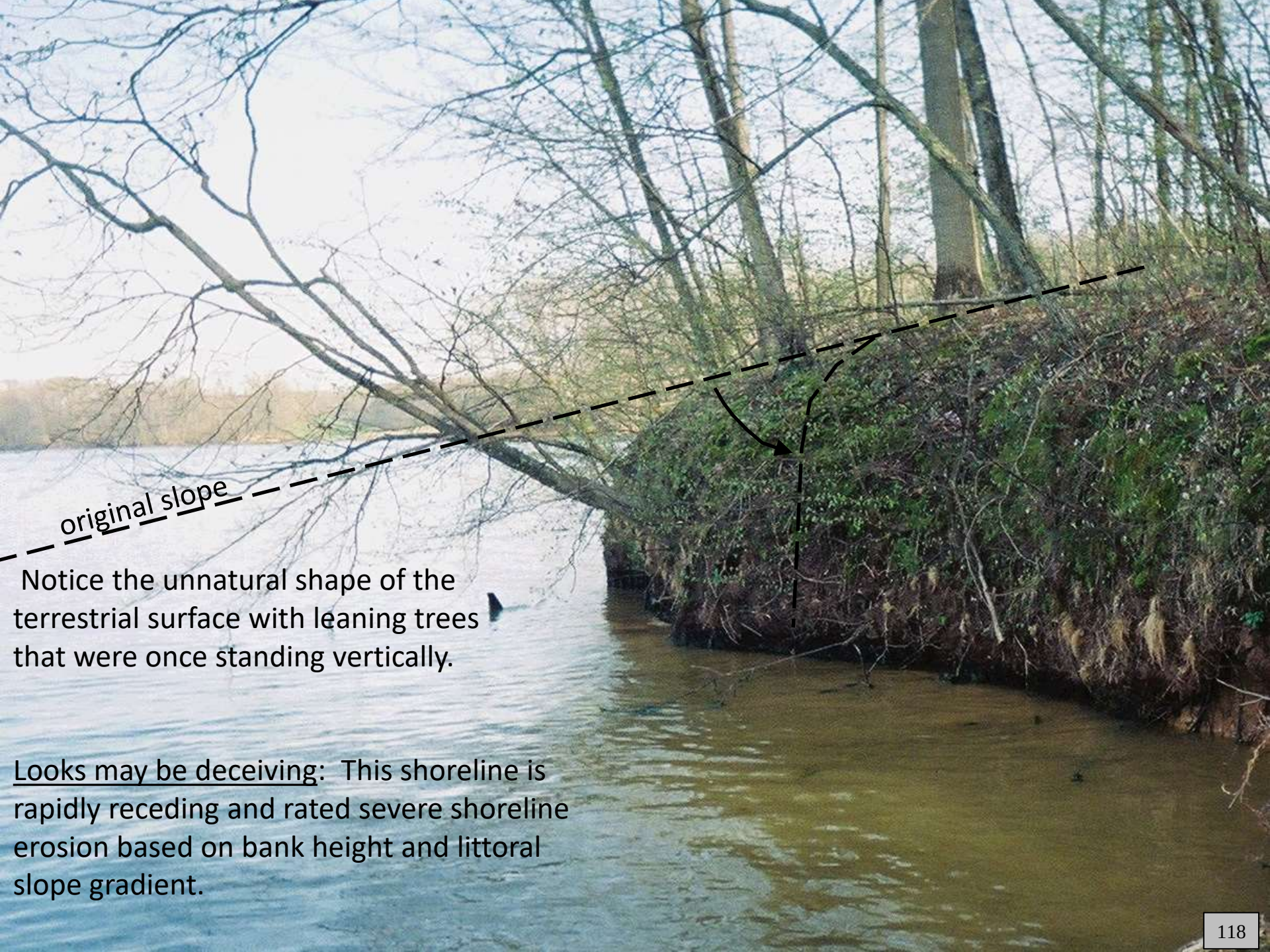


No Scale

A hanging root zone is simply an earthen flap, reinforced by roots, that will collapse sooner or later.



This eroded bank is 6 to 8 feet in height with a significant void hidden by the hanging root zone. When the root zone shears off, the raw bank will be exposed.

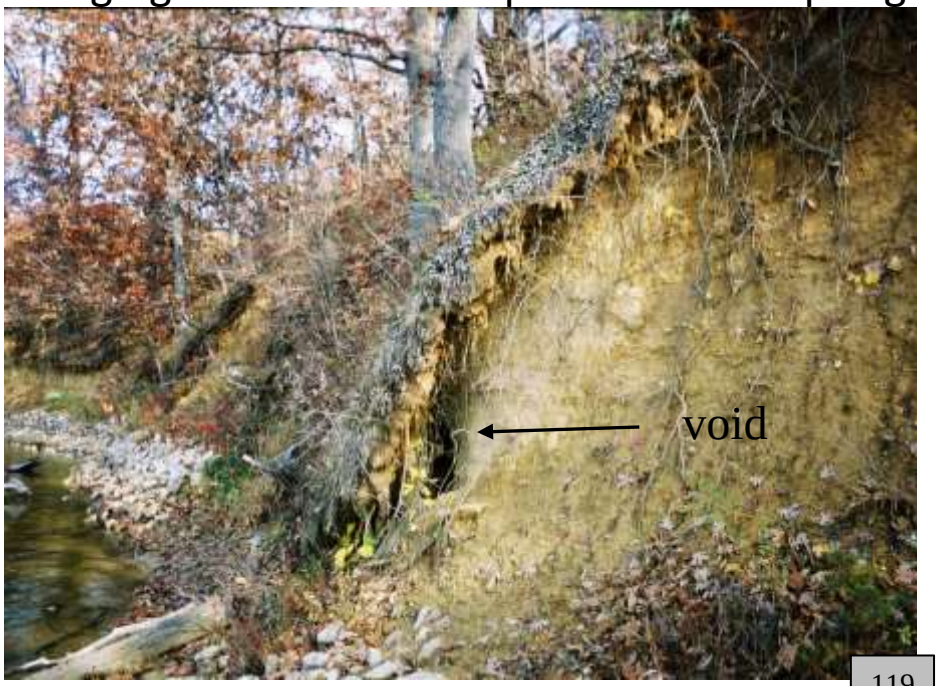


Notice the unnatural shape of the terrestrial surface with leaning trees that were once standing vertically.

<u>Looks may be deceiving</u>: This shoreline is rapidly receding and rated severe shoreline erosion based on bank height and littoral slope gradient.

Characteristics of a Hanging Root Zone

hanging root zone in the process of collapsing



Think about the unthinkable…..

What would happen if a city of over 100,000 people ran out of water?

Lake Springfield at full pool

In 1954, I saw the dry bottom of Lake Springfield from the US-66 bridge.

Hank Sutton

The city of Springfield, Illinois nearly ran out of water in 1954.
This photo was taken 6 ½ miles upstream from the dam.

The Drought of '53 - '54
The water level of Lake Springfield reached a record low, Dec. 29, 1954.

An aerial photo taken by CWLP employee Chuck Laswell shows Old Sugar and Lick creeks cross the dry bed of drought-ravaged Lake Springfield.
PHOTO COURTESY THE SANGAMON VALLEY COLLECTION AT LINCOLN LIBRARY
Illinois Times article - Aug. 16, 2012 - contact: Tara Mc Andrew

Shoreline Metrics, LLC
Survey Unit # 2

Project Survey, Supervision & Documentation

Riprap Production and Availability

Quarries with thick bedding layers can be used for production of all riprap sizes, but a thinly bedded deposit may be limited to the production of RR-3 only. Some quarries with high quality stone are so thinly bedded that they cannot produce riprap at all. Heavy duty riprap screening equipment "Grizzly Bar Screens" are very expensive and some quarries do not produce riprap because it may not be profitable in their market area.

There are fewer quarries that can produce the larger sizes of riprap and may be farther away from the project location. The rate of production of larger sizes of riprap is generally less than that of producing smaller sizes and may effect the price. An appropriate cost analysis should be conducted in addition to fetch when specifying the riprap size for a project.

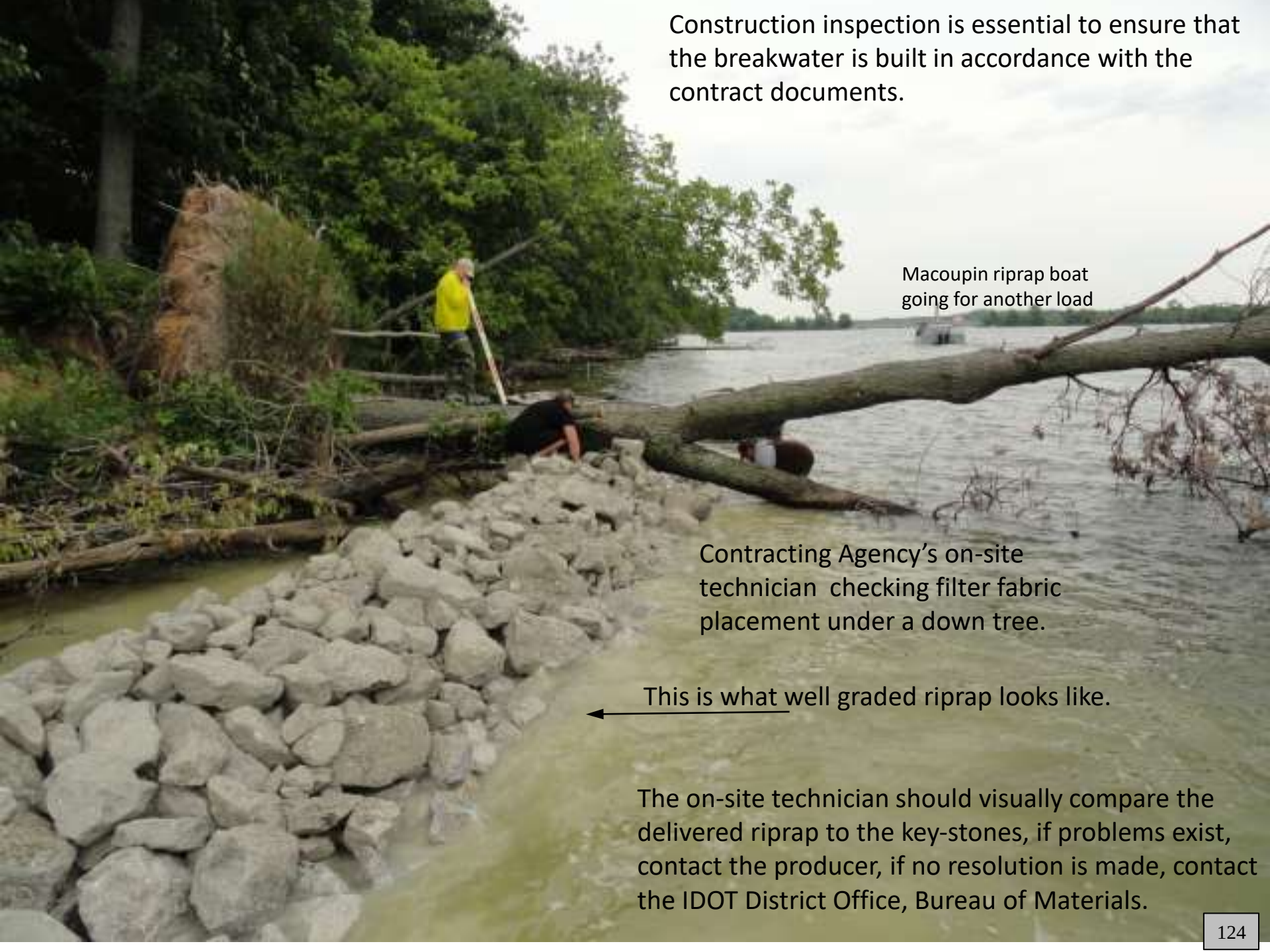
In some parts of central Illinois, the nearest quarries that produce 'A' quality riprap are up to 100 miles away. For example the RR-4 for a job at Clinton Lake came from Nokomis, Illinois located 85 miles away. Ten trucks were required daily to keep up with the riprap placement.

Example of a nearby quarry. RR-4 at Kinkaid Lake where only two trucks supplied the same daily quantity as that of the Clinton project, from a quarry located only 15 miles from the lake.

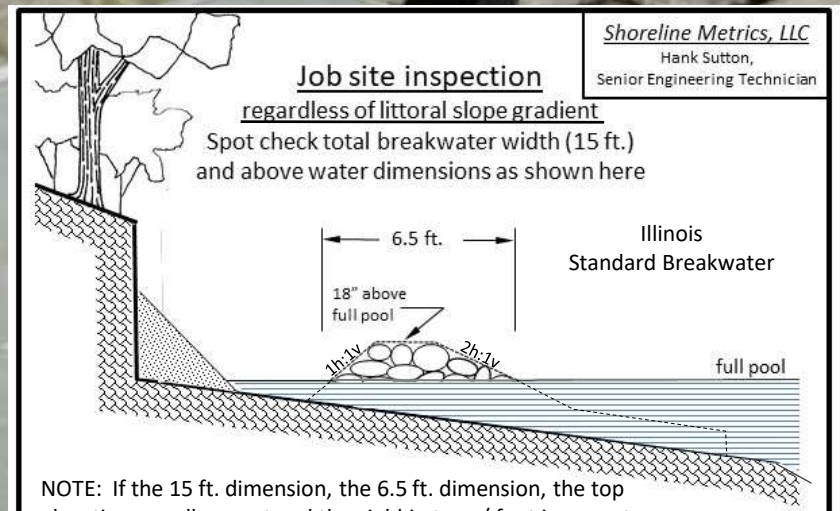

Thinly bedded limestone deposit


Riprap screening


Producer's stockpile

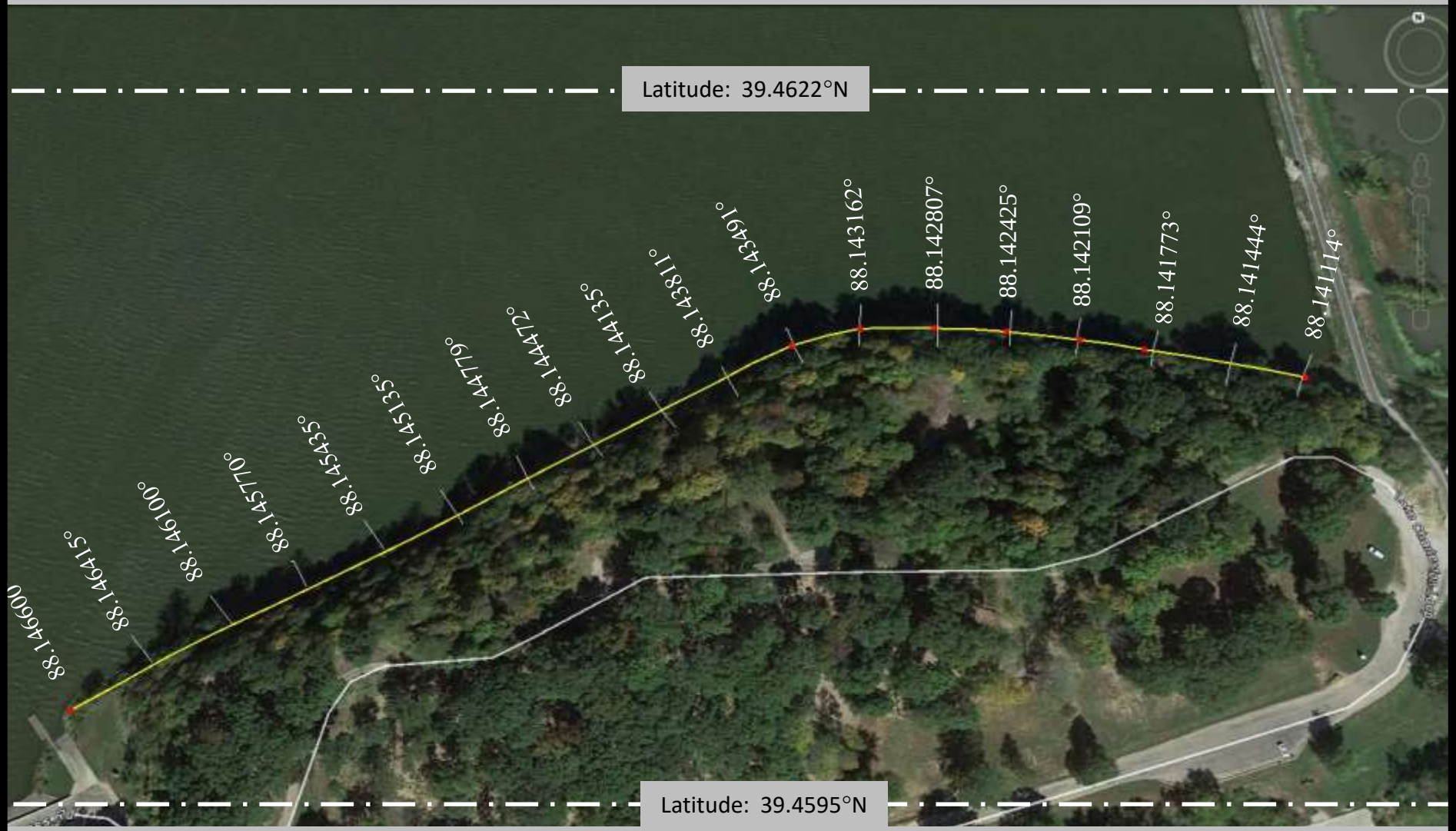

Construction inspection is essential to ensure that the breakwater is built in accordance with the contract documents.
Macoupin riprap boat going for another load
Contracting Agency's on-site technician checking filter fabric placement under a down tree.
This is what well graded riprap looks like.
The on-site technician should visually compare the delivered riprap to the key-stones, if problems exist, contact the producer, if no resolution is made, contact the IDOT District Office, Bureau of Materials.

Contracting Agency's on-site technician
Checking grade with a hand level.



NOTE: If the 15 ft. dimension, the 6.5 ft. dimension, the top elevation are all correct and the yield in tons / foot is correct, the breakwater would appear to be acceptable.

- Predetermined locations of Littoral Cross Sections



Shoreline Metrics, LLC
Hank Sutton, Senior Engineering Technician
(271) 899-9706
hank@ShorelineMetrics.com

Prepared by: Hank Sutton | June 20, 20

Shoreline Metrics, LLC
Hank Sutton
Senior Engineering Tech.

2018 Shoreline Stabilization Project - Littoral slope gradients

Raw Data

Reach #2
39° 42' 21.7"N 89° 40' 34.1"W - 17.5%
39° 42' 20.8"N 89° 40' 33.2"W - 15.0%
39° 42' 19.1"N 89° 40' 31.5" W - 13.8%
39° 42' 18.8"N 89° 40' 29.5" W - 12.5%
39° 42' 19.1"N 89° 40' 28.7" W - 8.8%
39° 42' 21.0"N 89° 40' 26.6" W - 12.5%
39° 42' 22.9"N 89° 40' 26.3" W - 15.0%
39° 42' 23.3"N 89° 40' 26.7" W - 17.5%
39° 42' 25.2"N 89° 40' 24.1" W - 16.3%
39° 42' 25.0"N 89° 40' 23.1" W - 15.0%
39° 42' 24.8"N 89° 40' 22.2" W - 12.5%
39° 42' 23.4"N 89° 40' 20.5" W - 12.5%
39° 42' 22.4"N 89° 40' 19.4" W - 13.8%
39° 42' 21.2"N 89° 40' 19.4" W - 12.5%
39° 42' 18.4"N 89° 40' 18.8" W - 12.5%
39° 42' 16.9"N 89° 40' 18.9" W - 11.3%
39° 42' 15.6"N 89° 40' 19.1" W - 11.3%
39° 42' 14.6"N 89° 40' 20.1" W - 16.3%
Average Littoral Slope 13.7%

Reach # 3
39° 42' 02.2"N 89° 40' 23.2" W - 12.5%
39° 42' 01.1"N 89° 40' 21.9" W - 15.0%
39° 41' 59.9"N 89° 40' 21.6" W - 10.0%

Reach # 4
39° 42' 00.9"N 89° 40' 17.8"W - 11.3%
39° 42' 01.4"N 89° 40' 17.2"W - 12.5%
39° 42' 02.0"N 89° 40' 16.1"W - 11.3%
39° 42' 02.9"N 89° 40' 13.5"W - 15.0%
39° 42' 03.2"N 89° 40' 10.5"W - 12.5%
39° 42' 03.1"N 89° 40' 09.0"W - 17.5%
39° 42' 03.4"N 89° 40' 07.2"W - 13.8%
39° 42' 04.1"N 89° 40' 05.8"W - 16.3%
39° 42' 05.1"N 89° 40' 04.3"W - 13.8%
39° 42' 05.8"N 89° 40' 03.2"W - 15.0%
39° 42' 07.0"N 89° 40' 02.1"W - 13.8%
Average Littoral Slope 13.9%

Reach # 5
39° 42' 01.2"N 89° 39' 58.0"W - 13.8%
39° 41' 58.6"N 89° 39' 57.9"W - 18.8%
39° 41' 58.5"N 89° 39' 56.9"W - 20.0%
39° 41' 59.1"N 89° 39' 54.2"W - 30.0%
39° 41' 58.8"N 89° 39' 52.5"W - 30.0%
39° 41' 57.8"N 89° 39' 49.2"W - 26.3%
39° 41' 57.1"N 89° 39' 47.7"W - 21.3%
39° 41' 56.9"N 89° 39' 47.0"W - 27.5%
Average Littoral Slope 23.5%

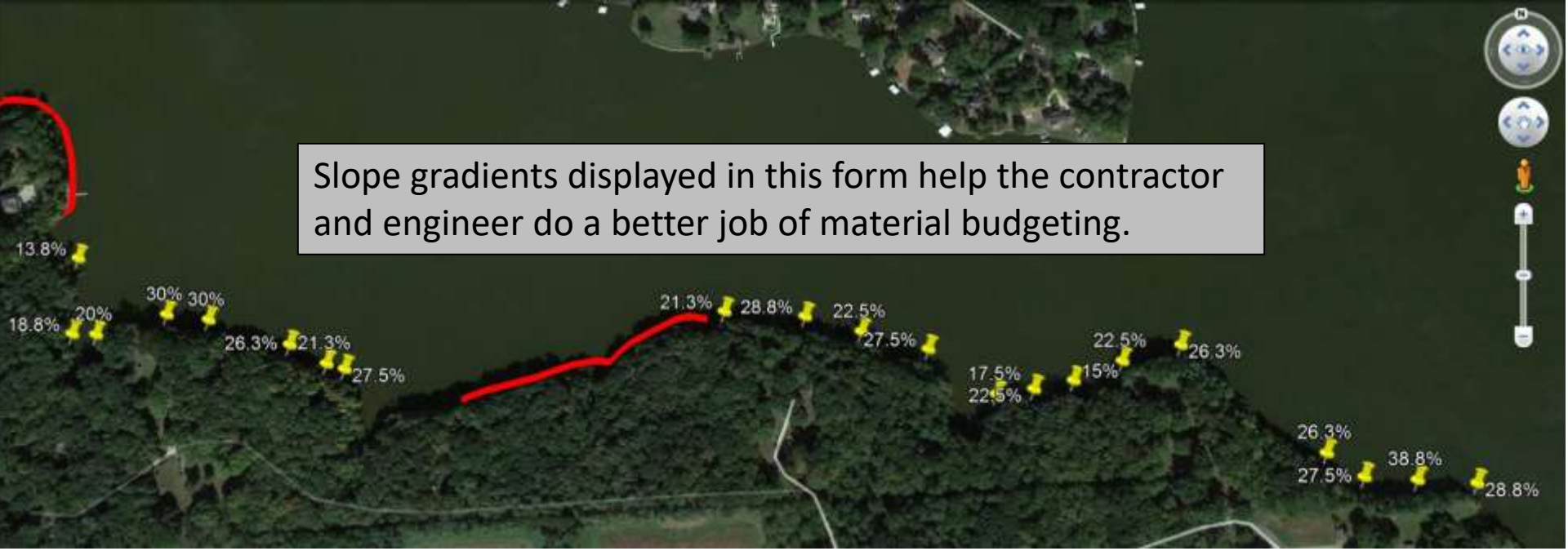
Reach # 6
39° 41' 58.1"N 89° 39' 31.9"W - 21.3%
39° 41' 57.8"N 89° 39' 28.7"W - 28.8%
39° 41' 57.2"N 89° 39' 26.5"W - 22.5%
39° 41' 56.5"N 89° 39' 23.9"W - 27.5%
39° 41' 54.9"N 89° 39' 21.4"W - 17.5%
39° 41' 55.0"N 89° 39' 19.9"W - 22.5%
39° 41' 55.2"N 89° 39' 18.3"W - 15.0%
39° 41' 55.9"N 89° 39' 18.2"W - 22.5%
39° 41' 55.7"N 89° 39' 16.3"W - 26.3%
39° 41' 52.4"N 89° 39' 08.9"W - 26.3%
39° 41' 51.6"N 89° 39' 07.6"W - 27.5%
39° 41' 51.4"N 89° 39' 05.6"W - 38.8%
39° 41' 51.2"N 89° 39' 03.3"W - 28.8%
Average Littoral Slope 23.0%

Reach # 7
39° 42' 04.1"N 89° 33' 38.8"W - 15.0%
39° 42' 05.0"N 89° 33' 38.7"W - 13.8%
39° 42' 05.9"N 89° 33' 39.0"W - 12.5%
Average Littoral Slope 13.8%

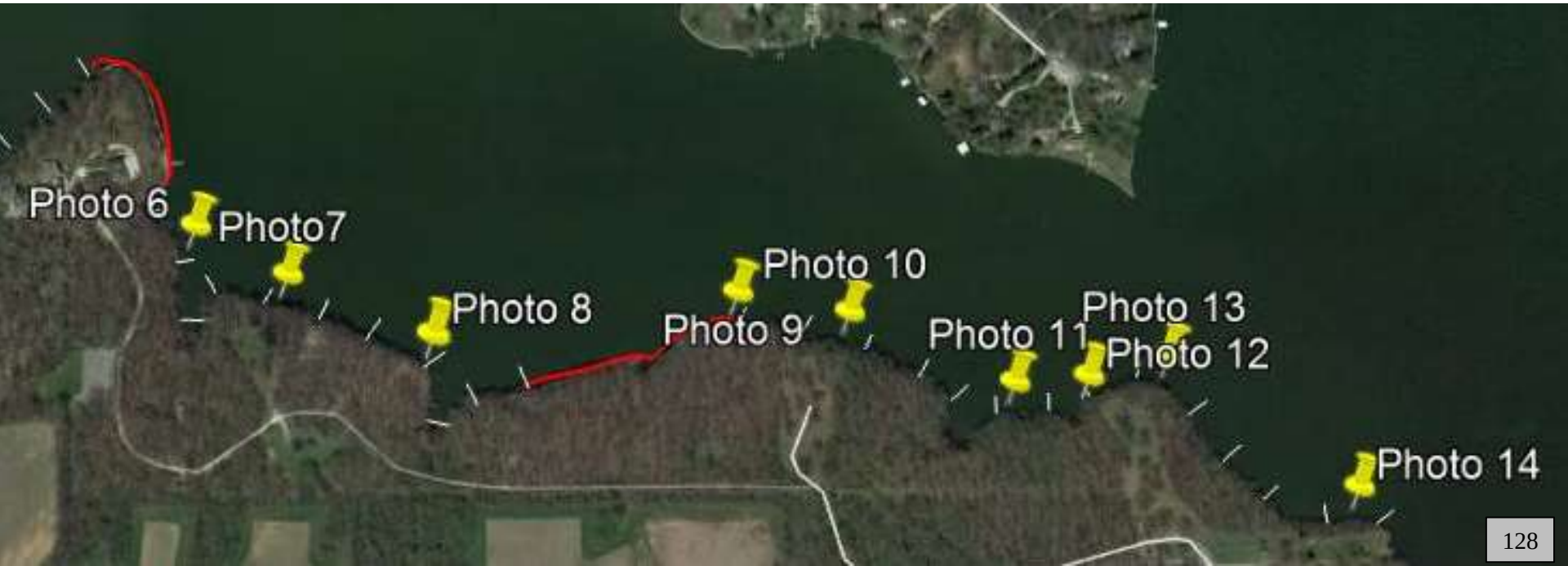
NOTE: Reaches # 1 & # 8 were not surveyed.

Prepared by: Hank Sutton 04/27/20

Slope gradients displayed in this form help the contractor and engineer do a better job of material budgeting.



[redacted] 2018 Shoreline Stabilization Project



A littoral zone survey will determine the true length of the riprap structure and not just the length of shoreline to be protected.

Tabulation of Scale Tickets reported weekly by the contractor

[redacted] Lake - 2010 Shoreline Project

Contractor: Lake Rip Rap, Inc.

Date	Ticket #	Tons	Running Total
5/18/2010	963666	23.70	23.70
5/19/2010	669	22.80	
	671	21.50	
	673	22.95	
	695	18.25	
	697	22.40	
	709	19.35	
	714	21.80	
	730	18.90	
	732	22.85	
	751	19.30	
	757	23.65	
	773	22.00	
	789	21.55	
	791	19.80	
	800	21.25	
	809	[illegible]	
	819	[illegible]	
	822	[illegible]	
	830	[illegible]	
	836	[illegible]	
	845	21.75	
	846	19.35	459.30
5/20/2010	857	22.85	
	859	23.15	
	861	20.75	
	876	20.40	
	878	22.85	
	882	20.75	
	898	22.60	
	901	18.90	
	903	21.55	
	920	23.35	
	924	21.35	
	945	19.60	
	947	22.50	
	973	22.50	
	974	19.25	
	987	23.00	
	988	19.65	
	964004	23.00	
	7	19.90	
	21	22.80	
	27	23.15	453.85

The contractor should be required to submit actual tonnage placed and yield check for each Area on a weekly basis.

Material Budgeting

If this procedure is followed, with yield checks for each area as completed, there will be a good outcome on quantities.

Engineer's Estimated Tonnage per Location (Area)

Area	Est. Tons
A 1	578
B 2	141
C 3	89
D 4	468
E 5	153
F 6	312
G 7	100
H 8	447
I 9	206
J 10	160
N 14	313
OP15	453
Q 16	229
R 17	237
S 18	194
T 19	174
U 20	180
V 21	55
W 22	134
X 23	140
Y 24	313
Z 25	100
AA 26	132
AB 27	100
AC 28	475

AF 31	394
AG 32	69
AH 33	474
AI 34	550
AJ 35	445
AK 36	297
AL 37	280
AM 38	58
AN 39	65
AO 40	83
AP 41	347
AR 42	59
AS 43	118
AT 44	135
AU 45	44
AV 46	88
AW 47	122
AX 48	56
AY 49	544
AAA 50	72
AAB 51	106
AAC 52	168
AAD 53	85
AAE 54	390
AAF 55	184
AAG 56	183
AAH 57	196
AAI 58	99
AAJ 59	116
AAK 60	856

Final Yield Check

Engineer's Estimate: 14,109 tons
Actual Tons Placed: 14,017.8

Final Yield: 99.4% of Engineer's Estimate

Material Budgeting

Flags set by the contractor mark load spacing and correct breakwater alignment.

[redacted] Lake - 2010 Shoreline Project

Weighted Average Water Haul Distance: 1.21 miles

Area	Length	Distance	Combined
A 1	520	1.25	650
B 2	105	0.90	94.5
C 3	85	0.90	76.5
D 4	347	[illegible]	[illegible]
E 5	163	[illegible]	[illegible]
F 6	285	[illegible]	[illegible]
G 7	80	0.80	64
H 8	346	0.80	276.8
I 9	163	0.70	114.1
J 10	154	0.80	123.2
K 11	198	0.90	178.2
L 12	161	1.00	161
M 13	95	1.00	95
N 14	275	1.10	302.5
OP 15	414	1.20	496.8
Q 16	203	1.25	253.75
R 17	191	1.30	248.3
S 18	160	1.30	208
T 19	139	0.90	125.1
U 20	185	1.10	203.5
V 21	55	1.20	66
W 22	102	1.20	122.4
X 23	109	1.10	119.9
Y 24	242	1.00	242
Z 25	77	0.90	69.3
AA 26	96	0.90	86.4
AB 27	74	0.90	66.6
AC 28	344	0.80	275.2
AD 29	65	0.80	52
AE 30	67	1.10	73.7
AF 31	326	1.10	358.6
AG 32	61	0.90	54.9
AH 33	308	0.80	246.4
AI 34	372	0.60	223.2
AJ 35	300	0.60	180
[illegible]	[illegible]	[illegible]	132.6
[illegible]	[illegible]	[illegible]	100
[illegible]	[illegible]	[illegible]	14.1
AN 39	64	0.20	12.8
AO 40	49	0.30	14.7
AP 41	285	1.00	285
AR 42	45	1.00	45
AS 43	80	1.00	80
AT 44	80	1.00	80
AU 45	31	2.25	69.75
AV 46	54	2.40	129.6
AW 47	71	2.60	184.6
AX 48	33	2.60	85.8
AY 49	318	2.60	826.8
AAA 50	71	1.25	88.75
AAB 51	69	2.80	193.2
AAC 52	106	2.80	296.8
AAD 53	55	2.75	151.25
AAE 54	230	2.70	621
AAF 55	143	2.50	357.5
AAG 56	139	2.50	347.5
AAH 57	133	2.60	345.8
AAI 58	70	2.50	175
AAJ 59	88	2.30	202.4
AAK 60	644	1.50	966
Wt. Average	10193	1.21	12332.45

If the bidders are given the weighted average water haul distance, they will be able to submit a better bid.

How the Contractor might use water haul distance for his Bid

Given:

1.21 miles weighted average water haul distance - 2.42 miles round trip

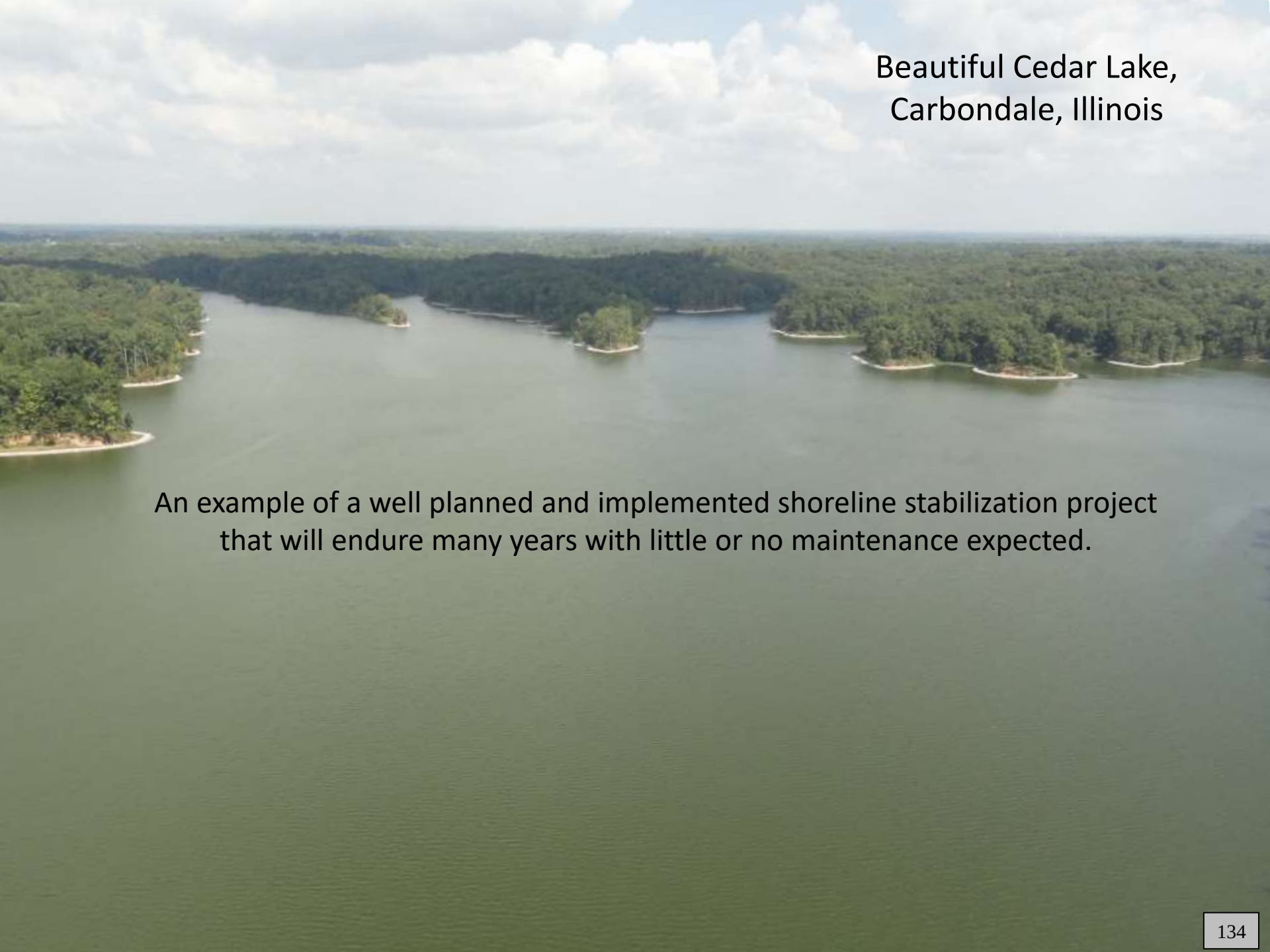
If the boat has a payload of 20 tons (a random figure for this illustration)

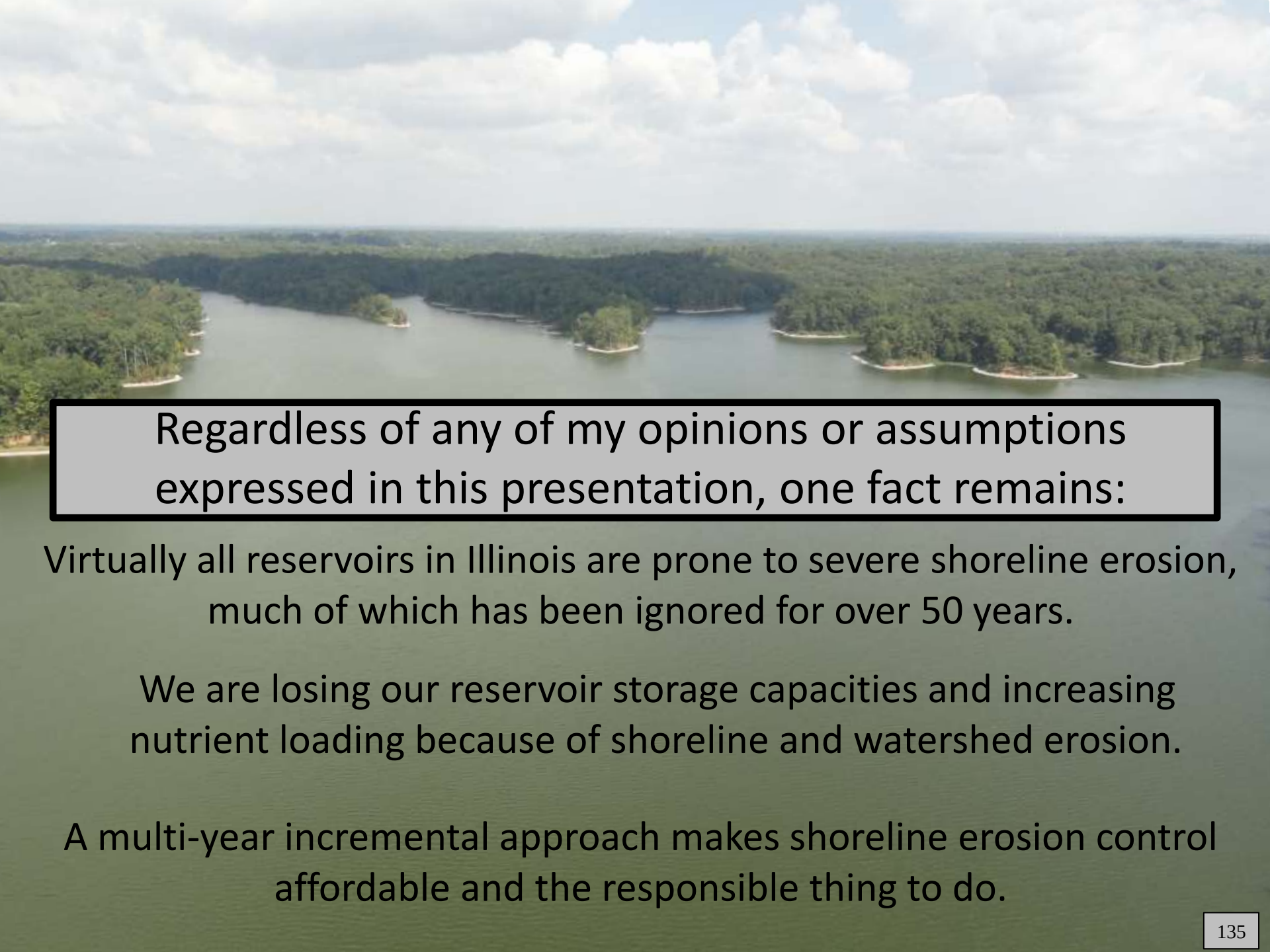
Engineers estimated tons - 14,109 tons divided by 20 tons = 706 round trips

706 trips X 2.42 miles = **1,708 miles** total cruising miles for the project

(distance equals Chicago to Seattle at bicycle speed)

At prevailing wage rates, the time required for cruising is a very significant component of the bid.


Beautiful Cedar Lake,
Carbondale, Illinois
An example of a well planned and implemented shoreline stabilization project that will endure many years with little or no maintenance expected.

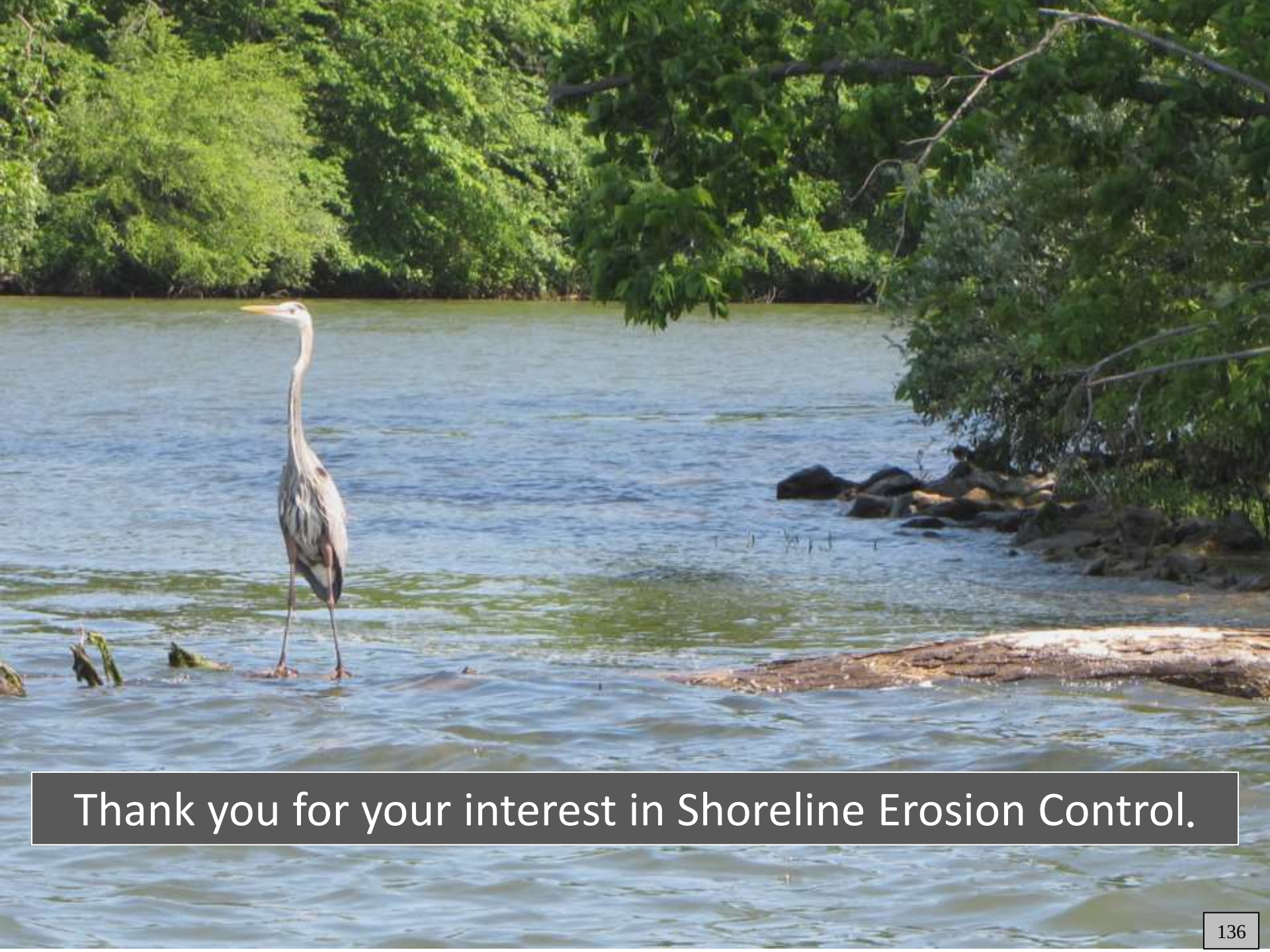


Regardless of any of my opinions or assumptions expressed in this presentation, one fact remains:

Virtually all reservoirs in Illinois are prone to severe shoreline erosion, much of which has been ignored for over 50 years.

We are losing our reservoir storage capacities and increasing nutrient loading because of shoreline and watershed erosion.

A multi-year incremental approach makes shoreline erosion control affordable and the responsible thing to do.



Thank you for your interest in Shoreline Erosion Control.

Questions?

Shoreline Metrics

Your critique or discussion, of opinions and conclusions expressed here, are always welcome.

Lake Rip Rap, Inc. ***has reorganized as*** ***Shoreline Metrics, LLC***

Contact: Hank Sutton (217) 899-9706 - hank@ShorelineMetrics.com

www.ShorelineMetrics.com

Link to Bioengineered Shoreline: Chicago Botanic Garden