City of Ramsey Mississippi River Bank Condition Inventory

Prepared by the

ANOKA CONSERVATION DISTRICT

for
the City of Ramsey
February 2016

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Executive Summary

The City of Ramsey contracted the Anoka Conservation District to complete an inventory of riverbank condition along the entire 5.8 miles of City that border the Mississippi River. The inventory provides the City with a comprehensive record of bank condition. Ten stretches of riverbank with severe or very severe erosion were identified, which if stabilized, would reduce sediment loading to the river by 5,148 tons per year.

The inventory is structured as this report as well as an atlas. The report provides details on the methodology used to estimate bank erosion severity and potential benefits provided by stabilizing the most severely eroding sections of riverbank. The 10 most severely eroding sections of riverbank are also detailed in the report with individual site profiles to highlight additional information and potential solutions. The atlas is presented in Appendix A and provides a complete record of aerial photographs with the corresponding erosion severity categorizations and key pictures collected during the field work portion of this effort. As not all pictures are presented in the atlas, the final deliverables also include the complete picture inventory collected in early December 2015.

Methods

Field Work

The project scope was determined to be the entire 5.8 miles of City that border the Mississippi River. An atlas of the target area was printed prior to conducting the field work to serve as a navigation tool on the river and ensure complete coverage of the riverbank.

The inventory was conducted on December 10th and 11th, 2015. The timing was optimal because the river level was relatively low, bank vegetation was dormant, and snow had not yet fallen to obscure the bank. Other times of the year were considered for the inventory, but frequent high water levels in the spring, dense bank vegetation in the summer, and river ice and snow on the bank in the winter all prevented the collection of a useful picture inventory.

The inventory crew consisted of two Anoka Conservation District (ACD) staff members. A small boat was used to navigate the river and take geotagged pictures using a handheld GPS. These pictures can be viewed similar to pictures taken on a standard camera, but they also contain spatial information (i.e. X and Y coordinates). This feature allows them to be accurately mapped in GIS software. In order to take high quality photos, the boat navigated at idle speed typically between 50 and 100 feet from shore depending on water depth.

Wisconsin NRCS Direct Volume Method – Bank Recession Rate Categorizations

The picture inventory was used to digitize a polyline in GIS along the entire riverbank. Using the Wisconsin NRCS Direct Volume Method, the polyline was classified as slight, moderate, severe, or very severe with respect to erosion severity (Table 1). These erosion categorizations were then converted to lateral recession rates using the table below for use in soil loss calculations.

Table 1: Erosion severity categories.

Symbol	Category	Lateral Recession Rate (ft/yr)	Description
	Slight	0.01—0.05	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang. No exposed tree roots.
	Moderate	0.06—0.2	Bank is predominantly bare with some rills and vegetative overhang. Some exposed tree roots but no slumps or slips.
	Severe	0.3—0.5	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross section becomes U-shaped as opposed to V-shaped.
	Very Severe	>0.5	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains, and culverts eroding out and changes in cultural features as above. Massive slips and washouts common. Channel cross section is U-shaped and stream course may be meandering.

Soil Loss Estimation

Any section of riverbank identified as either severe or very severe was included in a site profile for more detailed analysis. The analysis consisted of calculating the following variables for every section of severe or very severe erosion (Appendix B).

- ***Depth (D)***: horizontal distance from the toe to the top of the bank; calculated using GIS
- ***Height (H)***: vertical height; measured with November 2011 LiDAR elevation data using GIS
- ***Slope Length (SL)***: length of diagonal slope; calculated using depth and height measurements
- ***Recession Rate (RR)***: annual lateral recession of bank (0.4 ft/yr for severe erosion and 0.75 ft/yr for very severe erosion)
- ***Length (L)***: length of the erosion along the river; calculated using GIS

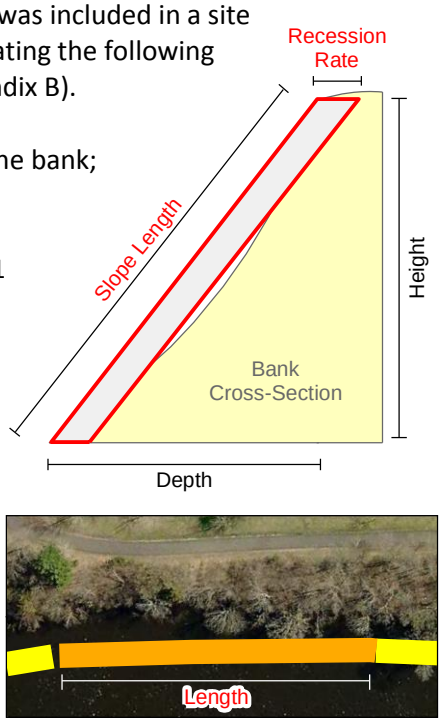


Figure 1: Diagrams of variables used for soil loss estimation.

These variables (Figure 1) were used in the equation below to estimate the annual soil loss. Sandy soil weighs approximately 100 pounds per cubic foot.

$$\frac{SL(ft) * RR(ft/yr) * L(ft) * 100(lb/ft^3)}{2000(lb/ton)} = \textbf{Estimated Soil Loss (tons/year)} \qquad \text{Equation 1}$$

Atlas Generation

All of this information was used to create an inventory atlas of the pool which can be found in Appendix A. The atlas contains erosion severity and photos of the shoreline.

Results

Erosion Severity

Most of the riverbank inventoried had limited erosion (Table 2). Approximately 78% of the riverbank was categorized as either slight (40%) or moderate (38%) erosion severity. This corresponds to a lateral recession rate of 0.0 – 0.2 ft/yr.

Table 2: Summary of erosion severity.

Erosion Severity	Length (miles)	%
Slight	2.32	40%
Moderate	2.21	38%
Severe	0.64	11%
Very Severe	0.60	10%
Total	5.78	100%

In contrast, 11% of the shoreline was categorized as severe and 10% as very severe (Table 2). These categories have lateral recession rates of 0.3 – >0.5 ft/yr.

Table 3: Severe and very severe erosion on public and private lands.

	Severe		Very Severe	
Ownership	Length (miles)	%	Length (miles)	%
Public	0.27	42%	0.37	61%
Private	0.37	58%	0.24	39%
Total	0.64	100%	0.60	100%

Overall, shoreline categorized as either severe or very severe is distributed relatively evenly between public and private ownership (51% and 49%, respectively). However, when looking at the severe and very severe categories individually, the breakdown is not as evenly balanced (Table 3). Public land has a lower percentage of the total severe sections (42%) and a higher percentage of the total very severe sections (61%).

Estimated Soil Loss

The total length of riverbank categorized with severe or very severe erosion is relatively equal between the two categories (Table 4). However, because of the higher lateral recession rate in the very severe sections (i.e. 0.75 ft/yr), those sections represent the majority (77%) of the estimated soil loss.

Table 4: Estimated soil loss by erosion severity.

Erosion Severity	Length (miles)	Estimated Soil Loss (tons/yr)	%
Severe	0.64	1174	23%
Very Severe	0.60	3974	77%
Total	1.24	5148	100%

Stabilization Considerations

The goal of most riverbank projects is to correct or prevent excessive erosion or undercutting through bank stabilization. Stabilization of eroding riverbanks is highly site-specific; there is not a simple solution that can be applied across all sites. For example, factors such as position along the river (e.g. outside bend), river dynamics (e.g. flow and flood elevations), and site accessibility must be considered individually for each project. That being said, stabilization approaches generally fall into two categories: hard armoring and bioengineering.

Hard armoring uses physical structures to protect the riverbank; riprap is used commonly for hard armoring. Riprap does not necessarily need to extend to the top of the slope to be effective and can be inter-planted with native species to soften its appearance. Often times, hard armoring the toe of the slope (i.e. the very bottom) up to a moderate height (e.g. the 2-year flood elevation) is sufficient for stabilizing the rest of the bank.

Bioengineering approaches combine engineering techniques with ecological principles to stabilize the bank. They rely heavily on deep-rooted native plants along with a variety of other natural materials to reinforce and stabilize eroding riverbanks. Bioengineering also incorporates the goals of fish and wildlife habitat restoration, maintenance of water quality, and aesthetic considerations. In addition to bank stabilization, many benefits are achieved through bioengineering:

- Improved aquatic and terrestrial habitat,
- Increased connectivity among habitats along the riverbank,
- Decreased water temperatures through shading, and
- Improved soil and water quality.

The stabilization solution for an eroding riverbank could certainly use a combination of hard armoring and bioengineering. In fact, ACD often recommends this combination on large river systems such as the Mississippi River because of the benefits provided by both approaches.

Possible Stabilization Approaches

Stabilization of riverbanks can be achieved through many different approaches. Below is a list of some common stabilization approaches (both bioengineering and hard armoring) to correct erosion issues. Again, a combination of approaches is often specified as the most effective solution.

- Restoration of Native Vegetation – Deep-rooted, native vegetation creates a buffer along the riverbank that can provide stabilization and minimize erosion. Furthermore, if the bank is damaged, the vegetation has the ability to self-heal with additional growth.
- Cedar Tree Revetment – Anchoring Eastern Red Cedar trees to the toe of the slope reduces water velocities near the bank to protect against erosion. Furthermore, the reduced water velocities promote sedimentation and can actually help rebuild the bank. This provides a cost-effective bioengineering option for moderate to severely eroding riverbanks.
- Live Staking – Dormant, live stakes of native species (e.g. Sandbar Willow) can be installed to establish a dense plant community with high stem density that will stabilize the riverbank.
- Hard Armoring – Hard armoring of the bank may be necessary along riverbanks on large systems that experience the greatest erosive forces (e.g. outside bends). However, it is often not necessary to hard armor the entire bank from the toe of the slope to the top of the bank. Rather, the hard armoring can extend to a predetermined elevation (e.g. 2-year or 5-year flood elevation), above which could be stabilized using the establishment of native vegetation. Furthermore, the sections that are hard armored can often be live staked to provide additional stabilization value, wildlife habitat, and improved shoreline aesthetics.

- Bank Reshaping – Reshaping a severely eroding riverbank may be necessary in order to stabilize vertical, bare banks. This approach must be coupled with other stabilization techniques because in and of itself it does not provide any stabilization benefits. It only creates a bank with suitable slopes for other stabilization approaches.

Favorable Practices for Riverbank Property Owners

Managing a riverbank can present a difficult challenge for property owners. Often times, a misunderstanding of factors that contribute to erosion can actually exacerbate the issue. Below is a list of practices that should be followed by property owners adjacent to rivers in order to minimize erosion and protect their property.

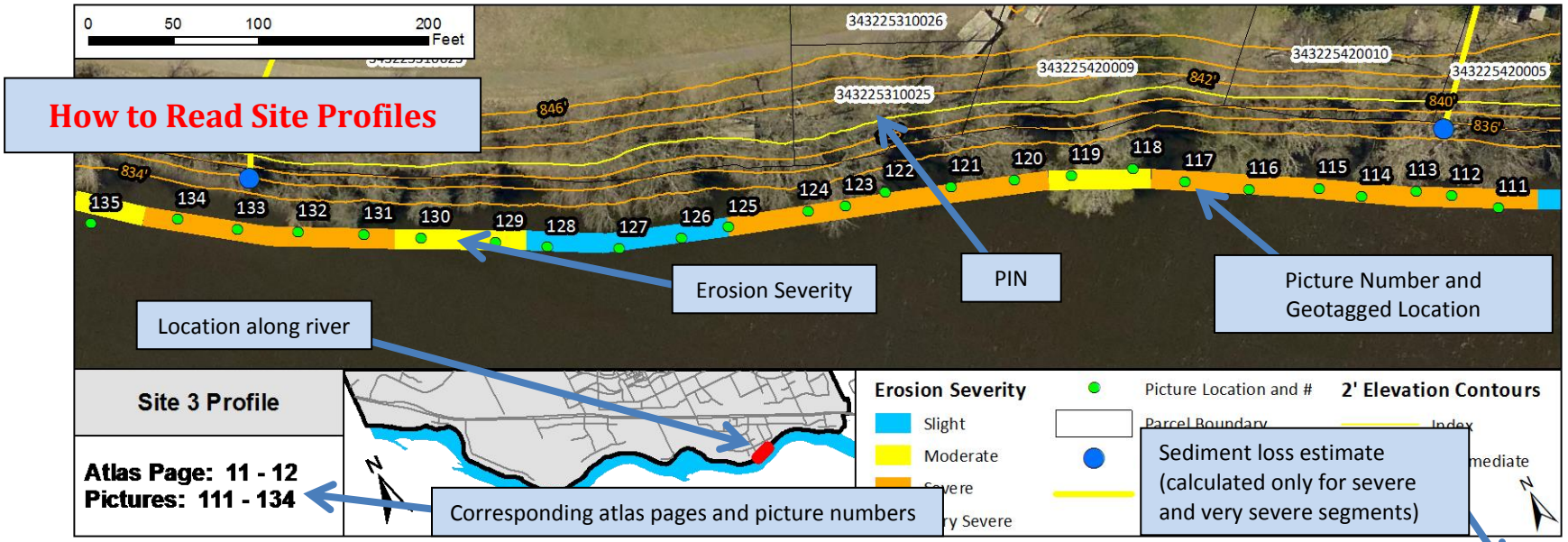
- Avoid mowing near the edge of the bluff or riverbank. Turf grasses have very shallow root systems, providing little soil stability. Deeper rooted species are also better at filtering out excess nutrients and sediments in runoff.
- Control runoff from downspouts and other hard surfaces at the top of the slope to prevent it from flowing over the riverbank. Promote infiltration of rain water into the soil but away from the riverbank where possible, or provide a pipe conduit down to the water's edge to transport water if necessary.
- Dispose of yard waste properly to avoid smothering riverbank vegetation and contributing nutrients to the river, which commonly occurs when leaves and grass clippings are thrown over the riverbank.
- Plant desirable species with preference for multi-stemmed plants with deep, dense, fibrous root systems. However, ensure the species are well suited to the soil type, moisture level, and available sunlight or they will not thrive.
- Prune lower branches on trees to increase the amount of light that penetrates to the ground. This will increase plant growth at ground level where the stems, roots, and foliage will help keep soil in place.
- Remove buckthorn, which is an invasive plant that is believed to release a natural herbicide that suppresses nearby plant growth.
- Remove fallen trees because they can redirect water toward the bank and exacerbate erosive river forces.
- Remove grapevines, which smother trees, shade out understory species, and provide little soil stabilization benefits.

Site Profiles

Detailed site profiles were created for stretches of riverbank throughout which severe or very severe erosion was documented. Table 5 below summarizes key information for each of the 10 site profiles. Following the table are the detailed site profiles that include a map of the site, a general description of the problem, and potential practices to address the erosion. Please note that potential solutions are speculative, and formal designs would need to be prepared prior to completing any stabilization work.

Table 5: Summary of site profiles.

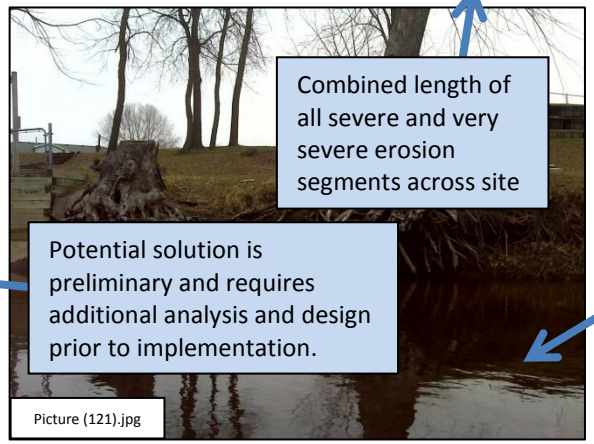
PROPERTY INFORMATION			ERODING FACE INFORMATION					
Site Profile #	**Ownership**	**PIN**	**Length (ft)**	**Height (ft)**	**Depth (ft)**	**Slope (H:V)**	**Recession Rate (ft/yr)**	**Soil Loss (tons/yr)**
1	Private	353225320005	111	12	25	2.1:1	0.4	61.6
2	Private	343225410004	116	22	36	1.6:1	0.4 - 0.75	123.0
3	Private/Anoka County (5 properties)	343225420005 343225420010 343225420009 343225310025 343225310023	566	6 - 10	22 - 40	3.7 - 4.2:1	0.4	323.7
4	Anoka County (3 properties)	343225320001 343225230003 333225110003	1227	4 - 16	7 - 30	1.8 - 2.5:1	0.4 - 0.75	821.0
5	Anoka County (4 properties)	333225110003 333225110002 333225120001 333225120005	1920	4 - 20	8 - 33	1.5 - 2.0:1	0.4 - 0.75	1869.6
6	Private (4 properties)	283225330011 283225330010 283225330009 293225440001	412	6	15 - 24	2.5 - 4.0:1	0.4	152.0
7	Private (2 properties)	293225340001 293225330005	653	4 - 12	7 - 24	1.7 - 2.5:1	0.4 - 0.75	280.4
8	Private (8 properties)	293225330003 293225330002 293225330001 293225320007 293225320006 293225320005 293225320003 303225410012	589	8 - 22	12 - 33	1.5 - 1.9:1	0.4 - 0.75	653.5
9	Private (7 properties)	303225110030 303225110010 303225110013 303225110011 303225110012 193225430014 193225430015	639	6 - 24	11 - 35	1.5 - 2.1:1	0.4 - 0.75	770.9
10	Private (4 properties)	193225430017 193225430018 193225430021 193225430003	325	6 - 8	11 - 14	1.8:1	0.4	92.4

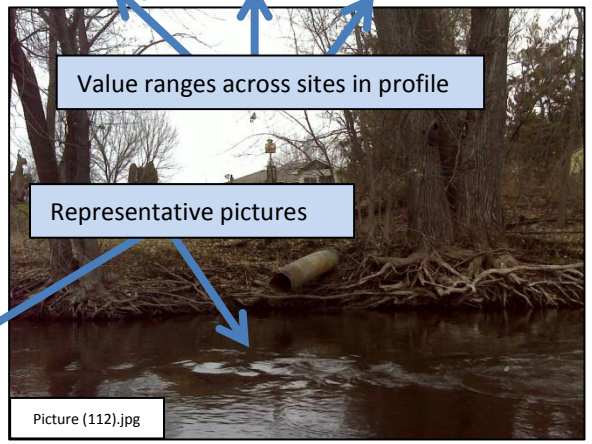


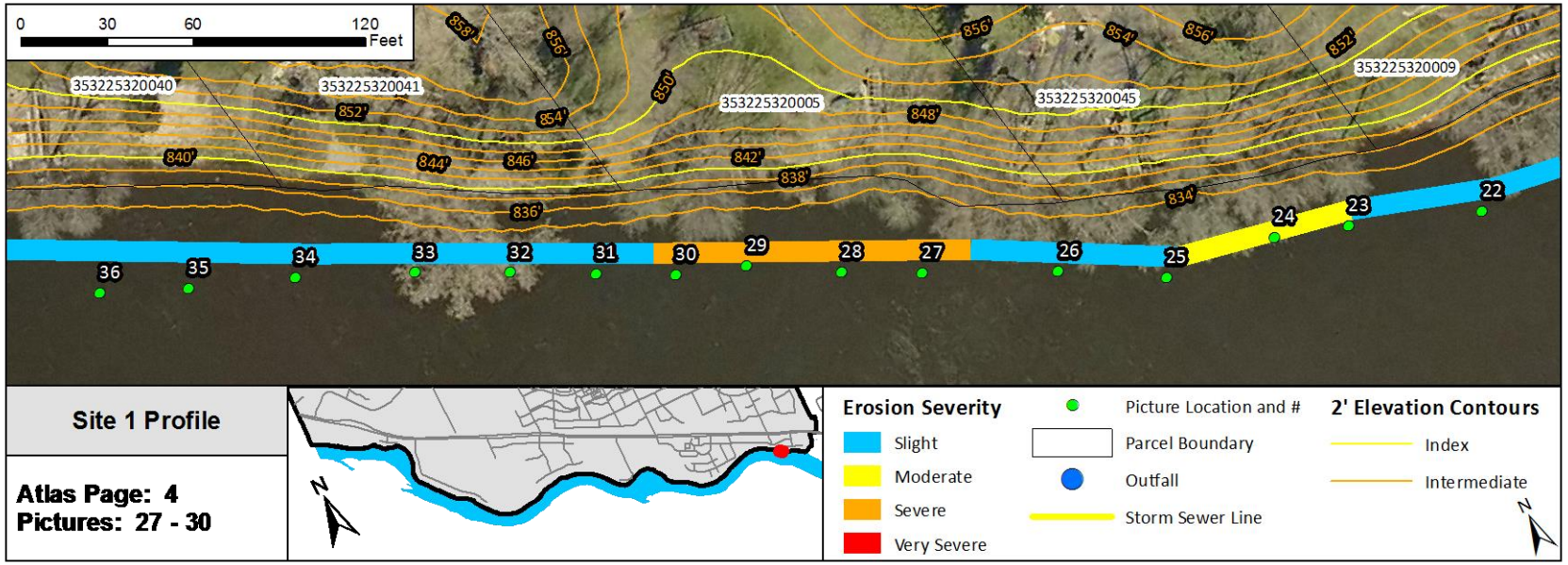
Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private/Anoka County	566	6 - 10	22 - 40	3.7 - 4.2	323.7

Additional Information: This site consists of five properties, four of which are private and one public (Anoka County). Erosion severity was categorized as severe because of the many exposed tree roots and undercut banks.

Potential Solution: Preservation of some of the severely undercut trees could be difficult, and regrading of the bank may be necessary. Stabilization could be accomplished using a combination of hard armoring at the toe of the slope and bioengineering on the upper portions of the bank.







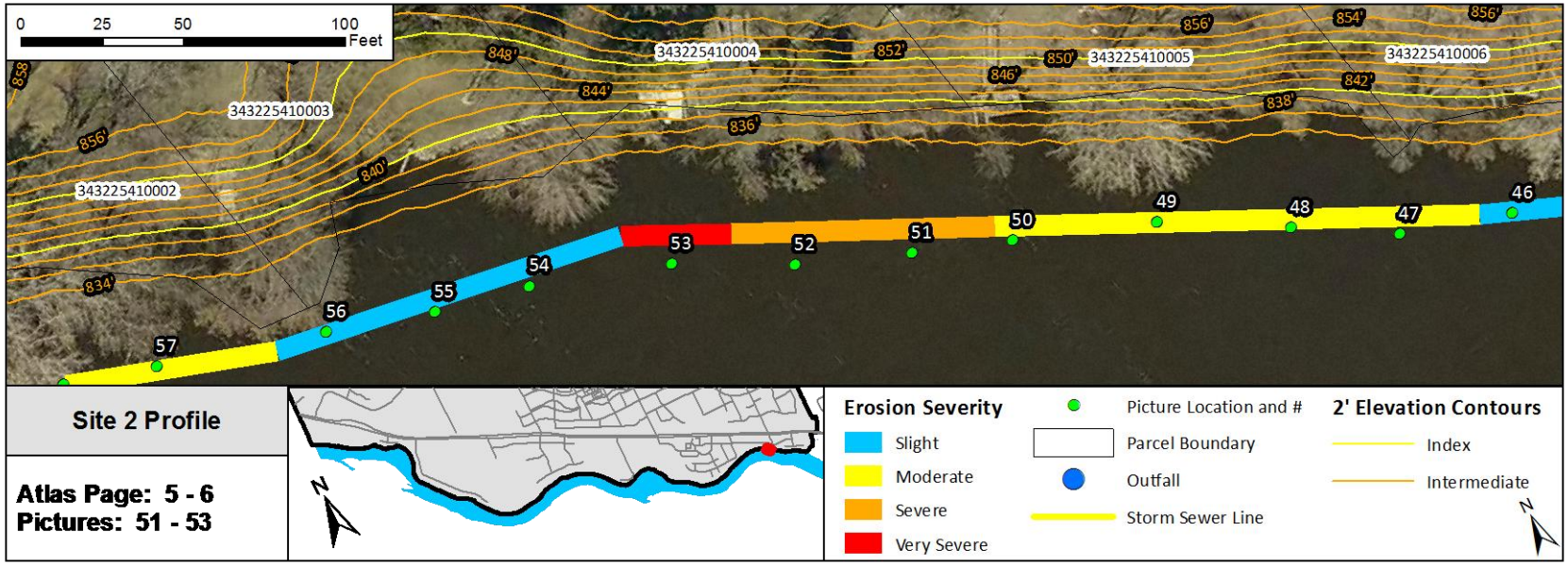
Additional Information: This site consists of one private residential property. Erosion severity was categorized as severe because of the many exposed tree roots and several areas with bank slumps.

Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private	111	12	25	2.1:1	61.6

Potential Solution: Stabilization of the riverbank could be accomplished using a combination of hard armoring at the toe of the slope and bioengineering on the upper portions of the bank. A cedar tree revetment could also be a possibility. Thinning of the canopy may be necessary to promote growth of native vegetation on the upper portions of the bank.


Picture (30).jpg


Picture (28).jpg



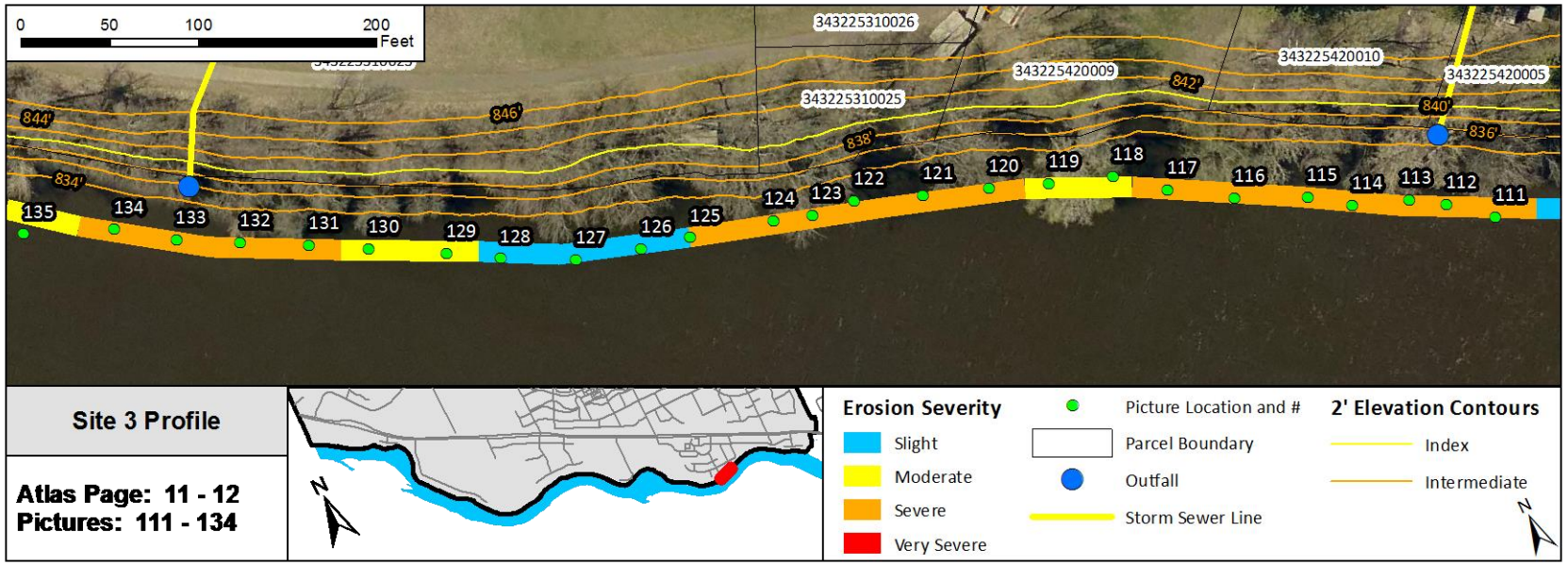
Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private	116	22	36	1.6	123.0

Additional Information: This site consists of one private residential property. Erosion severity was categorized as severe and very severe. The many fallen trees on the upstream stretch of the property resulted in the very severe categorization.

Potential Solution: Stabilization of the riverbank could be accomplished using a combination of hard armoring at the toe of the slope and bioengineering on the upper portions of the bank. Because of the large bank slumps, regrading of the bank will likely be required.


Picture (53).jpg


Picture (51).jpg



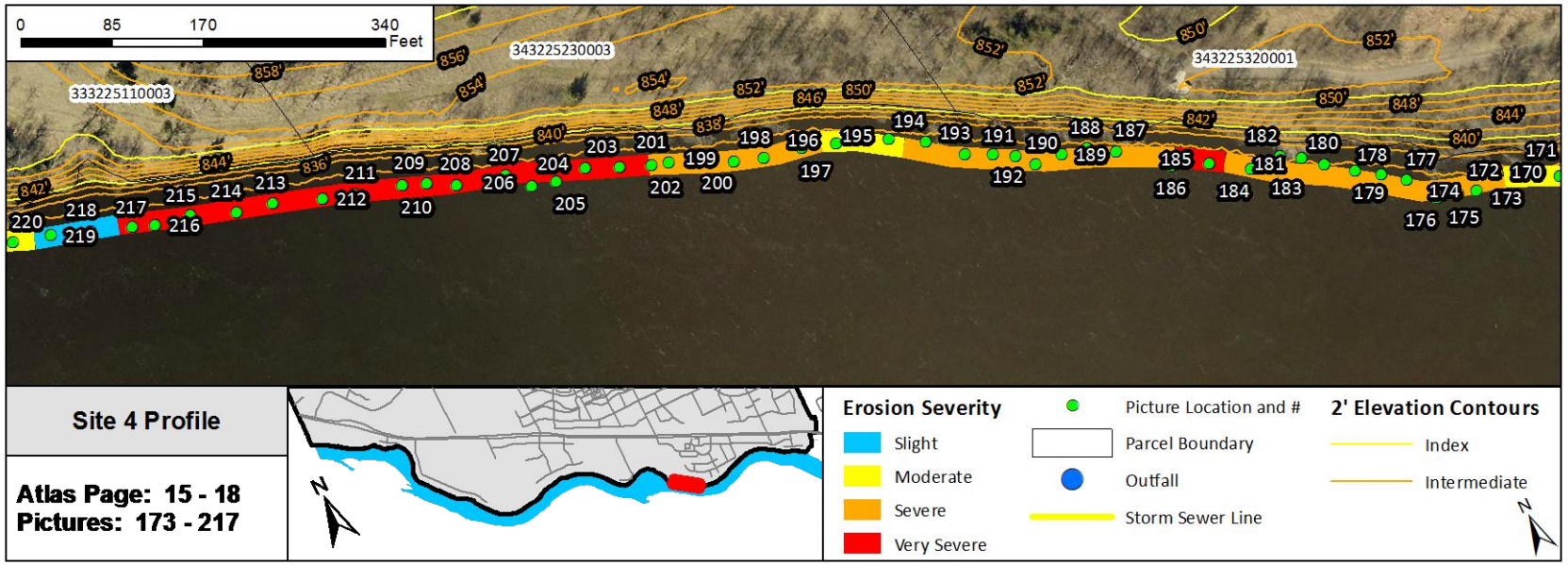
Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private/Anoka County	566	6 - 10	22 - 40	3.7 - 4.2	323.7

Additional Information: This site consists of five properties, four of which are private and one public (Anoka County). Erosion severity was categorized as severe because of the many exposed tree roots and undercut banks.

Potential Solution: Preservation of some of the severely undercut trees could be difficult, and reshaping the bank may be necessary. Stabilization could be accomplished using hard armoring at the toe of the slope and bioengineering on the upper portions of the bank. Cedar tree revetments may also be an option.


Picture (121).jpg


Picture (112).jpg



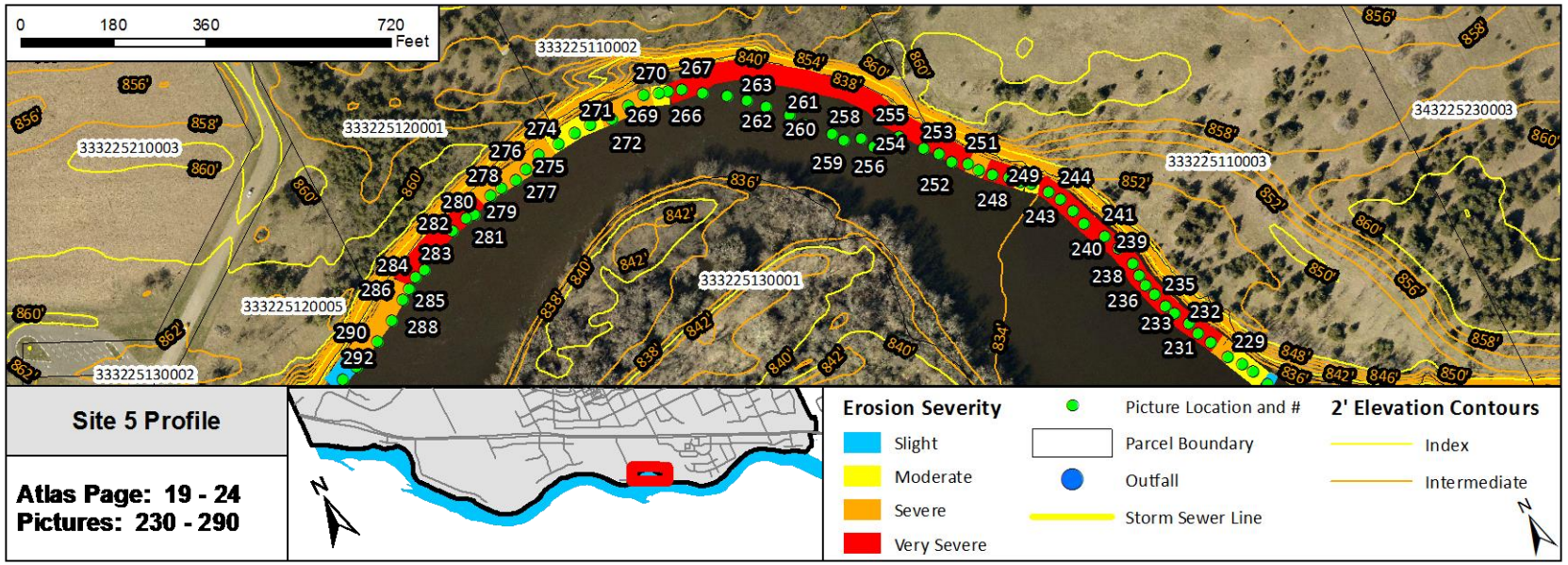
Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Anoka County	1227	4 - 16	7 - 30	1.8 - 2.5	821.0

Additional Information: This site consists of three parcels, all of which are owned by Anoka County. Erosion ranged from severe to very severe along this section with one small area categorized as moderate. The large sections of bare bank were categorized as very severe.

Potential Solution: Stabilization of some areas categorized as severe could be stabilized using cedar tree revetments and native vegetation. The sections of steep, bare bank could be stabilized using a combination of regrading, hard armoring at the toe of the slope, and bioengineering.


Picture (208).jpg


Picture (187).jpg



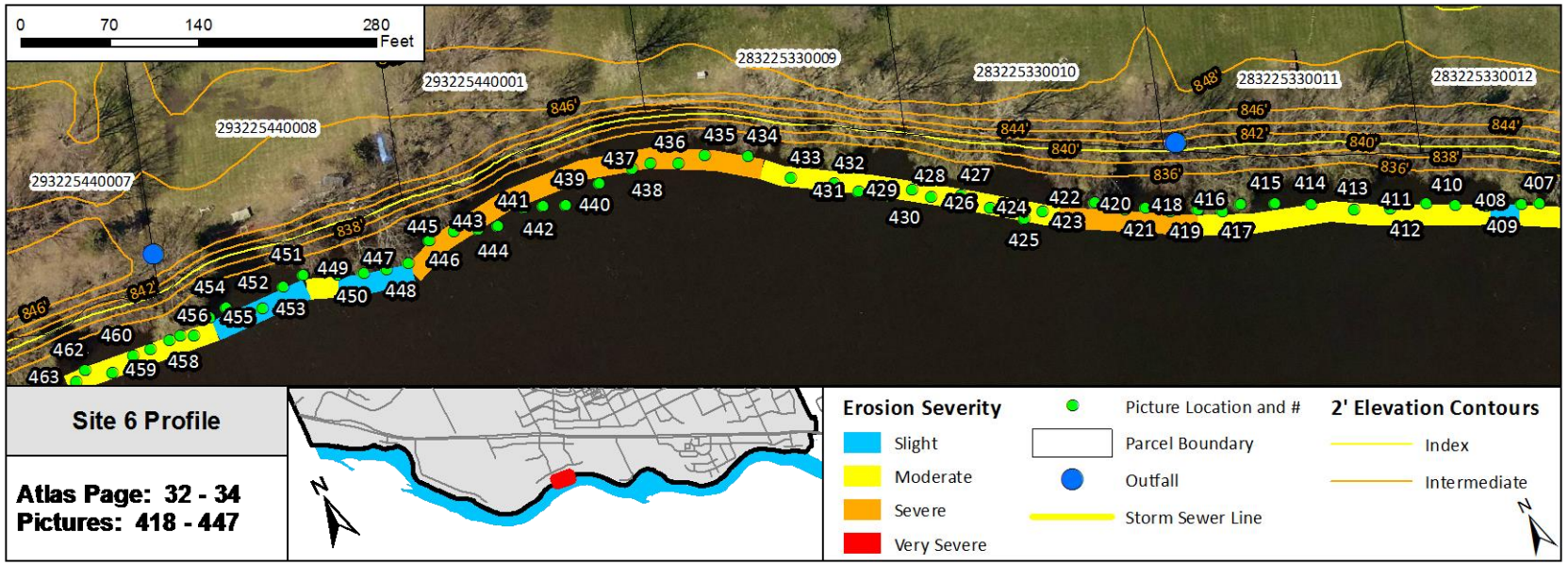
Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Anoka County	1920	4 - 20	8 - 33	1.5 - 2.0	1869.6

Additional Information: This site consists of four parcels, all of which are owned by Anoka County. Erosion ranged from severe to very severe along this section with short sections categorized as moderate. The large sections of bare bank were categorized as very severe.

Potential Solution: Stabilization of some areas categorized as severe could be stabilized using cedar tree revetments and native vegetation. The sections of steep, bare bank could be stabilized using a combination of regrading, hard armoring at the toe of the slope, and bioengineering.


Picture (259).jpg


Picture (235).jpg



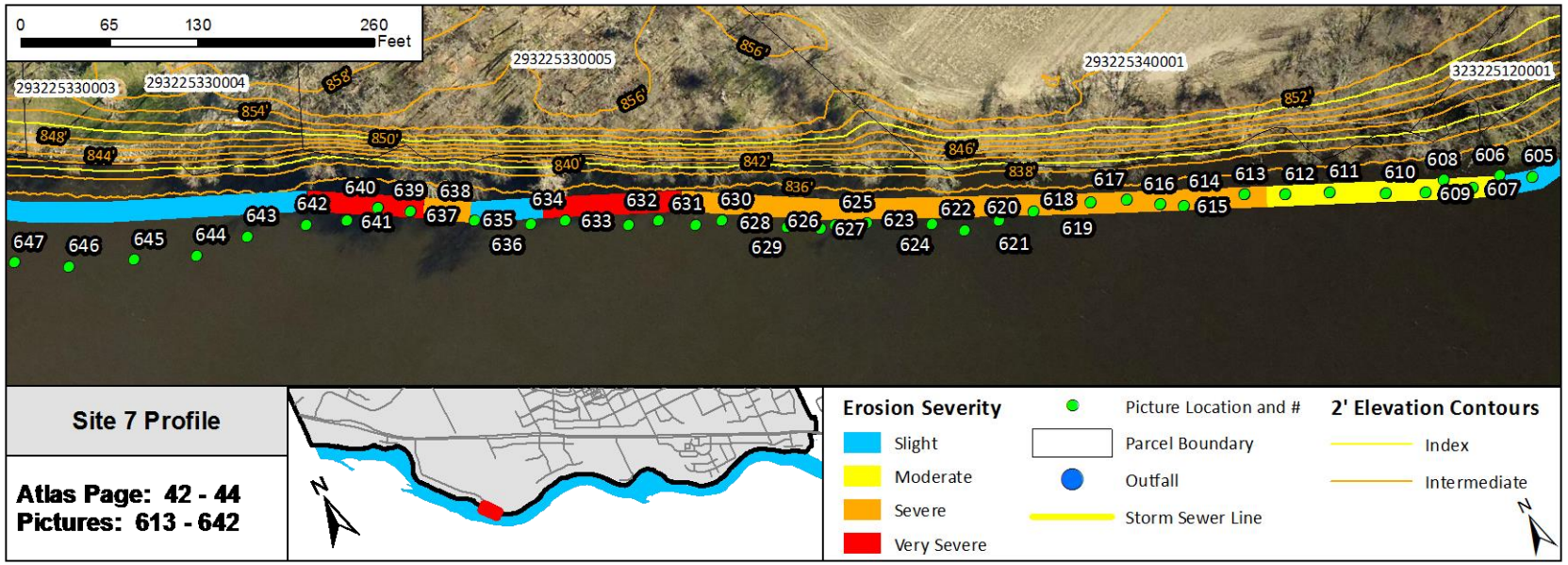
Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private	412	6	15 - 24	2.5 - 4.0	152.0

Additional Information: Two sections of severe erosion span a total of four privately owned properties in this site profile. The many exposed tree roots and bank undercutting resulted in the severe categorization.

Potential Solution: Much of the erosion could possibly be addressed using cedar tree revetments inter-planted with native vegetation (e.g. Sandbar Willow or Buttonbush). Areas with more severe undercutting may need to be regraded and may warrant hard armoring at the toe with native vegetation higher on the bank.


Picture (443).jpg


Picture (420).jpg



Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private	653	4 - 12	7 - 24	1.7 - 2.5	280.4

Additional Information:
Erosion at this site spans two private properties and ranges from severe to very severe. Much of the severe erosion consists of exposed tree roots and some bank undercutting. The very severe sections have fallen trees and bare bank.

Potential Solution: The severe sections may be effectively stabilized with cedar tree revetments and native vegetation (e.g. Sandbar Willow or Buttonbush). Areas with fallen trees and bare bank may need to be regraded and hard armored at the toe with native vegetation farther up the bank.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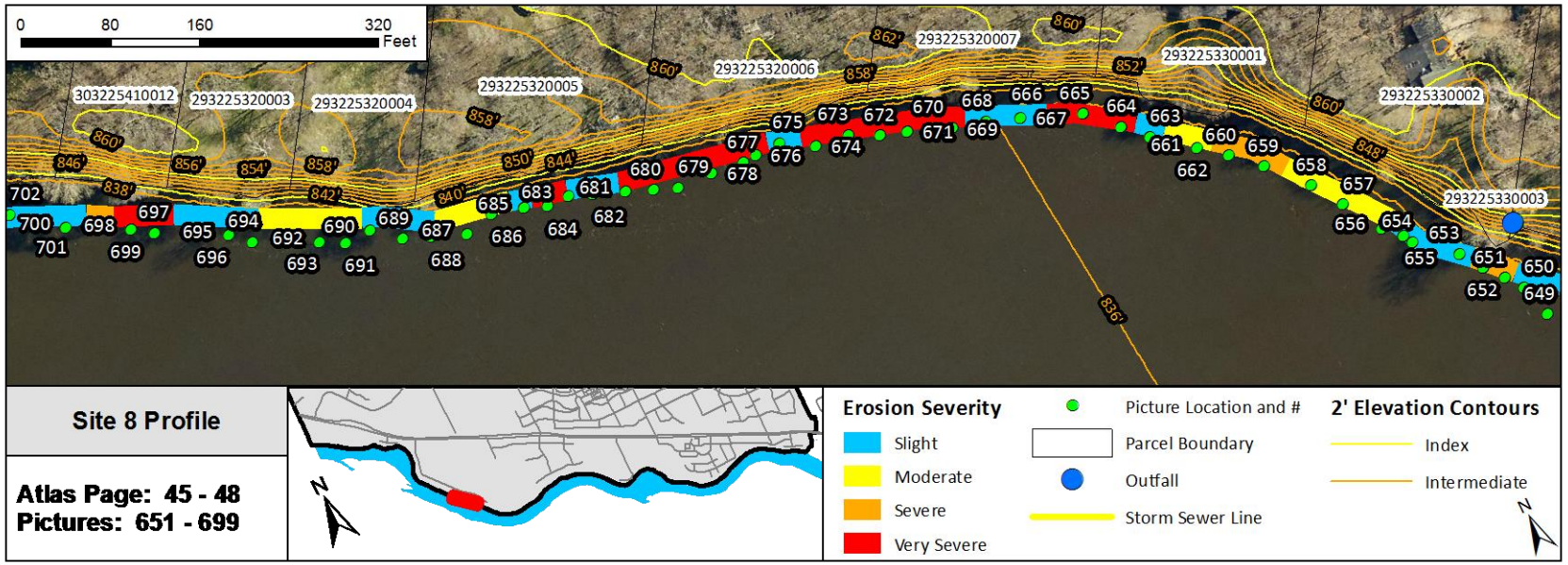
Picture (623).jpg



Additional Information:
Erosion at this site spans eight private properties and ranges from severe to very severe. The very severe sections have fallen trees and bare bank.

Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private	589	8 - 22	12 - 33	1.5 - 1.9	653.5

Potential Solution: Most of the erosion sections are very severe and will likely require regrading of the bank. Hard armoring of the slope toe up to a modest elevation (e.g. 2-year or 5-year flood elevation) with native vegetation establishment on the remaining areas higher up the bank may be an effective stabilization option.


Picture (698).jpg


Picture (670).jpg

Additional Information:
Erosion at this site spans seven private properties and ranges from severe to very severe, with most areas categorized as very severe. The very severe sections have fallen trees and bare bank.

Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private	639	6 - 24	11 - 35	1.5 - 2.1	770.9

Potential Solution: Most of the erosion sections are very severe and will likely require regrading of the bank. Hard armoring of the slope toe up to a modest elevation (e.g. 2-year or 5-year flood elevation) with native vegetation establishment on the higher bank areas may be an effective stabilization option.


Picture (844).jpg


Picture (813).jpg

Site Information	Ownership	Erosion Length (ft) Severe/Very Severe	Height (ft)	Depth (ft)	Slope (H:V)	Soil Loss (tons/yr)
	Private	325	6 - 8	11 - 14	1.8	92.4

Additional Information: Two sections of severe erosion span four private properties in this site profile. The erosion is characterized by exposed tree roots and some undercutting of the bank.

Potential Solution: Much of the erosion could possibly be addressed using cedar tree revetments inter-planted with native vegetation (e.g. Sandbar Willow or Buttonbush). Areas with more severe undercutting may need to be regraded and may warrant hard armoring at the toe with native vegetation higher on the bank.

Appendix A

Atlas

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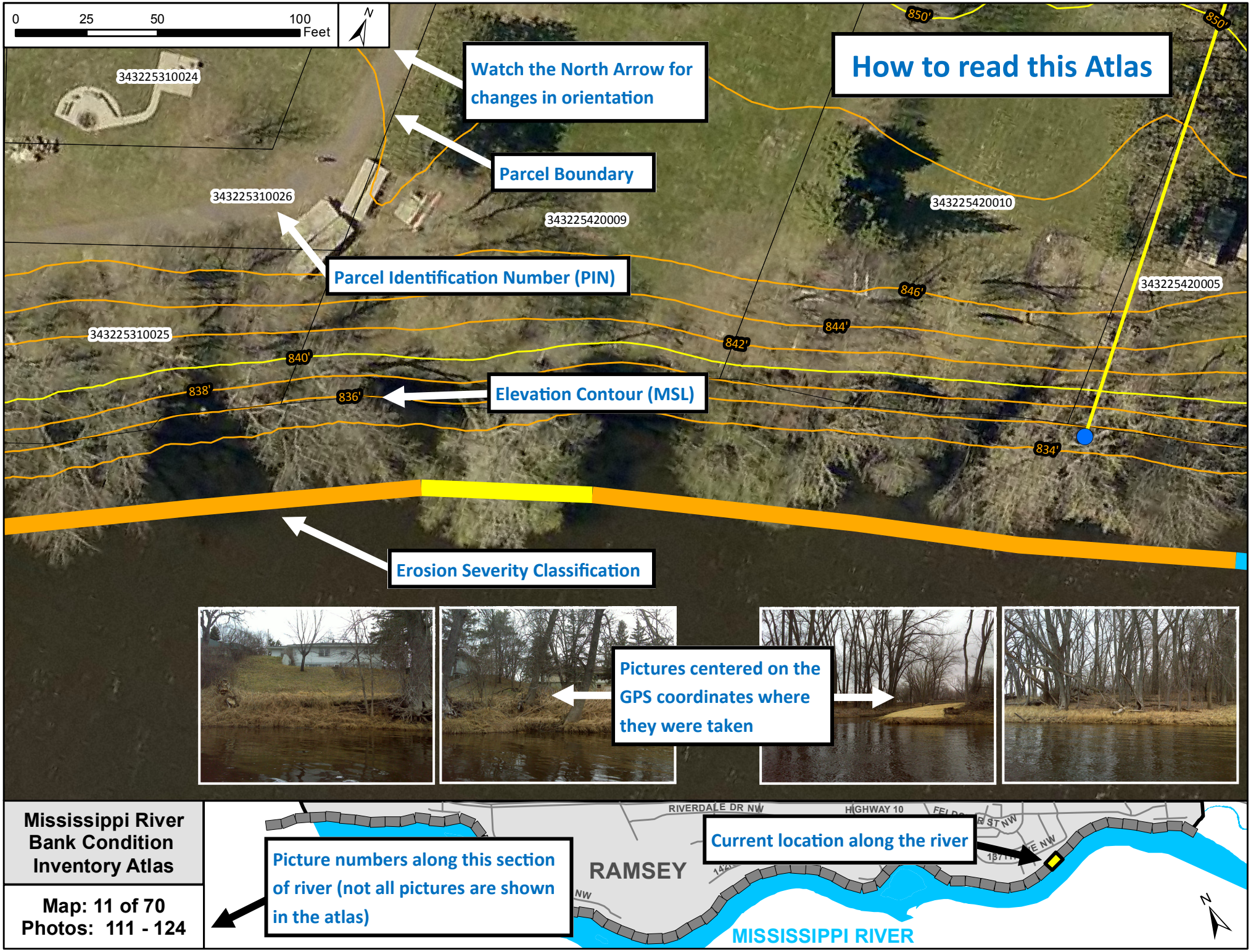

0 25 50 100 Feet
N
How to read this Atlas
Watch the North Arrow for changes in orientation
Parcel Boundary
Parcel Identification Number (PIN)
Elevation Contour (MSL)
Erosion Severity Classification
Pictures centered on the GPS coordinates where they were taken
343225310024
343225310026
343225310025
343225420009
343225420010
343225420005
850'
846'
844'
842'
840'
838'
836'
834'
Mississippi River Bank Condition Inventory Atlas
Map: 11 of 70
Photos: 111 - 124
Picture numbers along this section of river (not all pictures are shown in the atlas)
Current location along the river
RAMSEY
RIVERDALE DR NW
HIGHWAY 10
MISSISSIPPI RIVER

Inventory Atlas Legend

Erosion Severity

Symbol	Category	Lateral Recession Rate (ft/yr)	Description
	Slight	0.01—0.05	Some bare bank but active erosion not readily apparent. Some rills but no vegetative overhang. No exposed tree roots.
	Moderate	0.06—0.2	Bank is predominantly bare with some rills and vegetative overhang. Some exposed tree roots but no slumps or slips.
	Severe	0.3—0.5	Bank is bare with rills and severe vegetative overhang. Many exposed tree roots and some fallen trees and slumps or slips. Some changes in cultural features such as fence corners missing and realignment of roads or trails. Channel cross section becomes U-shaped as opposed to V-shaped.
	Very Severe	>0.5	Bank is bare with gullies and severe vegetative overhang. Many fallen trees, drains, and culverts eroding out and changes in cultural features as above. Massive slips and washouts common. Channel cross section is U-shaped and stream course may be meandering.

Other Features

2' Elevation Contours

Index

Intermediate

Parcel Boundary

Storm Sewer Line

Outfall

0 25 50 100 Feet

N

858'
850'
842'
840'
838'
856'
854'
846'
834'
836'
852'
844'
353225310036
353225310035
353225340001
353225320027
353225320035





Mississippi River Bank Condition Inventory Atlas

Map: 1 of 70
Photos: 1 - 9

0 25 50 100 Feet

N

353225320031

353225320032

353225320033

353225320034

353225320035

858'

856'

850'

846'

844'

854'

852'

858'

848'

838'

840'

842'

836'

834'

Mississippi River Bank Condition Inventory Atlas

Map: 2 of 70
Photos: 10 - 16

0 25 50 100 Feet

N

353225320029

353225320009

353225320045

353225320028

353225320030

353225320031

858'

856'

854'

852'

850'

848'

846'

844'

842'

840'

838'

836'

834'

Mississippi River Bank Condition Inventory Atlas

Map: 3 of 70
Photos: 17 - 25

0 25 50 100 Feet

N

858'
860'
858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'
834'

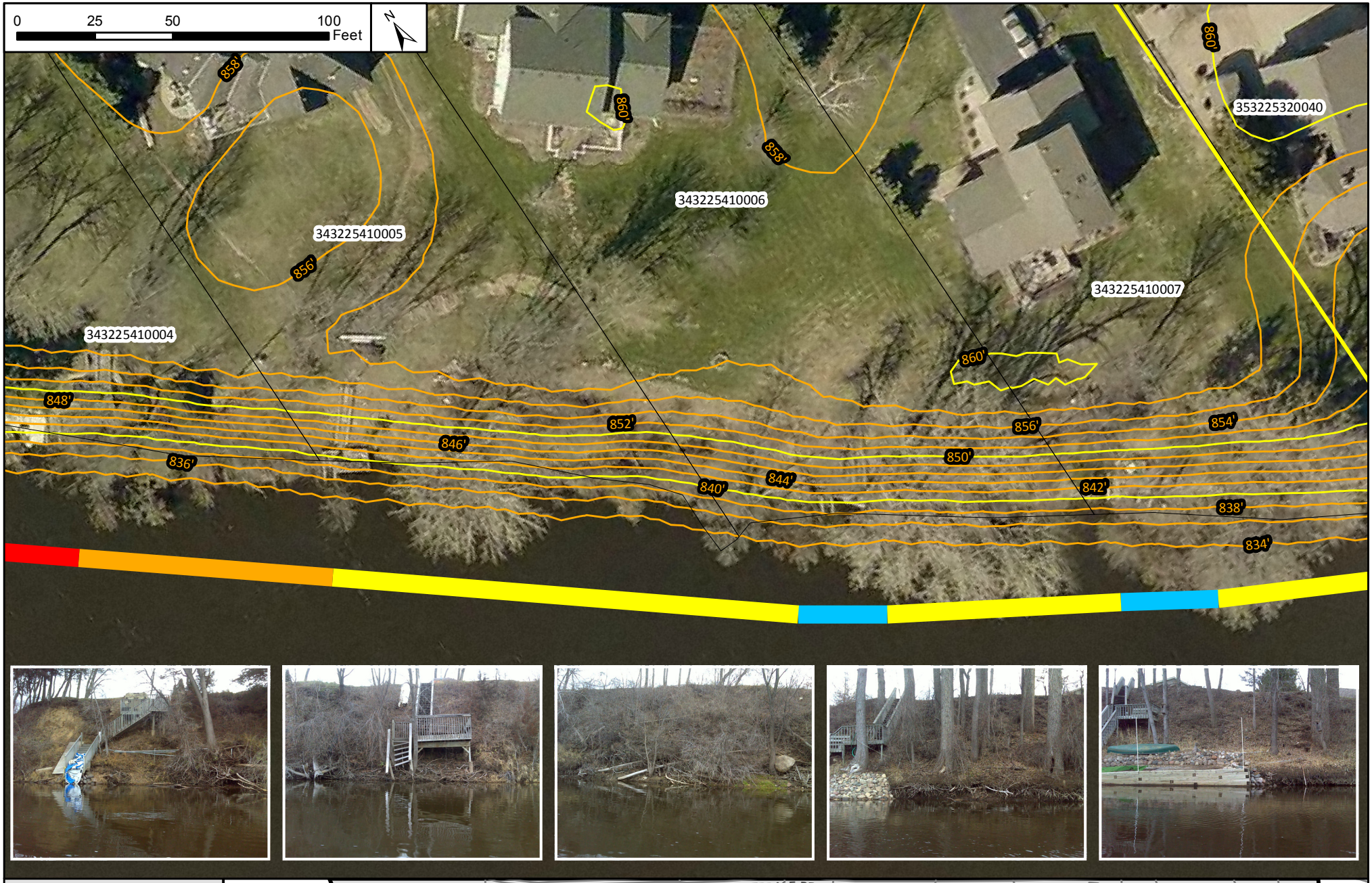
353225320009
353225320045
353225320005
353225320041
353225320040
343225410007





Mississippi River Bank Condition Inventory Atlas

Map: 4 of 70
Photos: 26 - 39



Mississippi River Bank Condition Inventory Atlas

Map: 5 of 70
Photos: 40 - 53

0 25 50 100 Feet

N

862'
860'
858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'
834'

343225410004
343225410003
343225410008
343225410002
343225140028





Mississippi River Bank Condition Inventory Atlas

Map: 6 of 70
Photos: 54 - 63

0 25 50 100 Feet

N

858'

858'

343225140028

343225140029

850'

856'

844'

852'

854'

846'

848'

842'

840'

838'

836'

834'

Mississippi River Bank Condition Inventory Atlas

Map: 7 of 70
Photos: 64 - 74

0 25 50 100 Feet

N

858'

856'

858'

343225140029

854'

850'

852'

848'

846'

844'

842'

838'

840'

834'

836'

Mississippi River Bank Condition Inventory Atlas

Map: 8 of 70
Photos: 75 - 85

0 25 50 100 Feet

N

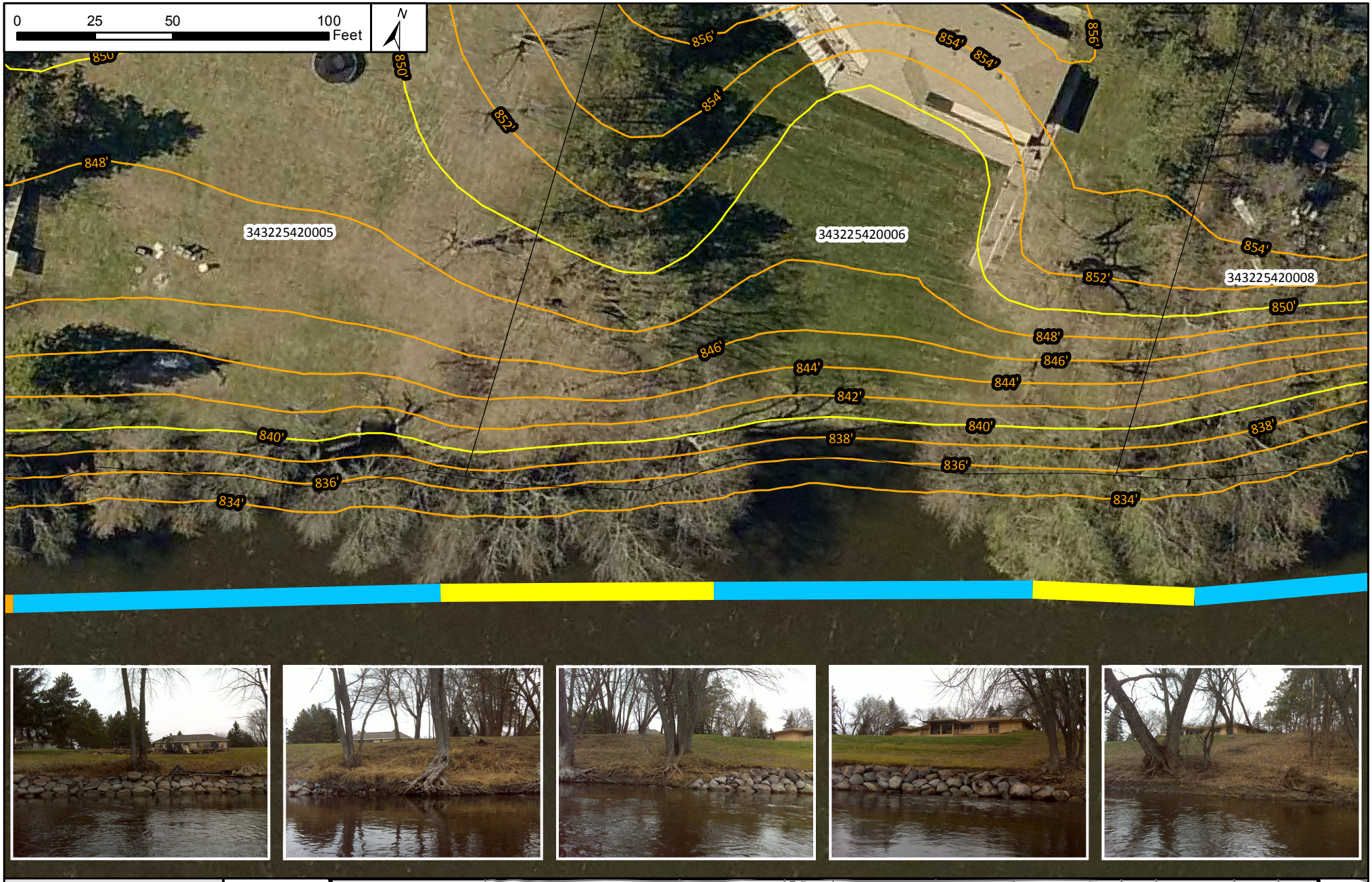
343225420008

343225420003

343225140029

Mississippi River Bank Condition Inventory Atlas

Map: 9 of 70
Photos: 86 - 97



Mississippi River Bank Condition Inventory Atlas

Map: 10 of 70
Photos: 98 - 110

0 25 50 100 Feet

N

343225310024

343225310026

343225310025

343225420009

343225420010

343225420005

850'

848'

846'

844'

842'

840'

838'

836'

834'

Mississippi River Bank Condition Inventory Atlas

Map: 11 of 70
Photos: 111 - 124

0 25 50 100 Feet

N

848'
846'
842'
844'
840'
838'
836'
834'

343225310024
343225310026
343225310023
343225310025





Mississippi River Bank Condition Inventory Atlas

Map: 12 of 70
Photos: 125 - 135

0 25 50 100 Feet

N

844'
842'
840'
846'
848'
343225310023
836'
838'
834'





Mississippi River Bank Condition Inventory Atlas

Map: 13 of 70
Photos: 136 - 148

0 25 50 100 Feet

N

850'
850'
848'
846'
844'
842'
840'
838'
836'
834'

343225320001

343225310023





Mississippi River Bank Condition Inventory Atlas

Map: 14 of 70
Photos: 149 - 163

0 25 50 100 Feet

N

852'

850'

852'

343225320001

850'

848'

846'

844'

842'

838'

840'

836'

834'

Mississippi River Bank Condition Inventory Atlas

Map: 15 of 70
Photos: 164 - 181

0 25 50 100 Feet

N

856' 854' 852' 850' 848' 846' 844' 842' 840' 838' 836' 834'

343225320001

343225230003





Mississippi River Bank Condition Inventory Atlas

Map: 16 of 70
Photos: 182 - 196

0 25 50 100 Feet

N

862'
860'
858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'
834'

343225230003





Mississippi River Bank Condition Inventory Atlas

Map: 17 of 70
Photos: 197 - 210

0 25 50 100 Feet

N

333225110003

343225230003

860'
858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'
834'





Mississippi River Bank Condition Inventory Atlas

Map: 18 of 70
Photos: 211 - 223

0 25 50 100 Feet

852'
850'
848'
846'
844'
842'
840'
838'
836'
834'

333225110003





Mississippi River Bank Condition Inventory Atlas

Map: 19 of 70
Photos: 224 - 238

0 25 50 100 Feet

N

860'
858'
856'
852'
333225110003
852'
846'
842'
838'
840'
848'
850'
854'
844'
836'
834'





Mississippi River Bank Condition Inventory Atlas

Map: 20 of 70
Photos: 239 - 252

0 25 50 100 Feet

N

858'

856'

860'

333225110002

333225110003

860'

856'

854'

858'

846'

850'

844'

842'

838'

840'

848'

852'

836'

Mississippi River Bank Condition Inventory Atlas

Map: 21 of 70
Photos: 253 - 264

0 25 50 100 Feet

N

860'

333225110002

856'

854'

856'

852'

846'

848'

850'

844'

840'

838'

842'

333225120001

836'

Mississippi River Bank Condition Inventory Atlas

Map: 22 of 70
Photos: 265 - 275

0 25 50 100 Feet

N

860'
856'
856'
333225120001
856'
852'
854'
858'
846'
844'
842'
848'
850'
840'
836'
838'
333225110002





Mississippi River Bank Condition Inventory Atlas

Map: 23 of 70
Photos: 276 - 286

0 25 50 100 Feet

N

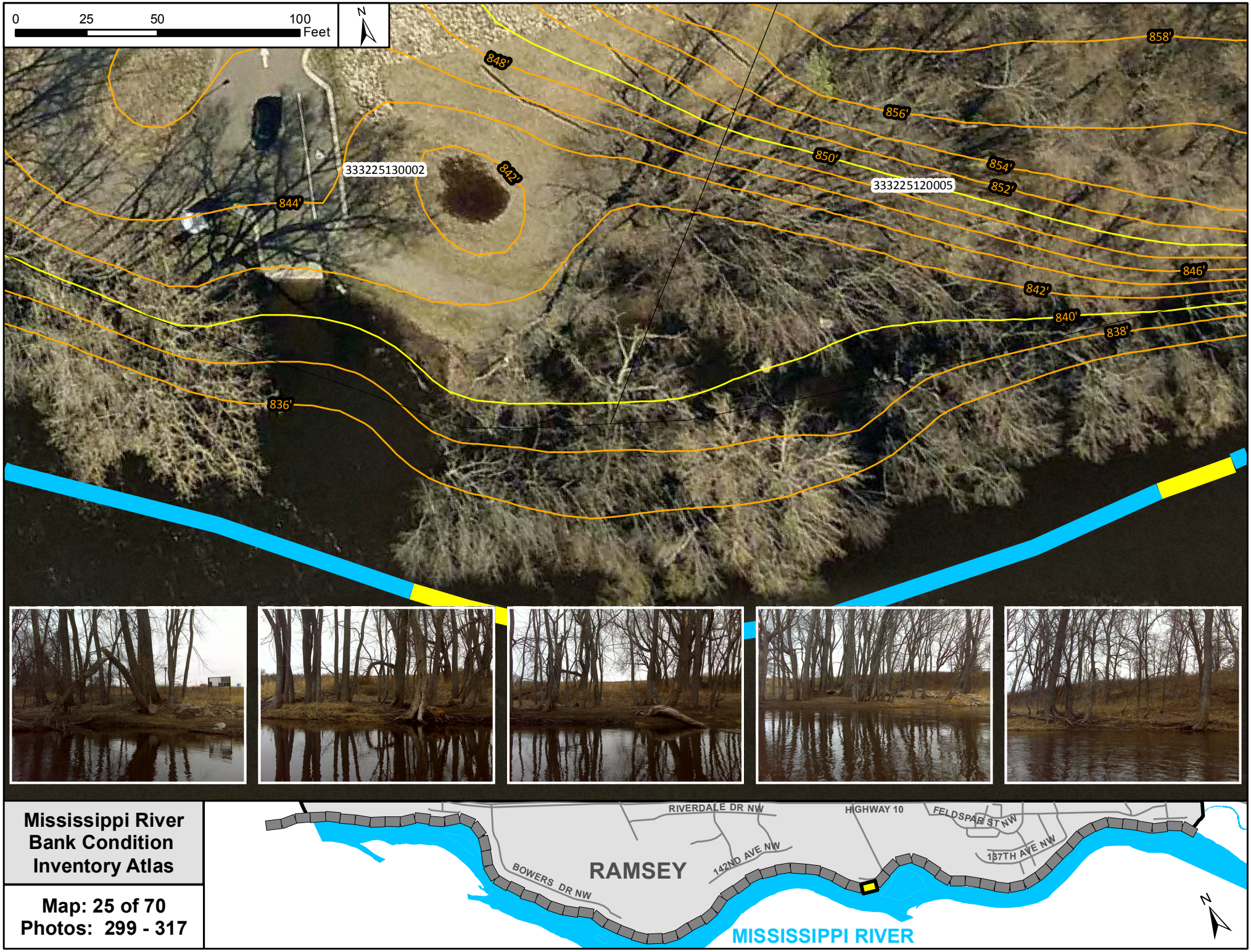
862'
860'
860'
858'
862'
333225120005
333225120001
852'
850'
854'
856'
848'
846'
844'
842'
840'
838'
836'





Mississippi River Bank Condition Inventory Atlas

Map: 24 of 70
Photos: 287 - 298



Mississippi River Bank Condition Inventory Atlas

Map: 25 of 70
Photos: 299 - 317

0 25 50 100 Feet

N

858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'

333225210003

333225130002



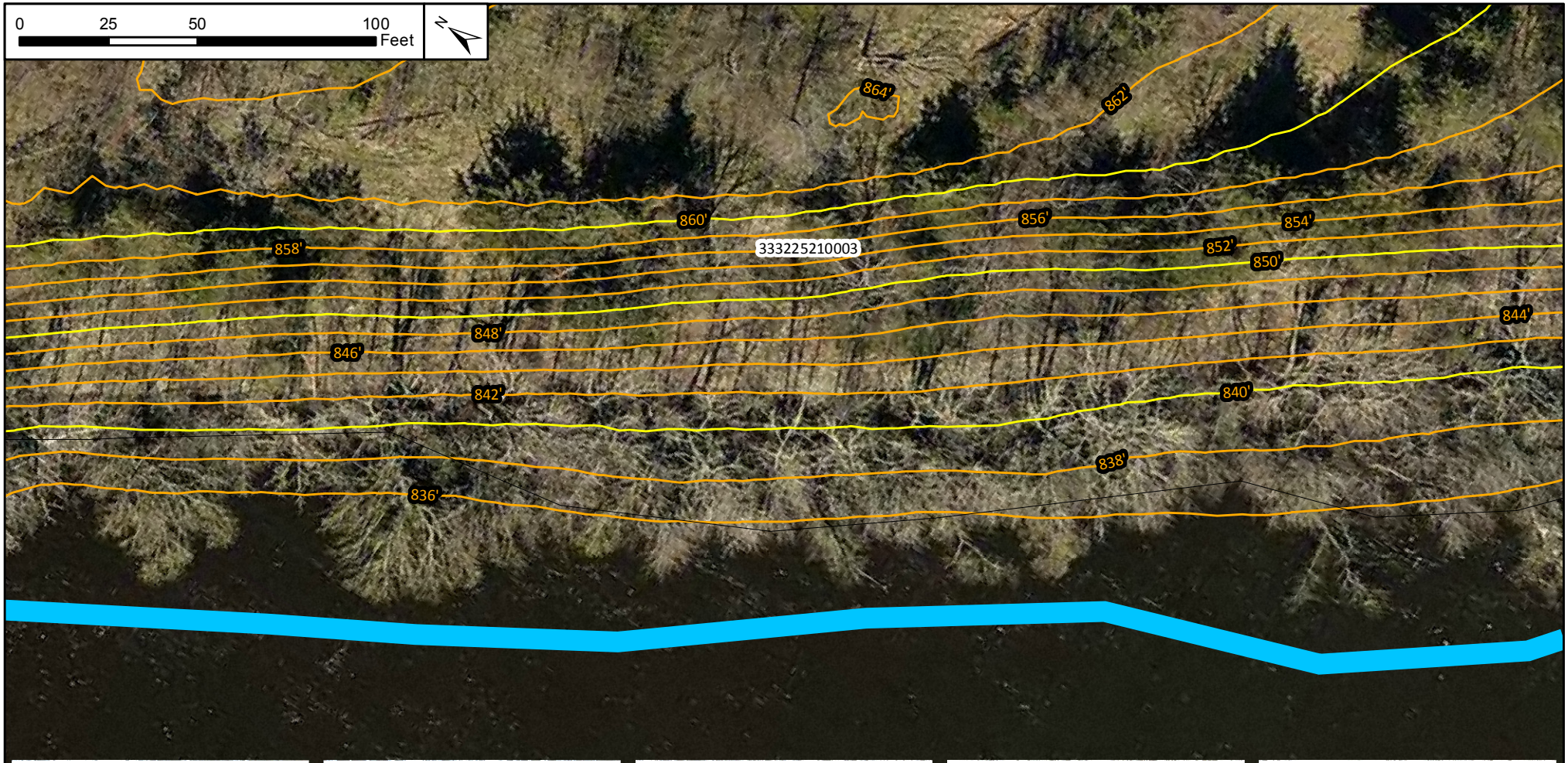


Mississippi River Bank Condition Inventory Atlas

Map: 26 of 70
Photos: 318 - 331

0 25 50 100 Feet

N

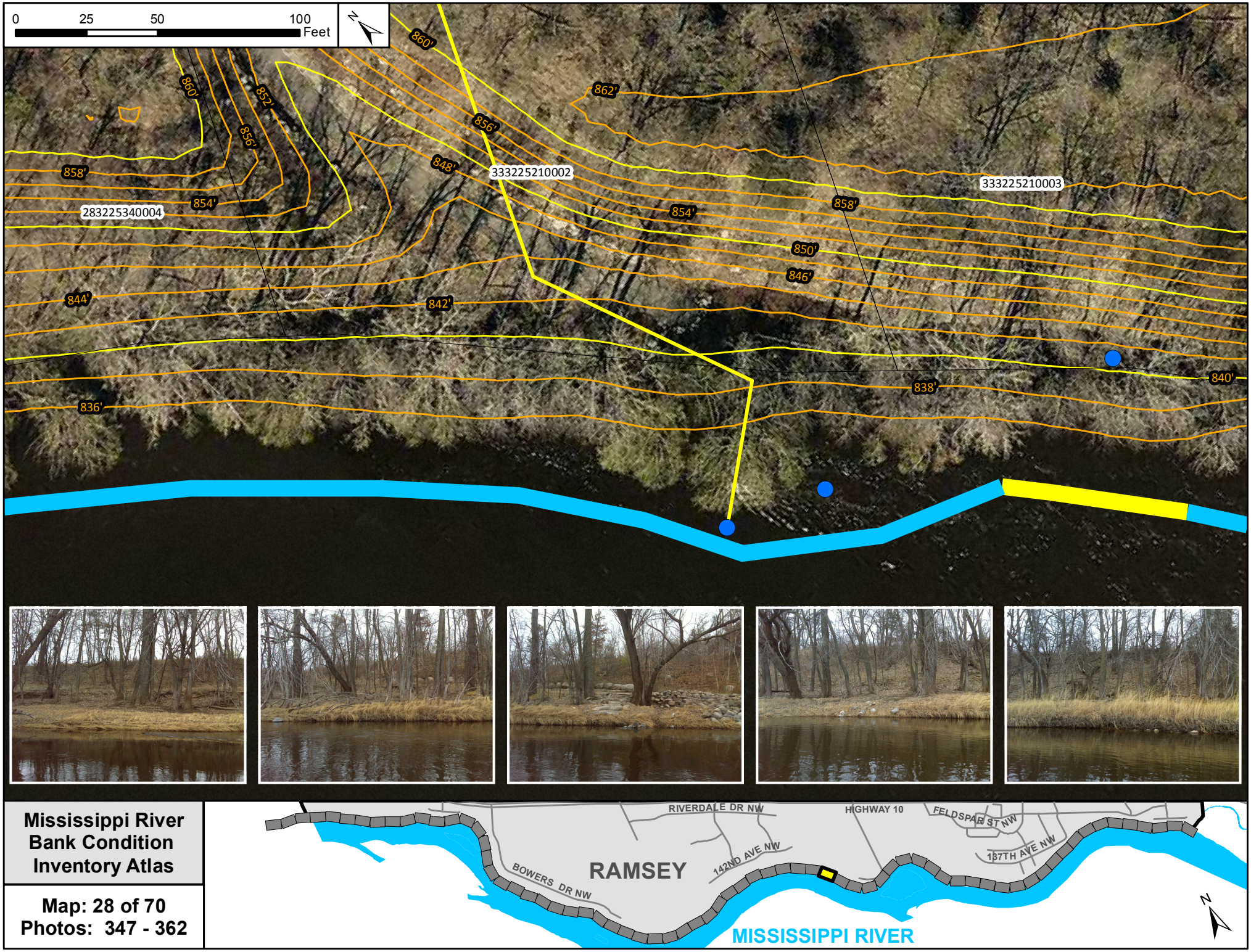






Mississippi River Bank Condition Inventory Atlas

Map: 27 of 70
Photos: 332 - 346



Mississippi River Bank Condition Inventory Atlas

Map: 28 of 70
Photos: 347 - 362

0 25 50 100 Feet

N

860'
854'
852'
850'
848'
846'
840'
836'
856'
858'
844'
842'
838'

283225340004





Mississippi River Bank Condition Inventory Atlas

Map: 29 of 70
Photos: 363 - 378

0 25 50 100 Feet

N

860'
858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'

283225330014
283225330015
283225340004





Mississippi River Bank Condition Inventory Atlas

Map: 30 of 70
Photos: 379 - 394

0 25 50 100 Feet

N

860'
858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'

283225330012
283225330013
283225330014





Mississippi River Bank Condition Inventory Atlas

Map: 31 of 70
Photos: 395 - 409

0 25 50 100 Feet

N

850'
848'
848'
846'
844'
846'
842'
844'
842'
840'
840'
838'
838'
836'
836'

283225330010
283225330011
283225330012





Mississippi River Bank Condition Inventory Atlas

Map: 32 of 70
Photos: 410 - 427

0 25 50 100 Feet

N

850'

293225440001

848'

283225330009

283225330010

293225440008

846'

844'

842'

838'

836'

840'

Mississippi River Bank Condition Inventory Atlas

Map: 33 of 70
Photos: 428 - 447

0 25 50 100 Feet

N

848'

848'

848'

293225440006

293225440007

293225440008

848'

846'

844'

842'

840'

838'

836'

Mississippi River Bank Condition Inventory Atlas

Map: 34 of 70
Photos: 448 - 470

0 25 50 100 Feet

N

293225440004

293225440005

293225440006

848'

848'

846'

844'

842'

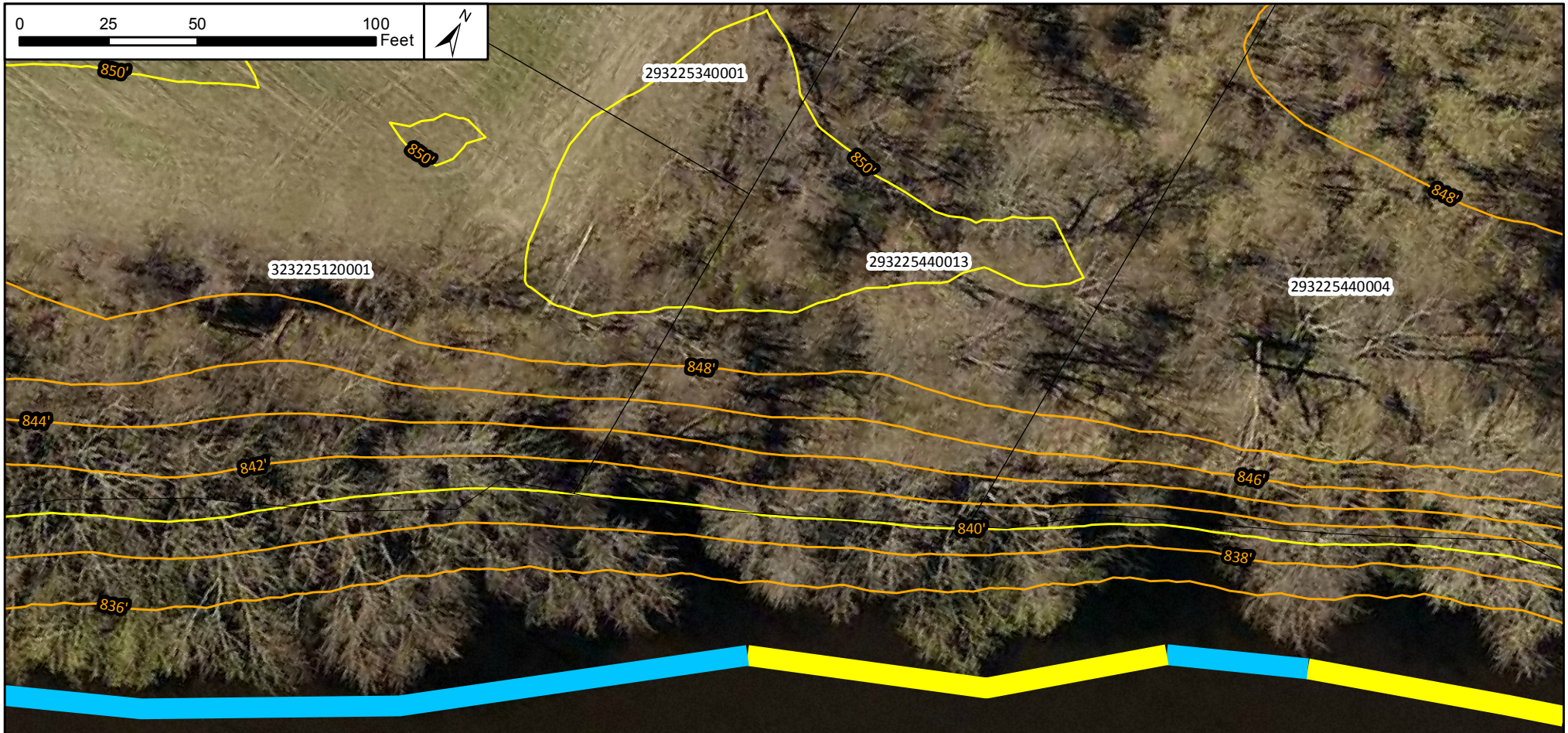
840'

838'

836'

Mississippi River Bank Condition Inventory Atlas

Map: 35 of 70
Photos: 471 - 491



Mississippi River Bank Condition Inventory Atlas

Map: 36 of 70
Photos: 492 - 512

0 25 50 100 Feet

N

850'

846'

848'

848'

323225120001

844'

846'

842'

840'

838'

836'

Mississippi River Bank Condition Inventory Atlas

Map: 37 of 70
Photos: 513 - 532

0 25 50 100 Feet

N

850'

848'

846'

850'

323225120001

850'

850'

846'

848'

844'

842'

840'

838'

836'

Mississippi River Bank Condition Inventory Atlas

Map: 38 of 70
Photos: 533 - 550

0 25 50 100 Feet

N

323225120001

850'
850'
848'
846'
844'
842'
840'
840'
838'
838'
836'





Mississippi River Bank Condition Inventory Atlas

Map: 39 of 70
Photos: 551 - 570

0 25 50 100 Feet

N

850'
848'
846'
844'
842'
840'
838'
836'

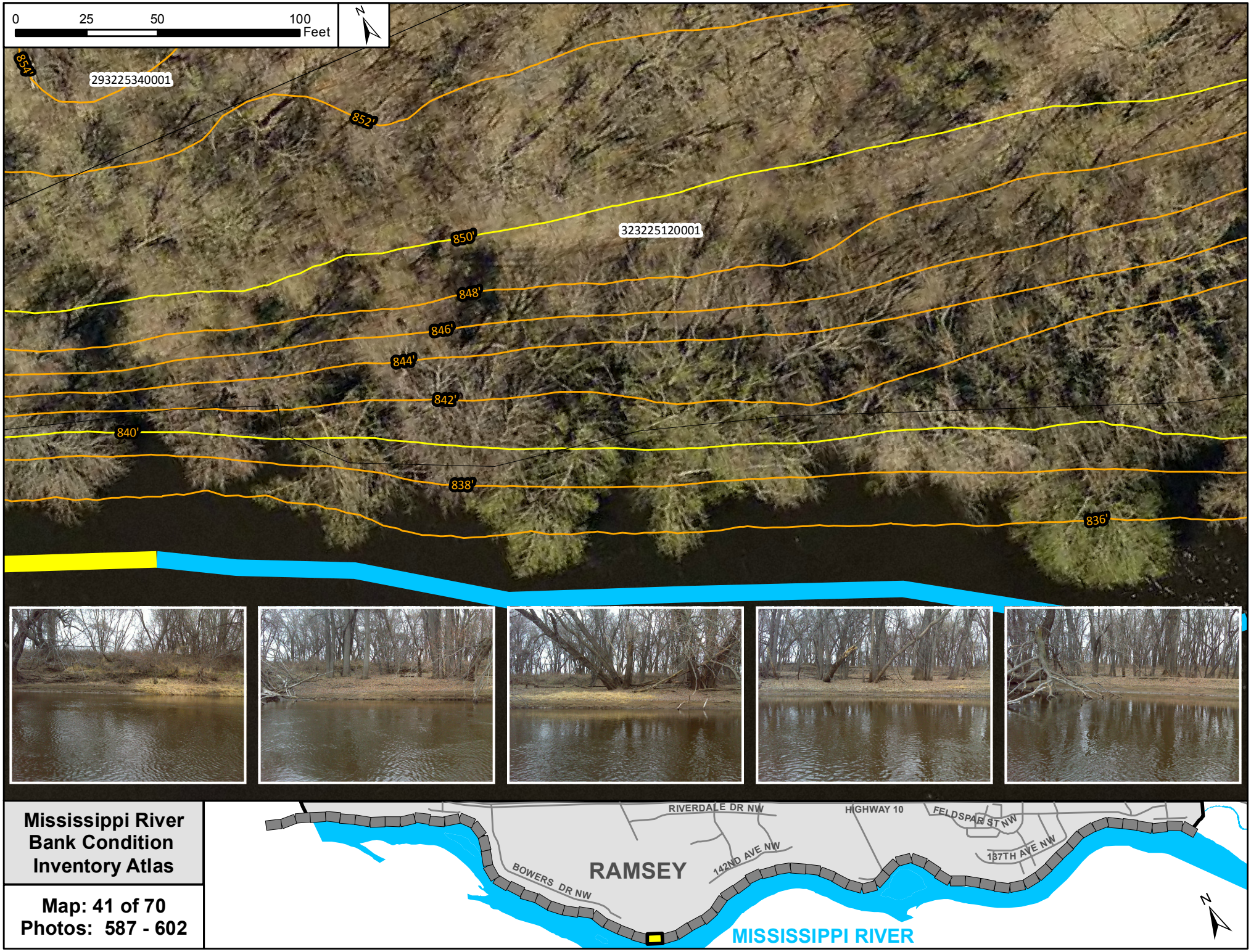
323225120001





Mississippi River Bank Condition Inventory Atlas

Map: 40 of 70
Photos: 571 - 586


0
25
50
100
Feet
N
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'
293225340001
323225120001
Mississippi River
Bank Condition
Inventory Atlas
Map: 41 of 70
Photos: 587 - 602
RIVERDALE DR NW
HIGHWAY 10
FELDSPAR ST NW
142ND AVE NW
187TH AVE NW
BOWERS DR NW
RAMSEY
MISSISSIPPI RIVER
N

0 25 50 100 Feet

N

854'

854'

854'

852'

850'

848'

846'

844'

842'

840'

838'

836'

293225340001

323225120001

Mississippi River Bank Condition Inventory Atlas

Map: 42 of 70
Photos: 603 - 620

0 25 50 100 Feet

N

858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'

293225340001
293225330005





Mississippi River Bank Condition Inventory Atlas

Map: 43 of 70
Photos: 621 - 638

0 25 50 100 Feet

N

860'
858'
858'
854'
852'
850'
848'
842'
838'
844'
856'
846'
840'
836'

293225330003
293225330004
293225330005





Mississippi River Bank Condition Inventory Atlas

Map: 44 of 70
Photos: 639 - 648

0 25 50 100 Feet

N

862'
860'
858'
860'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'

293225330001
293225330002
293225330003





Mississippi River Bank Condition Inventory Atlas

Map: 45 of 70
Photos: 649 - 664

0 25 50 100 Feet

N

862'
860'
858'
856'
854'
852'
850'
848'
846'
844'
842'
840'
838'
836'

293225320006
293225320007
293225330001





Mississippi River Bank Condition Inventory Atlas

Map: 46 of 70
Photos: 665 - 680

0 25 50 100 Feet

N

303225410012

293225320003

293225320004

293225320005

293225320006

860'

862'

858'

854'

848'

844'

852'

856'

850'

846'

840'

842'

838'

Mississippi River Bank Condition Inventory Atlas

Map: 47 of 70
Photos: 681 - 696

0 25 50 100 Feet

N

303225410008

303225410014

303225410011

303225410012

864'

860'

862'

856'

852'

848'

858'

854'

846'

850'

844'

840'

842'

838'

Mississippi River Bank Condition Inventory Atlas

Map: 48 of 70
Photos: 697 - 717

0 25 50 100 Feet

N

868'
866'
864'
862'
303225410008
303225410016
303225410005
303225410015
303225410006
860'
858'
856'
854'
852'
850'
848'
846'
842'
840'
838'
844'





Mississippi River Bank Condition Inventory Atlas

Map: 49 of 70
Photos: 718 - 732

0 25 50 100 Feet

N

303225140032

303225140030

303225140031

303225410004

303225410005

860' 864' 862' 854' 858' 852' 856' 850' 848' 846' 848' 846' 844' 840' 842' 838'





Mississippi River Bank Condition Inventory Atlas

Map: 50 of 70
Photos: 733 - 747

0 25 50 100 Feet

N

852'
850'
848'
850'
846'
844'
842'
840'
838'

303225140034
303225140026
303225140032





Mississippi River Bank Condition Inventory Atlas

Map: 51 of 70
Photos: 748 - 760

0 25 50 100 Feet

N

852'
854'
850'
852'
303225140034
303225140033
303225140023
303225140022
848'
850'
846'
842'
844'
838'
840'





Mississippi River Bank Condition Inventory Atlas

Map: 52 of 70
Photos: 761 - 775

0 25 50 100 Feet

N

856'
854'
852'
850'
854'
852'
850'
852'
842'
846'
848'
844'
850'
838'
840'

303225140018
303225140019
303225140020
303225140021
303225140022





Mississippi River Bank Condition Inventory Atlas

Map: 53 of 70
Photos: 776 - 791

0 25 50 100 Feet

N

856'
854'
852'
854'
848'
850'
846'
840'
844'
842'
838'

303225110020
303225110021
303225110022
303225140017
303225140018





Mississippi River Bank Condition Inventory Atlas

Map: 54 of 70
Photos: 792 - 806

0 25 50 100 Feet

303225110010
303225110029
303225110030
303225110019
303225110020
854'
856'
852'
850'
848'
844'
842'
840'
838'
846'





Mississippi River Bank Condition Inventory Atlas

Map: 55 of 70
Photos: 807 - 822

Mississippi River Bank Condition Inventory Atlas

Map: 56 of 70
Photos: 823 - 836

0 25 50 100 Feet

N

193225440001

193225430004

303225110011

193225430014

876'

870'

878'

872'

868'

303225110012

866'

876'

874'

860'

303225110013

854'

852'

858'

864'

862'

844'

848'

846'

850'

856'

193225430015

842'

840'

303225110014

Mississippi River Bank Condition Inventory Atlas

Map: 57 of 70
Photos: 837 - 851

0 25 50 100 Feet

N

193225430018

193225430017

193225430016

193225430015

193225430014

874'

878'

866'

876'

872'

864'

870'

868'

854'

866'

858'

846'

860'

862'

852'

842'

856'

850'

848'

844'

840'

Mississippi River Bank Condition Inventory Atlas

Map: 58 of 70
Photos: 852 - 866

0 25 50 100 Feet

N

872'
870'
872'
866'
866'
868'
862'
856'
854'
846'
860'
858'
864'
850'
852'
848'
844'
842'
840'

193225430021
193225430020
193225430019
193225430018





Mississippi River Bank Condition Inventory Atlas

Map: 59 of 70
Photos: 867 - 881

0 25 50 100 Feet

N

193225430002

193225430003

193225430021

193225340002

870'
868'
860'
864'
844'
842'
862'
866'
870'
872'
848'
856'
858'
850'
854'
840'
846'
852'





Mississippi River Bank Condition Inventory Atlas

Map: 60 of 70
Photos: 882 - 898

0 25 50 100 Feet

N

852'

848'

844'

193225340001

193225340002

844'

842'

840'

Mississippi River Bank Condition Inventory Atlas

Map: 61 of 70
Photos: 899 - 917

0 25 50 100 Feet

N

860'
852'
864'
860'
858'
193225310006
193225340001
854'
862'
856'
850'
848'
846'
844'
842'
840'





Mississippi River Bank Condition Inventory Atlas

Map: 62 of 70
Photos: 918 - 932

0 25 50 100 Feet

N

193225310004

193225310006

193225310005

858'

860'

858'

858'

848'

856'

854'

852'

842'

850'

846'

844'

840'





Mississippi River Bank Condition Inventory Atlas

Map: 63 of 70
Photos: 933 - 944

0 25 50 100 Feet

N

193225310004

193225320001

193225320002

193225310005

864'

862'

860'

858'

856'

854'

852'

850'

848'

846'

844'

842'

Mississippi River Bank Condition Inventory Atlas

Map: 64 of 70
Photos: 945 - 958

0 25 50 100 Feet

N

860'
852'
850'
848'
193225320001
856'
858'
862'
854'
846'
844'
842'



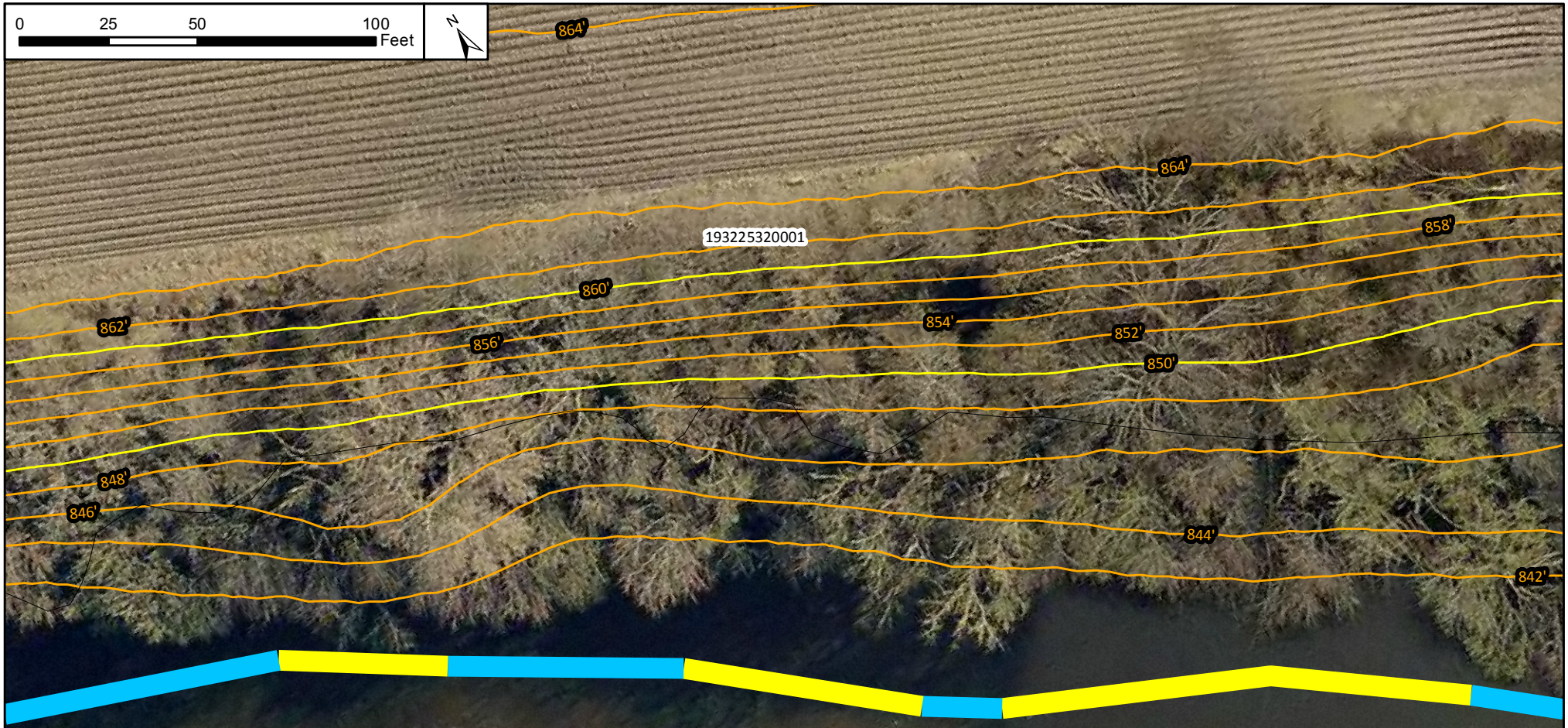


Mississippi River Bank Condition Inventory Atlas

Map: 65 of 70
Photos: 959 - 975

0 25 50 100 Feet

N



Mississippi River Bank Condition Inventory Atlas

Map: 66 of 70
Photos: 976 - 993

0 25 50 100 Feet

N

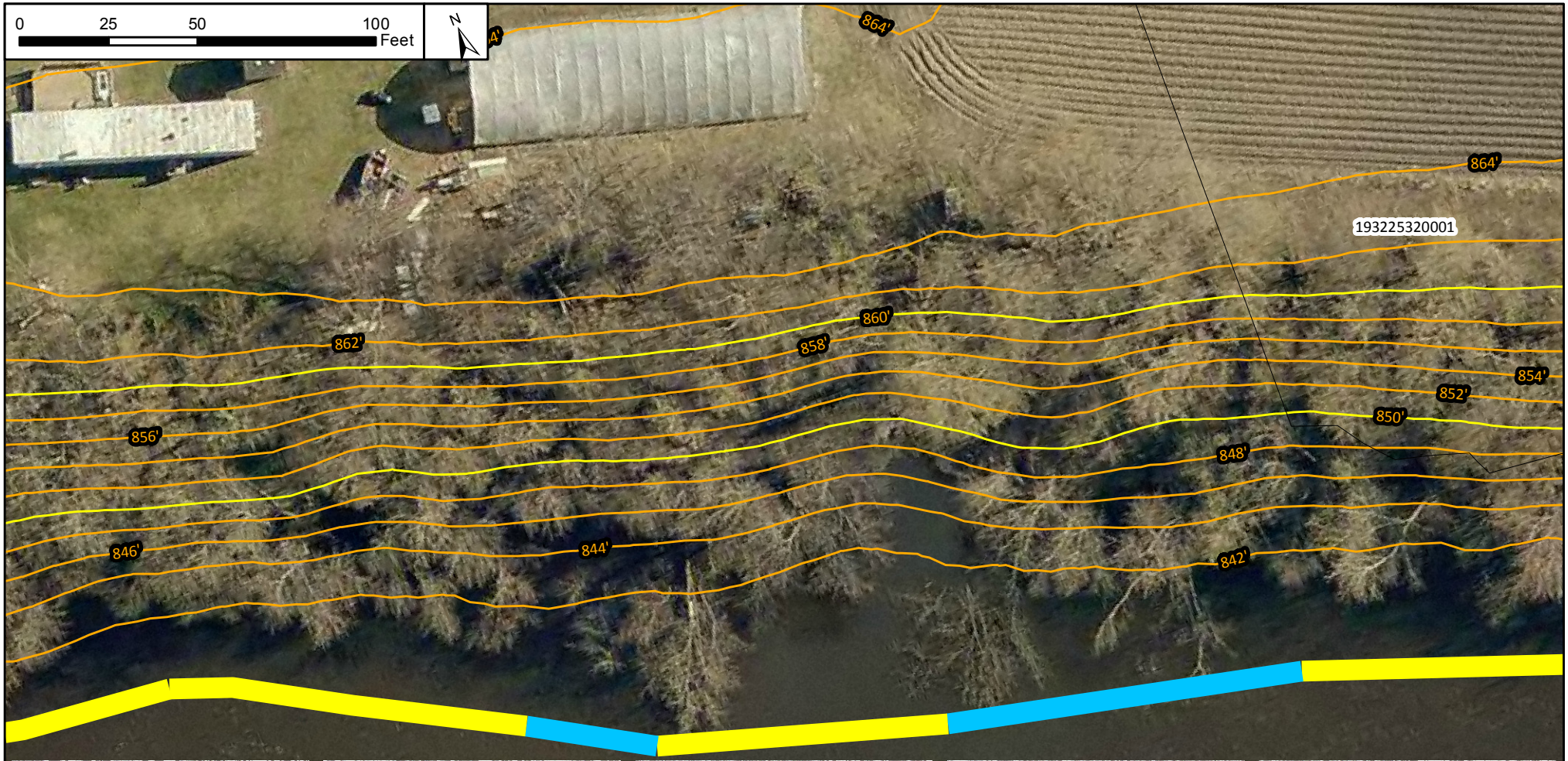
866'
864'
193225320001
862'
860'
858'
856'
854'
852'
850'
848'
846'
844'
842'





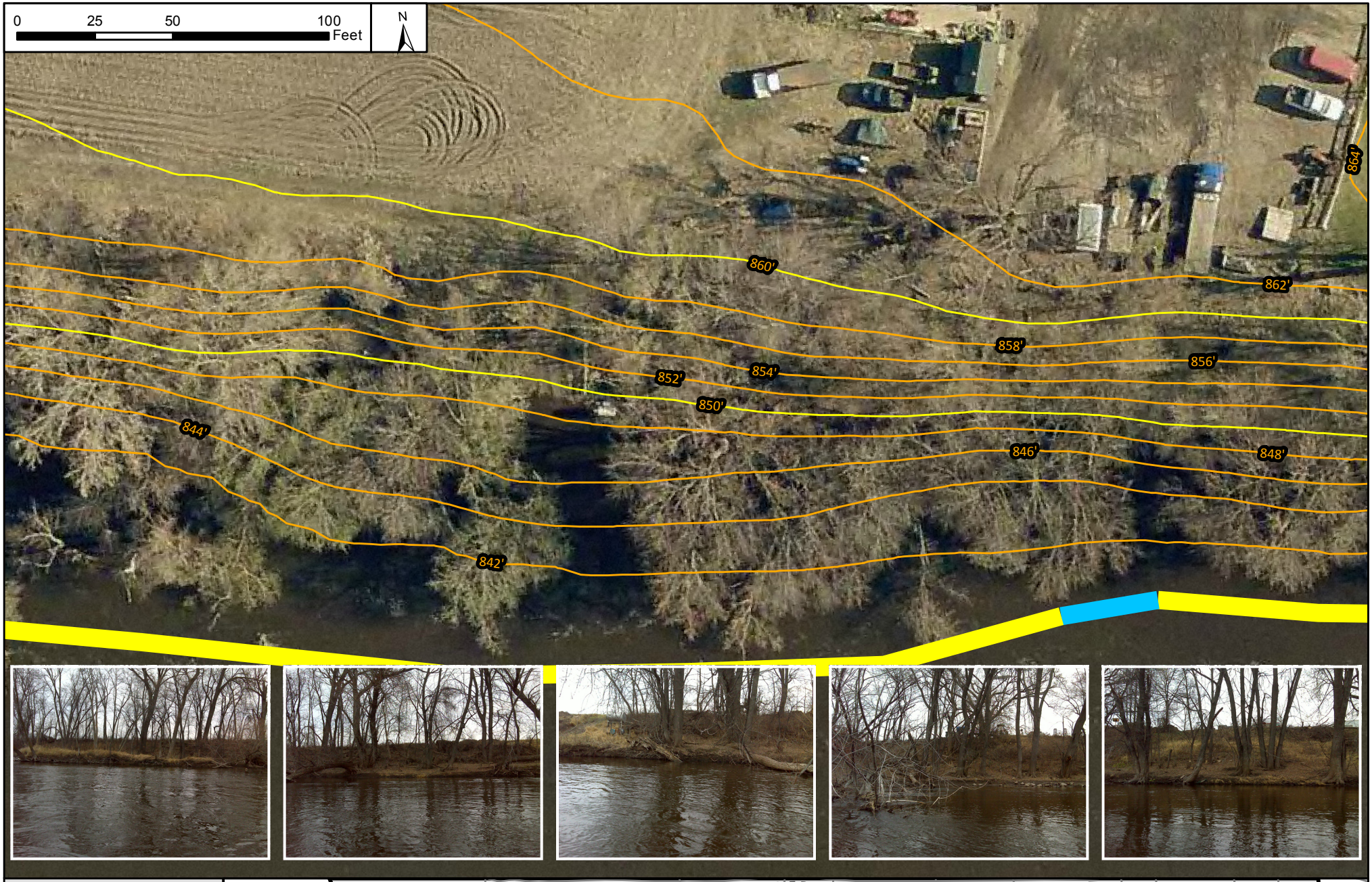
Mississippi River Bank Condition Inventory Atlas

Map: 67 of 70
Photos: 994 - 1012



Mississippi River Bank Condition Inventory Atlas

Map: 68 of 70
Photos: 1013 - 1027



Mississippi River Bank Condition Inventory Atlas

Map: 69 of 70
Photos: 1028 - 1041

0 25 50 100 Feet

N

860'
858'
856'
854'
852'
850'
848'
846'
844'
842'

Mississippi River Bank Condition Inventory Atlas

Map: 70 of 70
Photos: 1042 - 1048

Appendix B

Complete Soil Loss Estimation Table

Intentionally Blank

Table 6: Soil loss estimation details for each polyline categorized as severe or very severe.

PROPERTY INFORMATION			ERODING FACE INFORMATION					
Site Profile	Ownership	PIN	Length (ft)	Height (ft)	Depth (ft)	Slope:1 (H:V)	Recession Rate (ft/yr)	Soil Loss (tons/yr)
1	Private	353225320005	111	12	25	2.1	0.4	61.6
2	Private	343225410004	82	22	36	1.6	0.4	69.2
2	Private	343225410004	34	22	36	1.6	0.75	53.8
3	Private	343225420005, 343225420010, 343225420009	228	6	22	3.7	0.4	104.0
3	Private/Anoka County	343225420009, 343225310025, 343225310023	190	6	25	4.2	0.4	97.7
3	Anoka County	343225310023	148	10	40	4.0	0.4	122.0
4	Anoka County	343225320001	265	4	7	1.8	0.4	42.7
4	Anoka County	343225320001	47	14	30	2.1	0.75	58.3
4	Anoka County	343225320001, 343225230003	254	4	10	2.5	0.4	54.7
4	Anoka County	343225230003	162	4	8	2.0	0.4	29.0
4	Anoka County	343225230003, 333225110003	499	16	30	1.9	0.75	636.2
5	Anoka County	333225110003	39	4	8	2.0	0.4	7.0
5	Anoka County	333225110003	468	12	22	1.8	0.75	439.8
5	Anoka County	333225110003	62	18	32	1.8	0.75	85.4
5	Anoka County	333225110003	38	4	8	2.0	0.4	6.8
5	Anoka County	333225110003, 333225110002	637	18	30	1.7	0.75	835.7
5	Anoka County	333225110002	109	10	18	1.8	0.4	44.9
5	Anoka County	333225120001	175	16	24	1.5	0.4	101.0
5	Anoka County	333225120001	220	20	33	1.7	0.75	318.3
5	Anoka County	333225120001, 333225120005	172	4	8	2.0	0.4	30.8
6	Private	283225330011, 283225330010	110	6	24	4.0	0.4	54.4
6	Private	283225330009, 293225440001	302	6	15	2.5	0.4	97.6
7	Private	293225340001, 293225330005	431	4	10	2.5	0.4	92.8
7	Private	293225330005	102	12	21	1.8	0.75	92.5
7	Private	293225330005	34	4	7	1.8	0.4	5.5
7	Private	293225330005	86	14	24	1.7	0.75	89.6
8	Private	293225330003, 293225330002	41	8	15	1.9	0.4	13.9
8	Private	293225330001	70	8	12	1.5	0.4	20.2
8	Private	293225330001, 293225320007	80	18	30	1.7	0.75	105.0
8	Private	293225320007, 293225320006	148	22	33	1.5	0.75	220.1
8	Private	293225320006, 293225320005	138	18	30	1.7	0.75	181.1
8	Private	293225320005	33	16	28	1.8	0.75	39.9
8	Private	293225320003, 303225410012	54	18	27	1.5	0.75	65.7
8	Private	303225410012	25	8	13	1.6	0.4	7.6
9	Private	303225110030	94	14	29	2.1	0.75	113.5
9	Private	303225110010	221	12	24	2.0	0.75	222.4
9	Private	303225110013, 303225110011, 303225110012, 193225430014	262	24	35	1.5	0.75	417.0
9	Private	193225430014	35	8	14	1.8	0.4	11.3
9	Private	193225430015	27	6	11	1.8	0.4	6.8
10	Private	193225430017, 193225430018	153	8	14	1.8	0.4	49.3
10	Private	193225430021, 193225430003	172	6	11	1.8	0.4	43.1