

above ground storage tank
air quality
asbestos/lead-based paint
baseline environmental assessment
brownfield redevelopment
building/infrastructure restoration
caisson/piles
coatings
concrete
construction materials services
corrosion
dewatering
drilling
due care analysis
earth retention system
environmental compliance
environmental site assessment
facility asset management
failure analyses
forensic engineering
foundation engineering
geodynamic/vibration
geophysical survey
geosynthetic
greyfield redevelopment
ground modification
hydrogeologic evaluation
industrial hygiene
indoor air quality/mold
instrumentation
masonry/stone
metals
nondestructive testing
pavement evaluation/design
property condition assessment
regulatory compliance
remediation
risk assessment
roof system management
sealants/waterproofing
settlement analysis
slope stability
storm water management
structural steel/welding
underground storage tank

REPORT ON LAKE BOULEVARD BLUFF EVALUATION

LAKE BOULEVARD BETWEEN PARK STREET AND WATER STREET ST. JOSEPH, MICHIGAN

**SME Project No. KG59313
July 15, 2009**



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July 15, 2009

Mr. Tim Zebell, PE
City Engineer
City of St. Joseph
700 Broad Street
St. Joseph, Michigan 49085

RE: Lake Boulevard Bluff Evaluation
Lake Boulevard Between Park Street and Water Street
St. Joseph, Michigan
SME Project No. KG59313

Dear Mr. Zebell:

Soil and Materials Engineers, Inc. (SME) has completed an evaluation of the existing coastal bluff along Lake Boulevard between Park Street and Water Street for the City of St. Joseph. The accompanying report provides background information related to the bluff, summarizes our observations made along the bluff, presents our prioritized recommendations to address deficiencies observed, and includes a discussion on soil bioengineering measures that could be implemented to enhance vegetative cover on the bluff face. In addition, the report presents recommended guidelines that could be implemented to manage and regulate development and maintenance activities on or near the bluff.

We appreciate the opportunity to be of service. If you have questions or require additional information, please contact me.

Very truly yours,

SOIL AND MATERIALS ENGINEERS, INC.


Jeffery M. Krusinga, PE, GE
Senior Consultant

Enclosures: Two originals (one bound and one unbound)
CD with pdf file of report

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consultants in the geosciences, materials, and the environment

TABLE OF CONTENTS

SUMMARY	i
1. INTRODUCTION	1
2. BLUFF DESCRIPTION AND INFORMATION	1
2.1 Location and Setting	1
2.2 Generalized Geometry	2
2.3 Soil and Groundwater Information	2
2.4 Historical Aerial Photographs.....	3
3. VISUAL INSPECTION AND OBSERVATIONS	4
3.1 Sheet 1 – Park Street to Pearl Street	4
3.2 Sheet 2 – Pearl Street to Market Street	5
3.3 Sheet 3 – Market Street to Broad Street.....	6
3.4 Sheet 4 -- Broad Street to Ship Street.....	7
3.5 Sheet 5 – Ship Street to Firemen’s Monument	8
3.6 Sheet 6 – Firemen’s Monument to State Street	9
3.7 Sheet 7 – City-Owned Lot South of Sutherland Avenue	10
4. DISCUSSION, ASSESSMENT, AND RECOMMENDATIONS	10
4.1 Bluff Stability Considerations.....	10
4.2 General Assessment of Study Area.....	11
4.3 Recommendations for Improvements	12
4.4 Soil Bioengineering Measures	15
4.5 Bluff Management Recommendations.....	15
5. GENERAL COMMENTS	17
 APPENDIX A: SHEET 1: PARK STREET TO PEARL STREET SHEET 2: PEARL STREET TO MARKET STREET SHEET 3: MARKET STREET TO BROAD STREET SHEET 4: BROAD STREET TO SHIP STREET SHEET 5: SHIP STREET TO FIREMEN’S MONUMENT SHEET 6: FIREMEN’S MONUMENT TO STATE STREET SHEET 7: CITY-OWNED LOT SOUTH OF SUTHERLAND AVENUE	
 APPENDIX B: SITE PHOTOGRAPHS (NOS. 1 THROUGH 44)	
 APPENDIX C: FIGURE NO. 1: CONCEPTUAL REPAIR ILLUSTRATION FOR WATER STREET RETAINING WALL FIGURE NO. 2: LIVE STAKING ILLUSTRATIONS	

SUMMARY

A brief summary of the evaluation and the conclusions and recommendations are presented below:

1. SME conducted a visual evaluation of the existing bluff conditions along Lake Boulevard. The study area included the City of St. Joseph park area (Lake Bluff Park) extending north from Park Street to Water Street, and the City-owned vacant lot located south of the western terminus of Sutherland Avenue.
2. The bluff height throughout the study area ranges from about 30 to 40 feet. Inclinations along the bluff face range from about 4:1 (horizontal to vertical) to a steep as about 1:1. The elevation of the top of the bluff in the study area is situated about 45 to 60 feet above the level of Lake Michigan, which is located about 600 to 1,200 feet west of the base of the bluff.
3. A review of logs from available borings indicates the soils within the bluff area consist of natural sands and sandy silts extending to depths ranging from about 5 to 9 feet below the elevation of the bluff top, underlain by very stiff to hard natural clays extending to about 38 to 39 feet below the ground surface. The natural clays are underlain by medium dense to very dense natural sands extending to about 58 to 64 feet below the existing ground surface. The natural sands are underlain by medium dense to very dense natural silts that extended to the explored depths (75 to 80 feet) of the deeper borings. Based on our site observations, there are areas where fill has been placed on the natural bluff to alter or modify the topography of the slope. These conditions were not encountered in the borings reviewed by SME.
4. A summary of observations made along the bluff within the study area is provided in Section 3 of the report. Observations are noted on plan sheets (Sheets 1 through 7 contained in Appendix A) of the bluff area. Photographs to depict the existing bluff conditions are presented in Appendix B and a photographic key is presented on the plan sheets.
5. Based on our observations, the bluff area within the park area south of the Vietnam Memorial contains relatively good vegetative cover consisting of trees and brush. However, north of this location, there is evidence (e.g., tree stumps and brush stubble) of past clearing of brush and cutting of trees. Evidence of tree clearing and brush cutting is also apparent on the bluff face at the City-owned lot south of the western terminus of Sutherland Avenue. In many areas where there is current evidence of tree and brush clearing, the 1999 topographic survey noted the presence of tree and brush cover. This indicates clearing and cutting activities have occurred in the last 10 years.
6. A brief discussion on some of the factors that affect the stability of slopes or bluffs is presented in Section 4.1. Recommendations related to key elements of a bluff management plan are presented in Section 4.5. Guidelines for a bluff management plan are intended to enhance or at least maintain the stability of existing bluffs. The guidelines presented are intended to address conditions that can be easily affected (e.g., drainage patterns, vegetative cover, etc.) rather than conditions that cannot be easily changed, if at all (e.g., geology, soil strengths, etc.).

7. Several deficiencies or conditions along the bluff, which could lead to additional instability, were noted during our visual evaluation. We recommend these conditions be proactively addressed. In order of highest priority first, these conditions include: Address Retaining Wall Along Water Street (repair existing retaining wall in-place), Address Walkway to the south of the Broad Street stairway/pavilion (monitor the condition of the existing retaining wall and walkway and remove/reconstruct as necessary), Enhance Vegetative Cover in Steep Bluff Areas (consider implementing soil bioengineering measures), and Address Surface Water Discharges (collect and control surface runoff that is otherwise directed over the top of the bluff).
8. A brief discussion of soil bioengineering is presented in Section 4.5 and reference to the USDA Engineering Field Handbook is made. This handbook is available on the web without charge and illustrates various planting techniques and plant materials that could be considered for use along the bluff to enhance vegetative cover.

The summary presented above includes selected elements of our findings and recommendations and is provided solely for purposes of overview. It does not present details needed for the proper application of our findings and recommendations. It should, therefore, not be considered apart from the entire text of this report and appendices, with all of the qualifications and considerations mentioned therein.

REPORT PREPARED BY:

Jeffery M. Krusinga, PE, GE
Senior Consultant

REPORT REVIEWED BY:

Timothy H. Bedenis, PE
Chief Geotechnical Engineer

1. INTRODUCTION

This report presents the results of the evaluation performed by Soil and Materials Engineers, Inc. (SME) of the coastal bluff that extends along the west side of Lake Boulevard in St. Joseph, Michigan. More specifically, the limits of the bluff evaluated generally extend from Park Street on the south to Water Street on the north within the area referred to as Lake Bluff Park. Also included in the scope is a portion of the bluff situated on the west side of Lake Boulevard just south of the westerly terminus of Sutherland Avenue. All the bluff area included in the evaluation is owned by the City of St. Joseph. This evaluation was conducted in general accordance with the scope of services outlined in SME Proposal No. K09-0012, dated February 4, 2009. Our services were authorized by the City Commission at the regularly scheduled meeting on February 6, 2009. Mr. Tim Zebell, PE, City Engineer, acted as the primary point of contact for the City of St. Joseph.

2. BLUFF DESCRIPTION AND INFORMATION

2.1 Location and Setting

The subject bluff generally extends along the west side of Lake Boulevard and overlooks Lake Michigan located about 600 to 1,200 feet to the west. The bluff generally traverses in a south-southeast to north-northwest direction. While this bluff feature extends throughout most of the western edge of the City of St. Joseph, the bluff area of specific interest (i.e., the study area) extends between Park Street (southern boundary) and Water Street (northern boundary). The bluff extends roughly 2,750 feet between these two boundaries and generally encompasses the area known as Lake Bluff Park. The study area also includes a portion of the bluff located south of Park Street that includes a 60-foot-wide residential lot. This lot is currently vacant and is situated about 200 feet south of the westerly terminus of Sutherland Avenue. The bluff within the entire study area is owned by the City of St. Joseph.

Between Park Street and Water Street, the bluff area generally serves as a public park (i.e., Lake Bluff Park). The area landward of the top of the bluff in this area consists mostly of grassy lawn situated west of Lake Boulevard. Within the southern portion of this bluff area, an active railroad line is located near the toe of the bluff. About midway north of Park Street, the railroad line diverges (westerly) away from the bluff toe and Vine Street extends northerly along the bluff toe. Vine Street then becomes Water Street as the roadway turns easterly and Water Street intersects State Street at the north end of the study area. The bluff that is part of the study

area to the south of Sutherland Avenue is a vacant lot that is situated in an area where there are no houses along the bluff top on the west side of Lake Boulevard. The railroad line is also situated just beyond the toe of the bluff in this area. The area between the top of the bluff and Lake Boulevard in this area consists of a maintained lawn with scattered hardwood trees.

To assist with our evaluation, the City of St. Joseph provided SME with the digital files associated with a topographic survey that was completed in 1999 on behalf of the City of St. Joseph. The survey provided coverage of the entire city, and therefore included coverage of the subject bluff area. The survey included topographic contours plotted at 1-foot intervals, spot elevations to the nearest 0.1-foot, existing site features, and the aerial photographic base used to compile the survey. SME utilized the survey provided to develop base maps of the study area for use in this evaluation. These base maps are provided as Sheets 1 through 7 in Appendix A of this report. Sheets 1 through 6 cover the study area north of Park Street, while Sheet 7 covers the single lot that comprises the study area south of Sutherland Avenue. Each sheet includes a location map as an inset.

2.2 Generalized Geometry

Based on the topographic information included on Sheets 1 through 6, the top of the bluff north of Park Street is situated between about elevation 624 feet and 639 feet, while the toe of the bluff is situated between about elevation 591 feet and elevation 600 feet. The bluff height (i.e., the vertical distance between the toe of the bluff and the top of the bluff) in this area ranges from about 30 to 45 feet. The inclination of the bluff face in this area ranges from about 4:1 (horizontal to vertical) to 1:1.

Based on the topographic information included on Sheet 7, the top of the bluff within the study area south of Sutherland Avenue is situated at about elevation 652 feet and the toe of the bluff is situated at about elevation 613 feet. Therefore, the bluff height in this area is about 40 feet. The inclination of the bluff face in this area ranges from about 2:1 to 1½:1.

2.3 Soil and Groundwater Information

The scope of our evaluation did not include performing geotechnical borings along the bluff to evaluate soil and groundwater conditions at specific locations. However, available boring information from other projects completed along the bluff was reviewed by SME to develop a generalized understanding of the subsurface conditions. Specific boring information reviewed included the logs of two borings completed on behalf of the City of St. Joseph in 2006 for utility improvements along Lake Boulevard. Both of these borings were located within Lake Boulevard. One of these borings was located between Jones and Hoyt Streets and the other

boring was located between Pleasant and Ship Streets. Both of these borings were relatively shallow, and extended to depths ranging from about 16 to 18 feet. Other boring information reviewed included the logs of deeper borings performed by SME in 2008 for a private development at the corner of Lake Boulevard and Pleasant Street.

Based on the available boring information, the soil conditions along the bluff generally consist of natural sands and sandy silts extending to depths ranging from about 5 to 9 feet below the elevation of Lake Boulevard, underlain by very stiff to hard natural clays. Based on the deeper borings performed in 2008 by SME, the natural clays extend to about 38 to 39 feet below the existing ground surface. The natural clays are underlain by medium dense to very dense natural sands extending to about 58 to 64 feet below the existing ground surface. The natural sands are underlain by medium dense to very dense natural silts that extended to the explored depths (75 to 80 feet) of these deeper borings.

The shallow utility borings performed along Lake Boulevard did not encounter groundwater within the explored depths (16 to 18 feet). In the deeper borings performed by SME at the corner of Pleasant Street and Lake Boulevard, groundwater was encountered in the natural sands below the clays at depths ranging from about 54 to 55 feet. In terms of elevation, the groundwater was encountered at about 578 to 579 feet, which is relatively consistent with the surface water elevation of Lake Michigan.

The soil and groundwater conditions described above were developed from borings performed for other projects along the bluff. It should be noted that these generalized conditions may not be indicative of the conditions at specific locations along the bluff since soil and groundwater conditions may vary between or away from boring locations. Based on our site observations, there are areas along the bluff where fill has been placed. These conditions were not encountered in the borings reviewed by SME.

2.4 Historical Aerial Photographs

Historical aerial photographs of the study area were obtained by SME from a vendor source that SME typically uses to obtain historical information for conducting Phase I Environmental Site Assessments (ESA's). The aerial photographs obtained were collected in 1932, 1950, 1967, 1974, 1975, 1981, and 1992. The purpose of obtaining these photographs was to compare conditions along the bluff from these photographs to the current conditions. Specifically, we were looking to see if changes in vegetative cover (i.e., tree cover) could be distinguished from these photographs. Unfortunately, the flights to collect these photographs were conducted at relatively high altitudes. Therefore, the resolution of these photographs did not allow for sufficient details about vegetative cover to be distinguished.

As indicated above, the topographic survey completed in 1999 on behalf of the City of St. Joseph included aerial photography used to compile the topographic base. The resolution of that flight was sufficient to be able to distinguish general levels of tree cover present in 1999, and general tree cover is noted on the topographic base used to prepare Sheets 1 through 7 contained in Appendix A. Comments about the tree-cover conditions in 1999 compared to the current conditions observed by SME are provided below in Section 3.

3. VISUAL INSPECTION AND OBSERVATIONS

As part of our evaluation, SME made visits to the site on April 22 and 29, and May 1, 2009. These visits were made by Mr. Jeff Krusinga, PE, GE of SME. During the site visits, visual observations of the subject bluff were made and existing conditions noted. Photographs of the bluff area were also collected during the site visits. Selected photographs (Nos. 1 through 44) are contained in Appendix B. Where the subject of the photograph is discussed in the text of this report, the reader is referred to the appropriate numbered photograph in Appendix B. Each of the plan sheets in Appendix A also includes a key numbering system that references the photograph number and the direction of view.

The following subsections contain descriptions of the bluff conditions observed during our site visits. Each subsection is referenced to the specific sheet that provides plan coverage of the area observed.

3.1 Sheet 1 – Park Street to Pearl Street

This portion of the study area generally extends northward from Park Street on the south to about Pearl Street. This portion of the study area is covered by Sheet 1 in Appendix A. Photo Nos. 1 through 4 contained in Appendix B depict the conditions in this area of the bluff.

The area between Lake Boulevard and the edge of the bluff is generally a lawn area associated with a public park (Photo Nos. 1 and 2). The Berrien County Law Enforcement Memorial is located in the lawn area beyond the top of the bluff near the north end of this portion of the study area. In general, surface drainage appears to be directed away from the bluff edge toward Lake Boulevard. Based on our field observations, improvements such as new sidewalks near Lake Boulevard and new electrical access stations along the bluff top have been constructed since the date (1999) of the aerial flight used to compile the topographic base.

The bluff face in this area is relatively heavily vegetated with trees and brush (Photo Nos. 3 and 4). This vegetative cover is generally indicated on the topographic base for Sheet 1. The inclination of the bluff face in this area generally ranges from about 3:1 to 1½:1. Seepage was not observed emanating from the bluff face or from the area near the bluff toe. Although not noted on the topographic base for Sheet 1, a storm drain that extends down the bluff from Lake Boulevard discharges into an energy dissipater just beyond the bluff toe near the northern limits of the area covered by this sheet. An active railroad line is located just beyond the bluff toe in this area of the bluff.

3.2 Sheet 2 – Pearl Street to Market Street

This portion of the study area generally extends northward from Pearl Street on the south to about 170 feet north of Market Street. The northern limits of this portion of the study area are about coincident with the north edge of The Boulevard Inn (located on the east side of Lake Boulevard). This portion of the study area is covered by Sheet 2 in Appendix A. Photo Nos. 5 through 12 contained in Appendix B depict the conditions in this area of the bluff.

The area between Lake Boulevard and the edge of the bluff is generally a lawn area associated with a public park (Photo No. 5). Several war memorials are located in the lawn area within the northern portion of the area covered by Sheet 2. In general, surface drainage appears to be directed away from the bluff edge toward Lake Boulevard, although one area was observed where there had been some erosion at the bluff edge (Photo No. 6). This erosion was likely caused by water flowing over the edge of the bluff. Based on our field observations, improvements such as new sidewalks near Lake Boulevard, new electrical access stations along the bluff top, and new war memorials have been constructed since the date (1999) of the aerial flight used to compile the topographic base.

The bluff face in this area is relatively heavily vegetated with trees and brush (Photo No. 10). However, at the northern limits of the area covered by this sheet, there is evidence of past clearing of brush and cutting of trees (Photo No. 8). The inclination of the bluff face in this area generally ranges from about 3:1 to 1:1. Seepage was not observed emanating from the bluff face or from the area near the bluff toe. However, an area of standing water was noted in the area near the bluff toe within the southern portion of the area covered by this sheet (Photo No. 12). It appears that storm water that is discharged or directed to the bluff toe area simply ponds in this area and does not have a dedicated outlet.

Changes to the area beyond the bluff toe have occurred since the date of the aerial photography used to compile the topographic base. Specifically, a new gravel parking area is present to the south of the paved parking area for Silver Beach Pizza (Photo Nos. 9 and 11). It

appears the grading performed to construct this gravel parking area may have exacerbated the poor drainage conditions along the bluff toe as denoted by Photo No. 12. These parking areas generally are located just beyond the bluff toe within the northern portion of the area covered by Sheet 2. An active railroad line is located just beyond the bluff toe within the southern portion of the area covered by Sheet 2.

3.3 Sheet 3 – Market Street to Broad Street

This portion of the study area generally extends north from about 170 feet north of Market Street to about Broad Street. The northern limits of this portion of the study area extend just beyond the Broad Street stairway/pavilion. This portion of the study area is covered by Sheet 3 in Appendix A. Photo Nos. 13 through 20 contained in Appendix B depict the conditions in this area of the bluff.

The area between Lake Boulevard and the edge of the bluff is generally a lawn area associated with a public park (Photo Nos. 13 and 14). In general, surface drainage appears to be irregular and somewhat undefined, and some surface runoff may be directed toward the top edge of the bluff in this area. Evidence of runoff being collected and directed over the edge of the bluff top can be seen in Photo No. 16. At this location, surface drainage from the bluff top near the cannon exhibit is being directed down a concrete spillway and onto the paved walkway/ramp below.

The topographic survey compiled in 1999 that was used as the base for Sheet 3 indicates the presence of tree/brush cover along the bluff face in this area. However, our observations indicate there has been relatively extensive cutting of trees and brush along the bluff face (Photo Nos. 15 and 20). A comparison of the current conditions with the conditions indicated on the 1999 survey indicates the cutting and clearing has taken place in the last 10 years. Based on our field observations, improvements such as new electrical access stations along the bluff top have been constructed since the date (1999) of the aerial flight used to compile the topographic base. The inclination of the bluff face in this area generally ranges from about 4:1 to 1:1. Seepage was not observed emanating from the bluff face or from the area near the bluff toe. The toe of the bluff in the area covered by Sheet 3 extends to the paved parking area for Silver Beach Pizza and to an access drive from Vine Street to this parking area.

An existing paved walkway/ramp extends down the bluff face to the southwest from the pavilion area. This walkway is about 260-feet long and appears to have been constructed by using a concrete retaining wall system to laterally support the walkway on the downslope side. Considerable distress features such as rotation of the retaining wall, cracks in the wall, separations in the wall, and mass movement of the wall are apparent (Photo Nos. 17 and 19). It

appears past repairs to the retaining wall have included the addition of steel plates attached to soil anchors that extend into the backfill behind the retaining wall (into the slope). The retaining wall system that supports the walkway is judged to be in relatively poor condition, but the repairs completed appear to have stabilized the wall and the associated walkway on at least an interim basis.

Downslope of the paved walkway, there is a relatively steep bluff area where mass movement of the bluff face has occurred. This area of movement is denoted on Sheet 3 and is depicted in Photo No. 18. Concrete stairs with brick paver steps descend from the pavilion to the base of the bluff to the west. These stairs (known as the Broad Street stairway) are located just north of the paved walkway described above. We understand these stairs are a primary pedestrian route from the bluff top to the beach, retail, and residential areas beyond the bluff toe.

3.4 Sheet 4 – Broad Street to Ship Street

This portion of the study area generally extends north from Broad Street to about Ship Street. This portion of the study area is covered by Sheet 4 in Appendix A. Photo Nos. 21 through 26 contained in Appendix B depict the conditions in this area of the bluff.

The area between Lake Boulevard and the edge of the bluff is generally a lawn area associated with a public park (Photo No. 21). In general, surface drainage from the lawn area appears to be directed toward the edge of the bluff in this area, although areas with concentrated discharge were not observed. Surface water collected from concrete flatwork areas along the promenade area to the north of the pavilion is discharged onto the bluff face through scuppers in the surrounding retaining walls (Photo No. 26).

The topographic survey compiled in 1999 that was used as the base for Sheet 4 indicates the presence of tree/brush cover along the bluff face at about the midpoint of Sheet 4 (generally across from the terminus of Pleasant Street). However, our observations do not indicate the presence of this tree/brush cover (refer to the note on Sheet 4). Most of the bluff face is devoid of tree cover and is instead vegetated with grass (Photo No. 22). Based on our field observations, improvements such as new electrical access stations along the bluff top have been constructed since the date (1999) of the aerial flight used to compile the topographic base. The inclination of the bluff face in this area generally ranges from about 4:1 to 1½:1. Seepage was not observed emanating from the bluff face or from the area near the bluff toe. Vine Street extends along the bluff toe in this area.

Near the bluff toe within the southern portion of this sheet, there is an existing mechanically-stabilized earth (MSE) retaining wall that is not depicted in the topographic base compiled in 1999. This wall appears to have been constructed to create a pad area for a utility

structure. The general location of this wall is depicted by the note on Sheet 4 and the wall is shown in the lower portion of Photo No. 24. Another MSE retaining wall is located within the upper portion of the bluff within the southern portion of this sheet. This wall is also not depicted on the topographic base compiled in 1999, but a note on Sheet 4 indicates the approximate wall location. This MSE retaining wall can be seen in the upper portion of Photo No. 24 and is exhibiting excessive deflection at the top (Photo No. 25). Some of the poor performance of this MSE retaining wall could potentially be attributed to drainage being discharged onto the bluff face from the flatwork areas immediately upslope.

3.5 Sheet 5 – Ship Street to Firemen’s Monument

This portion of the study area generally extends north from Ship Street to about the location of Firemen’s Monument. This portion of the study area is covered by Sheet 5 in Appendix A. Photo Nos. 27 through 32 contained in Appendix B depict the conditions in this area of the bluff.

The area between Lake Boulevard and the edge of the bluff generally contains lawn and flatwork areas associated with a public park (Photo No. 27). A paved walkway extends from the bluff top down to Vine Street below (Photo No. 28). This paved walkway is sometimes referred to as the former “moving walkway” since an escalator-type walkway system used to be located here, but was subsequently removed. A retaining wall provides grade separation between the walkway and the slope to the east (Photo No. 28). This retaining wall appears relatively old and contains cracks and separations. In general, surface drainage from the area toward Lake Boulevard from the bluff top appears to be directed toward the top of the bluff in this area. However, surface water from the flatwork at the top of the walkway is intercepted and collected by a trench drain before being directed down the walkway. Vine Street, which is located along the toe of the bluff within the southern portion of this sheet, transitions into Water Street at about the location where the paved walkway meets the bluff toe.

A retaining wall extends along Water Street beginning at the base of the walkway (Photo Nos. 30 and 31). The overall length of this wall is about 470 feet and this wall extends into the area covered by Sheet 6 and terminates near State Street. This retaining wall appears to be a concrete gravity wall and the wall provides grade separation between the bluff face and the shoulder area along Water Street below. The maximum height of the wall is about 12 feet. The reinforced concrete wall contains numerous cracks and appears to be in generally fair condition.

We understand the origin of the wall is unknown, but we suspect the construction of the retaining wall dates back at least 50 years. One resident who provided input at a City Commission meeting on July 6, 2009, confirmed that she remembers the wall being present in its current configuration for at least 50 years.

Most of the bluff face in this area is covered with grass (Photo Nos. 31 and 32). The inclination of the bluff face in this area generally ranges from about 4:1 to 1:1. Seepage was not observed emanating from the bluff face. However, some seepage and staining were noted emanating from the cracks and weep holes in the retaining wall at the toe of the bluff along Water Street. The inclination of the bluff face in this area is considered very steep for a grass surface and signs of surface instability are apparent in the grass cover between the walkway and the bench area overlooking the bluff near Firemen's Monument (Photo No. 31). Signs of movement such as rotation in the wall and handrail are also apparent in the bench area (Photo No. 29).

3.6 Sheet 6 – Firemen's Monument to State Street

This portion of the study area generally extends eastward from Firemen's Monument to State Street. This portion of the study area is covered by Sheet 6 in Appendix A. Photo Nos. 33 through 38 contained in Appendix B depict the conditions in this area of the bluff. This portion of the bluff includes the amphitheatre (i.e., the Howard band shell) at the north end of Lake Boulevard. Port Street extends eastward from the northern end of Lake Boulevard and intersects State Street at the end of the bluff study alignment.

Most of the bluff in this area is covered with grass (Photo Nos. 34 through 36), although there are several large trees on the bluff face or in the area near the top of the bluff. The inclination of the bluff face in this area generally ranges from about 2:1 to 1½:1. Seepage was not observed emanating from the bluff face. However, some seepage and staining were noted emanating from the cracks and weep holes in the retaining wall at the toe of the bluff along Water Street. The inclination of the bluff face in this area is considered very steep for a grass surface and signs of surface instability are apparent in the grass cover on the bluff face (Photo No. 35). The retaining wall at the toe of the bluff that begins at about the base of the walkway depicted on Sheet 5 extends onto Sheet 6 and terminates near where Water Street meets State Street. Cracking is readily apparent in the wall (Photo Nos. 33 and 34).

In the amphitheatre area, surface drainage is undefined and standing water was observed during our site visit (Photo No. 38). Along the north side of Port Street, erosion from surface drainage was observed in the area that slopes down to State Street (Photo No. 37).

3.7 Sheet 7 – City-Owned Lot South of Sutherland Avenue

This portion of the study area generally consists of a 60-foot-wide vacant lot owned by the City of St. Joseph. The location of this lot is depicted on Sheet 7 in Appendix A. Photo Nos. 39 through 44 contained in Appendix B depict the conditions in this area of the bluff.

The area between Lake Boulevard and the top of the bluff is generally a maintained grass lawn covered with scattered hardwood trees (Photo Nos. 39 and 40). In general, surface drainage appears to be directed across the lawn area toward the bluff top.

The bluff face is generally not vegetated with trees and brush. Evidence of past tree and brush cutting were observed during our site visit (Photo No. 42). The inclination of the bluff face in this area generally ranges from about 2:1 to 1½:1. It appears that lawn debris (leaves, grass clippings, etc.) are cast over the top of the bluff and onto the bluff face. Seepage was not observed emanating from the bluff face or from the area near the bluff toe. An active railroad line is located just beyond the bluff toe in this area of the bluff (Photo Nos. 41 through 44).

4. DISCUSSION, ASSESSMENT, AND RECOMMENDATIONS

4.1 Bluff Stability Considerations

The stability of bluffs or slopes is affected by many factors. When assessing the condition or stability of bluffs or slopes, it is important to be aware of these factors so that areas of concern can be more easily identified. Factors that affect bluff or slope stability include:

- Geology;
- Soil (or rock) strengths;
- Slope geometry (e.g., slope or bluff height and inclination);
- Groundwater conditions;
- Soil moisture conditions;
- Vegetative cover; and
- Surface drainage.

When assessing the stability of a slope or bluff, geotechnical engineers typically consider a “factor of safety” (FOS), which is the ratio of forces resisting movement to the forces tending to cause movement (i.e., “driving forces”). A FOS greater than 1 indicates a slope is stable since the resisting forces are greater than the driving forces. However, a FOS of at least 1.3 to 1.5 is

preferred in most cases. Slope movement occurs when resisting forces are less than driving forces. However, there are many types of slope movements ranging from the shallow to deep and from global (i.e., widespread) to localized (i.e., isolated).

The bluffs that are a part of the study area are natural features that can be stable over periods of time, but changes (natural or man-made) can impact the stability and lead to bluff movements or failures. Bluffs such as those in the study area have generally receded to a stable configuration based on a unique combination of the factors presented above. However, sudden or gradual changes to the bluff can impact the stability of the bluff and lead to failures. Based on our experience, most of the changes that can negatively impact bluff stability over relatively short periods of time (i.e., years) are triggered by human activity. Natural changes to the bluff stability generally take much longer (i.e., decades or centuries).

4.2 General Assessment of Study Area

While conducting the visual inspection of the bluffs in the study area, special attention was given to factors that affect bluff stability and that are apparent from visual observation. Specifically, the extent of vegetative cover was noted, along with surface drainage conditions, the presence (or absence) of seepage along the face of the bluff, and the inclination of the slope.

Based on our observations, the bluff area covered on Sheets 1 and 2 contain relatively good vegetative cover consisting of trees and brush. However, beginning at the northern limits of the area covered by Sheet 2 (about coincident with the location of the Vietnam War Memorial), there is evidence of past clearing of brush and cutting of trees. Evidence of such clearing extends northward to the area of the Broad Street stairway/pavilion and to the north toward the bluff area opposite the terminus of Pleasant Street. Evidence of clearing includes the presence of tree stumps and brush stubble. Evidence of tree clearing and brush cutting is also apparent on the bluff face at the City-owned lot south of Sutherland Avenue. In many areas where there is current evidence of tree and brush clearing, the 1999 topographic survey noted the presence of tree and brush cover. This indicates clearing and cutting activities have occurred in the last 10 years.

We did not see evidence of seepage emanating from the bluff face within the study area. This may be due to the relatively impermeable clays that comprise the majority of the bluff based on our review of available boring information. Seepage as a result of perched groundwater at the shallow interface between the sands and silts overlying the less permeable clays was also not noted during our site inspections. It is possible that perched groundwater that may be present at shallow depths is being intercepted by sand-filled utility trenches extending along Lake Boulevard.

Relatively steep bluff face inclinations of about 1:1 were observed in areas that were generally absent of root reinforcement from dense tree and/or brush cover. These areas are located downslope of the paved walkway just south of the pavilion (refer to Sheet 3), and in the grassy bluff areas between the top of the retaining wall along Water Street and the top of the bluff near the former moving walkway (refer to Sheet 5) and the top of the bluff near the amphitheatre (refer to Sheet 6). Evidence of surficial instability (i.e., shallow soil movement along the bluff face) is present in these three areas where there is a combination of steep bluff inclination and limited root reinforcement from tree or brush cover.

4.3 Recommendations for Improvements

As part of the visual inspection of the bluff in the study area, several conditions of instability or potential instability were noted that we recommend be addressed. These conditions are described below, along with a potential approach (or approaches) for improvement or repair. The conditions described below are presented in our recommended order of priority, with the highest priority first.

1. Address Retaining Wall along Water Street

A concrete retaining wall is located within the northern portion of the study area (refer to Sheets 5 and 6). This retaining wall is about 470-feet long and is situated along Water Street beginning at the base of the former moving walkway and extending to near the intersection of Water Street and State Street. This retaining wall appears to be a concrete gravity wall and the wall provides grade separation between the bluff face and the shoulder area along Water Street below. The maximum height of the wall is about 12 feet. Specific details about the existing wall construction are not known since plans of the original wall construction were not available.

The retaining wall contains numerous cracks and appears to be in generally fair condition. We understand the origin of the wall is unknown, but we suspect, and one City resident has stated, the construction of the retaining wall dates back at least 50 years. We consider this retaining wall a relatively critical feature since it supports the bluff area that contains the Howard band shell and the wall provides grade separation between the bluff toe and Water Street, which is the only route from the north to the beach and the residential/retail areas to the west of the bluff.

Based on the suspected age of the wall and condition of the wall based on visual observations, it is our opinion that the wall is nearing the end of its service life. We cannot predict how much longer the wall will function based on the currently available information. However, since this would be a significant and major project, we recommend planning and preliminary design for a new retaining wall commence now so that the wall can be replaced in a proactive manner. If planning and design for the new wall does not commence until significant distress and even failure of the wall occurs, significantly more disruption could occur and there could be a loss of bluff area (and the improvements supported by the bluff) behind the wall.

We recommend that the new retaining wall in this area consist of a new wall that is built immediately in front of the existing wall. The existing wall should remain in-place to mitigate disturbance to the bluff behind the existing wall. Based on our experience, we believe the new retaining wall could consist of a reinforced concrete “skin” that is constructed against the existing wall. We anticipate the thickness of the structural skin may be approximately 12 to 18 inches. For this approach we anticipate soil anchors or soil nails will need to extend through the new structural skin and into the bluff behind the wall to provide lateral support for the wall system. Although the new structural skin will extend toward Water Street and reduce the room between the existing roadway and the new wall by the thickness of the new skin, it appears that Water Street is sufficiently wide in this area to accommodate this reduction in width. It is possible that the new retaining wall could extend to a higher height than the existing wall. This would allow for the slope behind the wall to be flattened compared to the current inclination, which could enhance the surficial stability of the bluff face in this area. The face of the new wall could also be provided with architectural treatments (e.g., coloring and texturing) to enhance the aesthetics of the wall.

An illustration of the concept for repair of this retaining wall is shown on Figure No. 1, Conceptual Repair Illustration for Water Street Retaining Wall, contained in Appendix C. This figure is provided for illustration only and is not intended for final design or construction. Based on our experience and on a rough estimate of the height and surface area of the wall face, we estimate repairing the existing wall as outlined above could cost in the range of \$250,000 to \$300,000.

2. Address Condition of Walkway to the South of the Pavilion

As noted above in Section 3.3, an existing paved walkway extends down the bluff face to the southwest from the pavilion area. This walkway is about 260-feet long and appears to have been constructed by using a concrete retaining wall system to support the walkway on the downslope side. The retaining wall system that supports the walkway is judged to be in relatively poor condition, but the repairs completed appear to have stabilized the wall and the associated walkway on at least an interim basis. We expect that the wall and the walkway supported by the wall will remain in a stable condition similar to the existing conditions until changes in the bluff in this area are experienced (e.g., moisture levels become elevated due to heavy rainfall) or until components of the wall fail (e.g., the anchors corrode, the concrete cracks further, etc.).

Based on our observations of the condition of the existing walkway, we believe minor repairs, such as patching, may be made to maintain the cosmetic appearance or “walkability” of the existing walkway. However, we believe structural repairs to or replacement of the existing walkway should not be made in its current location and configuration if additional movements of the wall are experienced. Therefore, once additional movement of the wall occurs, we believe the existing retaining wall system and associated walkway will need to be taken out of service. Consideration should be given to removing the retaining wall and the walkway before further movement of the wall and the walkway supported by the wall is experienced since such movement could lead to significant disturbance to the bluff in this area. As an alternative and as a means to keep the wall and associated walkway in-service as long as practical, the condition of the wall and walkway could be monitored on a regular basis by the City of St. Joseph to look for changes in the condition of the wall. In general, we would expect changes in the condition of the wall to result from

specific events such as heavy rainfall or snowmelt along the bluff area. Therefore, regular monitoring of the walkway should be performed, particularly after significant precipitation events and other weather events that could adversely affect the performance of the wall.

If the community wishes to continue to maintain a ramp system for accessibility to the bluff toe in this location, the existing walkway would need to be replaced with a new walkway since an existing stairway to the base of the bluff is located at the pavilion immediately north of the walkway. A new at-grade walkway (i.e., without steps) would need to be supported either by a retaining wall system or would need to be similar in configuration to the timber stair system recently installed by the City of St. Joseph and located at the western terminus of Lake Court.

3. Enhance Vegetative Cover in Steep Bluff Areas

Relatively steep bluff face inclinations of about 1:1 were observed in areas that were generally absent of root reinforcement from dense tree and/or brush cover. These areas are located downslope of the paved walkway just south of the pavilion (refer to Sheet 3), and in the grassy bluff areas between the top of the retaining wall along Water Street and the top of the bluff near the former moving walkway (refer to Sheet 5) and the top of the bluff near the amphitheatre.

We recommend vegetative cover in these steep bluff face areas be improved and enhanced beyond the root reinforcement provided by the current grass or ground cover. Ideally, vegetative cover in these areas should consist of vegetation that has roots that extend several feet into the subsurface. These root systems provide reinforcement to the soil in these shallow zones and serve to enhance soil moisture conditions since the vegetation tends to take up moisture from the soil. More information about planting approaches of soil bioengineering measures is provided below in Section 4.4.

4. Correct Uncontrolled Runoff

At the north end of the study area where Port Street extends east from the northern terminus of Lake Boulevard, there appears to be a significant amount of runoff channeled down toward Water Street (refer to Photo No. 37). Consideration should be given to installing a catch basin in this area to collect this runoff and convey the flow to a storm sewer. Permanent erosion control measures may also be required to mitigate erosion potential before the runoff reaches the new catch basin.

In pavilion area, we observed scuppers that allow surface water that collects on the flatwork to discharge through the short perimeter walls and onto the bluff face below. This discharge is leading to erosion of the bluff face in these areas. We recommend runoff from the flatwork areas of the pavilion be directed into a drainage collection system that conveys the flow to the base of the bluff.

Upslope of the walkway to the south of the pavilion, we observed a location adjacent to the canon exhibit where drainage from the bluff top is being directed over the bluff edge and into a paved spillway that discharges onto the walkway. We recommend that surface drainage from the bluff top not be directed over the edge of the bluff. If practical, surface drainage in the park area should be collected in small yard inlets and directed to the storm sewer system along Lake Boulevard via pipe flow.

4.4 Soil Bioengineering Measures

Soil bioengineering entails the use of vegetative measures (i.e., plant materials) to provide “structural” reinforcement to the soil and to protect the surface from surface water flow to mitigate erosion and surficial slope failures. We believe the use of plant materials such as trees and shrubs could be used to enhance the surficial stability of areas of the bluff that are relatively steep and where such vegetation is currently not present. A definitive guide to soil bioengineering is provided in Chapter 18 (Soil Bioengineering for Upland Slope Protection and Erosion Reduction) of the USDA Engineering Field Handbook. This guide can be found on the web and is available for downloading free of charge.

For the subject bluff, we believe the use of live staking would be a measure to establish woody plant materials on the bluff face without causing significant disturbance to the bluff. Live staking generally involves the insertion of live, rootable cuttings into the ground. These live cuttings can relatively quickly generate a root base into the underlying soil. More information on live staking and associated plant materials that are conducive to live staking is presented in the referenced USDA Handbook. Illustrations of live staking are presented on Figure No. 2, Live Staking Illustrations, contained in Appendix C.

4.5 Bluff Management Recommendations

We understand the City of St. Joseph is interested in potentially implementing a bluff management plan within the bluff areas owned by the City of St. Joseph. Such a plan could become a model for bluff areas that are owned by private parties. Such plans are probably best implemented on a group or association basis rather than an individual basis. If individuals implement such practices but adjacent neighbors do not, poor management practices of one resident could negatively impact the bluff area of the neighbor. The purpose of the bluff management plan would be to discourage or prohibit practices that tend to destabilize the bluffs and to identify practices that could be implemented to enhance the stability of the bluffs.

In general, a bluff management plan needs to recognize that there are certain factors that affect the stability of the bluffs that cannot be changed (or at least *easily* changed). These factors include geology, soil and rock strengths, groundwater conditions, and slope geometry (unless retaining walls are built). A bluff management plan should encourage the implementation of practices that tend to enhance or at least maintain the stability of bluffs.

Some key elements of a bluff management plan could include the following:

Vegetative Cover: Practices that enhance vegetative cover on the bluff face should be encouraged. Conversely, practices that reduce vegetative cover (such as arbitrary cutting of trees and clearing of brush) should not be allowed. In general, a dense covering of low-height woody vegetation can enhance the bluff stability by providing root reinforcement in shallow soil zones and by providing erosion resistance at the ground surface. Vegetative cover also reduces soil moisture levels (by the process of evapotranspiration whereby soil moisture levels are reduced by the uptake of soil moisture in the plant roots) and intercepts or “knocks down” (called “interception”) the energy from direct rainfall that could otherwise detach and erode soil particles from the ground surface.

Trees should be pruned to promote the health of the tree rather than solely to promote views. Trees should not be cut down unless thinning would improve the stand of trees or unless the tree is dying or at risk for toppling. Trees that are removed should have the stump and root system left intact since the roots will provide some soil reinforcement and erosion protection for several years after tree removal. However, eventually the stump and root systems will decompose and become ineffective. Therefore, replacement of the root systems should be encouraged with new plantings.

Surface Drainage: Surface runoff should not be allowed to flow over the top of slopes since the runoff can promote erosion of the slope or bluff face. Surface water collected by drainage collection systems (such as roof downspouts or storm sewers) should not be discharged at the top of or onto the face of bluffs or slopes. Instead, these flows should be conveyed in a controlled manner to the base of slopes or bluffs and discharged beyond the toe.

Walkways/Pathways: Dedicated pathways or walkways should be provided on slope or bluff faces if pedestrian access is required. Keeping pedestrians on dedicated walkways or pathways keeps vegetation from becoming trampled and keeps erosion features from forming in trails that would otherwise be arbitrarily formed along the slope face. As an example of this concept, dedicated pathways are implemented throughout dune areas at many state parks along the shores of the Great Lakes to limit trampling and destruction of vegetation that enhances the stability of the dunes. Stairways and boardwalks are also provided in state parks to keep pedestrians on a dedicated path.

Filling or Disturbance: The placement of fills on the bluff face or near the top of the bluffs should be discouraged since the added soil mass tends to increase driving forces tending to destabilize the bluff. An example of this would be where fills are placed at the rear of homes near the bluff edge to establish more rear yard space or a space for a patio. Disturbances to the bluff face, such as excavations for utilities should be limited and even eliminated if possible. Disturbed areas, even if backfilled with engineered fill, will likely not be as stable as undisturbed bluff areas where steep slope face inclinations are present. Fill or debris such as leaves and grass clippings discarded on the face of slopes can also suffocate vegetative cover on the slope face. Therefore, we recommend that slope areas or bluff areas not be used for compost disposal or debris disposal.

5. GENERAL COMMENTS

Our evaluation of the bluffs in the study area was based on visual observations and review of readily available data. Therefore, the contents of this report should not be treated as an in-depth engineering evaluation. If additional information or data regarding the bluffs in the study area is developed or provided, we should review the new information or data and make modifications (if required) to our opinions and recommendations contained herein.

APPENDIX A

SHEET 1: PARK STREET TO PEARL STREET

SHEET 2: PEARL STREET TO MARKET STREET

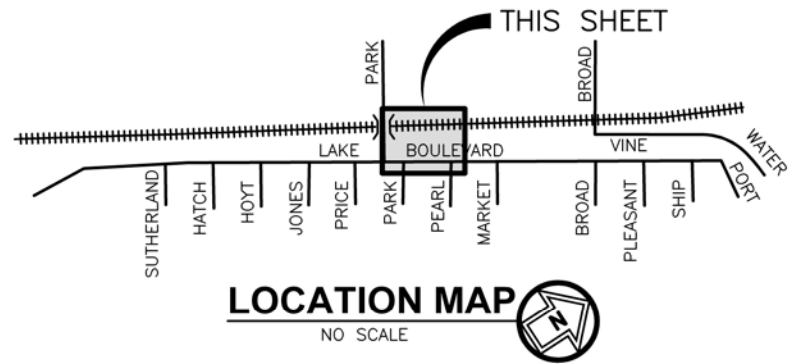
SHEET 3: MARKET STREET TO BROAD STREET

SHEET 4: BROAD STREET TO SHIP STREET

SHEET 5: SHIP STREET TO FIREMEN'S MONUMENT

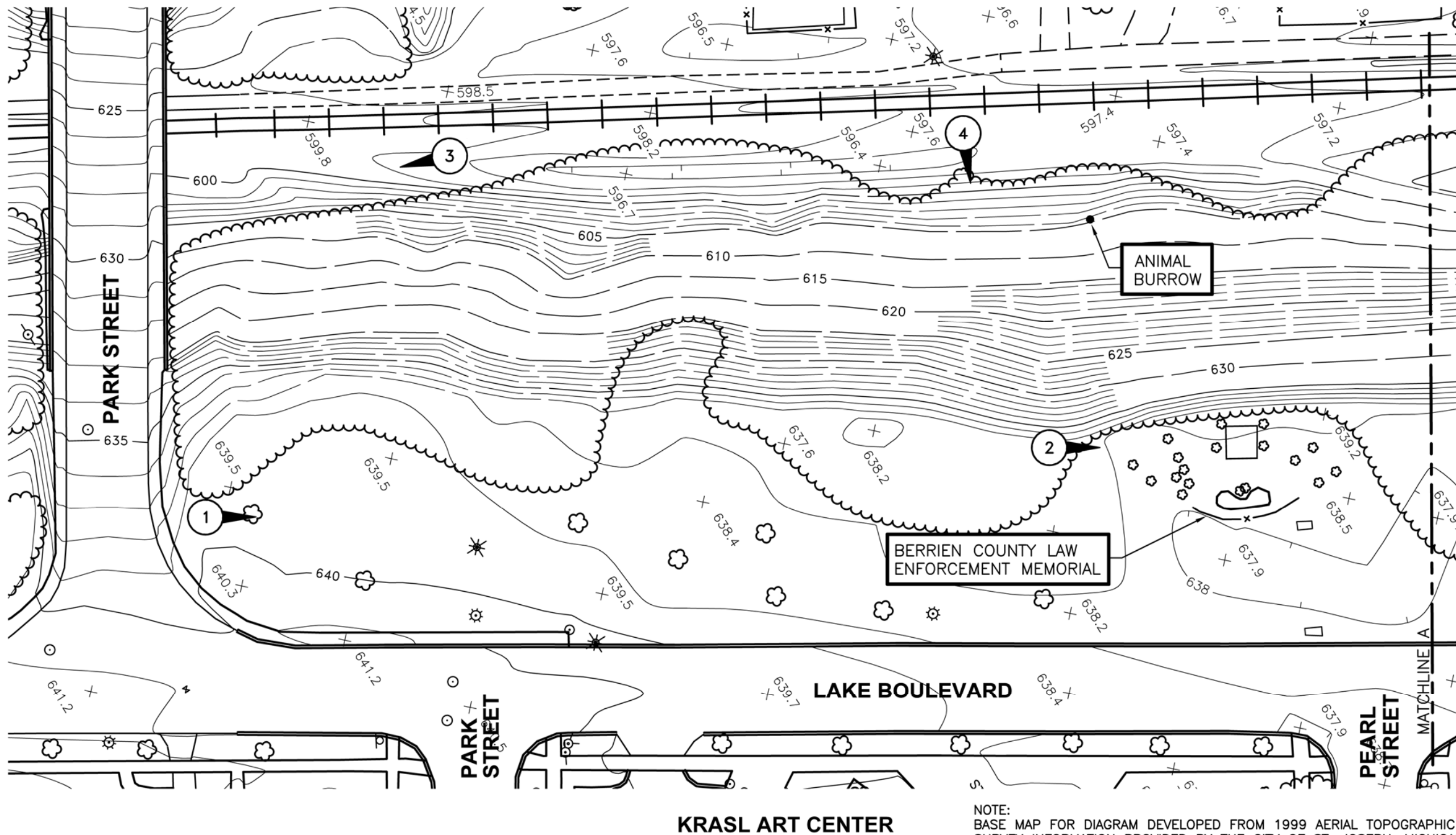
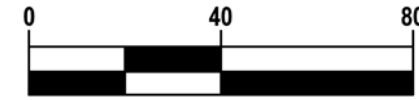
SHEET 6: FIREMEN'S MONUMENT TO STATE STREET

SHEET 7: CITY-OWNED LOT SOUTH OF SUTHERLAND AVENUE



GENERAL OBSERVATIONS DURING SITE RECONNAISSANCE

1. SIDEWALK AND WALKWAY IMPROVEMENTS HAVE BEEN COMPLETED SINCE PREPARATION OF TOPOGRAPHIC SURVEY.
2. ELECTRICAL ACCESS BOXES AND AN ELECTRICAL LINE ARE LOCATED ALONG TOP OF BLUFF.
3. SURFACE DRAINAGE AT TOP OF BLUFF IS GENERALLY DIRECTED AWAY FROM THE TOP OF THE SLOPE.
4. SEEPAGE WAS NOT OBSERVED ALONG THE BLUFF FACE OR BLUFF TOE.
5. BLUFF FACE IS GENERALLY VEGETATED WITH TREES AND BRUSH.



NOTE:
 BASE MAP FOR DIAGRAM DEVELOPED FROM 1999 AERIAL TOPOGRAPHIC SURVEY INFORMATION PROVIDED BY THE CITY OF ST. JOSEPH, MICHIGAN

No.	1				
Revision Date	07-15-2009				

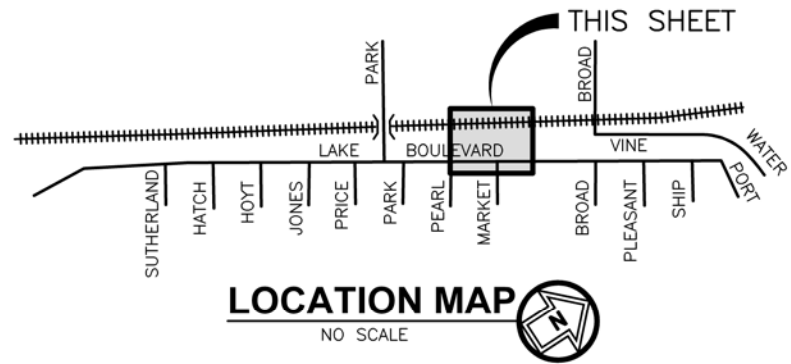
**LAKE BOULEVARD
 BLUFF EVALUATION
 ST. JOSEPH, MICHIGAN**

Date	04-03-09
Drawn By	SRG
Designed By	JMK
Scale	1" = 40'
Project	KG59313

plymouth
 bay city
 grand rapids
 kalamazoo
 lansing
 shelby twp.
 toledo
 traverse city

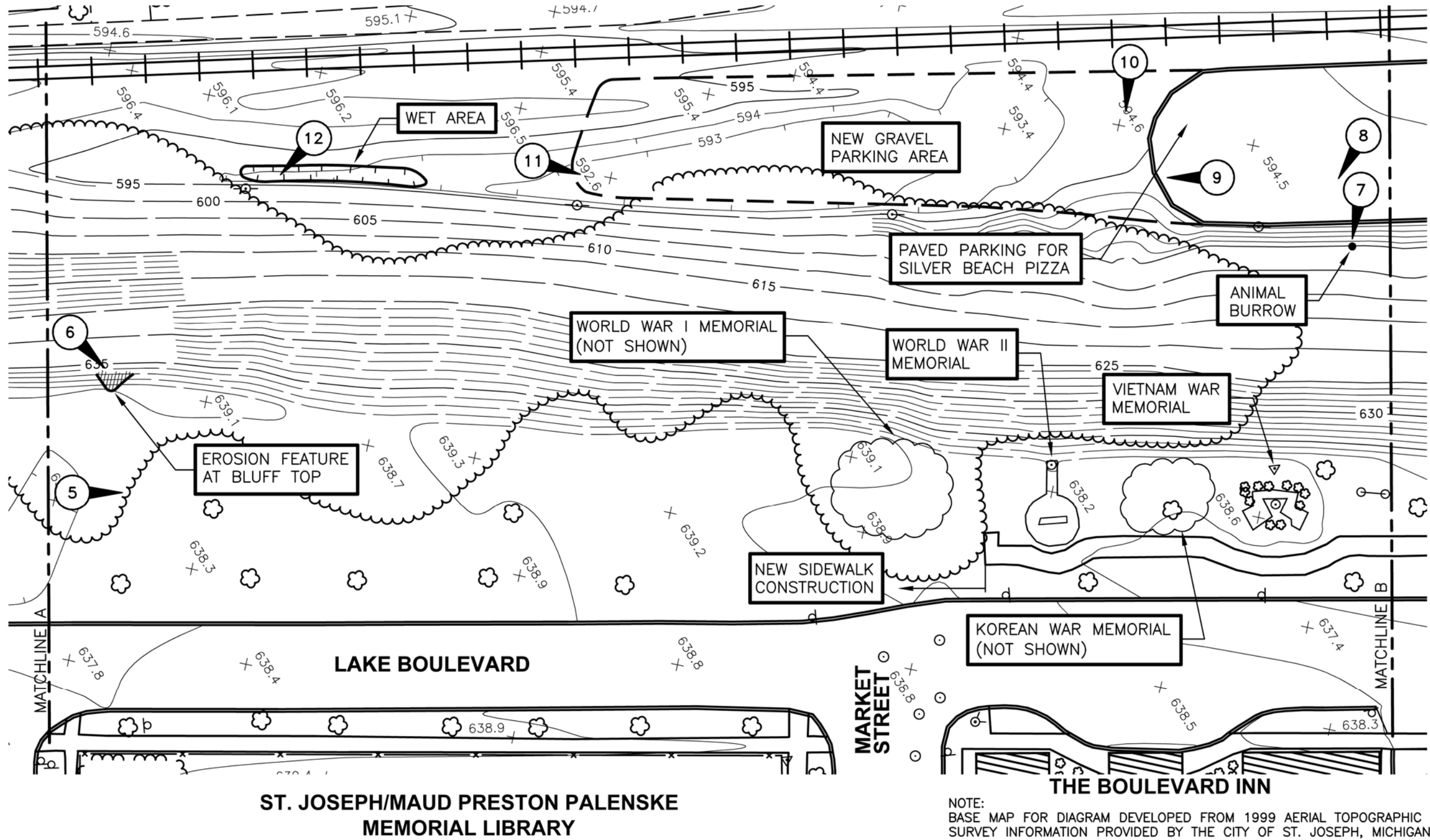
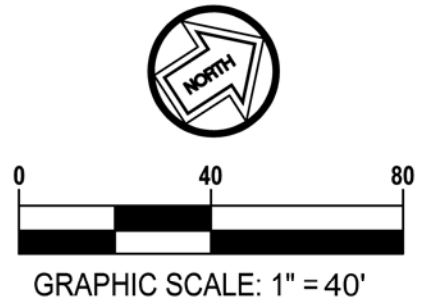


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GENERAL OBSERVATIONS DURING SITE RECONNAISSANCE

1. SIDEWALK AND WALKWAY IMPROVEMENTS HAVE BEEN COMPLETED TO THE SOUTH OF THE WORLD WAR II MEMORIAL SINCE PREPARATION OF TOPOGRAPHIC SURVEY.
2. ELECTRICAL ACCESS BOXES AND AN ELECTRICAL LINE ARE LOCATED ALONG TOP OF BLUFF. ROOTS OF TREES HAVE BEEN CUT WHEN ELECTRICAL LINE TRENCHED IN ALONG BLUFF TOP.
3. SURFACE DRAINAGE AT TOP OF BLUFF IS GENERALLY DIRECTED AWAY FROM THE TOP OF THE SLOPE.
4. SEEPAGE WAS NOT OBSERVED ALONG THE BLUFF FACE OR BLUFF TOE, BUT AN AREA OF PONDED WATER AT THE TOE WAS OBSERVED (SEE PHOTO NO. 12).
5. BLUFF FACE IS GENERALLY VEGETATED WITH TREES AND BRUSH. THERE IS EVIDENCE OF TREE CUTTING AND BRUSHING AT NORTH END OF THIS SHEET.



NOTE:
BASE MAP FOR DIAGRAM DEVELOPED FROM 1999 AERIAL TOPOGRAPHIC SURVEY INFORMATION PROVIDED BY THE CITY OF ST. JOSEPH, MICHIGAN

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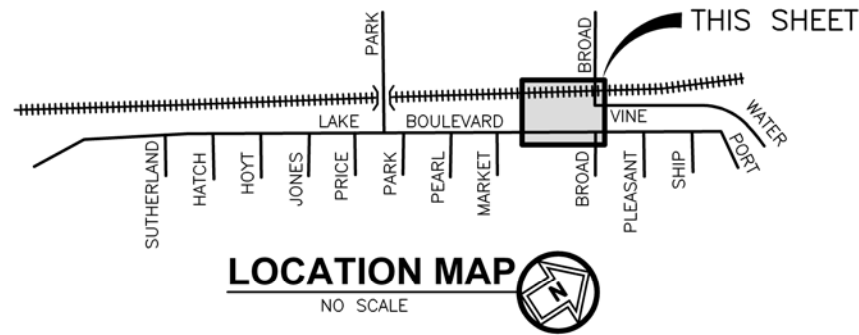
**LAKE BOULEVARD
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plymouth
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traverse city

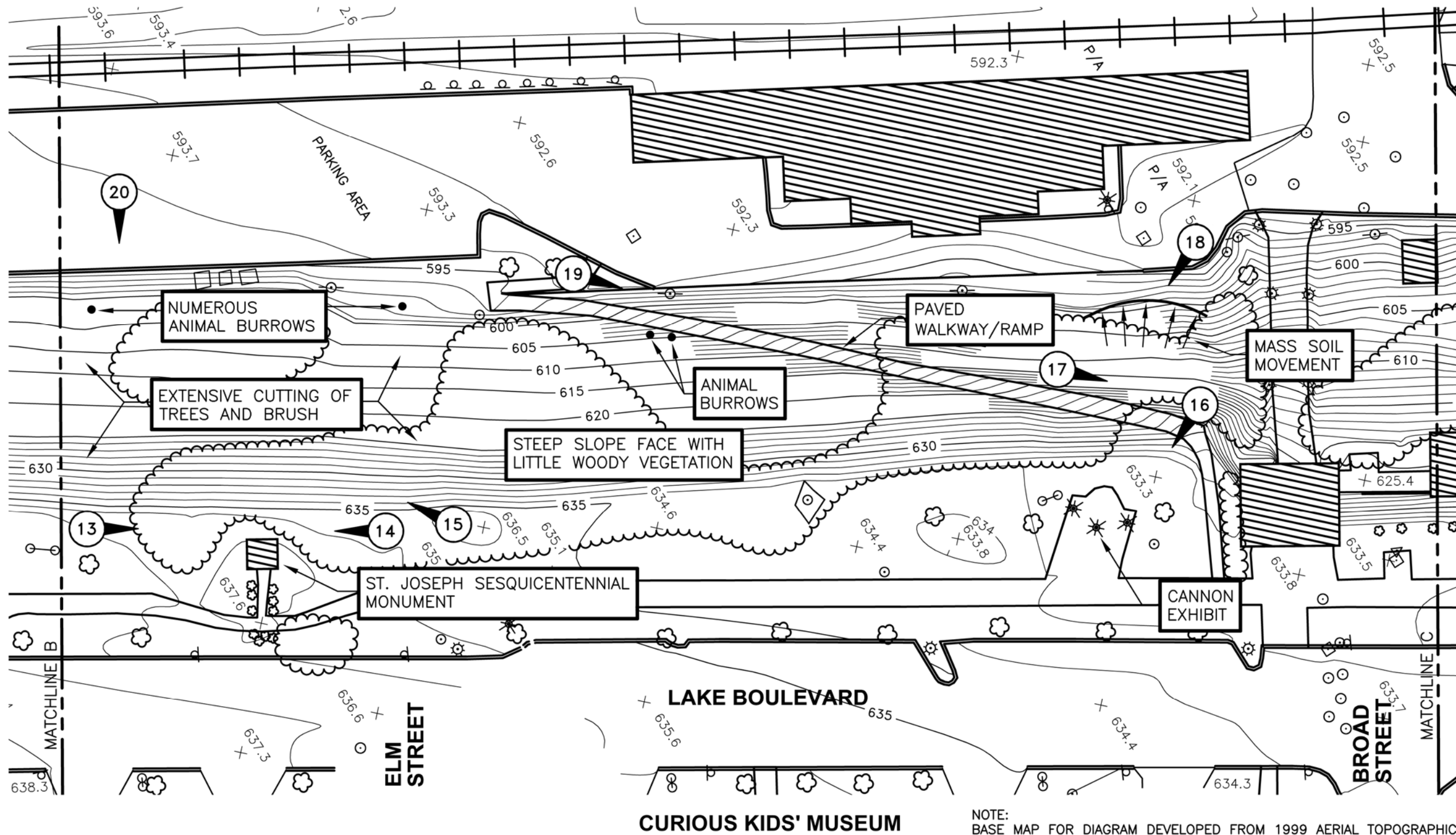
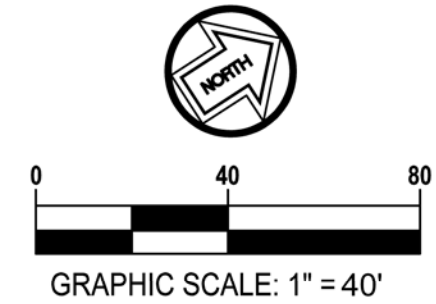


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GENERAL OBSERVATIONS DURING SITE RECONNAISSANCE

1. ELECTRICAL ACCESS BOXES AND AN ELECTRICAL LINE ARE LOCATED ALONG TOP OF BLUFF.
2. SURFACE DRAINAGE AT TOP OF BLUFF IS GENERALLY UNDEFINED.
3. SEEPAGE WAS NOT OBSERVED ALONG THE BLUFF FACE OR BLUFF TOE.
4. NUMEROUS ANIMAL BURROWS OBSERVED IN THIS AREA OF THE BLUFF.
5. EXTENSIVE TREE CUTTING AND BRUSHING HAVE OCCURRED IN THIS AREA OF THE BLUFF.
6. DISTRESS FEATURES, SUCH AS ROTATION, CRACKING AND SEPARATIONS ARE APPARENT IN THE CONCRETE RETAINING WALL THAT SUPPORTS THE WALKWAY/RAMP TO BASE OF BLUFF. REPAIRS HAVE BEEN MADE TO THE WALL.
7. RUNOFF FROM STAIRWAY AND RESTROOM FACILITY HAS LED TO LOCALIZED EROSION.



CURIOUS KIDS' MUSEUM

NOTE:
BASE MAP FOR DIAGRAM DEVELOPED FROM 1999 AERIAL TOPOGRAPHIC SURVEY INFORMATION PROVIDED BY THE CITY OF ST. JOSEPH, MICHIGAN

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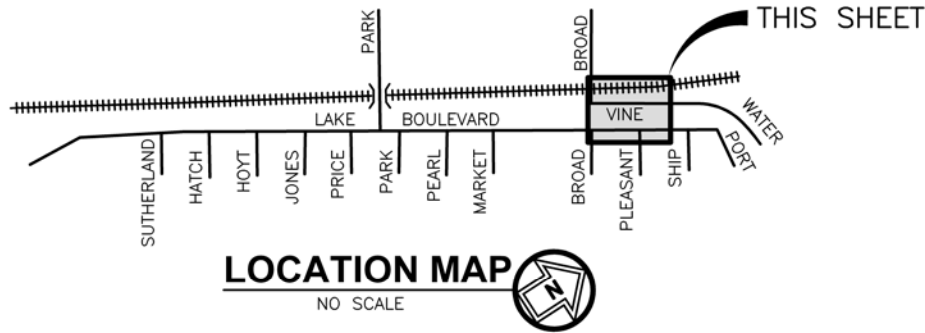
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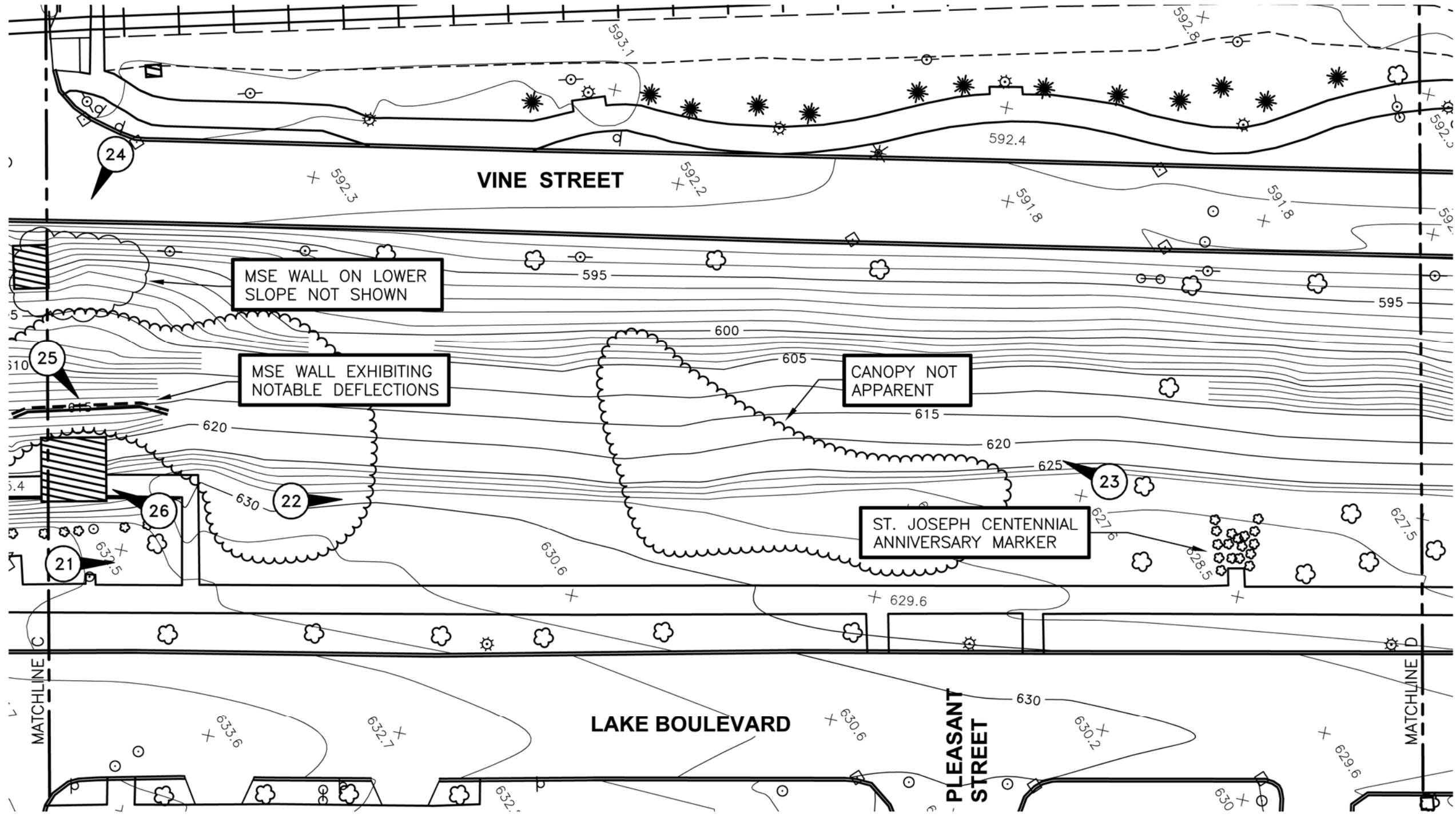
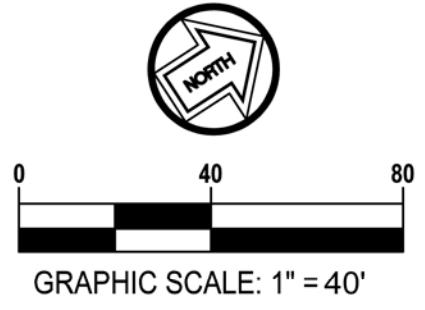


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GENERAL OBSERVATIONS DURING SITE RECONNAISSANCE

1. SEEPAGE WAS NOT OBSERVED ALONG THE BLUFF FACE OR BLUFF TOE.
2. BLUFF FACE IS MORE UNIFORM IN INCLINATION IN THIS AREA.
3. MOST OF BLUFF FACE IS VEGETATED WITH GRASS.
4. MSE RETAINING WALL IN UPPER PORTION OF BLUFF JUST NORTH OF THE STAIRWAY IS DEFLECTING/MOVING (SEE PHOTO NO. 25). LOWER MSE WALL FOR UTILITY PAD IS IN GOOD CONDITION (SEE PHOTO NO. 24).
5. ONLY A FEW ANIMAL BURROWS OBSERVED IN THIS AREA OF THE BLUFF.



NOTE:
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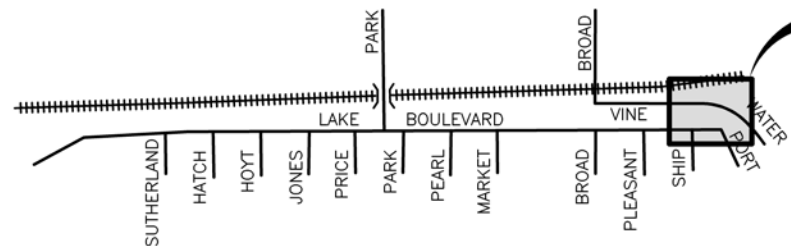
**LAKE BOULEVARD
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ST. JOSEPH, MICHIGAN**

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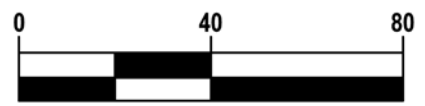
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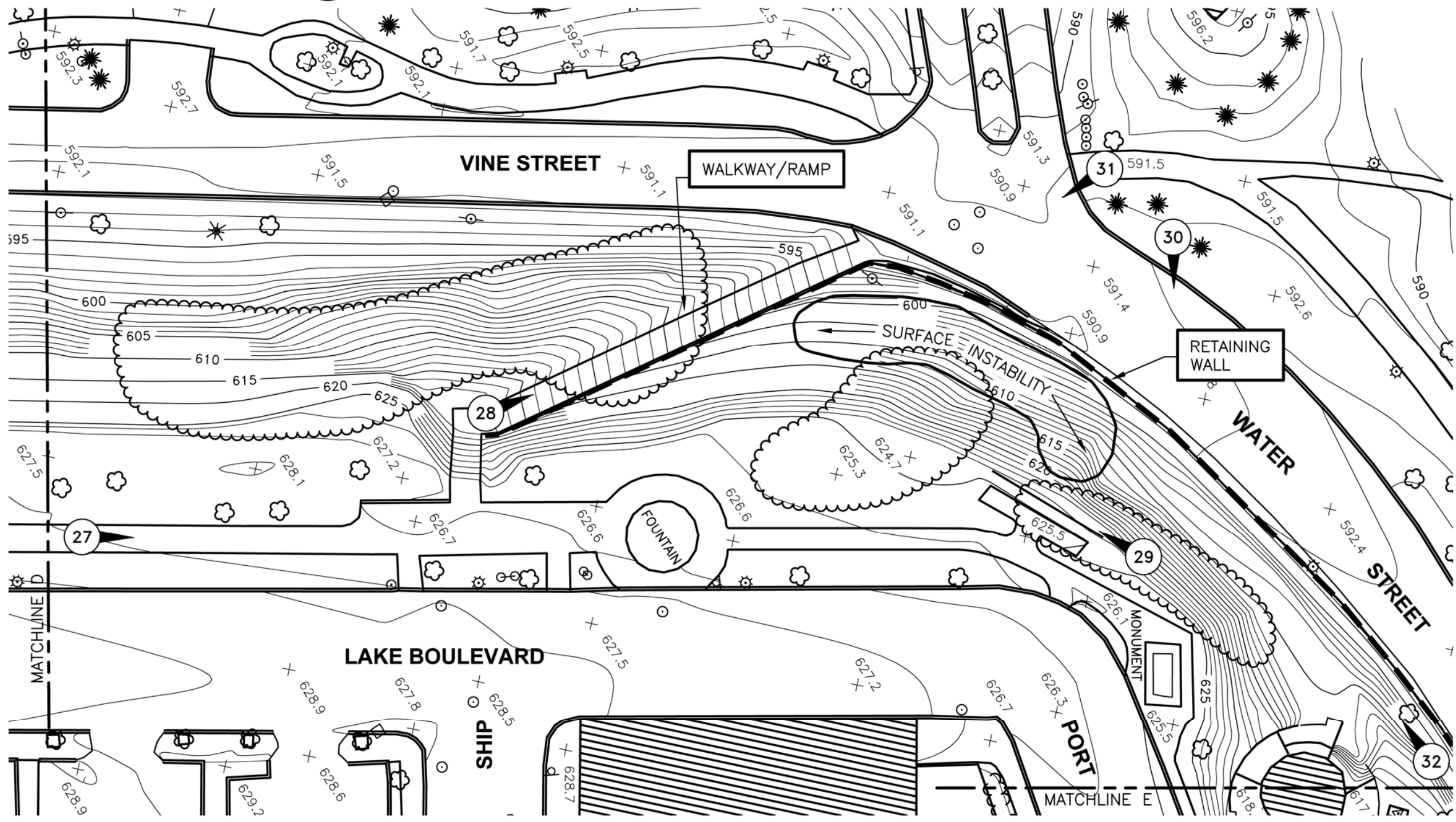
LOCATION MAP
NO SCALE

GENERAL OBSERVATIONS DURING SITE RECONNAISSANCE

1. MOST OF BLUFF FACE IS VEGETATED WITH GRASS. THERE ARE ALSO SEVERAL LARGE TREES PRESENT.
2. SEEPAGE WAS NOT OBSERVED ALONG THE BLUFF FACE.
3. CONCRETE RETAINING WALL ALONG WATER STREET HAS CRACKS AND SEEPAGE IS EVIDENT AT SOME OF THE WALL WEEP HOLES.
4. BLUFF FACE IS VERY STEEP BETWEEN THE WALKWAY/RAMP AND THE AMPHITHEATRE. SOME OF THE GRASSY AREAS ARE ERODING IN THE STEEPEST SLOPE AREAS.
5. CONCRETE WALL AT BENCH AREA IS DEFLECTING (SEE PHOTO NO. 29).



GRAPHIC SCALE: 1" = 40'



NOTE:
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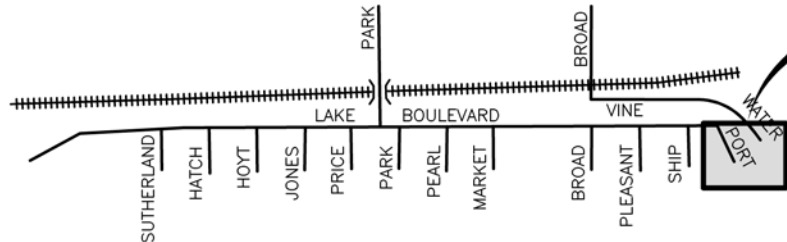
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traverse city



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GENERAL OBSERVATIONS DURING SITE RECONNAISSANCE

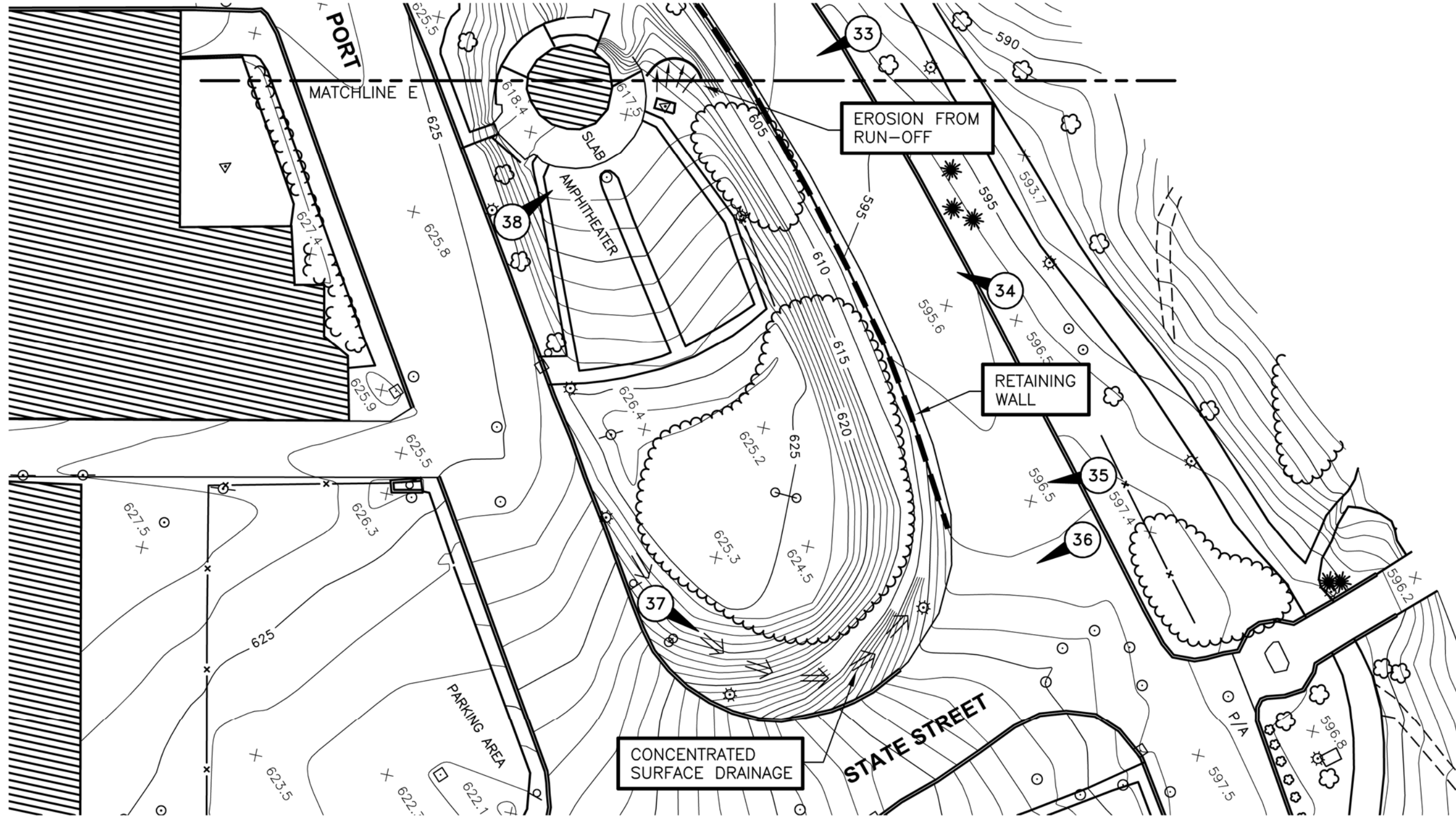
1. MOST OF BLUFF FACE IS VEGETATED WITH GRASS. THERE ARE ALSO SEVERAL LARGE TREES PRESENT.
2. SEEPAGE WAS NOT OBSERVED ALONG THE BLUFF FACE.
3. CONCRETE RETAINING WALL ALONG WATER STREET HAS CRACKS AND SEEPAGE IS EVIDENT AT SOME OF THESE CRACKS.
4. BLUFF FACE ABOVE THE RETAINING WALL IS VERY STEEP IN THIS AREA. SOME OF THE GRASSY AREAS ARE ERODING IN THE STEEPEST SLOPE AREAS.
5. THERE IS CONCENTRATED SURFACE DRAINAGE IN THE GRASS AREA BEHIND THE CURB ON THE WEST SIDES OF PORT AND STATE STREETS. (SEE PHOTO NO. 37).
6. THERE WAS PONDED WATER IN THE AMPHITHEATRE AREA AT THE TIME OF OUR SITE VISIT (SEE PHOTO NO. 38).



LOCATION MAP
NO SCALE



GRAPHIC SCALE: 1" = 40'



NOTE:
BASE MAP FOR DIAGRAM DEVELOPED FROM 1999 AERIAL TOPOGRAPHIC SURVEY INFORMATION PROVIDED BY THE CITY OF ST. JOSEPH, MICHIGAN

Revision Date	07-15-2009
No.	1

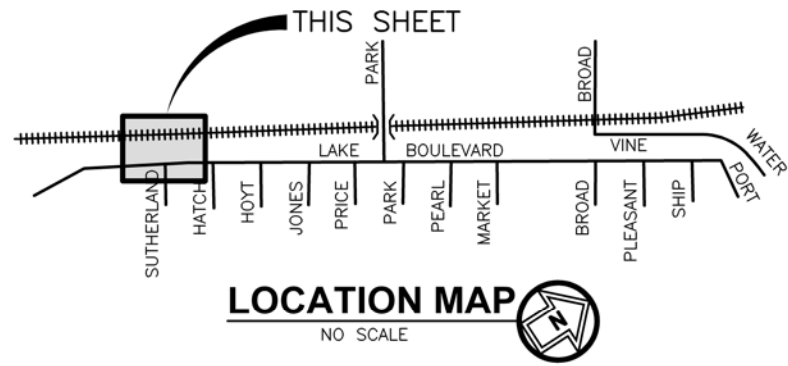
**LAKE BOULEVARD
BLUFF EVALUATION
ST. JOSEPH, MICHIGAN**

Date	04-03-09
Drawn By	SRG
Designed By	JMK
Scale	1" = 40'
Project	KG59313

plymouth
bay city
grand rapids
kalamazoo
lansing
shelby twp.
toledo
traverse city

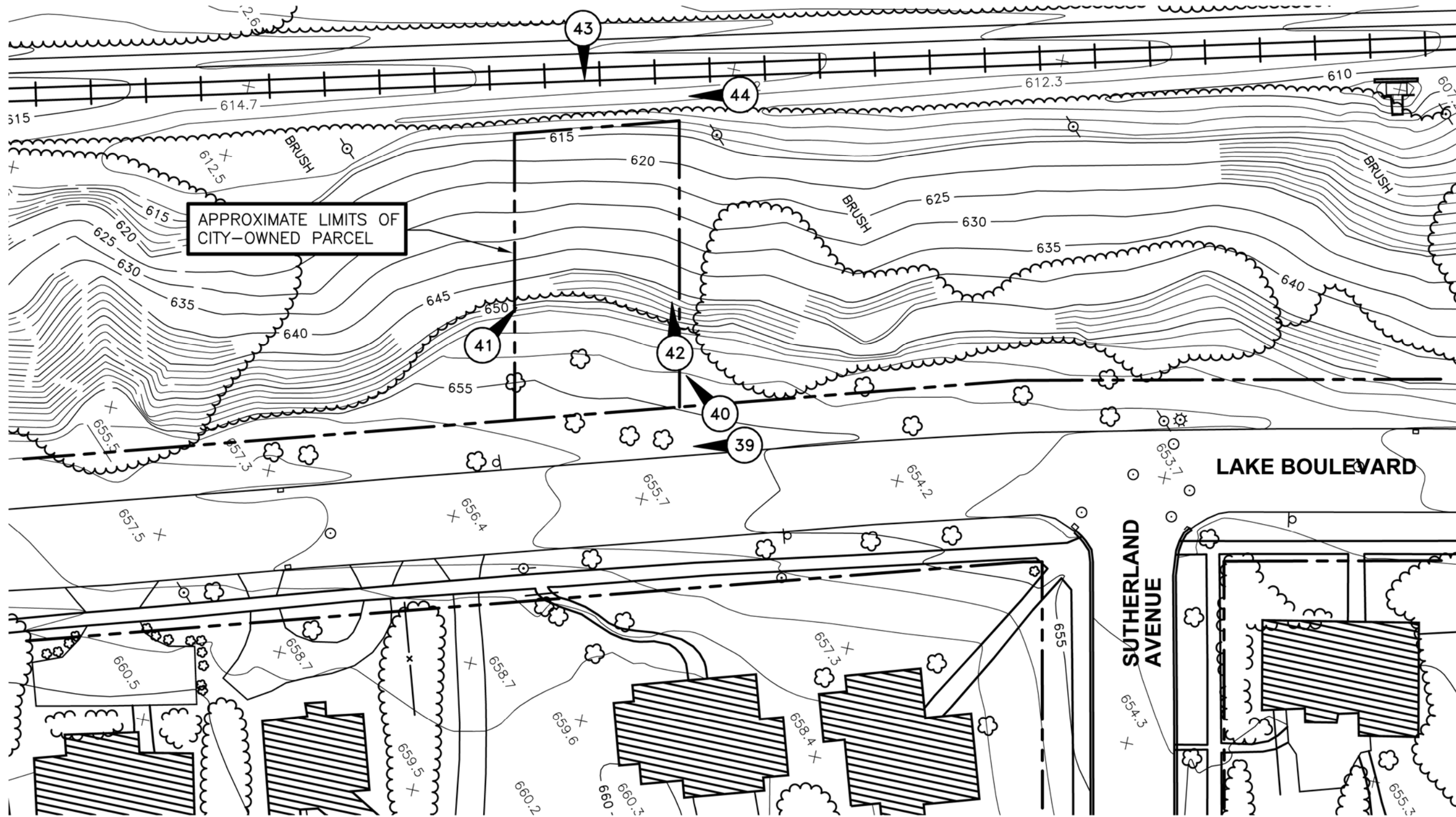
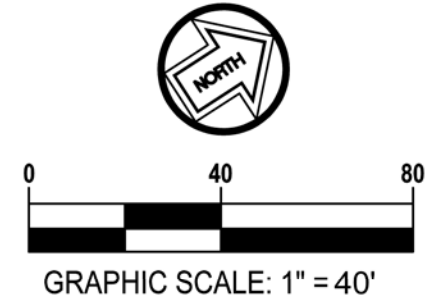


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GENERAL OBSERVATIONS DURING SITE RECONNAISSANCE

1. MOST OF BLUFF FACE IS VEGETATED WITH BRUSH THAT HAS RECENTLY BEEN TRIMMED/CUT.
2. AREA AT THE TOP OF THE BLUFF IS A MAINTAINED GRASS LAWN WITH SCATTERED LARGE HARDWOOD TREES.
3. DEBRIS SUCH AS YARD WASTE AND CONCRETE WASTE HAS BEEN CAST OVER THE TOP OF THE BLUFF.
4. SEEPAGE WAS NOT OBSERVED ALONG THE BLUFF FACE OR AT THE BLUFF TOE.



NOTE:
 BASE MAP FOR DIAGRAM DEVELOPED FROM 1999 AERIAL TOPOGRAPHIC
 SURVEY INFORMATION PROVIDED BY THE CITY OF ST. JOSEPH, MICHIGAN

Revision Date	07-15-2009
No.	1

**LAKE BOULEVARD
 BLUFF EVALUATION
 ST. JOSEPH, MICHIGAN**

Date	04-03-09
Drawn By	SRG
Designed By	JMK
Scale	1" = 40'
Project	KG59313

- plymouth
- bay city
- grand rapids
- kalamazoo
- lansing
- shelby twp.
- toledo
- traverse city



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APPENDIX B

SITE PHOTOGRAPHS (NOS. 1 THROUGH 44)



PHOTO NO. 1: Looking northeast along the top of the bluff from near the south end of Sheet 1.



PHOTO NO. 2: Looking along the top edge of the bluff behind the Berrien County Law Enforcement Memorial.

SME PROJECT NO.:	KG59313
DATE:	APRIL 29, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 3: Looking south from the base of the bluff toward the Park Street bridge.



PHOTO NO. 4: Note the relatively dense tree and brush cover along the bluff face.

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DATE:	APRIL 29, 2009
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LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 5: Looking northeast along the top of the bluff from near the south end of Sheet 2.



PHOTO NO. 6: Erosion just beyond the top edge of the bluff.

SME PROJECT NO.:	KG59313
DATE:	APRIL 29, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
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PHOTO NO. 7: Animal burrow near the bluff toe.



PHOTO NO. 8: Note the brush and tree removal in the left portion of the photo.

SME PROJECT NO.:	KG59313
DATE:	APRIL 29, 2009
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PHOTO NO. 9: Looking southerly along the base of the bluff.



PHOTO NO. 10: Note the presence of more trees and brush on the bluff face in this area compared to Photo No. 8.

SME PROJECT NO.:	KG59313
DATE:	APRIL 29, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
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PHOTO NO. 11: Looking northeast along the base of the bluff.



PHOTO NO. 12: Wet area at toe of bluff likely due to poor surface drainage.

SME PROJECT NO.:	KG59313
DATE:	APRIL 29, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 13: Looking northeast along the top edge of the bluff. Note the scar from the utility trench running parallel with the top edge of the bluff.



PHOTO NO. 14: Looking southerly at the utility trench scar along the top edge of the bluff.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 15: Looking southwest. Note the lack of tree and brush cover except for in the far left of the photo.



PHOTO NO. 16: Looking south from the walkway toward the cannon exhibit. Note the paved spillway where surface runoff is being directed over the bluff edge and to the walkway.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 17: Looking northeast at the upper portion of the walkway retaining wall. Note the steel plates and anchorages.



PHOTO NO. 18: Mass soil movement near the base of the bluff below the walkway. Note the leading edge of the mass protrudes above the bluff face below.

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DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 19: Looking northeast up the walkway. Note the retaining wall movements.



PHOTO NO. 20: Note the general lack of tree and brush cover on the bluff face.

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DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 21: Looking northeast along the bluff top from near the south end of Sheet 4.



PHOTO NO. 22: Looking northeast along the bluff face. Note most of the bluff cover is grassy.

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LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 23: Looking southwest along the bluff face.



PHOTO NO. 24: Looking southeast. The lower MSE wall is in good condition. The upper MSE wall (behind the tree) is experiencing excessive deflections at the top.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 25: Upper MSE wall looking northeast.



PHOTO NO. 26: Surface drainage from flatwork is being discharged onto the bluff face through scuppers in the walls.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 27: Looking northeast along the sidewalk between Lake Boulevard and the bluff edge.



PHOTO NO. 28: Looking down (to the north) along the former “moving walkway”. Note the cracking in the retaining wall to the right.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 29: Note the lean (downslope) in the wall and handrail at right.



PHOTO NO. 30: Concrete retaining wall along Water Street. Note cracks in the concrete.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 31: Concrete retaining wall along Water Street near base of walkway. Note water stains at drain discharge location.



PHOTO NO. 32: Looking west along the relatively steep grassy slope above concrete retaining wall along Water Street.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 33: Note the cracking and concrete deterioration in the retaining wall.



PHOTO NO. 34: Looking southwest at the concrete retaining wall along Water Street.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 35: Note cracking near the end of the concrete wall and erosion along grassy slope face.



PHOTO NO. 36: Looking south where Water Street meets State Street.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 37: Erosion due to concentrated surface drainage.



PHOTO NO. 38: Ponded water in the flatwork area of the Howard band shell.

SME PROJECT NO.:	KG59313
DATE:	MAY 1, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 39: Looking southwest along the western edge of Lake Boulevard.



PHOTO NO. 40: Looking west at area above the edge of bluff.

SME PROJECT NO.:	KG59313
DATE:	APRIL 29, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 41: Looking north from near top edge of the bluff.



PHOTO NO. 42: Looking northwest down the bluff face. Note the brush that has been cut.

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DATE:	APRIL 29, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN



PHOTO NO. 43: Looking southeast at the bluff face from beyond railroad tracks. Note lack of tree cover and that brush has been cut.



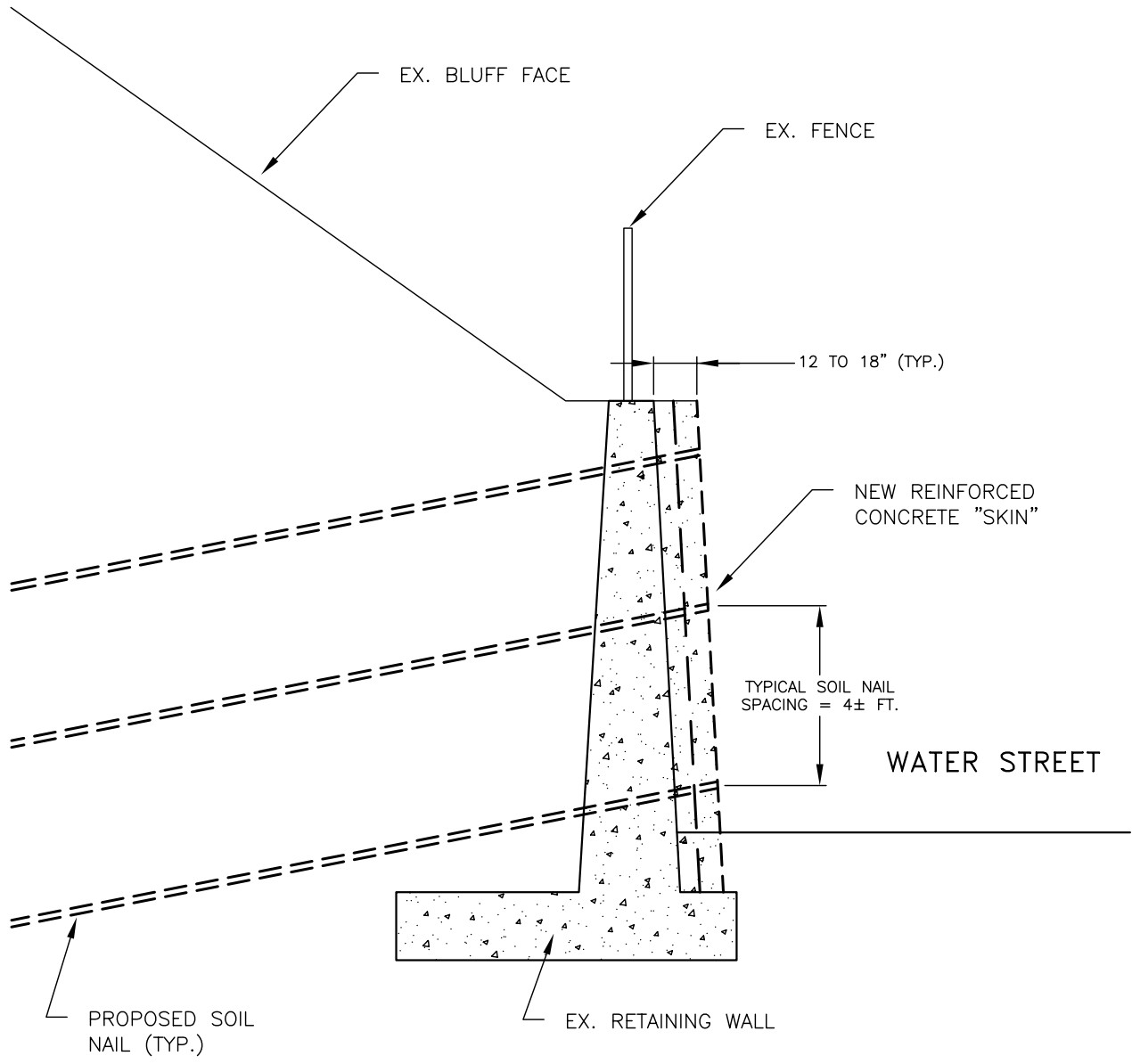
PHOTO NO. 44: Looking southwest along the toe of bluff.

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DATE:	APRIL 29, 2009
PROJECT:	LAKE BOULEVARD BLUFF EVALUATION
LOCATION:	ST. JOSEPH, MICHIGAN

APPENDIX C

**FIGURE NO. 1: CONCEPTUAL REPAIR ILLUSTRATION FOR
WATER STREET RETAINING WALL**

FIGURE NO. 2: LIVE STAKING ILLUSTRATIONS



N.T.S.

NOTES:

1. ILLUSTRATION IS FOR CONCEPTUAL PURPOSES ONLY – NOT FOR CONSTRUCTION AND NOT INTENDED AS A FINAL DESIGN.
2. DIMENSIONS AND DETAILS OF EXISTING RETAINING WALL SYSTEM HAVE NOT BEEN FIELD VERIFIED.

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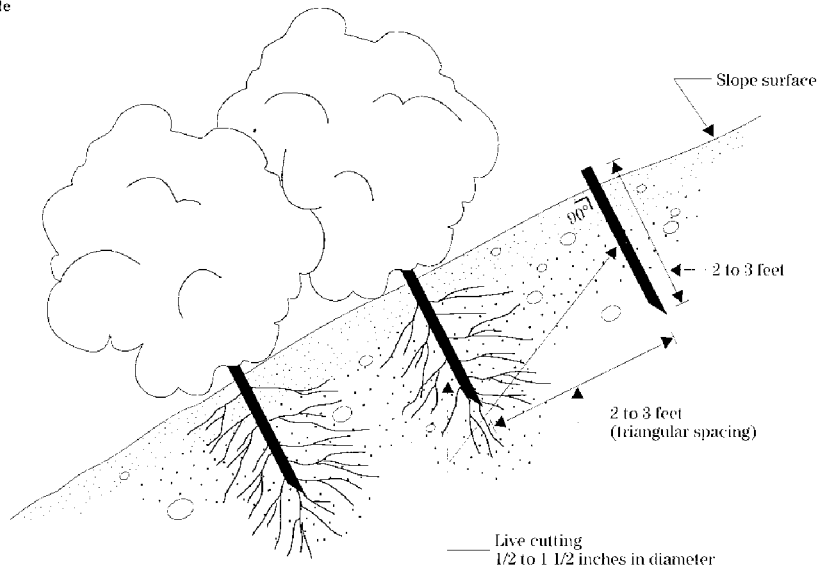
 www.sme-usa.com	plymouth bay city grand rapids kalamazoo lansing shelby twp. toledo traverse city	Date	07-06-09	CONCEPTUAL REPAIR ILLUSTRATION FOR WATER STREET RETAINING WALL LAKE BOULEVARD BLUFF EVALUATION ST. JOSEPH, MICHIGAN	No.	Revision Date
		Drawn By	GM			
		Designed By	JMK			
		Scale	NTS			
		Project	KG59313			

Figure No. 1

Cross section
Not to scale



SCHEMATIC CROSS SECTION OF LIVE STAKES



PHOTO OF LIVE STAKE AFTER ROOTING

ILLUSTRATIONS COURTESY OF CHAPTER 18 OF THE USDA ENGINEERING FIELD HANDBOOK

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 <p>www.sme-usa.com</p>	<p>plymouth bay city grand rapids kalamazoo lansing shelby twp. toledo traverse city</p>	Date	07-06-09	<p>LIVE STAKING ILLUSTRATIONS LAKE BOULEVARD BLUFF EVALUATION ST. JOSEPH, MICHIGAN</p>	No.	Revision Date
		Drawn By	GM			
		Designed By	JMK			
		Scale	NTS			
		Project	KG59313			

Figure No. 2