ENGINEER'S REPORT

STREAMBANK FLOOD DAMAGE FEASIBILITY ANALYSIS

KELLOGG, MINNESOTA 2010

I hereby certify that this plan, specification or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Nathan W. Anderson, P.E.

5 Jan 2011 — 46020

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Shaping The Horizon

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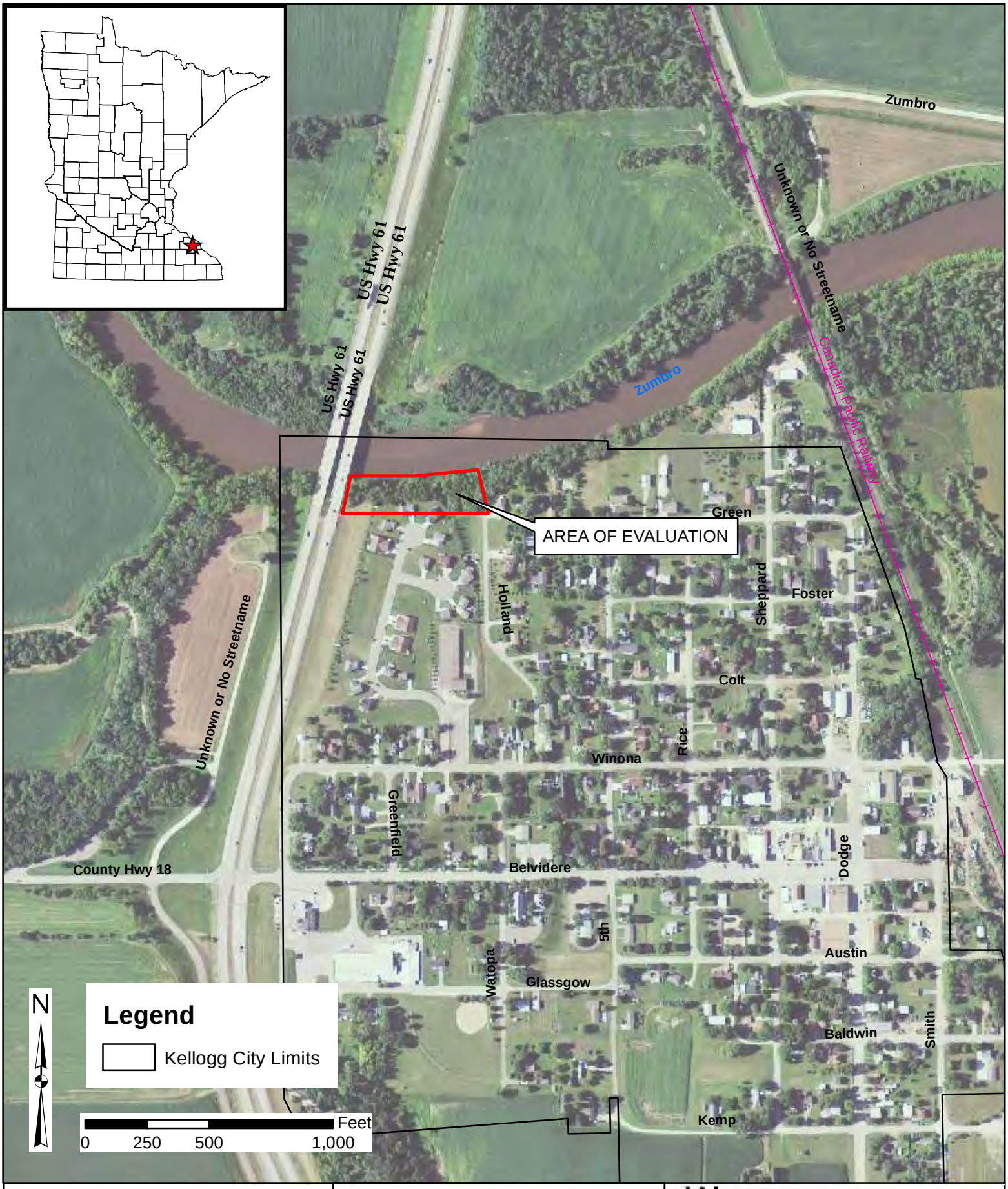
Part I - Introduction

Background

Severe flooding during September of 2010 resulted in streambank erosion along the south bank of the Zumbro River just east of Highway 61 in the City of Kellogg (See Figure 1.1). The erosion resulted in a series of slope failures that are now threatening several homes located on the southern perimeter of the river bank. The exposed bank is approximately 60 feet high and is continuing to fail at an undetermined rate. Shortly after the flood several Federal, State and Local government agencies were made aware of the damage and performed various levels of site investigation. In order to coordinate recovery efforts the Wabasha County Soil and Water Conservation District (SWCD) became the interagency lead for the recovery of this site. The SWCD held several interagency meetings to discuss potential design alternatives and funding options. The project was designated as an eligible Emergency Watershed Protection (EWP) program site by the Natural Resources Conservation Service (NRCS), with cost-share funding potentially available through one or more State agencies from designated Minnesota Flood Relief funds. However, initial cost estimates exceeded the funding likely available and several concerns were raised regarding the evaluated alternatives. Specifically, concerns were raised that the alternatives did not adequately address impacts to existing City utilities and infrastructure, nor did they adequately address the necessary site mitigation requirements should the threatened homes be removed. Because of these concerns, the Minnesota Board of Water and Soil Resources (BWSR) provided a grant for the City of Kellogg to further investigate the various design alternatives as well as investigate new alternatives that were not previously considered. The intent of this study is to identify and evaluate feasible alternatives to address the erosion issues and either protect, relocate, or remove the threatened homes and infrastructure. The results of this analysis will then be used to coordinate funding efforts as appropriate.

Project Scope

The scope of this study is to evaluate and present alternatives to address the continuing slope failure and related threats to existing homes and infrastructure at the site. Of primary concern are three existing homes located above the river which appear to be the



FLOOD DAMAGE
ALTERNATIVES ANALYSIS

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FIGURE 1.1

PROJECT SITE MAP

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most likely to be impacted. The analysis of alternatives is broadly divided into two separate approaches. The first approach is to remove the existing homes and allow the slope to fail while providing a minimal amount of site mitigation. The second approach is to stabilize the river bank through one or more construction techniques with the intent of preserving as much infrastructure as possible. With these two approaches in mind the scope of this report is outlined as follows:

1) An evaluation of the existing site conditions and what will likely take place in the future if the slope stability issue at the site is not addressed.
2) An evaluation of the option to purchase the impacted properties from the existing landowners (buy-out), or relocate the homes.
3) Evaluations of various construction alternatives to stabilize the failing slope and protect the existing structures.

Programs and Funding

A detailed discussion of specific government programs and/or funding options is beyond the scope of this report. However, the alternatives presented generally assume participation in one or more specific Federal or State government programs. These programs often have requirements that will in some cases be relevant to the alternatives evaluated or the described mitigation process. Where applicable, this report makes note of the potential programs for the various alternatives as they are currently understood, and describes the process of going through that program in the same context.

Cost Opinions

Preliminary opinions of probable construction cost have been prepared for the improvements discussed in this report. The opinions of probable cost include the costs associated with engineering and include a contingency allowance. The opinions of cost have been prepared to reflect anticipated costs during the 2011 construction season for projects let by competitive bidding unless noted otherwise. No attempt has been made to forecast any price increases or decreases. The opinions of probable cost are presented for planning purposes only, and are not a guarantee of the final project cost.

Part II – Existing Site Conditions

Description

Prior to the September flood the site consisted of a steep bluff slope located on the southern bank of the Zumbro River. The site is located on the outside of a sweeping bend of the river, as shown in Figure 1.1. LIDAR data taken in 2008 shows a stable slope of approximately 1.43 to 1 (or ~70%). The existing slope was heavily vegetated with predominate cover of small to medium sized trees. On top of the slope several homes were constructed south of the project area as part of Berhens Rivers Edge subdivision. These homes were originally set back from the top edge of the bank anywhere from 20 to 50 feet, depending on the individual structure. As a result of the flood the existing slope was badly eroded. The erosion primarily took place along the toe of the slope which resulted in a series of shallow slides moving up the slope to the south as the erosion progressed. As the slope failed, the eroded material was transported downstream as primarily bed load. The end result was a very steep slope with approximately 10 to 20 feet of material removed (horizontally) at the toe. Figure 2.1 shows a portion of the eroded bank shortly after the flood. The exposed soil shows where shallow slides have taken place.

Figure 2.1: Eroded Bank After Flood

In addition to the slope erosion, the flood water also created a scour hole estimated to be 10 to 12 feet deep along the south bank of the river throughout the length of the project area. The Minnesota Department of Natural Resources (MNDNR) took river depth and velocity measurements along select river cross sections shortly after the flood which confirmed the presence of a scour hole.

In the two months following the event the bank has continued to fail. Material from the upper part of the slope has sloughed and has begun to fill in the scour hole below. (Bed load from upstream may also be filling the scour hole.) With the water level of the river returning to normal, further erosion at the toe appears to have slowed significantly. However, the subsequent failures in the upper part of the bank have displaced several additional medium sized trees, and material has begun to slip away in several of the yards above, as shown in Figure 2.2. During the site investigation depressions and longitudinal cracking were noted all along the top of the bank, indicating the site remains unstable.

Figure 2.2: Failing Upper Bank

With the bank continuing to fail, several of the impacted residents have expressed concerns that their homes may be in danger. The home nearest to the slope is now approximately 10-12 feet away from the edge of the bank and the footings of the homes'

deck are now partially exposed. The majority of the vegetation on the upper part of the slope has now sloughed off. Figure 2.3 shows the home closest to the edge shortly after the flood. The orange fence indicates the edge of bank. Since the time of this photo, the edge has moved several feet closer to the home.

Figure 2.3: Home Next to Bank

Site Geology

An accurate understanding of the site geology is necessary to predict the likely failure methods of the unstable slope, as well as form a plan for mitigating the site should a construction alternative ultimately be selected. Information regarding the site geology was primarily obtained from published records taken from the Wabasha County Geologic Atlas with assistance from BWSR, and through visual inspection of the exposed materials from the bottom of the embankment. No soil borings were taken during this investigation. If future work is to take place at this site, soil borings should be obtained and a detailed geotechnical analysis should be performed.

From visual inspection, the underlying material primarily consists of alternating layers of sand and gravel deposits. The deposits appear to be relatively dense and somewhat poorly graded. These observations are consistent with information in the Geologic Atlas

which shows that the foundation material is floodplain alluvium consisting of fine sand and silty material. Figure 2.4 shows a close-up view of the soil taken from the bottom of the slope.

Figure 2.4: Sandy Soils

Given the absence of any underlying clay material, notable failure planes, or soft foundation material, it is unlikely that the site will experience any sudden deep-seated failures typically associated with saturated clay soils. Rather, the likely failure mode will be a series of shallow sloughs as the material on the outside face of the slope weathers and/or erodes, or as the material at the toe washes away (primarily during high river flows). This failure method is supported from on-going observations at the site which have showed a gradual decrease in the slope since the end of the flood event. Some of the sloughed material can be seen in loose piles at the toe of the slope. If the slope were to become saturated the possibility of local shear failure also exists. While this failure mechanism is more common in soft clays, it can also occur in highly saturated loose sands. This type of failure is different than a deep-seated failure in that it would likely be associated with the added stress from structures located near the edge of the slope. While this type of failure mechanism isn't expected, it should be mentioned that it is possible under certain circumstances and it is more likely to affect individual structures.

Hydrologic and Hydraulic Information

Estimated flow rates for the Zumbro River at Kellogg are presented below for several typical return periods. This data was primarily obtained from readily available analysis methods and information provided by the MNDNR based on previous studies. A simplified regression analysis was completed using the USGS on-line Streamstats program. Similarly, the results of a previous regression analysis completed by the MNDNR are presented. Finally, a flood frequency analysis (Bulletin 17B, Log-Pearson Type III distribution) was completed using stream gage records from gage number 05374900 located just downstream of the Highway 61 bridge. This information is presented here only for reference. A detailed hydrologic/hydraulic study was not conducted as part of this analysis. The flow rates shown only represent mean values and the relevant confidence intervals are not presented. This information will be used for planning purposes in order to determine the approximate elevations to which protection measures would be provided. Any future designs should include a more detailed hydraulic analysis. For the purposes of this report, the maximum design flood elevation is assumed to be 684 feet MSL (NGVD 29 datum) which roughly corresponds to the river stage during the September flood. The normal water elevation at the site is assumed to be 672 MSL.

Table 2.1:

RETURN PERIOD	ANALYSIS METHOD		
	USGS Regression (Streamstats) (cfs)	MNDNR Study (Regression) (cfs)	LPIII-Analysis (Gage 05374900) (cfs)
2-Year	10000	N/A	9331
10-Year	23900	31750	16772
50-Year	38300	37881	22696
100-Year	45100	44089	25036

Existing Infrastructure

The immediate infrastructure concerns are primarily focused on the three existing homes nearest the edge of the bank and associated utilities. For the purposes of this report the homes are referred to as follows:

Home #1: 230 Red School Lane

Home #2: 225 Red School Lane

Home #3: 515 N. Holland Street

All of the homes in and around the project area are currently served by City water and sewer. In addition, underground electric, television, phone service, and LP gas tanks/services are known to be in the area.

Figure 2.5 provides a site map of the area depicting the home numbers as listed above and the approximate locations of existing utilities.

Topography

Figure 2.6 shows pre-flood and post-flood topographic maps of the project area. The pre-flood contours were derived from State provided LIDAR data taken in 2008. The post-flood contours were derived from a combination of LIDAR data, survey information provided by the NRCS, and bathymetric information provided by the MNDNR. Due to the limited amount of data available for the post-flood conditions, the contour information shown in Figure 2.6 should be considered approximate. Subsequent surveys will be required for any future design.

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FIGURE 2.5
SITE UTILITY MAP
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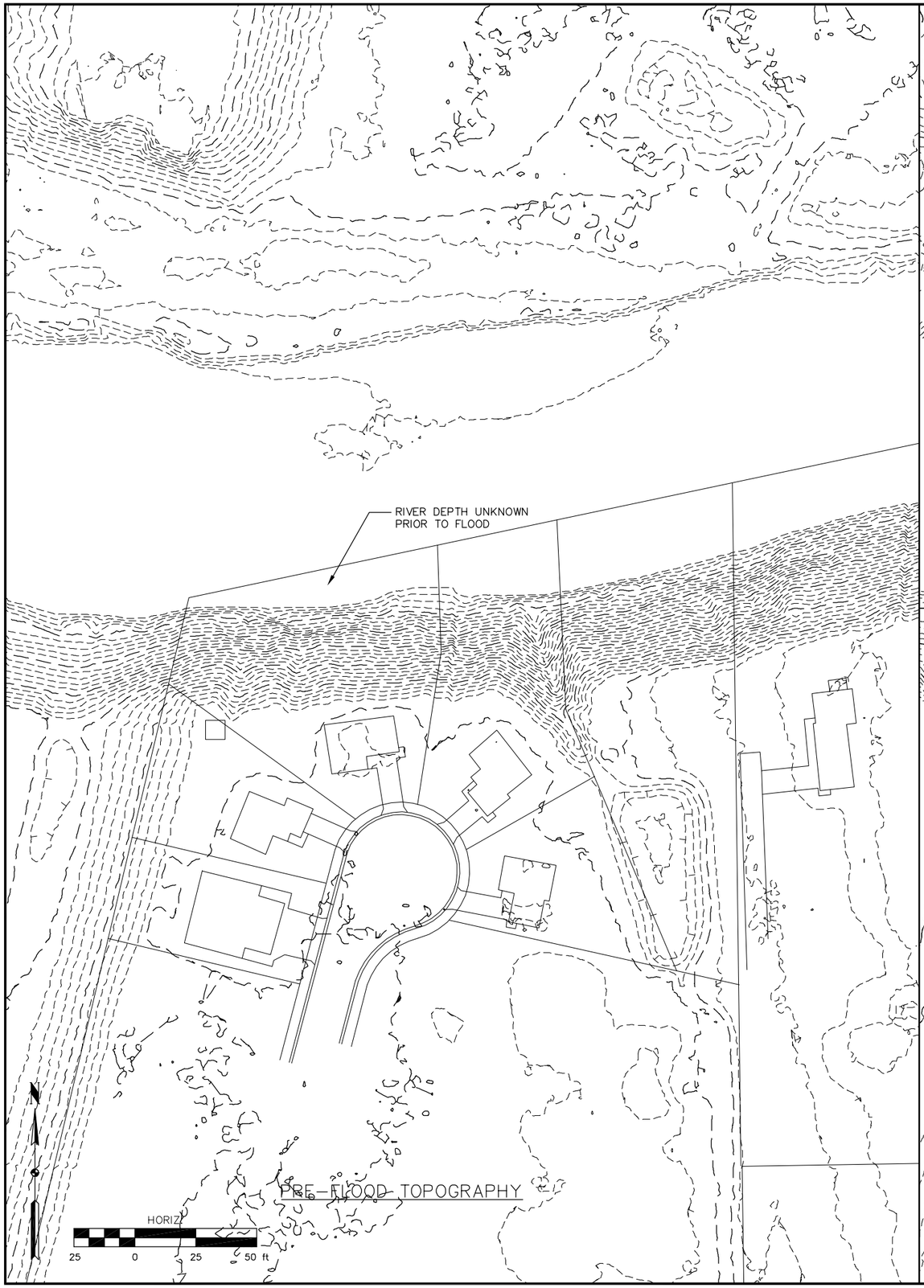

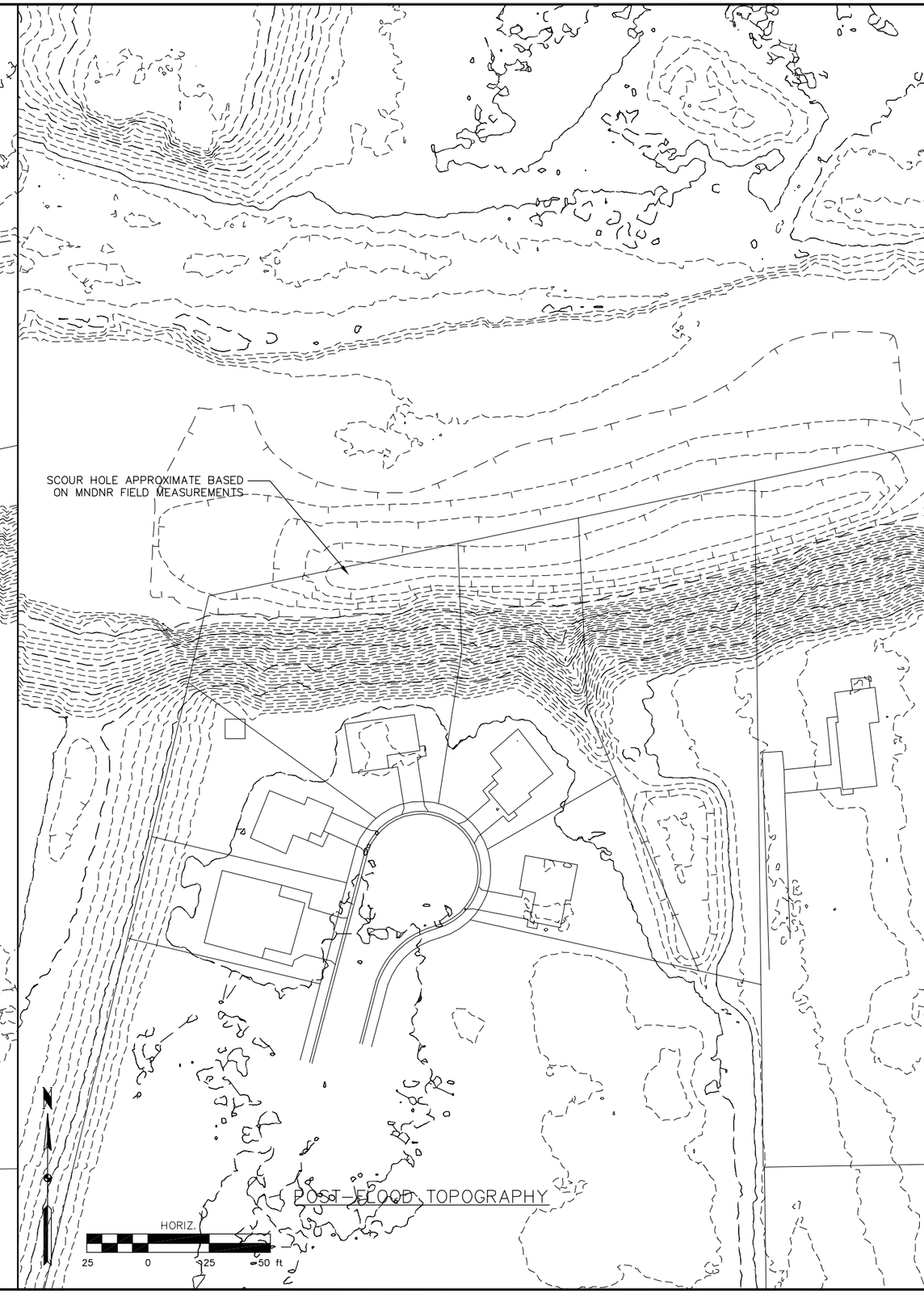

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FIGURE 2.6
SITE TOPOGRAPHIC MAPS
KELLOGG, MINNESOTA

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SHEET 12

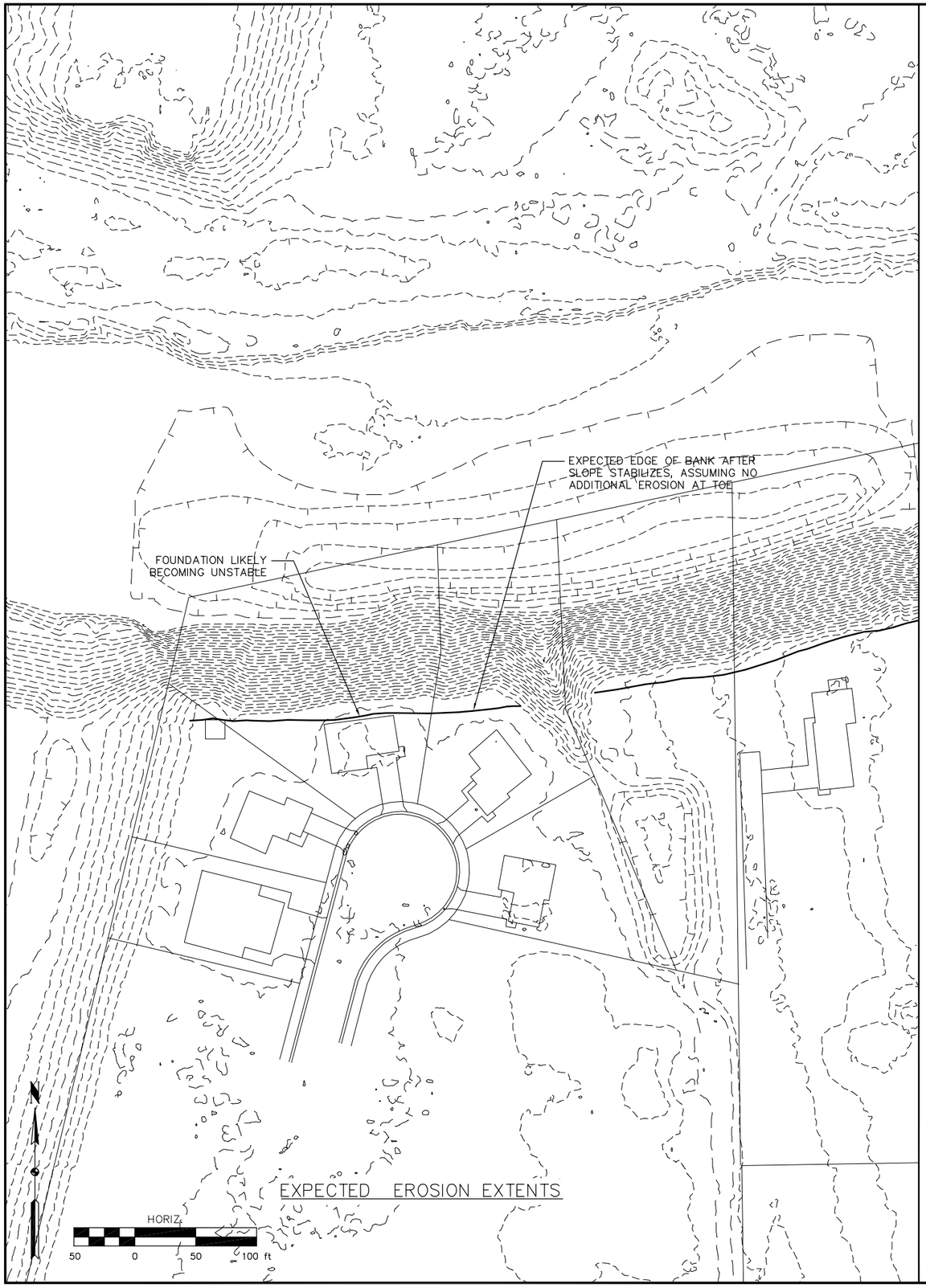
Part III – Do Nothing Alternative

Based on site observations and the information presented above, the existing slope will likely continue to fail in a predictable multi-stage process. In the short term, the upper part of the slope will continue to slough off until the natural angle of repose of the material is established. Since the new slope is effectively a cut-slope, it is reasonable to assume that the natural slope will stabilize at something less steep than the existing conditions due to loss of compaction and reduced overburden pressure. While the pre-flood slope was approximately 1.5H:1V, the failing slope will likely stabilize somewhere between 1.6H:1V to 1.7H:1V. This will occur as a result of the erosion at toe that took place during the September flood, and will be largely unavoidable unless action is taken to prevent it. While the rate of this failure mechanism cannot be predicted with a high degree of certainty, it is assumed that the sloughing failure rate will increase during times of freeze-thaw and extended wet or dry periods. Given the sloughing rate observed during the months following the flood (October and November of 2010) the site will likely stabilize within one to two years without any further disturbances.

In the long term the stability of the site will be determined by subsequent erosion at the toe caused by flowing water in the Zumbro River. As the toe erodes it will cause a cascading effect on the upper part of the slope that will result in additional sloughing failure above. The rate of erosion at the toe will largely be determined by the frequency and magnitude of future runoff events. Under average flow conditions, which were generally observed during the months following the flood, it appears that erosion at the toe has slowed dramatically. However, any future runoff event of adequate magnitude could cause further erosion. The toe of the embankment now consists of loose sand and gravel that is devoid of permanent vegetation and should be considered highly erodible. In the long term there is also a greater chance of local shear failure near Home #1 due to the loss of material from the face of the existing slope.

Due to the erosion that has already occurred, Home # 1 will become increasing at risk as time progresses. As the slope approaches a stable angle the new top of bank will likely form within several feet of the existing foundation wall of the home. From this it can be concluded that Home #1 should not remain in its current state unless measures are taken to address the ongoing slope failure.

With regard to the other two homes that are closest to the edge of the slope (Homes #2 and #3), it is unlikely that the current erosion process will terminate near enough to the structures to have an immediate impact. However, the new top of bank will likely be within 10 to 25 feet from each home. If a single moderate to large runoff event were to occur, further failure of the slope (and subsequent damage to the homes) could be rapid. Given the proximity of the existing structures to the edge of the slope these homes should also not remain in their current state unless measures are taken to address the potential of future slope failure. Figure 3.1 graphically depicts the likely extents of the slope failure without further toe erosion if left unmitigated.



EXPECTED EROSION EXTENTS

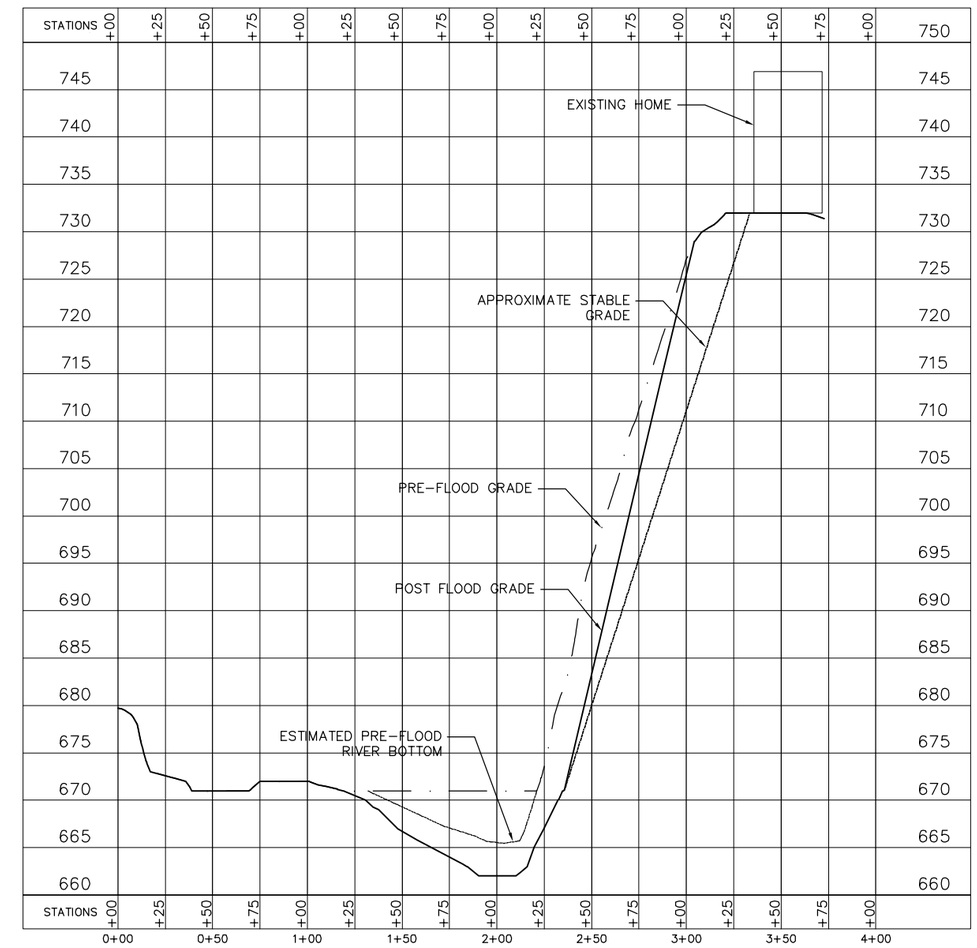


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FIGURE 3.1
PROJECTED STABLE CONDITIONS
KELLOGG, MINNESOTA

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Part IV – Buyout & Relocation Alternatives

Overview

Several programs and/or funding options exist to assist effected landowners, thereby allowing them to vacate or relocate their current property, and limit their amount of economic loss. While an in-depth discussion of specific programs is beyond the scope of this report, it is assumed that that these efforts would be facilitated through one (or a combination) of the two following programs:

1. Emergency Watershed Protection program administered by the NRCS
2. Flood Damage Reduction Grant Program administered by the MNDNR

The potential exists for additional funding to supplement either of these programs through a special State appropriation for Minnesota flood relief. Additional information regarding each of these programs can be found on the respective agencies' web site.

Regardless of the program ultimately utilized the end result is that the existing structures (in this case homes) would either be removed (demolished) or relocated. The purpose of this section is to examine the removal or relocation process in detail and identify the associated site requirements.

Both the NRCS and MNDNR have previously completed preliminary cost estimates for removal and/or relocation alternatives. However these previous estimates were generally focused on the value of the effected properties alone and did not provide a detailed analysis of the site utilities and associated requirements. This report utilized this information as a starting point for the cost opinions provided below. This analysis does not make any assumptions as to who will be responsible for specific costs or how the overall cost breakdown is established between the various parties involved.

Existing Home Values

The first step in the removal/relocation process would be to acquire the impacted properties from the current owners. Depending on the specific program options this could take on several forms. In some cases the entire property may be purchased with

no further involvement from the home owner. In other scenarios the property may be purchased and entered into a permanent easement where the owner retains possession of the property. The purchase(s) and the amount of compensation would need to be negotiated between the participating government agency and the land owners as applicable. The specifics of the property acquisition process are beyond the scope of this report. However, because the property acquisition would be a significant portion of the overall project budget a rough idea of these costs are needed for planning purposes.

Shortly after the flood the Southeastern Minnesota Multi-County Housing and Redevelopment Authority (HRA) sponsored an appraisal of the three homes along the edge of the bank. The HRA provided the appraisal findings for this report and this information is presented in Table 4.1.

Table 4.1

	Estimated Market Value	Fair Market Value
Home #1	$151,100	$181,320
Home #2	$162,800	$244,200
Home #3	$206,100	$247,640
Total:	**$520,000**	**$673,160**

For planning purposes this report assumes a fair market value for the costs of the impacted properties. This includes all associated legal fees, closing costs, moving expenses, etc. required to vacate the current residents from their homes.

Structure Removal Alternative

This alternative assumes that the homes in question are to no longer remain in place and that the home owners have been compensated based on fair market value as described above. In addition to the property acquisition fees, there will also be fees required to properly demolish the abandoned homes, terminate utility services, and provide a basic level of site mitigation. A construction cost opinion for the described demolition project is presented below. The line items presented in the cost opinion are generally self explanatory with the exception of the reinstatement of natural gas services. Because the City of Kellogg does not have a centralized gas distribution system, a series of Liquid Propane (LP) tanks have been set up around town and these

tanks each serve several homes (see Figure 2.5). The tanks for this area would need to be relocated and the remaining services reinstated.

Opinion of Probable Cost – Demolition

Item	Description	Unit	Quantity	Unit Price	Cost
1	Mobilization	LS	1	$5,000	$5,000
2	Home #1 Structure Demolition	Each	1	$7,500	$7,500
3	Home #2 Structure Demolition	Each	1	$7,500	$7,500
4	Home #3 Structure Demolition	Each	1	$7,500	$7,500
5	Home #1 Foundation Removal	Each	1	$18,000	$18,000
6	Home #2 Foundation Removal	Each	1	$18,500	$18,500
7	Home #3 Foundation Removal	Each	1	$19,000	$19,000
8	Driveway Removal	SY	275	$14	$3,850
9	Hauling & Disposal	CY	70	$100	$7,000
10	Utility Excavation	LS	1	$5,000	$5,000
11	Demolish & Cap Sanitary Services	Each	3	$350	$1,050
12	Demolish & Cap Water Services	Each	3	$300	$900
13	Demolish Electrical Services	Each	3	$250	$750
14	Demolish Gas Services	Each	3	$600	$1,800
15	Demolish Communication Services	Each	3	$250	$750
16	Relocate Existing LP Tanks	LS	1	$1,200	$1,200
17	Reinstate Gas Services	Each	2	$350	$700
18	Site Grading	LS	1	$5,000	$5,000
19	Seed & Mulch	SY	2600	$1.25	$3,250
				Subtotal:	**$106,000**
				Contingencies (~10%):	$10,500
				Engineering, Legal, Administrative (~15%)	$17,500
				Site Demolition Total:	**$134,000**

The cost opinion presented above includes the minimum amount of site mitigation needed as a result of the demolition project. At the previous interagency meetings considerable discussion was generated as to what was required to completely mitigate the site. Because of these concerns, the site mitigation options have been broken out and additional information is presented in the subsequent sections.

Structure Relocation Alternative

The option of physically moving the existing home(s) to alternate sites would generally follow the same procedure as that of the structure removal option. Rather than being

compensated for the cost of the property the reimbursement money would instead be used for relocation fees. The concept behind this option is that cost to relocate a structure would be less than the replacement cost (fair market value) if a comparable structure were to be built elsewhere.

As part of this analysis several local contractors were contacted to discuss the moving process. The prevailing opinions were that none of the homes in question are good candidates for relocation. The primary concerns were that the type of construction (split level design) are difficult to relocate and some damage to the structure was likely. Also, given the local housing market the relocation costs may exceed the costs of new construction. Concerns were also raised about the proximity of the homes to the edge of the cliff and the potential difficulty of getting the required equipment on to the site safely. Because of these concerns this option is not recommended and no further consideration of expenses is presented.

Final Site Mitigation

During previous interagency meetings a considerable amount of discussion was generated regarding the final mitigation of the site. Specifically, discussion revolved around the competing needs to stop the on-going erosion with the need to work within the available funding parameters and program constraints. Assuming that the existing homes are removed, there are several compelling reasons to further mitigate the site. First, the existing unstable slope presents a safety risk and possible liability to the owner. Second, as discussed above, the slope will continue to erode without mitigation. It is possible that without efforts to stabilize the toe of the slope future erosion could threaten additional homes and infrastructure. Finally, while possibly less of a priority; further erosion will contribute a significant amount of sediment to the river system.

Additional discussion will likely be needed before a final site mitigation plan is determined. At a minimum, it is recommended that an access control fence be erected some distance back from the edge of the slope if no further mitigation is to be done. If it is decided that further mitigation work is required the most feasible option would be to use heavy equipment to reduce the angle of the slope and install a minimum amount of toe protection. The reduced angle would also allow more cost effective bioengineering measures to be installed along the bank. With the homes removed, site access

becomes more feasible and work could proceed by starting at the top of the slope. Figure 4.1 provides a conceptual site plan and typical cross section for this mitigation alternative. Site mitigation cost opinions are presented below.

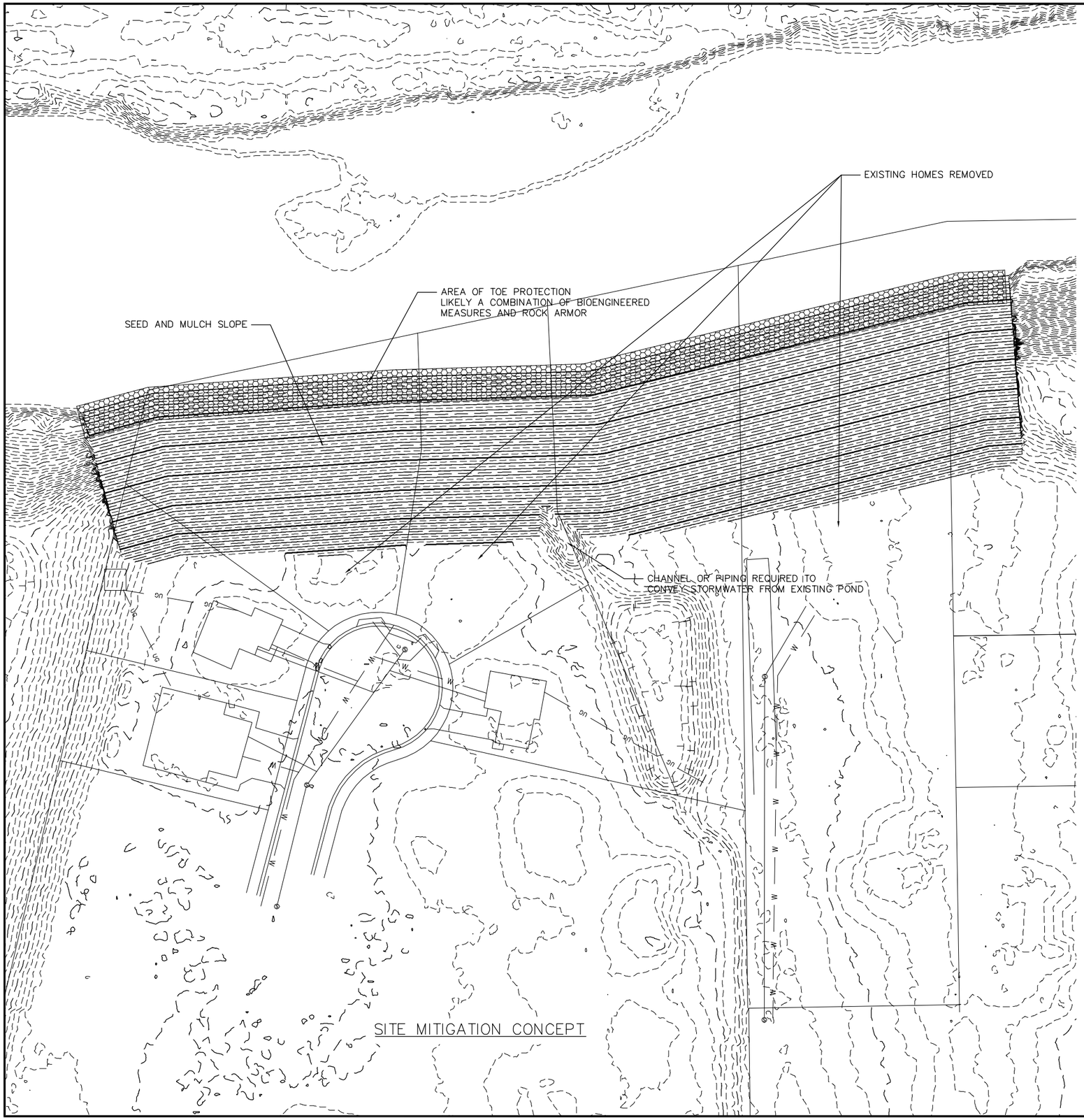
Opinion of Probable Cost – Mitigation Option A

Item	Description	Unit	Quantity	Unit Price	Cost
1	Mobilization	LS	1	$500	$500
2	Chain Link Fence	LF	750	$20	$15,000
				Subtotal:	$15,500
				Contingencies (~10%):	$1,500
				Mitigation Total:	**$17,000**

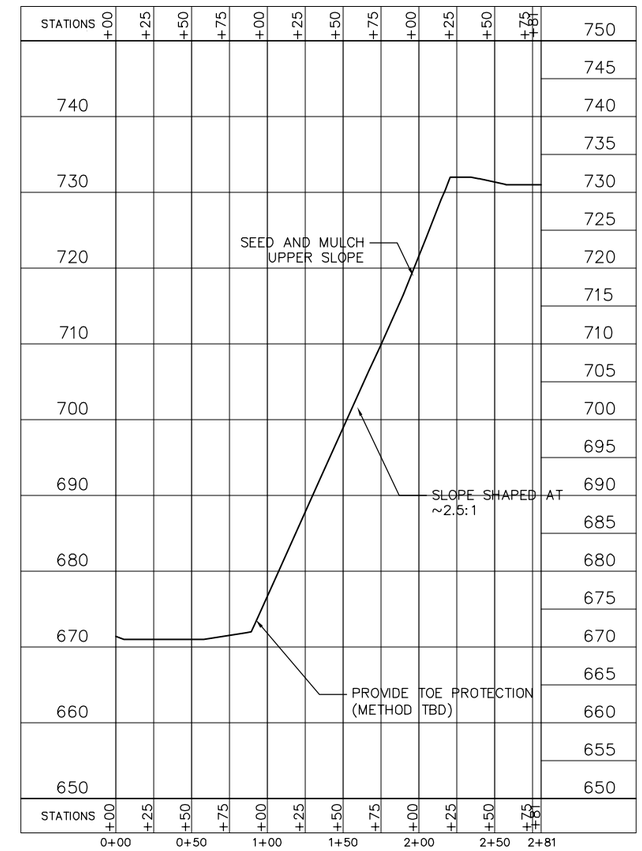
Opinion of Probable Cost – Mitigation Option B

Item	Description	Unit	Quantity	Unit Price	Cost
1	Mobilization	LS	1	$5,000	$5,000
2	Clear & Grub	LS	1	$25,500	$25,500
3	Site Grading & Earthwork	LS	1	$115,000	$115,000
4	Toe Protection Measures*	LS	1	$60,000	$60,000
5	Seeding & Mulching	SY	9200	$1.25	$11,500
				Subtotal:	$217,000
				Contingencies (~10%):	$22,000
				Engineering, Legal, Administrative (~15%)	$36,000
				Mitigation Total:	**$275,000**

*Toe protection measures to be determined during design. Measures are likely to include a combination of rock protection with one or more bioengineering techniques. The most appropriate technique cannot be selected without a more detailed analysis, which is beyond the scope of this report.



SITE MITIGATION CONCEPT



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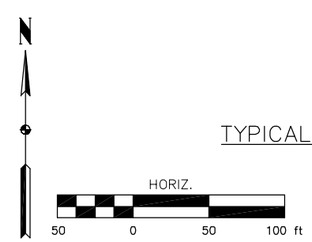

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FIGURE 4.1
SITE MITIGATION CONCEPT–OPT B
KELLOGG, MN

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Permits

Construction activities at the proposed site will likely require several permits. The following paragraphs provide a summary of the typical permits required for construction projects along riverbanks. Depending on the funding sources additional permits and/or approvals may be required. A review of permitting requirements should be conducted before any project is started. Additional information regarding the likely permitting requirements is provided in Part V.

NPDES – A National Pollution Discharge Elimination System (NPDES) permit may be required depending on the level of site mitigation determined necessary. This permit is required for construction projects with a footprint exceeding one acre. The total impacted area for the structural demolition alone is approximately .8 acres. If additional area was to be disturbed because of site mitigation this permit may be required. This permit is issued by the Minnesota Pollution Control Agency (MPCA). The typical permit fee is $400.00

WCA/404/PUBLIC-WATERS – As part of the Clean Water Act, Minnesota Wetland Conservation Act (WCA), and Minnesota Public Waters regulations, approval will be needed if any work is to proceed below the ordinary high water level. Approval for each of these permits is issues separately, however the permits are listed together as the application is typically filed jointly. Fees will vary depending on the anticipated impacts.

MNDOT – While several access points exist for the upper slope area, access to the toe is quite limited. Any project requiring access to the toe of the bank will likely need to enter from the west side of the site adjacent to the highway bridge. Because of this it may be desirable to obtain access directly from the highway. This would require a separate permit from the Minnesota Department of Transportation (MNDOT).

Summary

This section presented an overview of various buy-out and relocation alternatives to address property concerns as a result of the on-going slope failure at the project site. Property acquisition and site demolition cost opinions were presented along with a discussion of typical permitting requirements. Options to relocate the existing homes were determined to be not feasible.

In addition to the property acquisition process a discussion of the site mitigation requirements was also presented. The level of mitigation required will depend on several factors including the desire of the future owners to stabilize the site and the funding available support construction activities.

Table 4.2 provides a summary of the cost opinions presented above.

Table 4.2: Summary of Costs

Item	Cost Opinion
Property Acquisition	$673,160
Site Demolition	$134,000
Site Mitigation	
Option A: Minimum Site Mitigation	$17,000
Option B: Full Site Mitigation	$275,000
Total Option A	**$824,160**
Total Option B	**$1,082,160**

Part V – Construction Alternatives

Overview

This section explores various construction alternatives to address the on-going erosion and slope failure at the site. The options presented offer varying degrees of site restoration in an attempt to efficiently manage the available funding. Additional information regarding site access and material costs is also presented.

Site Access & Sequencing

During the previous interagency meetings, site access emerged as one of the major technical obstacles for the implementation of any construction alternative. As described in Part II, the bank is very steep and approximately 60 feet tall. The existence of homes along the perimeter restricts access and limits the activities that can take place from the top without further endangering the structures. Site access presents a challenge because of the quantity of material (and related expense) that must be brought in to create a stable haul road which would in turn allow access to the toe. It would clearly be desirable to avoid having to access the slope from the toe. However, given the restrictions of the site, access to the toe appears to be required. During the course of this evaluation no viable alternative was identified that allows the existing homes to remain intact without first providing access to the toe of the slope.

The following describes the recommended approach to gain access to the river bottom with the intent of stabilizing the toe of the slope. This process is generally applicable to all of the alternatives presented. It is assumed that access from Highway 61 will be granted by MNDOT. If access from the highway is approved the area most suited for constructing a haul road is immediately downstream of the bridge within the road ditch. First, the access area would be excavated and graded at approximately 10H:1V to create a cut in the existing bank. After the site grading is completed, shot-rock would be dumped and/or placed into the river to fill in the scour hole along the river bank. This would continue until enough material was placed to create a traversable bench above the water surface. Trucks would back into the construction area on top of the placed fill and place rock along the toe of the bank until completed along the entire alignment. It should be noted that during the construction of the bench unstable portions of the upper

bank will likely need to be pulled down and/or shaped from below to provide safe working conditions. Depending on the design the existing homes may still be in place and the construction process could significantly destabilize the site on a temporary basis. As long as construction can proceed in a timely manner it is unlikely that there will be significant additional risk to either Home #2 or #3. However, as described in Part II, Home #1 is very close to the existing edge and there would be relatively little room to remove material during construction. Several contractors were consulted as part of this investigation and they generally agreed that as long as a cautious approach was taken the bench could be constructed as described without damaging Home #1 (other than removing the existing deck). As a precaution, if the final design called for Home #1 to remain in place it is recommend that the current residents vacate the structure during construction, and that they be made to understand and agree to risks associated with project. Upon completion of the bench heavy equipment could then be brought in to construct the remainder of the project as designed. The dumped material would remain in place and become integral to the stabilization measures. Construction would proceed in vertical increments until complete.

Construction Materials

Most of the alternatives identified are based on the placement of relatively large amounts of earthen/rock material. As such, it is expected that material costs will make up a significant portion of the overall project budget should a construction alternative ultimately be selected. The costs for these types of materials tend to be variable depending on the quantity required, specified gradations, and distance from the source to the project site. As part of this evaluation, several local contractors and material suppliers were consulted in order to determine the availability of certain products and the likely unit costs. Figure 5.1 shows a map of the area surrounding the City of Kellogg and calls out the location of potential rock and earthfill sources. Table 5.1 shows the unit costs of various materials examined in detail. These unit costs are reflected in cost opinions throughout this report.

Table 5.1: Unit Costs

Material	Unit Cost	Unit
Graded Rock Riprap (Machine Placed)	$50	CY
Graded Rock Riprap (Dumped)	$26	CY
3” Graded Rockfill	$26	CY
Shot Rock	$16	CY
Dredge Sand (Drainfill)	$14	CY
Select Earthfill	$16	CY
Non-woven Class I Geotextile	$2.25	SY

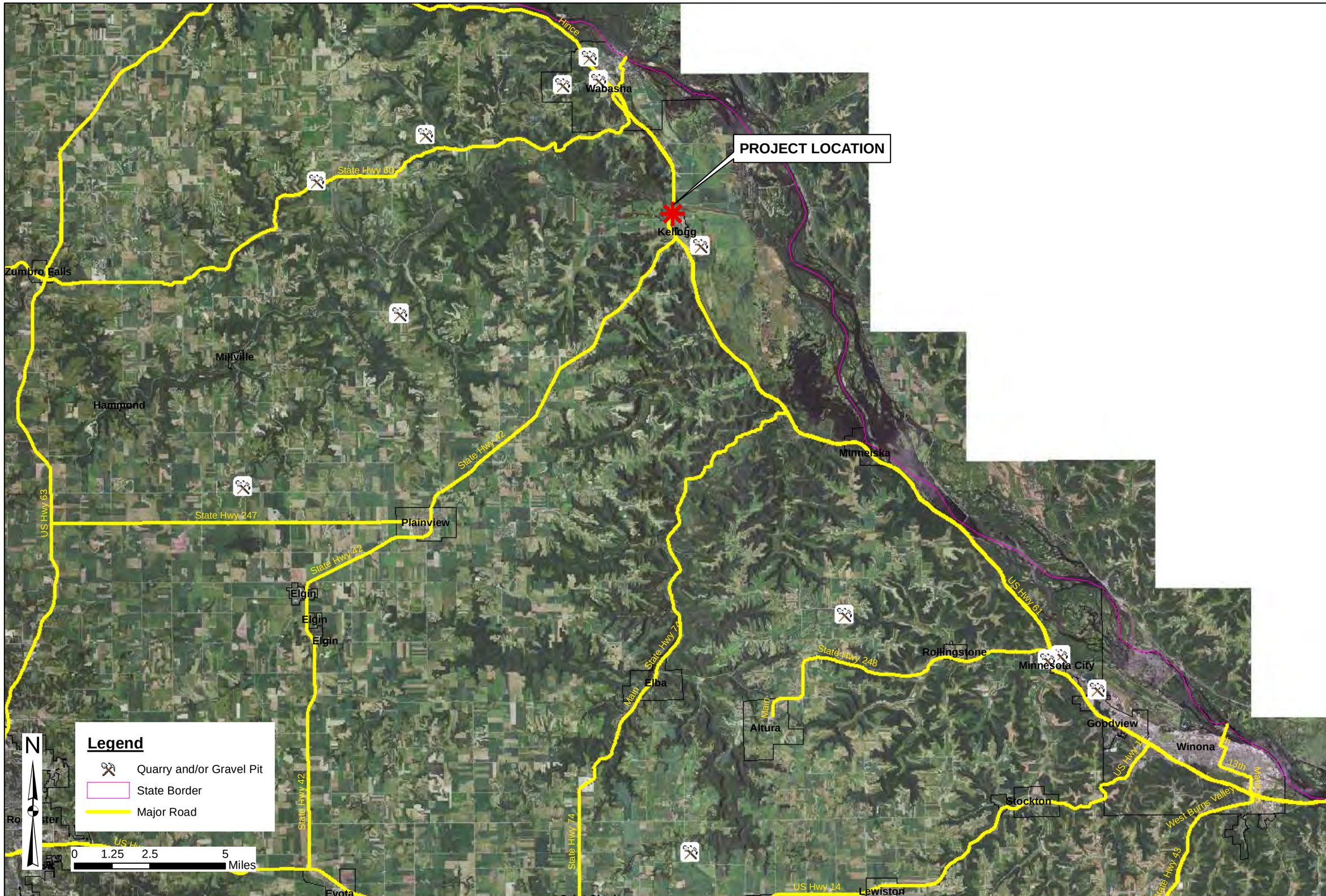

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FIGURE 5.1
MATERIAL LOCATION MAP
KELLOGG, MN

SCALE: AS SHOWN
PROJECT NO. 7520.00
DRAWN BY: nwa
CHECKED BY: SDS, WKA
PAGE 27

Alternative I: Full Slope Stabilization

A preliminary analysis of this alternative was developed by the NRCS and presented at the previous interagency meetings. The alternative calls for the stabilization of the toe of the slope with riprap and rock fill material, and the stabilization of the upper embankment with compacted earth fill and erosion control measures. The preliminary cost opinion presented by the NRCS was approximately $1.3 million. This approach was successfully implemented at a similar site in nearby Minnesota City shortly after a flooding event in 2007. However the Minnesota City site did not have the access restrictions that are associated with this site.

The primary objective of this alternative is to provide protection for all of the existing homes that are currently threatened. As presented in Part II, Home #1 is located approximately 10-12 feet away from the edge of the existing bank. Because of this, there is very little room to stabilize the slope by removing material from the top. Given the current proximity of Home #1 to the existing edge of the slope the location of this structure's footings is the primary design constraint. This alternative addresses this constraint by placing material at the toe of the slope and building upwards at a stable grade. The NRCS design presented a final slope with an average grade of approximately 2H:1V. This is generally the steepest recommended grade for slope stabilization practices consisting of riprap and unreinforced earth fill. In practice, machine placed riprap alone can be successfully placed as steep as 1.5H:1V. However, rock fill and earthfill generally cannot be placed steeper. Because the riprap in this design supports these materials, it is recommended that the riprap also be placed no steeper than 2H:1V.

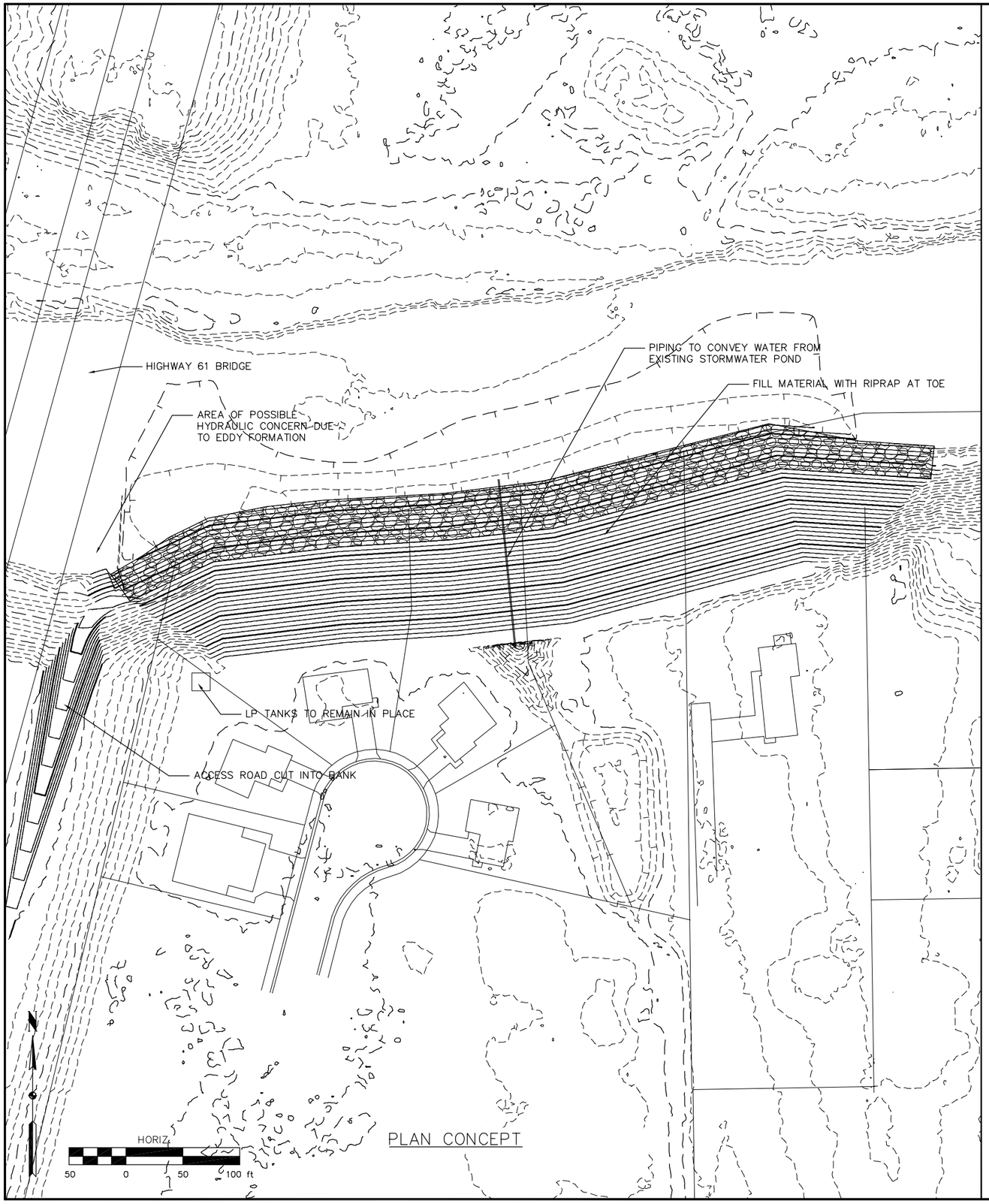
After further review of this option, WHKS concludes that the conceptual design presented by the NRCS would be adequate to prevent further slope failure and achieve the desired objectives. However, due to the constraints associated with the maximum steepness of the slope (2H:1V) the final design would require material to be placed approximately 25 feet into the river, which is approximately 13 feet beyond the edge of the pre-flood bank. The placement of this material would restrict the existing channel capacity. The likely results of this would be increased tractive stress upstream and downstream of the site with additional erosion on the north bank. The protruding fill

would also likely create an eddy current on the upstream side of the fill material during periods of high flow, which could negatively impact the hydraulics of the Highway 61 Bridge. Because of these potential impacts this option is only recommended with reservations. The design should consider the potential impacts of the surrounding area and a hydraulic analysis of the bridge should be completed. Many of the concerns presented could likely be addressed by adding additional material upstream of the site to improve hydraulic efficiency or by adding additional design components. A complete hydraulic analysis of this design alternative is beyond the scope of this report.

As part of this evaluation, the NRCS design was revised and the unit quantities were further refined. In addition, a new cost opinion was prepared. The design concept is presented in Figure 5.2 and a revised cost opinion is presented below.

Opinion of Probable Cost – Alternative I

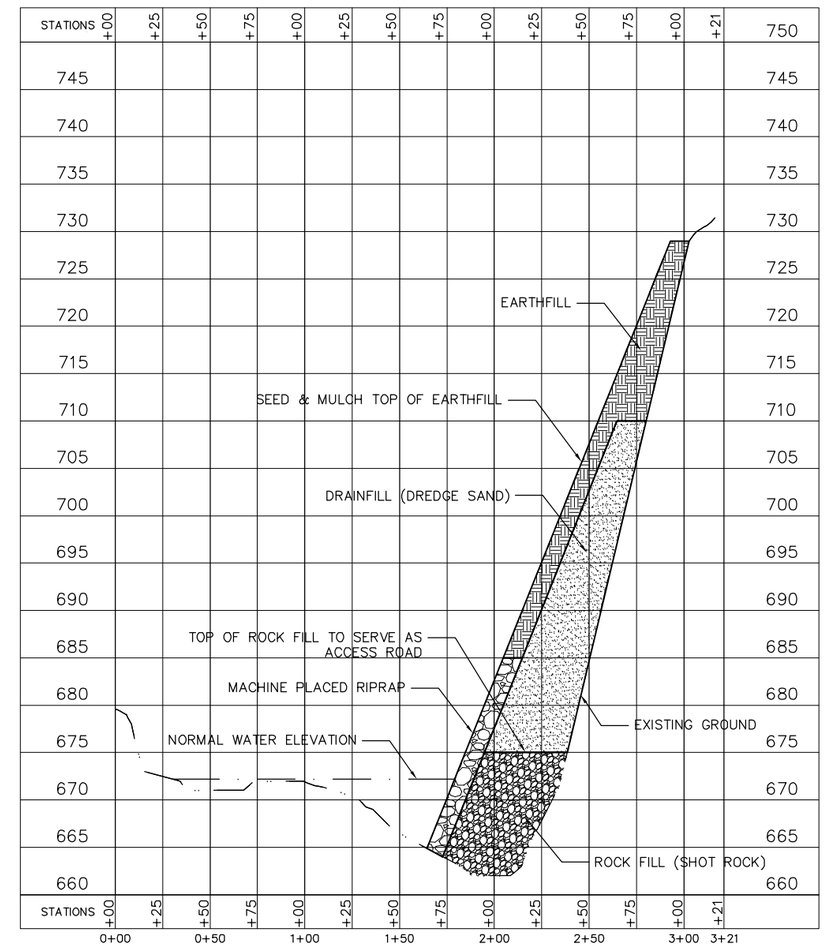
Item	Description	Unit	Quantity	Unit Price	Cost
1	Mobilization	LS	1	$5,000	$5,000
2	Clearing, Grubbing & Disposal	LS	1	$20,000	$20,000
3	Access Road	LS	1	$25,000	$25,000
4	Shot Rock	CY	15000	$16	$240,000
5	Drainfill	CY	25000	$14	$350,000
6	Earthfill	CY	10000	$16	$160,000
7	Rock Riprap (Placed)	CY	5600	$50	$280,000
9	Seeding & Mulching	SY	6000	$1.25	$7,500
10	Geotextile	SY	3600	$2.25	$8,100
11	Pollution Control	LS	1	$8,000	$8,000
				Subtotal:	$1,103,600
				Contingencies (~10%):	$110,400
				Engineering, Legal, Administrative (~15%)	$182,000
				Mitigation Total:	**$1,396,000**



PLAN CONCEPT

NOTES

THE TYPICAL CROSS SECTION IS SIMILAR TO THE ONE PRESENTED BY THE NRCS. IT IS ONLY INTENDED TO SHOW THE MAJOR ZONES OF FILL AND THE TYPES OF MATERIALS LIKELY TO BE USED. GRADING AND CUT SECTIONS ARE INTENTIONALLY NOT SHOWN. FINAL ELEVATIONS AND DIMENSIONS TO BE DETERMINED IN THE DESIGN PHASE.



TYPICAL CROSS SECTION

N

HORIZ.
40 0 40 80 ft

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FIGURE 5.2
ALTERNATIVE I CONCEPT
KELLOGG, MINNESOTA

SCALE: AS SHOWN
PROJECT NO. 7520
DRAWN BY: NWA
CHECKED BY: SDS, WKA
SHEET 30

Alternative II: Toe Protection & Buy-Out of House #1

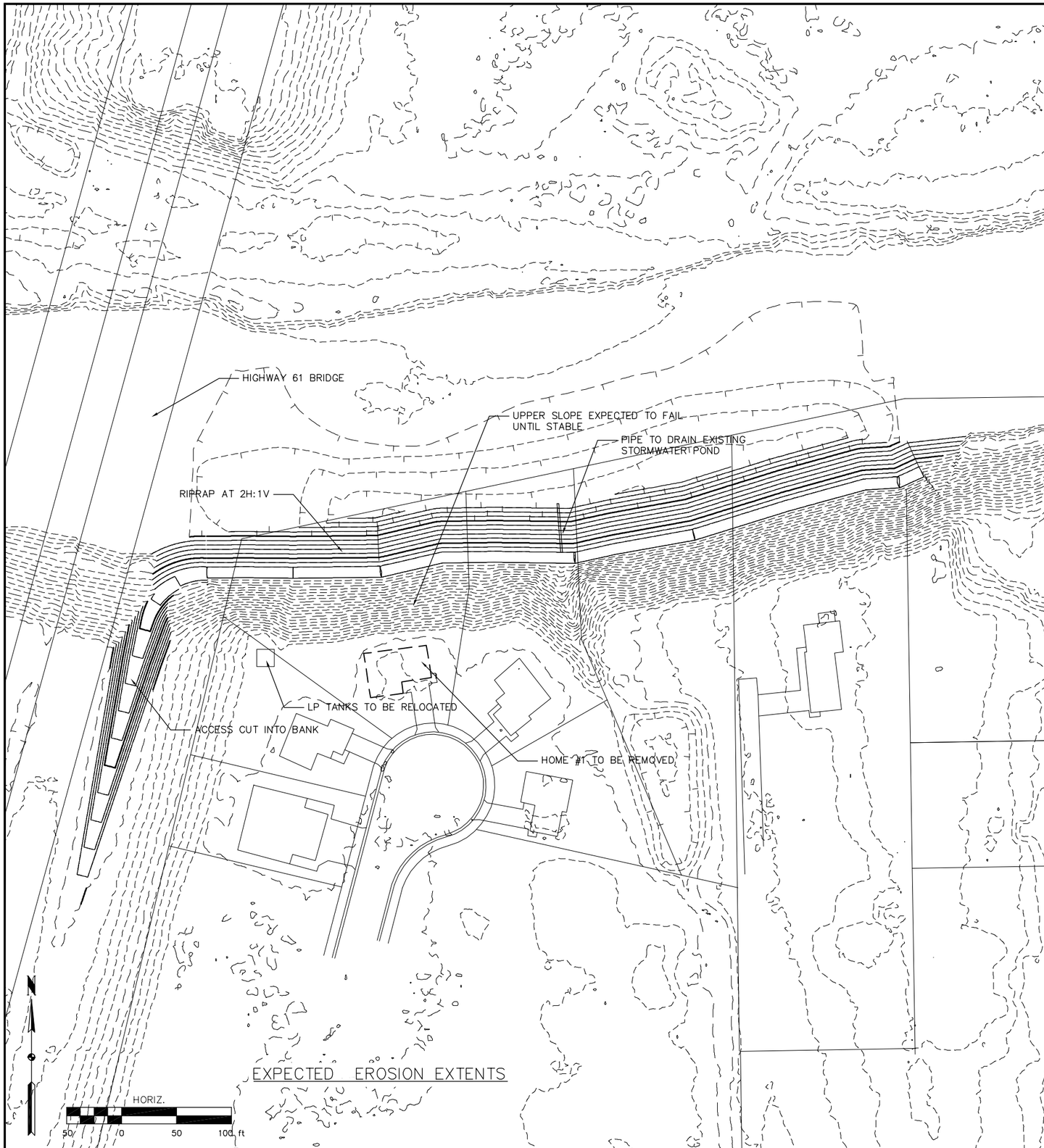
This alternative is similar to Alternative I with the exception that only the toe of the slope is to be stabilized and no further work is to be done to the upper part of the slope. As determined in Part II, without stabilizing the upper slope, Home #1 will likely become unstable due to on-going slope failure as a result of the flood. Therefore, this alternative assumes that Home #1 would need to be removed through the process described in Part III.

This alternative was specifically identified for analysis during the interagency meetings in order to examine options with potential reductions in construction costs. The concept behind this alternative is that once the toe is stabilized the upper bank would be allowed to fail at its natural rate until it becomes stable. With the toe protected, further erosion as a result of future runoff events would be avoided. While Home #1 would be removed, Homes #2 and #3 would remain in place, assuming local slope failure criteria was met (this would be evaluated during the design phase).

The design for this alternative includes placing riprap and rock fill along the toe of the slope below the water surface and up to the proposed flood elevation. Construction would likely proceed as described above. Some excavation along the toe would be required to provide an even foundation and clear debris. As the riprap/rockfill is placed it would be used to create an access bench which heavy equipment would use to traverse. The design concept is presented in Figure 5.3 and an opinion of probable cost is presented below. The typical section in Figure 5.3 shows geotextile placed under the riprap to prevent the foundation material from migrating up through the rocks. In lieu of geotextile a properly graded rock/gravel filter could also be used.

Opinion of Probable Cost – Alternative II

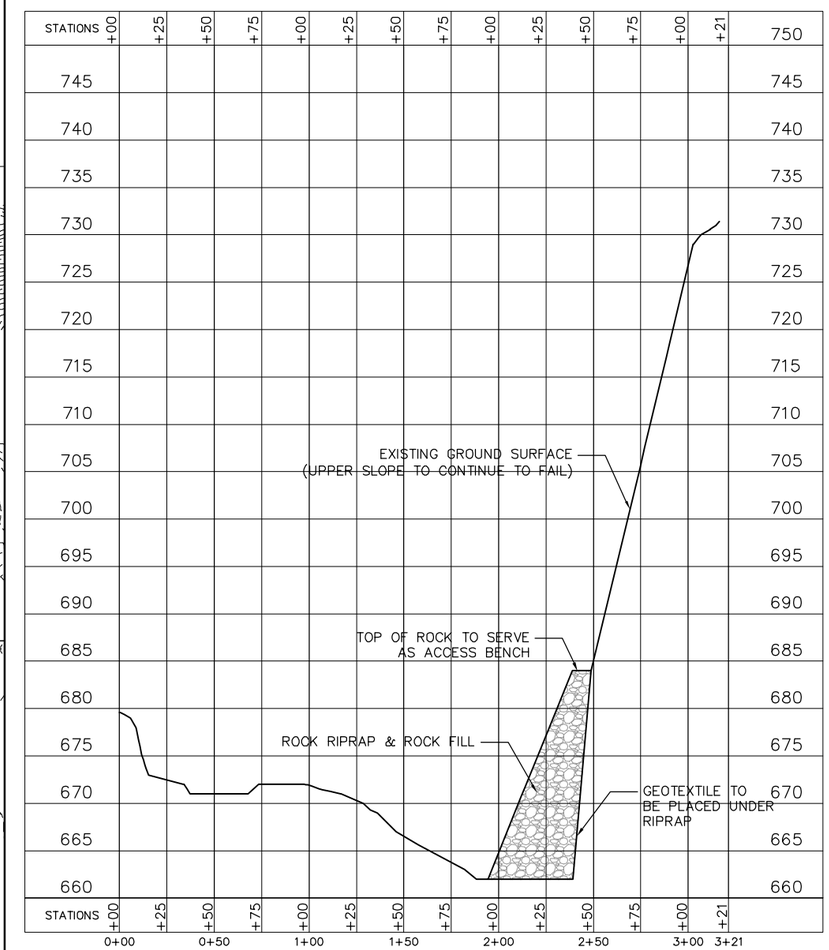
Item	Description	Unit	Quantity	Unit Price	Cost
1	Property Acquisition	LS	1	$181,000	$181,000
2	Mobilization	LS	1	$5,000	$5,000
3	Home #1 Structure Demolition	Each	1	$7,500	$7,500
4	Home #1 Foundation Removal	Each	1	$18,000	$18,000
5	Driveway Removal	SY	100	$14	$1,400
6	Hauling & Disposal	CY	10	$500	$5,000
7	Utility Excavation	LS	1	$5,000	$5,000
8	Demolish & Cap Sanitary Sewer Services	Each	1	$350	$350
9	Demolish & Cap Water Services	Each	1	$300	$300
10	Demolish Electrical Services	Each	1	$250	$250
11	Demolish Gas Services	Each	1	$600	$600
12	Demolish Communication Services	Each	1	$250	$250
13	Relocate Existing LP Tanks	LS	1	$1,200	$1,200
14	Reinstate Gas Services	Each	2	$350	$700
15	Access Road	LS	1	$25,000	$25,000
16	Toe Excavation	CY	1500	$5	$7,500
17	Geotextile	SY	6000	$2.25	$13,500
18	Shot Rock	CY	13000	$16	$208,000
19	Rock Riprap	CY	3000	$50	$150,000
20	Site Grading & Earthwork (Lot Area)	LS	1	$3,000	$3,000
21	Pollution Control	LS	1	$8,000	$8,000
22	Seeding and Mulching	SY	3000	$1.25	$3,750
				Subtotal:	$645,300
				Contingencies (~10%):	$65,000
				Engineering, Legal, Administrative (~15%)	$106,700
				Site Demolition Total:	**$817,000**



EXPECTED EROSION EXTENTS

NOTES

THE TYPICAL IS ONLY INTENDED TO SHOW THE MAJOR ZONES OF FILL AND THE TYPES OF MATERIALS LIKELY TO BE USED. GRADING AND CUT SECTIONS ARE INTENTIONALLY NOT SHOWN. FINAL ELEVATIONS AND DIMENSIONS TO BE DETERMINED IN THE DESIGN PHASE.



TYPICAL CROSS SECTION

N

HORIZ.
40 0 40 80 ft

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FIGURE 5.3
ALTERNATIVE II CONCEPT
KELLOGG, MINNESOTA

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PROJECT NO. 7520
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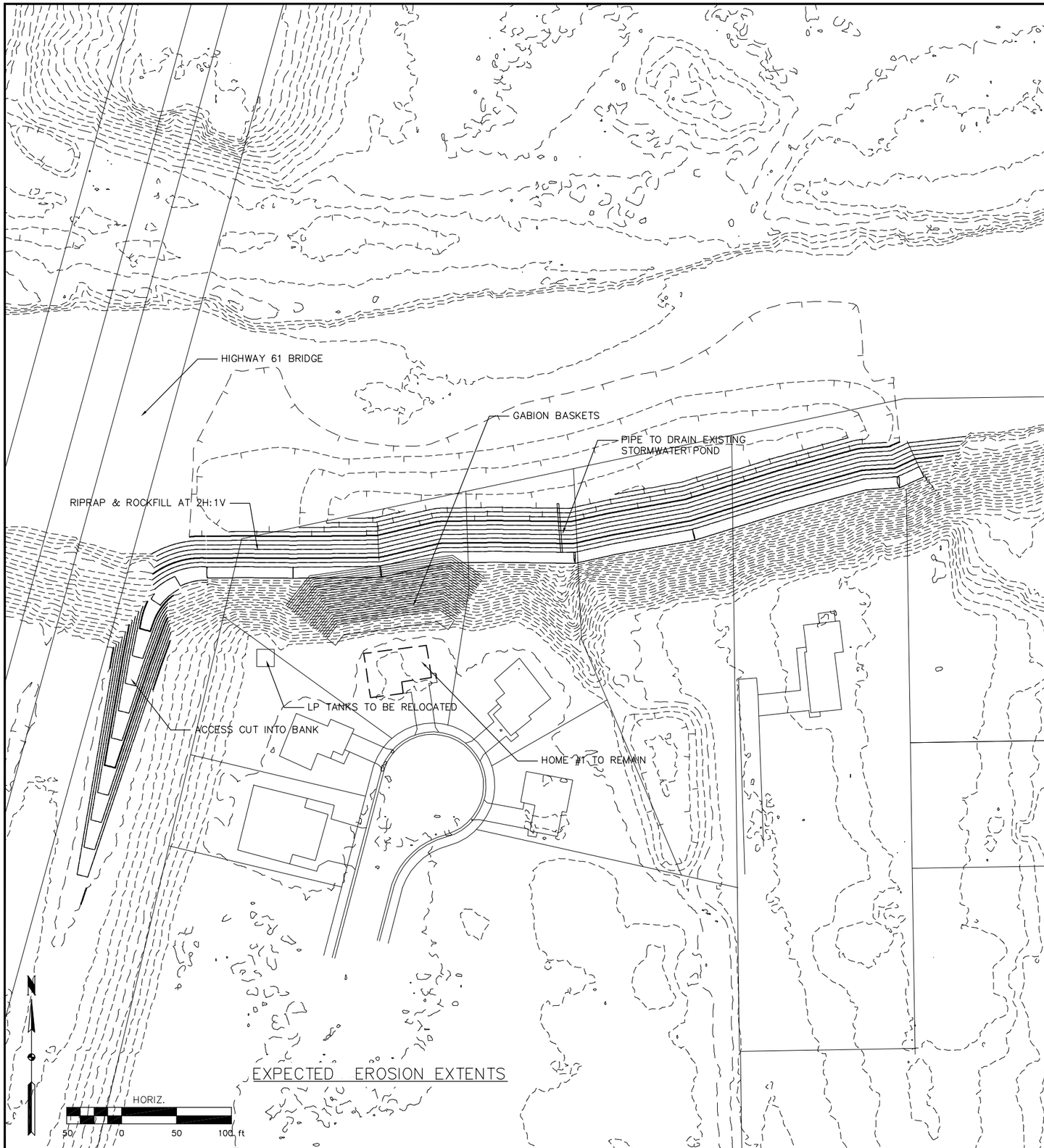
CHECKED BY: SDS, WKA
SHEET 33

Alternative IIA: Toe Protection& Gabions

Alternative II assumed that Home #1 would be removed because the upper slope could not be adequately stabilized. The placement of the toe near the existing bank does not allow for traditional earthfill construction above it due to the steepness. However with an adequate toe established it would not be necessary to mitigate the entire upper slope. Rather a short section of structural measures could be built in the immediate vicinity of Home #1 only. If these measures were properly tied into the existing bank the slope could continue to fail on both sides and Home #1 could remain in place. Several structural alternatives could be employed to support the section in question, but the most likely candidate would be rock filled gabions because they are easily stackable and well suited for the situation. The only concern with this option is that the back yard of home #1 would be substantially reduced. The existing deck on the home would likely need to be removed to allow construction to take place below. The design concept is presented in Figure 5.4 and an opinion of probable cost is presented below. Additional information regarding gabion designs will be presented in subsequent alternatives.

Opinion of Probable Cost – Alternative IIA

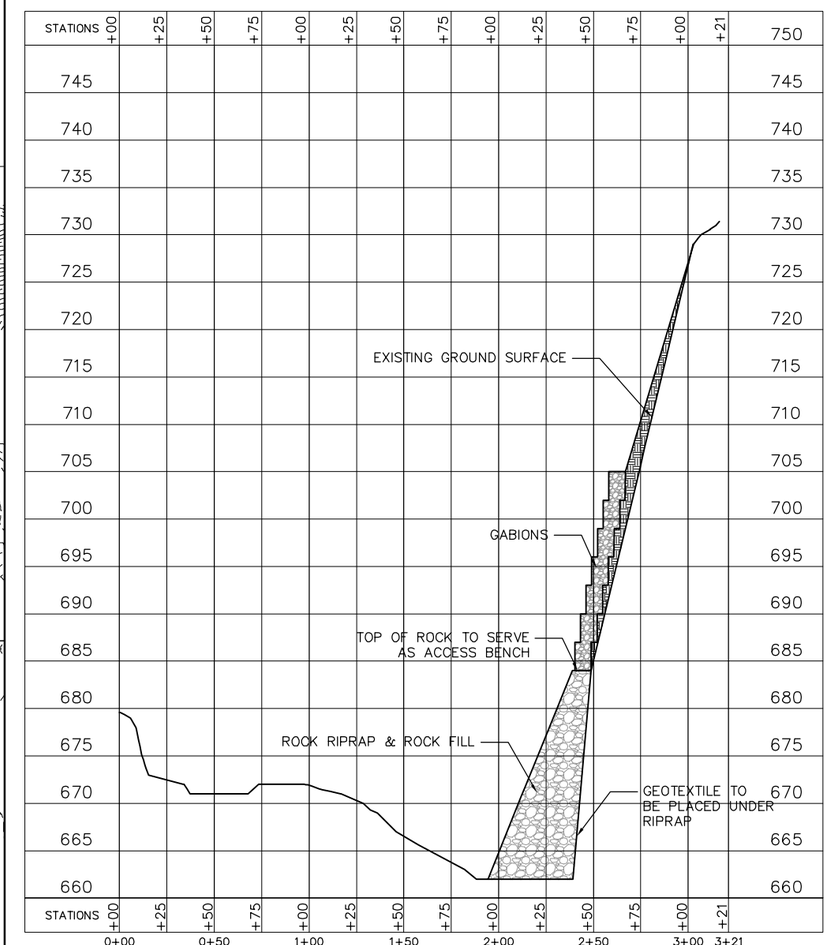
Item	Description	Unit	Quantity	Unit Price	Cost
1	Mobilization	LS	1	$5,000	$5,000
2	Relocate Existing LP Tanks	LS	1	$1,200	$1,200
3	Reinstate Gas Services	Each	2	$350	$700
4	Access Road	LS	1	$25,000	$25,000
5	Toe Excavation	CY	1500	$5	$7,500
6	Geotextile	SY	6000	$2.25	$13,500
7	Gabion Baskets-Filled	LS	1	$235,000	$235,000
8	Shot Rock	CY	13000	$16	$208,000
9	Rock Riprap	CY	3000	$50	$150,000
10	Pollution Control	LS	1	$8,000	$8,000
				Subtotal:	$653,900
				Contingencies (~10%):	$66,000
				Engineering, Legal, Administrative (~15%)	$108,100
				Site Demolition Total:	**$828,000**



EXPECTED EROSION EXTENTS

NOTES

THE TYPICAL IS ONLY INTENDED TO SHOW THE MAJOR ZONES OF FILL AND THE TYPES OF MATERIALS LIKELY TO BE USED. GRADING AND CUT SECTIONS ARE INTENTIONALLY NOT SHOWN. FINAL ELEVATIONS AND DIMENSIONS TO BE DETERMINED IN THE DESIGN PHASE.



TYPICAL CROSS SECTION

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40 0 40 80 ft

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FIGURE 5.4
ALTERNATIVE IIA CONCEPT
KELLOGG, MINNESOTA

SCALE: AS SHOWN
PROJECT NO. 7520
DRAWN BY: NWA
CHECKED BY: SDS, WKA
SHEET 35

Other Alternatives Considered

Alternatives I and II represent a more detailed analysis of the options previously identified during the interagency meetings. As part of this analysis several additional alternatives were examined, and those that were deemed feasible from a constructability standpoint are presented below. In each case presented however, it quickly became apparent the project cost would likely be significantly higher that either Alternative I or II. Given the known budget constraints for this site, these alternatives were not examined in greater detail. While these alternatives may provide one or more technical advantages, all are considered non-feasible from a cost perspective. A brief summary of these alternatives is presented below.

Alternative III: Bin Walls– Bin walls consist of sheet metal plates bolted together to create a series of interconnected boxes. The boxes are set on a stable foundation and filled with select material to create gravity stabilized embankment. For the situation at Kellogg, a stable foundation would need to be created by excavating at the toe of the slope and placing a thick layer of rock fill (similar to Alternative II). The bins would then be placed on the rock using crane and filled to create a near vertical wall approximately 25 feet high. This vertical extension would then allow the upper slope to be filled at an approximately 2H:1V. Figure 5.5 shows a typical bin wall installation.

Cost Opinion – $2,250,000 – $2,750,000

Figure 5.5: Typical Bin Wall Installation

Alternative IV: MSE System – A Mechanically Stabilized Earth (MSE) system is a general term used to describe designs that incorporate structural components and/or geotextile layers to reinforce the soil in a vertical application. The use of these components allows soil to be placed at steeper angles than would normally be possible, and various systems provide provisions for erosion control. The MSE systems examined for this site generally included the use of embedded geotextile with wrapped or rocked faces. In general, these types of systems are placed above the normal water level. At this site the MSE system would be used to reinforce the upper part of the embankment, and a stable foundation would need to be provided. As a rule of thumb the embedment length of the geotextile for the examined systems is 60%-70% of the retained height. This means that for the site at Kellogg a significant amount of material would need to be brought in to construct the embankment and the finished slope would extend well into the Zumbro River. Figures 5.6 and 5.7 show a typical finished MSE installation and cross section respectively.

Cost Opinion – $2,000,000 – $2,500,000

Figure 5.6: Typical MSE Installation

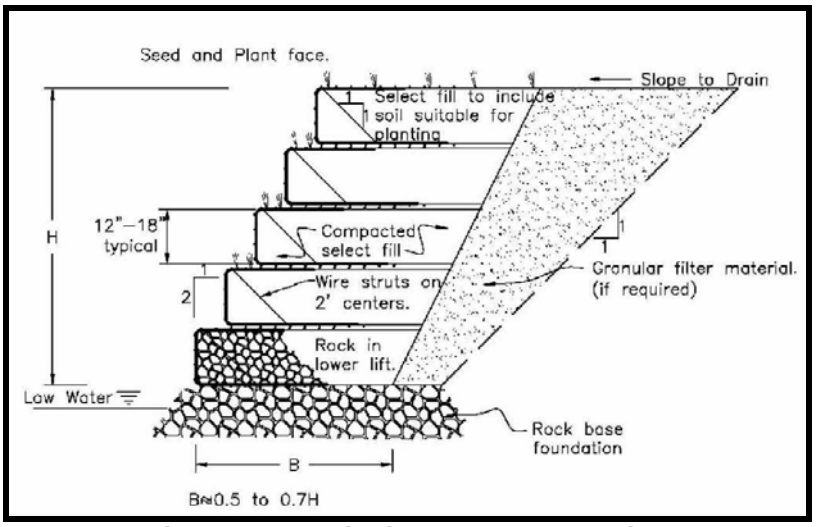

Figure 5.7 Typical MSE Cross Section

Alternative V: Gabion Baskets – Gabions are wire mesh baskets filled with stone and stacked to form an erosion resistant retaining wall. (One variation of a gabion basket includes a geotextile liner that allows the stone to be replaced with sand or gravel fill.) As with the two previous options, a stable foundation would need to be created before the gabions could be placed. This would involve placing material similar in scope to alternative II. While gabions can be placed under water it is not recommend for this site due to corrosion concerns and the possibility of damage from debris and bed load. If a basket was to tear or break the rock fill could fall out and the wall could fail. Therefore a gabion alternative would primarily limited to the stabilization of the upper slope above the normal water level. Figure 5.8 shows a typical gabion wall after construction.

Cost Opinion – $2,000,000 – $2,500,000

Figure 5.8: Typical Gabion Construction

Hydraulic Alteration

The Zumbro River is known to carry a substantial sandy bed load in the project area. Because of this, alternatives that alter the river hydraulics with the intent to trap bed load (such as stream barbs and bend-way weirs) were considered as means to eliminate erosion at the toe of the slope. However, the challenges associated with site access would require fill to be placed at the toe prior to construction as previously described. With rock fill in place these options are no longer applicable. No further consideration of cost was given for any of these alternatives.

Permits

The permit requirements for the construction alternatives presented will be similar to those presented in Part IV. Refer to the previous section for specific permit information and descriptions. Table 5.2 provides a summary of the anticipated permits required for each alternative presented; including those presented in Part IV.

Table 5.2: Summary of Likely Permits

Alternative	PERMIT				
	404	WCA	PUBLIC WATERS	NPDES	MNDOT
Buy-Out Alternative I					
Buy-Out Alternative II	X	X	X	X	
Construction Alternative I	X	X	X	X	X
Construction Alternative II	X	X	X	X	X
Construction Alternative IIA	X	X	X	X	X
Construction Alternative III	X	X	X	X	X
Construction Alternative IV	X	X	X	X	X
Construction Alternative V	X	X	X	X	X

Summary

This section presented an overview of various construction alternatives to address property concerns as a result of the on-going slope failure at the project site. Property acquisition and site demolition cost opinions were presented along with a discussion of typical permitting requirements.

Table 5.3 provides a summary of the various cost opinions presented above.

Table 5.3: Summary of Construction Costs

Item	Cost Opinion
Alternative I – Full Slope Mitigation	$1,396,000
Alternative II – Toe Protection	$817,000
Alternative IIA – Toe Protection & Gabions	$828,000
Alternative III – Bin Walls	$2.25-$2.75 Million
Alternative IV – MSE Design	$2-2.5 Million
Alternative V – Gabions	$2-2.5 Million

Part VI - Conclusions & Recommendations

This alternatives analysis examined several general approaches to address the continuing slope failure at the project site in the City of Kellogg. The primary concern when examining this site is the potential of the failing slope to impact three existing homes and City infrastructure located at the top of the embankment. The first concept evaluated was the do nothing alternative. Examination of the slope showed a series of shallow sloughing failures proceeding up the face of the embankment as a result of erosion at the toe that took place during the September 2010 flood. Based on the analysis of the existing site conditions, we conclude that Home #1 will become increasing unstable as the upper part of the existing slope continues to fail. Failure of the existing slope is likely to the point where the footings of Home #1 will be impacted. From this it can be concluded that Home #1 should not remain in its current state unless measures are taken to address the ongoing slope failure. While currently appearing stable, the toe of the existing slope should be considered highly erodible. Additional erosion at the toe and subsequent failure of the upper slope is likely to coincide with large runoff events in the river below. Homes #2 and #3 will likely not be impacted as a result of the current failure; however a single runoff event of adequate magnitude, or situation where the slope becomes saturated, could pose an immediate hazard.

Recognizing that the three existing homes are threatened, the second concept evaluated was the option to purchase the impacted properties through one of several government assisted programs. Specifically, this option examined the possibility of purchasing the properties and demolishing the existing homes or relocating the structures to new sites. This report outlines the general buy-out/relocation process and provides information from recent property assessments. Demolition requirements and site mitigation alternatives are also presented. It was determined that relocating the existing homes is not feasible and only buy-out options should be considered.

The final approach examined was the evaluation of several construction based alternatives to stabilize the slope and prevent further erosion. All of the evaluated alternatives would require access to the toe of the slope, which in turn requires a significant amount of material to be placed in the river for access. Alternative I was developed on the concept of stabilizing the entire slope with the intent of keeping all of

the existing homes and infrastructure intact. This alternative was largely based on a previous NRCS design and includes the placement of riprap and rock fill at the base of the slope. While technically feasible, the final design would require that fill material be placed approximately 25 feet out into the river. This has the potential to create hydraulic issues for the Highway 61 Bridge located upstream of the site as well as redirect erosive forces to different parts of the streambank. For these reasons, Alternative I is only recommended with reservations and further analysis should be conducted before this option is selected. Alternative II utilizes rock fill and riprap at the base of the slope to stabilize the toe. The concept behind this alternative is that the site would be protected from future erosion from large runoff events. The upper slope would be allowed to continue failing at its natural rate until it becomes stable. Because work would not be done to the upper slope, Home #1 would need to be removed through one of the buy-out alternatives previously presented. Alternative IIA presents a variation of this alternative where Home #1 would not need to be removed, however the costs are similar and there are several drawbacks that may need further consideration. Other construction alternatives evaluated (Alternatives III-V) included a bin wall design, mechanically stabilized earth design, and gabion baskets. While feasible from a technical standpoint, and potentially offering several advantages, all of these alternatives were determined to be non-feasible from a cost perspective. Detailed cost opinions for these alternatives were therefore not completed.

Table 6.1 provides a summary of the cost opinions for all the evaluated alternatives. Applicable property acquisition and site demolition costs are broken out separately as these fees may apply to separate funding programs.

Table 6.1: Summary of Cost Opinions

Alternative	Description	Cost Opinion
Buy-Out Alternative I	Buy-Out with Minimal Site Mitigation	
	Property Acquisition	$673,160
	Demolition	$134,000
	Site Mitigation Opt. A	$17,000
	Total:	**$824,160**
Buy-Out Alternative II	Buy-Out with Full Site Mitigation	
	Property Acquisition	$673,160
	Demolition	$134,000
	Site Mitigation Opt. B	$275,000
	Total:	**$1,082,160**
Construction Alternative I	Full Slope Stabilization	**$1,396,000**
Construction Alternative II	Toe Stabilization & Buy Out	
	Property Acquisition	$181,000
	Construction	$636,000
	Total:	**$817,000**
Construction Alternative IIA	Toe Stabilization & Gabions	**$828,000**
Construction Alternative III	Bin Walls	**$2.25-$2.75 Million**
Construction Alternative IV	MSE Design	**$2-2.5 Million**
Construction Alternative V	Gabions	**$2-2.5 Million**

Due to the on-going slope failure and imminent threat to Home #1, WHKS recommends that some form of action be taken as soon as possible. From a strictly cost perspective the most feasible alternative appears to be either Buy-Out Alternative I or Construction Alternative II/IIA. The final decision on what approach is best suited for the situation will depend on a variety of factors such as project funding, program constraints and the desires of the local community. In addition, it must be restated that there is an amount of uncertainty associated with the value of the structures themselves. Program determinations, subjective appraisal variables, and fluctuating market prices are all factors that could shift the projected project costs. Both of the lowest cost options involve the removal of at least one existing home. If it is determined that the removal of homes is not desired the City should further consider one of the other construction alternatives presented.

WHKS & Co. requests that the City of Kellogg review this report and provide guidance on proceeding.