US Army Corps of Engineers

Lower Missouri Jefferson City L-142 Flood Risk Management Study

Draft Integrated Feasibility Report and Environmental Assessment

Appendix A3 – Engineering

November 2024

MISSOURI DEPARTMENT OF NATURAL RESOURCES

APPENDIX A3 - ENGINEERING

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1.0 General

The focus of the Feasibility Study is on establishing project elements and features, developing design assumptions, evaluating alternatives and collection of assessment data. The results of the engineering investigations, studies, and designs developed during the screening of alternative plans, and then development for the Tentatively Selected Plan (TSP), are presented in this engineering appendix. The TSP plan, and this Appendix, will be further refined prior to the Agency Decision Milestone (ADM).

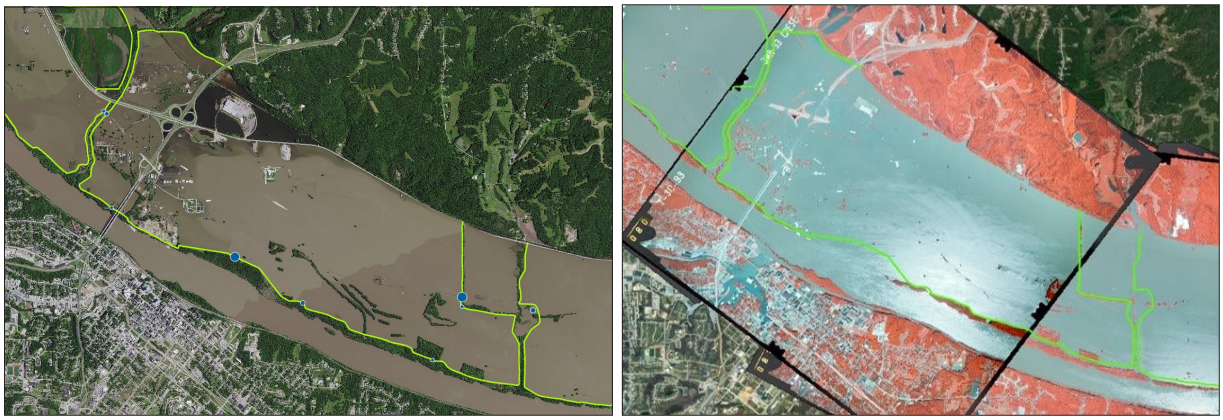
Flooding has frequently damaged development on the north bank of the Missouri River in Jefferson City, Missouri. In 1989, the City of Jefferson City requested that the U.S. Army Corps of Engineers (USACE) initiate a re-evaluation of flood risk measures on the left bank of the Missouri River. The USACE completed the Initial Appraisal of the authorized Missouri River Levee System (MRLS) Unit L-142 in June 1991. The initial appraisal was favorable for continued study and identified levee alternatives to reduce recurring flood damages. The USACE announced the beginning of this Re-evaluation Study on June 1, 1993. However, in July 1993 this area experienced the flood of record leading to widespread impacts throughout the Lower Missouri River corridor, and the non-federal Capital View levee overtopped and breached. From July 1993 through October 1995, the study was suspended pending further evaluation. After the Flood of 1993, flood hazard mitigation funds provided by the Federal Emergency Management Agency (FEMA) and the City removed many residences and other damageable property from the area known as Cedar City. The alternatives formulated in the initial appraisal continued to be useful guidelines, but several factors, primarily the 1993 flood experience and the removal of damageable development from the Cedar City floodplain, prompted a distinct set of alternatives for the post-1993 condition. A General Reevaluation Report was completed in 2001 for the MRLS Unit 142-L. That study resulted in an NED plan to build a levee that at the time was designed to an Annual Exceedance Probability (AEP) of 0.001. The NED plan had an estimate of $24,507,600 (October 2000 pricing) and a benefit-cost ratio of 2.2 to 1. However, after public backlash on the proposed plan, the City of Jefferson City decided to not proceed with the project. The area was again flooded in 2019 after overtopping and breach of the Capital View levee. After the flood of 2019, USACE initiated a new feasibility study of the area with the Missouri Department of Natural Resources (MoDNR) as the Sponsor. The post 2019 study evaluated several alternatives, including the 2001 MRLS 142-L selected plan.

The Flood of 1993 remains the flood of record at Jefferson City, with a recorded maximum stage of 38.7 feet and discharge of 750,000 cfs at the Jefferson City Missouri River gage, corresponding to a roughly 0.2% (1/500 yr) AEP flow. The 2019 flood recorded a maximum river stage of 33.4 feet and discharge of 366,000 cfs, an approximate 10% (1/10 yr) AEP flow. Figure 1 shows the difference in inundation between the 2019 and 1993 flood events at the Capital View Drainage District leveed area.

Figure 1 Inundation Extent Comparison at Capital View levee for 2019 and 1993 flood events

2019 Event
10 yr (~10% AEP)

1993 Event
500 yr (~0.2% AEP)



2.0 Geotechnical and Geology

2.1 REGIONAL AND SITE GEOLOGY

The regional geology in the area surrounding the proposed project lies between the Dissected Till Plains and the northern edge of the Ozark Plateaus. The strata are of the Ordovician System, Canadian Series. Formations and relative thicknesses of the units in the region described in an up-strata direction are the Gasconade (290 feet), Roubidoux (90 feet), and Jefferson City/Cotter (345 feet). At the flanks of the Ozark Dome, the strata have a general east-west strike and a dip of 1 degree to the north.

The Missouri River Valley was incised in the Pleistocene Epoch by glacial melt waters. When floodwaters receded, the valley was filled with glacial outwash consisting of sand, gravel, silts, and clays. The northern edge of the valley is near the southern extent of the Kansan Glaciation.

2.1.1 Site Geology

The proposed site is located within the alluvial valley of the Missouri River. The site is relatively flat with the ground elevation varying between 535 and 570 feet NAVD88. The Missouri River Valley at the location of the proposed levee system is filled with alluvial deposits consisting of gravel, sand, silts and clays. Two broad strata are present: (1) a substratum of highly permeable sand and gravel, varying in thickness between 75 and 80 feet; and (2) a fine-grained top stratum of silty clay, which is less permeable, ranging in thickness between 5 and 15 feet. The bottom of the blanket is approximately at elevation 530.0 feet.

The left bank of the valley is bounded by steep bluffs of the Jefferson City/Cotter Formations. Considered nearly identical, the formations consist of light brown to brown, medium to finely crystalline, medium to thick bedded, cherty argillaceous dolomite with thin lenses of shale and sandstone. The bluffs are steeply sloping to nearly vertical, with an average height of 150 feet. The Jefferson City formation unconformably overlies the Roubidoux Formation. The contact is approximately 20-50 feet below the base of the bluffs. The Roubidoux consists of sandstones, dolomitic sandstones, and cherty sandstones. Approximately 90 feet of alluvial sediment in the valley rests upon a dolomite, which is the base of the Roubidoux or possibly the top of the dolomitic Gasconade Formation.

2.2 BORINGS FOR THIS FEASIBILITY ASSESSMENT

Existing subsurface information was used to develop the Tentatively Selected Plan (TSP). Additional drilling was assigned to better understand the selected TSP alignment but cannot begin until right of entry negotiations have been completed. Existing subsurface information used to develop the TSP consists of borings completed in 1976 and in 1993 and is discussed in the following section.

2.3 GEOPHYSICAL INVESTIGATIONS

No geophysical investigation has been performed at this site to date and it is projected that one will not be needed for the feasibility.

2.4 COMPLETED SOILS EXPLORATION

Subsurface investigations were performed for a previously proposed L-142 levee project (Historic L-142) that never went to final design and construction. Borings for this project were completed in 1976 by Layne-Western and by USACE in 1993. Additional borings will be completed to supplement these historic subsurface investigations once the TSP has been determined as part of this ongoing feasibility study. This section summarizes the historic borings information as contained in Appendix B of the L-142 General Reevaluation Report published in 2001 (L-142 GRR).

The borings performed by Layne-Western were drilled in 1976 for what was originally called the Jefferson City Memorial Airport levee which later became the proposed L-142 levee project. Logs for these borings are contained in the L-142 GRR. Forty-five borings were completed by Layne-Western of which 5 were extended to bedrock refusal. Out of the 5 borings drilled to refusal, 4 of them reached refusal between 87 and 92 feet below ground surface (bgs). The last boring drilled to refusal was completed near Bluff Road (Missouri Route 94) and reached refusal at 52 feet bgs. The upper 5 to 10 feet of clay and silt layers were underlain by silty sand extending to around 30 feet bgs; then layers of sand were identified until reaching bedrock. Borings typically had between 5 and 10 feet of clay, underlain by silty sand to around 30 feet, which was underlain by sand to bedrock.

Ten borings were completed by USACE in 1993. Eight of these borings extended to a depth of 25 feet, one boring extended to 20 feet bgs, and one boring extended to 35 feet bgs. The upper 5 to 20 feet bgs was comprised of clay and silt. This upper blanket material was then underlain by silty sand or clean sand to the end of boring. At the time of drilling groundwater was encountered in the borings at depths between 12 to 17 feet bgs. Note that groundwater level is anticipated to be closely linked to the river elevation based on project site's proximity to the river.

2.5 UNDERSEEPAGE EVALUATION OF ALTERNATIVES

Underseepage in foundation soils beneath levees and floodwalls can lead to levee failures due to the piping failure mechanism and must be addressed during the design phase with proper underseepage risk reduction measures. The piping failure mechanism is not related to buried pipes but is instead named for pipe shaped erosion features that can form due to underseepage. Underseepage risk reduction measures can have a significant impact on levee construction cost. These measures may consist of the addition of underseepage soil berms and/or relief wells on the landside of the levee. Where room is available, as appears to be the general case here, underseepage berms are the most cost-effective way to address underseepage concerns. As an aide in developing construction costs and determining the TSP, initial underseepage berm requirements were developed for the multiple levee alternatives that are under investigation by the design team. Methodology for the development of screening level underseepage berm needs varied from assuming the underseepage berms contained in the Historic L-142 levee design to screening level empirical underseepage analysis. For the alternatives that were somewhat close to the Historic L-142 alignment and height, the berms developed for the 2001 L-142 GRR were assumed. For other alternatives empirical underseepage analysis and simple logic were employed.

Underseepage analysis performed for the Historic L-142 design and new underseepage analysis specifically performed for this feasibility study were both based on the methodology from the memorandum "Design and Proportioning of Long Berms" that was approved by the Chief of Engineers 18 January 1954. This methodology requires the assumption of specific foundation sand to blanket soil permeability ratios (Kf/Kb) that are recommended within the noted document and were developed based on historical performance of levees along the lower Missouri River. Refer to Appendix B of the 2001 L-142 GRR for details regarding assumptions that were made for that analysis. For the current analysis a single blanket thickness of 10 feet was selected. Additionally, based on the clay and silt materials sampled in the top blanket and the existing permeable sand layer at the bottom, a permeability ratio of 500 between the blanket and foundation sand was assigned. Underseepage analysis performed, assumed water at the top of the levee and underseepage uplift requirements contained in the 08 May 2015 MFR entitled "Missouri River Levee System (MRLS) R471-460 & L-455 Pre-Construction, Engineering and Design (PED); Revised per USACE-HQ Comments". This document's requirements included underseepage uplift safety factors of 1.6 at the toe of a levee and 1.0 at the toe of any underseepage berm.

The following subsections discuss underseepage remediation developed or assumed for the various alternatives considered.

2.5.1 Underseepage – CA1 Existing Capital View Alignment, 34-ft Stage

The alignment of CA1 follows, as the name implies, the alignment of the existing Capital View levee. Underseepage berms were developed along this alignment by performing empirical analyses for representative sections along the levee alignment. This analysis was based on the methodology outlined in Appendix B of EM 1110-2-1913. This alignment is the closest of the alternatives to the Missouri River or to the associated tie-back on Turkey Creek and generally lies hundreds of feet riverward of the 2001 L-142 levee design. CA1 has a levee crest height that corresponds to a 34-ft stage at the Jefferson City, Missouri River Gage JFFM7. The existing Capital View levee has a crest height that corresponds to a 30.5-ft stage at JFFM7. Stage 0 at Gage JFFM7 corresponds to elevation 520.2 ft NAVD88. **Table 1** provides underseepage berm needs for the Existing Capital View Alignment, 34-ft Stage alternative.

Table 1 Underseepage - CA1

Stationing	Underseepage Berm needed (yes/no)	Width (Ft) *[1]	Height (Ft)
0+00 to 85+00	No	NA	NA
85+00 to 190+00	Yes	50	3
190+00 to 310+00	No	NA	NA
310+00 to 366+00	Yes	50	3

*[1] A levee sections as short as 50 feet is allowed when modifying existing levees with no known underseepage problems

2.5.2 Underseepage – CA2 Turkey Creek & Riverside Setback, 34-ft Stage, Capital View Removed

CA2 assumes an alignment that is offset 1,000 feet landward of the existing Capital View levee alignment. Consistent with the CA1 alignment, this alternative has a levee crest that is equivalent to a 34-ft stage at the JFFM7 gage. With a levee crest height of roughly 11 feet below the Historic L-142 levee design, it was determined that an empirical analysis would be appropriate at this stage to gain a better understanding of underseepage berm needs. This analysis led to a determination that no underseepage berms should be assumed in the evaluation of this alternative.

2.5.3 Underseepage – CA4 Optimization Alignment, 37-ft Stage, Capital View Remains and CA5 Optimization Alignment, 37-ft Stage, Capital View Removed

The optimization alternatives, CA4 and CA5, roughly follow the Historic L-142 Alignment for much of its length, although the east tieback of this alignment is roughly 4,000 feet eastward of the Historic Alignment. Additionally, they have a proposed levee crest height that is consistent with a 37 -ft river at JFFM7, or roughly 8 feet below the Historic L-142 levee crest design. CA4 assumes the Capital View levee will remain in place and CA5 assumes the Capital View levee will be removed. Based on this information it was felt that empirical underseepage analysis would be appropriate for the evaluation of these proposed alternatives when determining the TSP. This analysis resulted in underseepage berm requirements for CA4 and CA5 that are contained in **Table 2.**

Table 2 Underseepage- CA4 and CA5

Stationing	Underseepage Berm needed (yes/no)	Width (Ft)	Height (Ft)
0+00 to 310+00	Yes	150 *[1]	3

*[1] The calculated required width was 50 feet however the USACE NWK standard is a minimum of 150 feet for new levee construction.

2.5.4 Underseepage – CA6 Historic L-142 Alignment, 45-ft Stage, Capital View Remains and CA7 Historic L-142 Alignment, 45-ft Stage, Capital View Removed

As implied by the name, the Historic L-142 alternative matches the L-142 Feasibility level levee design contained in the 2001 L-142 GRR. This includes both the levee alignment and the levee crest height that is equivalent to a 45-ft stage at JFFM7. CA6 assumes the existing Capital View Levee will remain and CA7 assumes that it will be removed. Underseepage berms from the L-142 GRR were determined to be appropriate for evaluating these alternatives. The required berms for this alternative were directly drawn from Sheet B-4.4 in the 2001 L-142 GRR. **Table 3** indicates the underseepage berm requirements for CA6 and CA7.

Table 3 Underseepage – CA6 and CA7

Stationing	Underseepage Berm needed (yes/no)	Width (Ft)	Height (Ft)
0+00 to 70+00	Yes	250	4
70+00 to 75+00	No	NA	NA
75+00 to 93+00	Yes	250	4
93+00 to 95+00	No	NA	NA
95+00 to 120+00	Yes	250	4
120+00 to 130+00	No	NA	NA
130+00 to 210+00	Yes	250	4
210+00 to 215+00	No	NA	NA
215+00 to 250+00	Yes	250	4

2.5.5 Underseepage – Combined Alternatives 8 and 9 - Highway Alignment Alternative

This proposed alternative extends from the bluffs to the Historic L-142 Alignment along the U.S. Highway 54 berm. It then follows the Historic L-142 Alignment but has a crest height of Stage of 37 of Gage JFFM7, well below the Historic L-142 alternative. It was assumed for this assessment that due to the significant width of the highway embankment and the significant distance of the highway embankment from the Missouri River and tie-back creeks, no seepage berms would be required. Because the portion of the alignment along the Historic L-142 alignment has a lower crest than that documented in the L-142

GRR, an empirical analysis was performed along this portion of the alternative. **Table 4** documents seepage berms needed for CA8 and CA9.

Table 4 Underseepage - Highway Alignment Combined Alternatives 8 and 9

Stationing	Underseepage Berm needed (yes/no)	Width (Ft)	Height (Ft)
0+00 to 74+00 (Highway)	No	NA	NA
72+00 to 220+00 (L-142, Stage 37)	No	NA	NA
220+00 to 235+00	Yes	150*[1]	3
235+00 to 272+30	Yes	250	4

*[1] The USACE NWK standard is a minimum of 150 feet for new levee construction.

2.5.6 Underseepage – Combined Alternative 13 Hybrid Alignment, 41-ft Stage, Partial Capital View Removal

This proposed alignment starts at the river bluffs and extends in a southwestern direction on the east side of U.S. Highway 54 until it is within 165 feet of the Katy Trail where it turns in a north westerly direction at Station 10+00. It then crosses U.S. Highway 54 and runs west/northwest until roughly Station 45+00 where it turns to run in a southwesterly direction east of Turkey Creek. The levee runs in this southwesterly direction to Station 95+00, crossing U.S. Highway 63 between Stations 66+00 and 67+50. At Station 95+00 the levee turns to run in a south westerly direction to Station 283+00. In this stretch of levee, the levee runs along both Sandstone Drive and then Mokane Road, passes to the south of the airport and runs along the south side of the WWTP. At Station 283+00 the levee runs northward along the west side of a drainage ditch. This ditch lies roughly 2,600 feet to the west of Niemans Creek. Niemans Creek extends to the Missouri River. The levee extends along the said drainage ditch to the river bluff which is located at Station 314+00. Underseepage is driven by the Missouri River, the Turkey Creek tie back, and the drainage ditch tieback. **Table 5** documents seepage berms and relief wells needed for CA13.

Table 5 Underseepage CA13

Stations	Underseepage Berm Width (Ft)	Underseepage Berms Height (Ft)	Relief Wells Required (Number)
(start) 0+00 to 110+00	150	3	0
110+00 to 135+00	150	3	0
135+00 to 146+00 (WWTP Reach)	None	None	3
146+00 to 183+00	150	3	0
183+00 to 225+00	None	None	0
225+00 to 280+00	None	None	0
280+00 to 314+00 (end)	150	3	0

*Reaches where highway serves as levee will not require berms. This includes U.S. Highways 63 and 54

2.6 SLOPE STABILITY ANALYSIS OF ALTERNATIVES

Levee slope stability is a major consideration when designing levee berms. Where stability analysis of a levee section indicates that the levee slope has an inadequate safety factor, mitigation measures such as stability berms and horizontal sand drains can be added to achieve required safety factors. The stability assessment of the proposed alternatives ranged from simply using the stability berms designed in L-142 GRR for the Historic L-142 Levee alternative to performing stability analysis for other alternatives under consideration. Soil strength parameters and stability analysis used for the determination of stability berms for the 2001 L-142 GRR could not be located.

Where stability analysis was performed, slope stability safety factor requirements listed in Table 6-1b of EM 1110-2-1913, “Design and Construction of Levees” were used to determine adequacy of slopes and need for any necessary slope stability mitigation measures. Stability analysis was performed in accordance with USACE stability analysis requirements contained in EM 1110-2-1902, “Slope Stability” for the long-term steady seepage case. The software programs Seep/W and Slope/W were used to execute the stability analysis. Levee alternatives were broken up into a limited number of reaches based on levee height. A single simplified soil type model was assumed for all alternatives considered. It consisted of levee and levee berms constructed of somewhat impervious random soil, a ten-foot-thick impervious clay blanket, and deep foundation sand. In a few cases, a horizontal sand drain was included within the levee embankment model. Where needed to achieve required safety factors, stability berms were added. This simplified model was deemed adequate for this stage of work. The same soil strength parameters were used for slope stability analysis of all levee alternatives. The permeability and soil strength values assumed for this pre-TSP level stability analysis are contained in **Table 6**.

Table 6 Soil Strength Parameters Assumed for Pre-TSP Stability Checks

Soil Layer	**Unit Weight (pounds)**	**ϕ’ (degrees)**	**C’ (pounds/square foot)**	**Permeability Values (feet/second)**
Levee Embankment	115	30	0	3x10-7
Horizontal Sand Drain	125	30	0	0.0003
Blanket	120	30	0	3x10-6
Foundation Sand	125	30	0	0.0003

The typical section used to evaluate the Capital View raise and the optimization alternatives is depicted in F**igure 2**. The Historic L-142 levee design is depicted in **Figure 3**. The typical L-142 cross-section was also assumed when evaluating the highway Levee alternative and CA 13.

Figure 2 Typical Cross Section 1

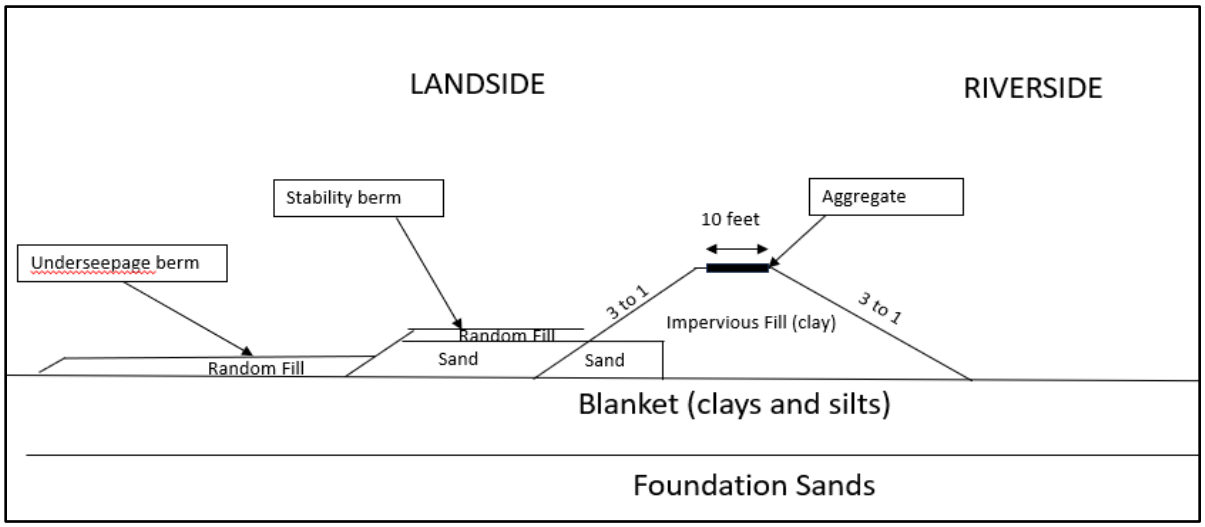
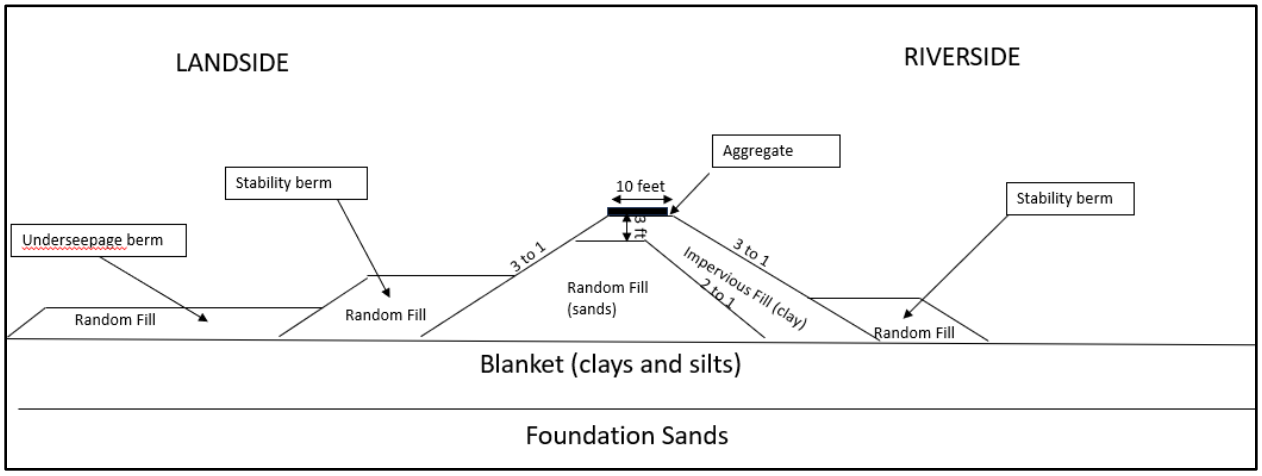


Figure 3 Typical Cross Section 2 (Historic L-142 Levee Design)



The following subsections discuss stability analysis and required mitigations.

2.6.1 Stability – CA1 Existing Capital View Alignment, 34-ft Stage

No historical stability analysis was available for this alternative; therefore, stability analysis was performed. Stability sections analyzed were primarily selected based on levee height and proximity to the river. Assumptions regarding levee fill soil parameters and foundation soil parameters were held constant for this TSP selection level stability analysis. Mitigations that were considered included both stability berms and horizontal sand drains. Because the team determined that the existing levee would be demolished and rebuilt rather than simply raised, landside sand drains were selected for several sections where the raised levee stability was inadequate. The landside sand drains used were 10 foot long by 2 foot in height. No stability berms were required, although seepage berms listed in the underseepage section were included in the stability analysis evaluation. **Table 7** lists the mitigation features to be considered during comparison of this levee alternative to other levee alternatives.

Table 7 Stability Berms – CA1

Stationing	Horizontal Sand Drain Needed (length, height)	Stability Berm needed (yes/no)	Width (Ft)	Height (Ft)
0+00 to 85+00	No	No	NA	NA
85+00 to 190+00	No	No	NA	NA
190+00 to 310+00	10 Ft, 2 Ft	No	NA	NA
310+00 to 366+00	10 Ft, 2 Ft	No	NA	NA

2.6.2 Stability – CA2 Turkey Creek & Riverside Setback, 34-ft Stage, Capital View Removed

As previously note in the underseepage section, this alternative has an alignment offset of 1,000 feet landward of the existing Capital View alignment and has a levee crest height equivalent to a 34-ft stage at JFFM7. It was assumed that this levee section would require the same mitigation measures deemed necessary for CA1 Existing Capital View Alignment, 34-ft Stage (previously discussed). **Table 8** summarizes where the noted horizontal sand drains would be required.

Table 8 Stability Berms – CA2

Stationing	Horizontal Sand Drain Needed (length, height)	Stability Berm needed (yes/no)	Width (Ft)	Height (Ft)
0+00 to 85+00	No	No	NA	NA
85+00 to 190+00	No	No	NA	NA
190+00 to 310+00	10 Ft, 2 Ft	No	NA	NA
310+00 to 366+00	10 Ft / 2 Ft	No	NA	NA

2.6.3 Stability – CA4 Optimization Alignment, 37-ft Stage, Capital View Remains and CA5 Optimization Alignment, 37-ft Stage, Capital View Removed

As previously noted, this alternative roughly follows the Historic L-142 alignment for much of its length but has a levee crest height that is consistent with a 37-ft stage at the Missouri River Gage JFFM7, or roughly 8 feet below the Historic L-142 proposed levee crest. Because this alternative is significantly lower that the Historic L-142 design analyzed in the 2001 GRR, stability analysis was performed for this alternative. The alignment was broken down into three reaches for purposes of this analysis. Analysis resulted in mitigations that included both horizontal sand drains and stability berms. Refer to the **Table 9** for stability mitigation recommendations based on this analysis.

Table 9 Stability Berms – CA4 and CA5

Stationing	Horizontal Sand Drain Needed (length, height)	Stability Berm needed (yes/no)	Width (Ft)	Height (Ft)
0+00 to 114+00	14 Ft, 2 Ft	No	NA	NA
114+00 to 301+00	26 Ft, 2 Ft	Yes	20	5
301+00 to 337+00	14 Ft, 2 Ft	No	NA	NA

2.6.4 Stability – CA6 Historic L-142 Alignment, 45-ft Stage, Capital View Remains and CA7 Historic L-142 Alignment, 45-ft Stage, Capital View Removed

As implied by the name, the Historic L-142 alternative matches the design presented in the 2001 L-142 GRR. This includes both the levee alignment and the levee crest height that is based on a Missouri River 45-ft stage at JFFM7. A 45-ft stage corresponds to an elevation of 565.2 ft NAVD88 at the JFFM7 gage. The stability berms depicted in the 2001 GRR are 15 feet and 20 feet below the top of levee resulting in stability berm top elevations of between elevations of 545 and 550. No sand drains were included as part of these alternatives. With ground elevations along the alignment of between 543 and 550 it was determined that only a very small portion of this levee required stability berm based on the original design.

Table 10 Stability Berms – CA6 and CA7

Stationing	Landside Stability Berm (length, height)	Riverside Stability Berm (length, height)
0+00 to 70+00	10 Ft, 30 Ft	10 Ft, 20 Ft
70+00 to 75+00	None	None
75+00 to 93+00	None	None
93+00 to 95+00	None	None
95+00 to 120+00	None	None
120+00 to 130+00	None	None
130+00 to 210+00	None	None
210+00 to 215+00	None	None
215+00 to 250+00	None	None

2.6.5 Stability – CA8 Highway Alignment, 37-ft Stage, Capital View Remains and CA9 Highway Alignment, 37-ft Stage, Capital View Removed

This proposed alternative extends from the bluffs to the Historic L-142 Alignment along the U.S. Highway 54 berm. It then follows the Historic L-142 Alignment (although the crest portion that follows along the historic alignment will be equal to a 37-ft stage at JFFM7). It was assumed for this analysis that due to the significant width of the highway embankment and the distance of the highway embankment from the

Missouri River and tie-back creeks, no stability berms would be required. Additionally, no sand drains were needed for these alternatives. Because this proposed alternative is roughly 8 feet lower than the Historic L-142 alternative and the alignment requires no stability berms along portions of its alignment to match this alternative, no stability berms were assumed to be required for these alternatives.

2.6.6 Stability – CA13 Hybrid Alignment, 41-ft Stage, Partial Capital View Removal

The levee crest height of this alternative is consistent with a Missouri River Stage of 39 at Gage JFFM7 or elevation of 559.2 ft NAVD88. Analysis resulted in the determination that stability berm mitigations were needed at several reaches along the proposed alignment. No sand drains were required. Refer to the **Table 11** for stability mitigation recommendations based on this analysis.

Table 11 Stability – CA13

Stationing	Landside Stability Berm (length, height)	Riverside Stability Berm
0+00 to 110+00	None	None
110+00 to 135+00	15 Ft, 10 Ft	None
135+00 to 146+00 (WWTP)	None	None
146+00 to 183+00	15 Ft, 10 Ft	None
183+00 to 225+00	None	None
225+00 to 280+00	None	None
280+00 to 313+00	None	None

*Reaches where highway Serves as levee will not require berms. This includes U.S. Highways 63 and 54

2.7 CONSTRUCTION TECHNIQUES

It is anticipated that conventional earth moving, placement, and compaction equipment will be used for the construction of all alternatives. Section 5 in this Appendix has more detailed discussion on construction procedures.

2.8 POTENTIAL BORROW SITES AND DISPOSAL

See Sections 3.6 and 3.7 in the Appendix for borrow discussions.

3.0 Civil Requirements

3.1 EXISTING CONDITIONS

3.1.1 Study Area

The study area is at the southern edge of Callaway County, Missouri, along the left bank of the Missouri River from Turkey Creek (river mile 144.5) on the west to the approximate area of Niemans Creek (river mile 140.5) on the east. The area is known informally as North Jefferson City, and much of the area has been incorporated into the city limits of Jefferson City. Jefferson City, the state capitol, had its origin on the opposite riverbank, but annexed significant acreage in the project area.

3.2 SITE SELECTION AND PROJECT DEVELOPMENT

3.2.1 Existing Capital View Levee

Non-Federal Levee: Capital View levee is located on the left descending bank of the Missouri River, river mile 144.5 to 139.8. The existing Capital View project is a levee system that reduces occurrence of flooding for approximately 3,300 acres of Missouri River floodplain in Callaway County, Missouri. This levee was not federally constructed. The levee system includes 8.8 miles of vegetated earthen levee, and 18 gravity drains. The levee is operated and maintained by the local sponsor, Capital View Drainage District.

Critical Infrastructure: Capital View leveed area contains the Jefferson City Memorial Airport, a Missouri Air National Guard Facility, the Jefferson City Regional Wastewater Treatment Plant, MFA Agri Services, Hitachi Energy, Katy Trail – North Jefferson City Trailhead, Capital Bluffs Event Center, Midwest Block and Brick Co, Capital Sand, Asphalt, and Concrete Plant, other various businesses, and numerous miles of underground and overhead utilities.

Transportation Corridors: The existing Capital View levee reduces flood risk to approximately 2.0 miles of State Highway Route 94, approximately 3.0 miles of old State Highway Route 94, approximately 0.5 miles of State Highway Route W, approximately 2.0 miles of asphalt surfaced County Roads, and approximately 0.4 miles of gravel City Roads.

Commercial and Residential Areas: The Capital View levee reduces flood risks to approximately 2,300 acres of agricultural cropland, the town of North Jefferson City, 20 businesses, five residences, 10 combined barns or machine sheds, one grain bin, two irrigation systems, the Cedar City Lions Club Building and Corley Park, the Jefferson City Park pavilion, and recreational fields, approximately 3.0 miles of Katy Trail State Park.

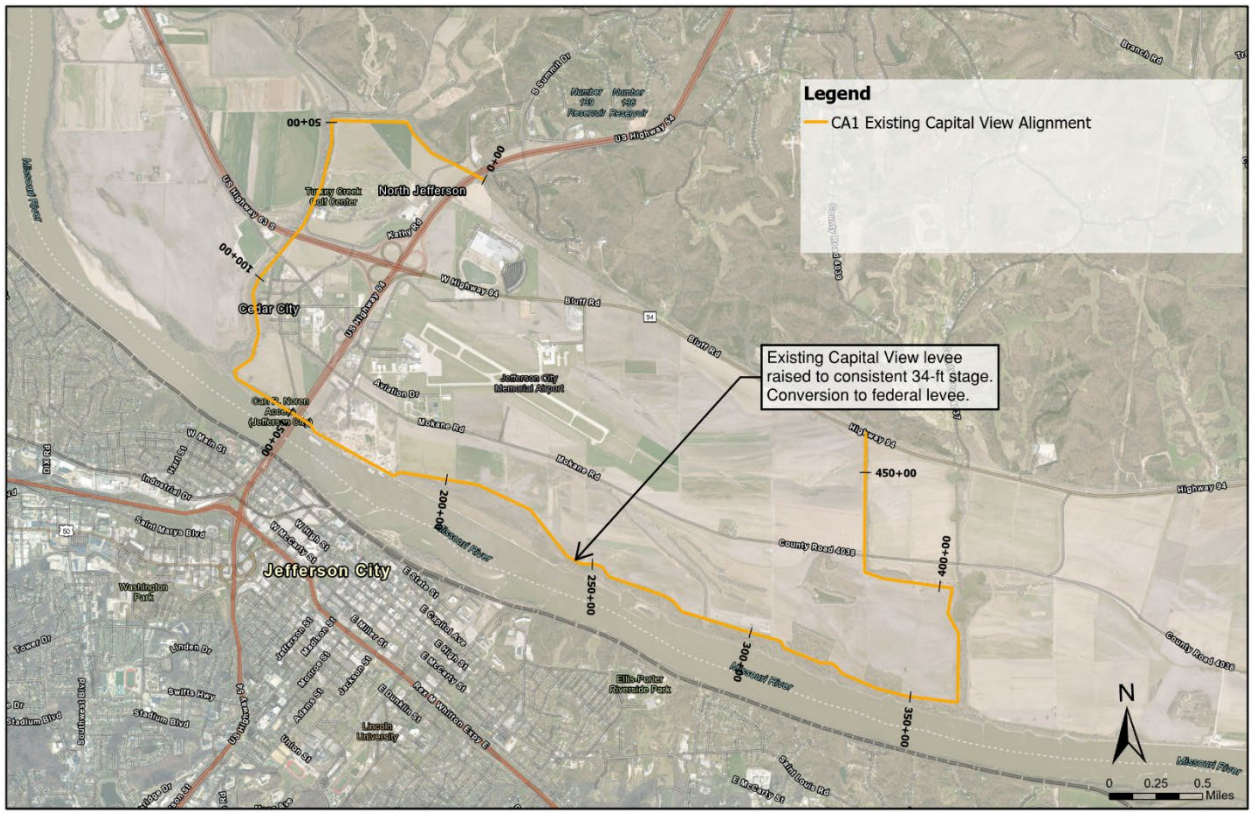
3.2.2 Combined Alternative 1 (CA1) Existing Capital View Alignment, 34-ft Stage

CA1 (**Figure 4**) evaluates increasing the height of the levee along the existing Capital View levee alignment. The existing capital view levee is vegetated with an average height of 6 feet. It was constructed with a 12-foot-wide top width and has 3.5H:1V side slopes. The material composition is unknown and assumed to be material with unknown compaction.

To move forward with development of the feasibility study, the assumption was made that the existing levee would be degraded and reconstructed from station 0+00 to to 464+22 meeting federal standards for material composition and compaction to the elevation associated with 34-foot stage.

CA1 would reduce occurrence of flooding for approximately 3,300 acres of Missouri River floodplain in Callaway County.

Figure 4 CA1 Existing Capital View Alignment, 34-ft Stage



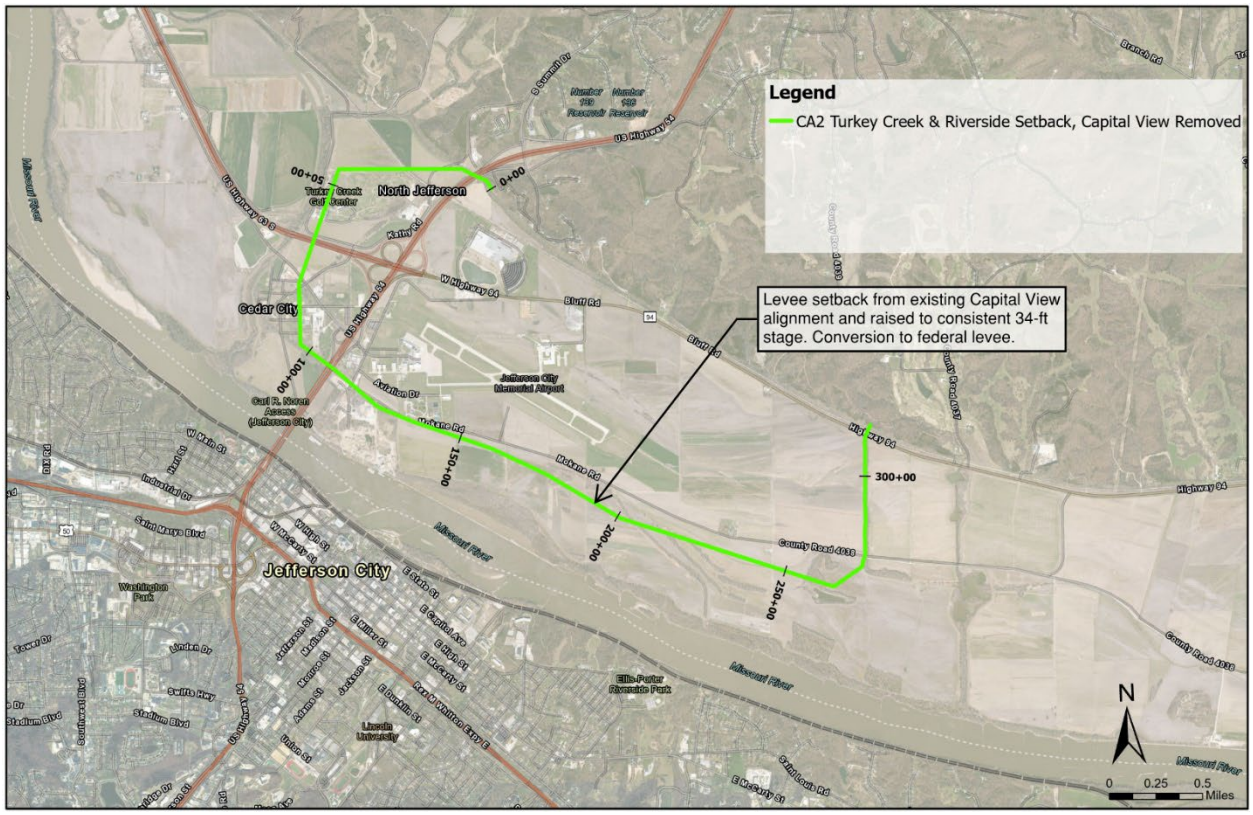
3.2.3 CA2 Turkey Creek and Riverside Setback, 34-ft Stage, Capital View Removed

CA2 (**Figure 5**) evaluates construction of a new levee setback approximately 1000 at along the Turkey Creek reach. The setback levee is located at the northeast side of the existing Capital View protected area set along a farm field and along the western edge of a golf course. It then crosses U.S Highway 54 at a high ground location and cuts South through grounds of Old Cedar City, where there are few residences and City owned community gardens and practice baseball fields. The proposed alignment follows along Sandstone Drive to the South, around to the East and ties into the existing embankment of South Hwy 54. The alignment continues from the north Hwy 54 embankment and follows along to the East approximately 1000 feet setback from the bank of the Missouri River. It then connects to high ground at the Bluff my turning north along a tributary that feeds to Niemans Creek.

The setback levee would be constructed from station 0+00 to 314+82 meeting federal standards for material composition and compaction. The existing Capital View levee would be deconstructed and used for borrow material to construct the setback levee. Additional borrow material is required to complete the proposed alternative.

CA2 would reduce occurrence of flooding for approximately 2,300 acres of Missouri River floodplain in Callaway County, Missouri.

Figure 5 CA2 Turkey Creek and Riverside Setback, 34-ft Stage, Capital View Removed



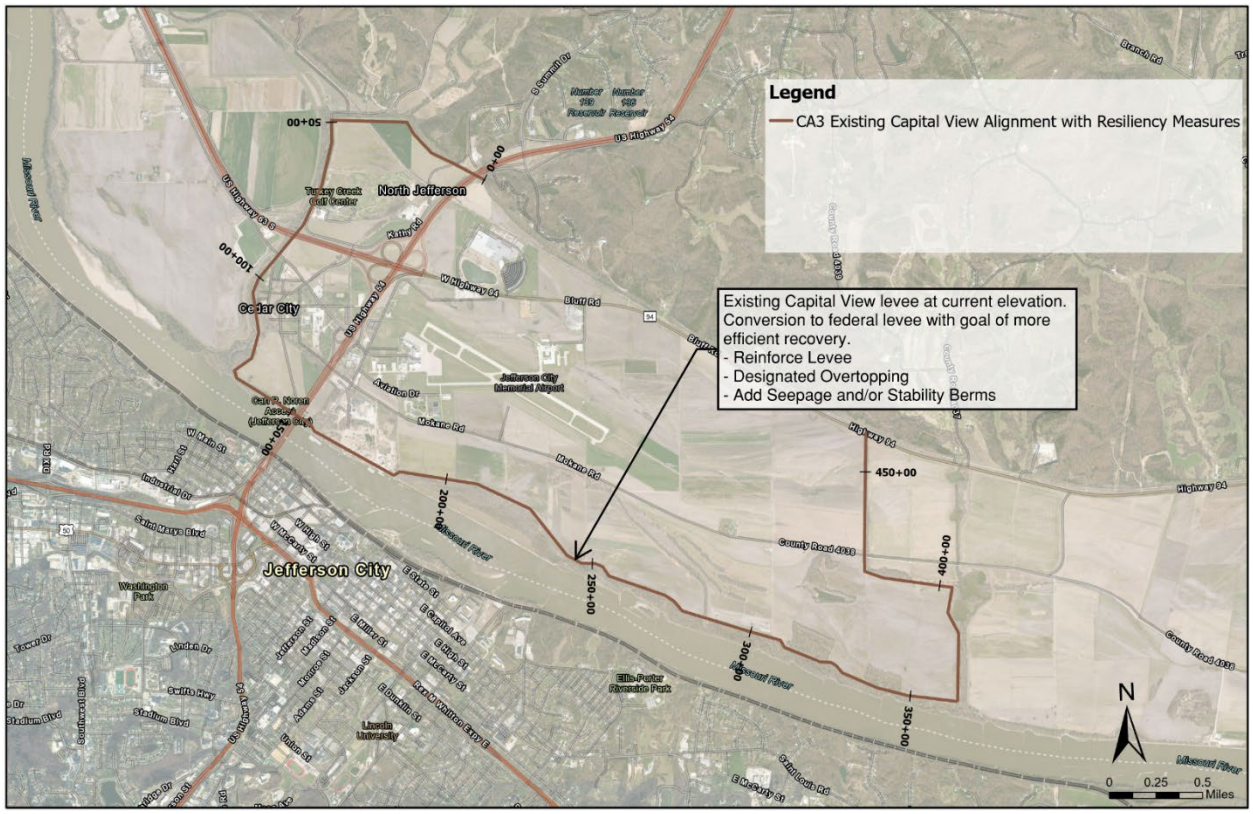
3.2.4 CA3 Existing Capital View Alignment with Resiliency

CA3 (Figure 6) evaluates utilization of the existing Capital View alignment with added resiliency. See the discussion in 3.2.1 for the site description of the existing Capital View levee.

To move forward with development of the feasibility study, the assumption was made that the existing levee would be degraded and reconstructed from station 0+00 to 464+22 meeting federal standards for material composition and compaction to the existing elevations. Resiliency measures such as armorment, designated overtopping, and closure structures at key locations of previously identified weak points.

CA3 would reduce occurrence of flooding for approximately 3,300 acres of Missouri River floodplain in Callaway County, Missouri.

Figure 6 CA3 Existing Capital View Alignment with Resiliency



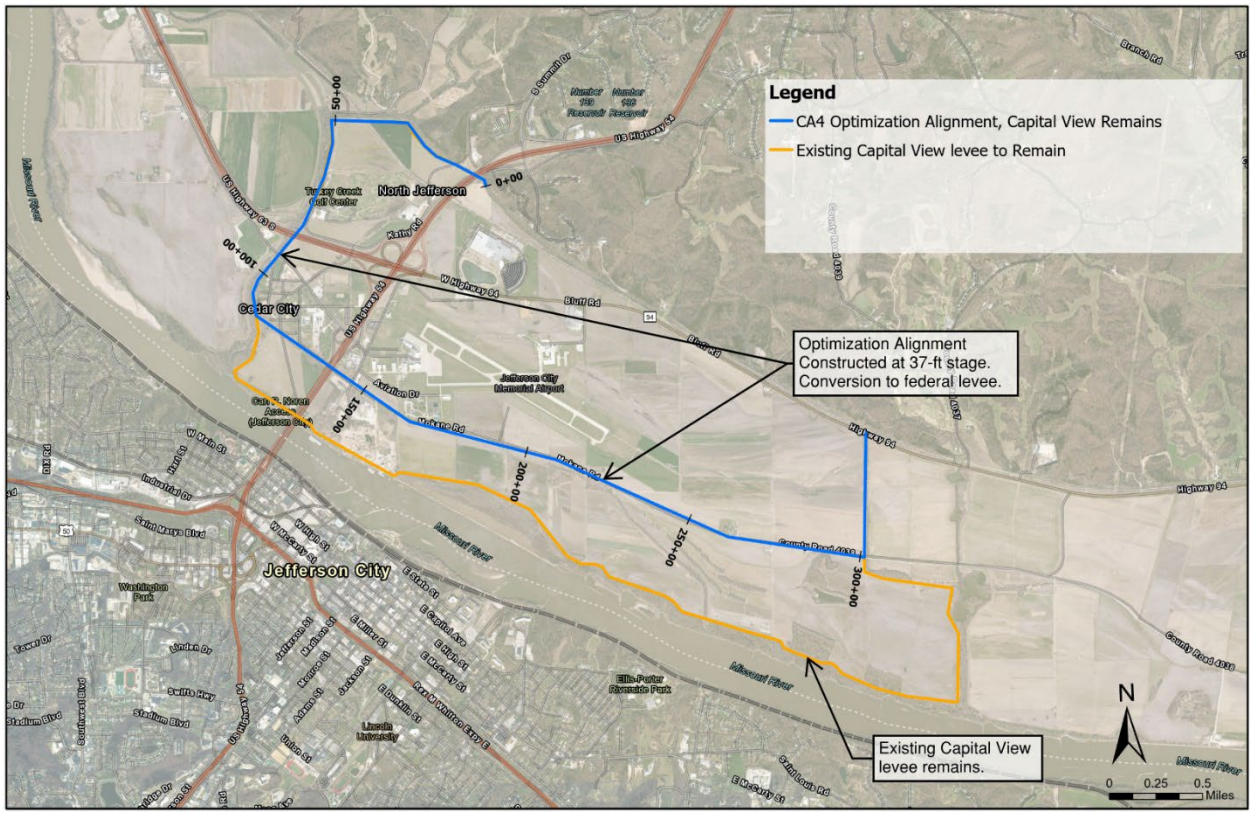
3.2.5 CA4 Optimization Alignment, 37-ft Stage, Capital View Remains

CA4 (Figure 7) was developed as a new levee alignment built to the elevation equaling the 37-foot stage. A version of this alignment was brought forward and recommended for consideration by the public to minimize real estate impacts by optimizing the use of existing property owned by the City of Jefferson and existing right(s)-of-way (ROW). The alignment follows the existing Capital View levee from station 0+00 to 113+00. It then turns and establishes a new alignment following the Missouri River at an offset that utilizing the existing ROW and property owned by the City of Jefferson along Sandstone Drive and Mokane Road. It ties into high ground at the bluff by turning north along the existing Capital View levee station 430+00 to 464+22.

The optimization-alignment levee would be constructed from station 0+00 to 337+05 meeting federal standards for material composition and compaction. The portions of the existing Capital View levee that overlaps the proposed alignment for this alternative will be degraded and reconstructed meeting federal standards to the proposed elevations. The remaining Capital View levee would remain unchanged. Borrow material is required to complete this proposed alternative.

CA4 would reduce occurrence of flooding for approximately 2,200 acres of Missouri River floodplain in Callaway County, Missouri. The Capital View levee would remain protecting 1,100 acres between the existing levee and the proposed federal levee footprint, though a lower level of protection.

Figure 7 CA4 Optimization Alignment, 37-ft Stage, Capital View Remains



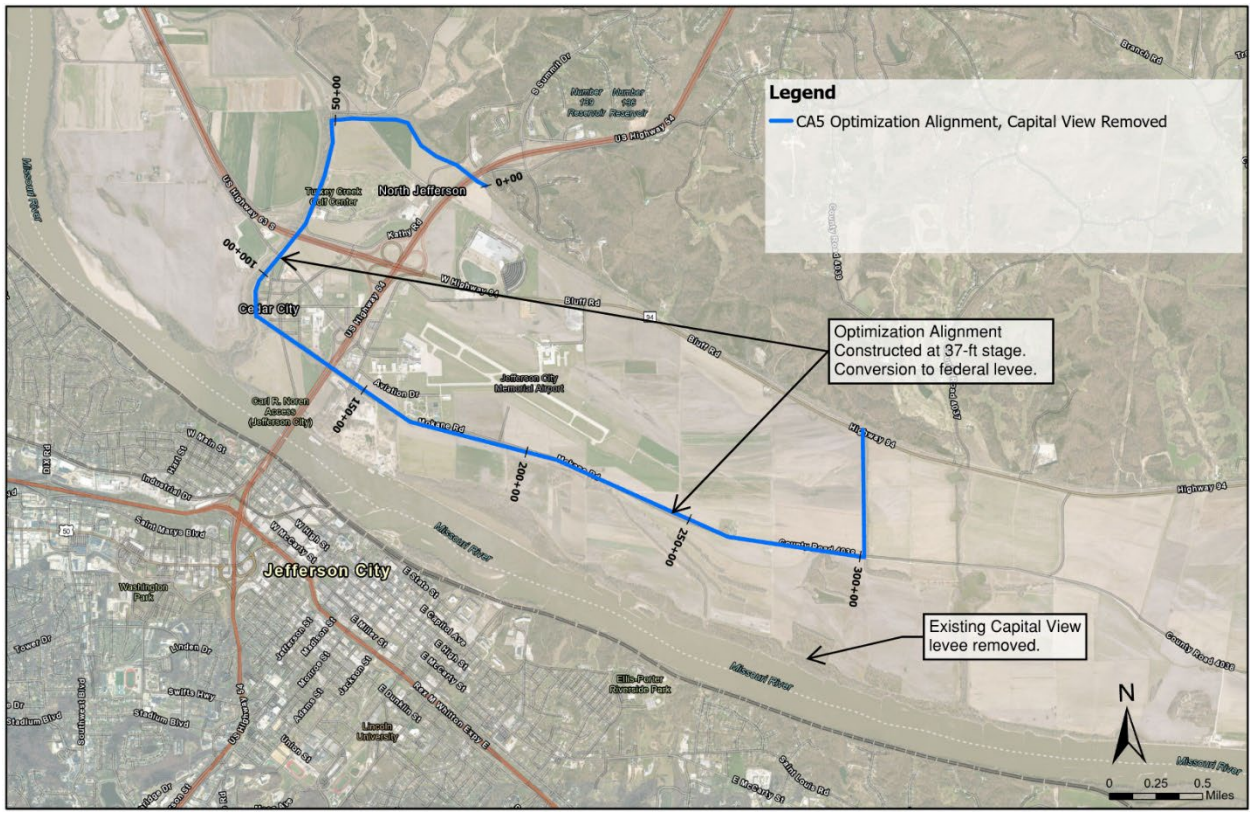
3.2.6 CA5 Optimization Alignment, 37-ft Stage, Capital View Removed

CA5 (**Figure 8**) weas developed as a new levee built to the elevation that correlates to a 37-foot stage. A version of this alignment was presented for consideration by the public to minimize real estate impacts by optimizing the use of existing property owned by the City of Jefferson and existing ROW. The alignment follows along the existing Capital View levee from station 0+00 to 113+00. It then turns and follows along Missouri River at an offset that utilizes the existing ROW and property owned by the City of Jefferson and along Sandstone Drive and Mokane Road. It connects to high ground at the bluff by turning north along the existing Capital View levee station 430+00 to 464+22.

The optimization alignment levee would be constructed from station 0+00 to 337+05 meeting federal standards for material composition and compaction. The portions of the existing Capital View levee that overlaps the proposed alignment for this alternative would be degraded and reconstructed meeting federal standards to the proposed elevations. The remaining existing Capital View levee would be fully deconstructed and used for borrow material to construct the setback levee. Additional borrow material is required to complete the proposed alternative.

CA5 would reduce occurrence of flooding for approximately 2,200 acres of Missouri River floodplain in Callaway County, Missouri.

Figure 8 CA5 Optimization Alignment, 37-ft Stage, Capital View Removed



3.2.7 CA6 Historic L-142 Alignment, 45-ft Stage, Capital View Remains

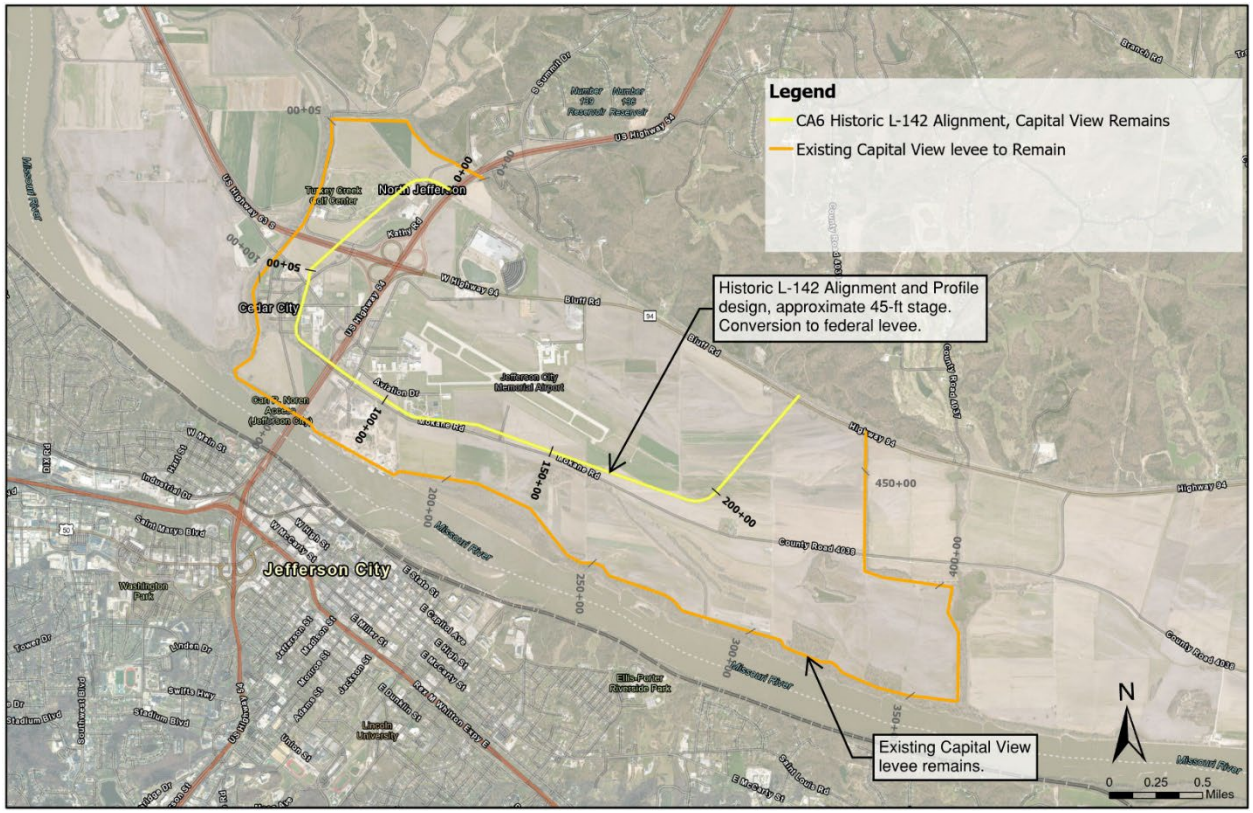
CA6 (**Figure 9**) was developed as a new levee built to the elevation that correlates to a 45-foot stage. This alignment was previously developed and designed to 95% completeness and was never constructed. The proposed alignment begins at high ground along the South U.S. Highway 54 embankment and continues along the east side of the golf course and crosses U.S. Highway 63 at a high point west of the U.S. Highway 63/54 interchange. The alignment continues through old Cedar City, tying into the bridge abutment along Sandstone Drive at U.S. Highway 54. It then continues to follow Mokane Road to the East then turns north just east of the airport.

The historic L-142 alignment levee would be constructed from station 0+00 to 247+27 meeting federal standards for material composition and compaction. The remaining existing Capital View levee would go on unchanged. Borrow material is required to complete the proposed alternative.

CA6 would reduce occurrence of flooding for approximately 1,500 acres of Missouri River floodplain in Callaway County, Missouri. The Capital View levee would remain protecting 1,700 acres between the existing levee and the proposed federal levee footprint, though a lower level of protection.

CA6 and CA7 have the smallest leveed area and would conflict with the airport master plan.

Figure 9 CA6 Historic L-142 Alignment, 45-ft Stage, Capital View Remains



3.2.8 CA7 Historic L-142 Alignment, 45-ft Stage, Capital View Removed

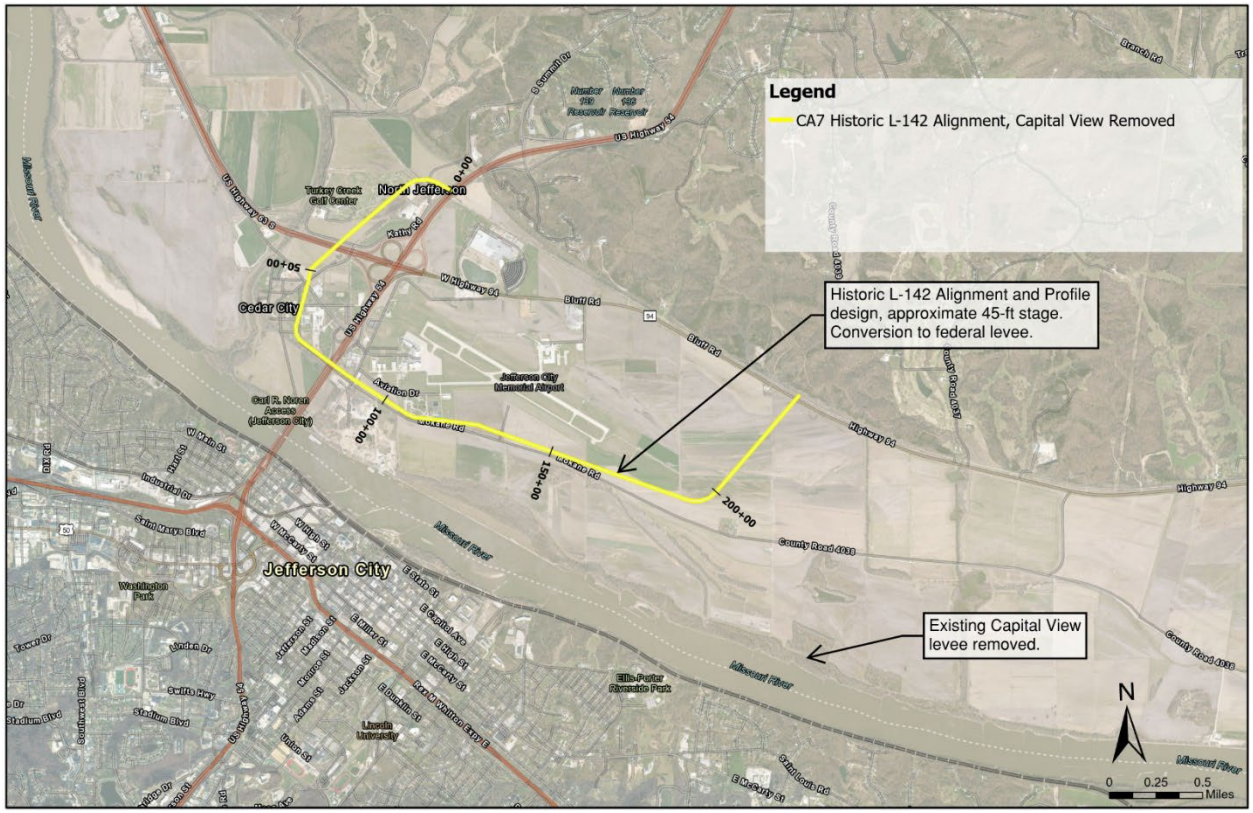
CA7 (**Figure 10**) was developed as a new levee built to the elevation that correlates to a 45-foot stage. This alignment was previously developed and designed to 95% completeness and was never constructed. The proposed alignment begins at high ground along the South U.S. Highway 54 embankment and continues along the east side of the golf course and crosses U.S. Highway 63 at a high point west of the U.S. Highway 63/54 interchange. The alignment continues through old Cedar City, tying into the bridge abutment along Sandstone Drive at U.S. Highway 54. It then continues to follow Mokane Road to the East then turns north just east of the airport.

The historic L-142 alignment levee would be constructed from station 0+00 to 247+27 meeting federal standards for material composition and compaction. The remaining existing Capital View levee would be fully deconstructed and used for borrow material to construct the setback levee. Additional borrow material is required to complete the proposed alternative.

CA7 would reduce occurrence of flooding for approximately 1,500 acres of Missouri River floodplain in Callaway County, Missouri.

CA6 and CA7 have the smallest leveed area and would conflict with the airport master plan.

Figure 10 CA7 Historic L-142 Alignment, 45-ft Stage, Capital View Removed



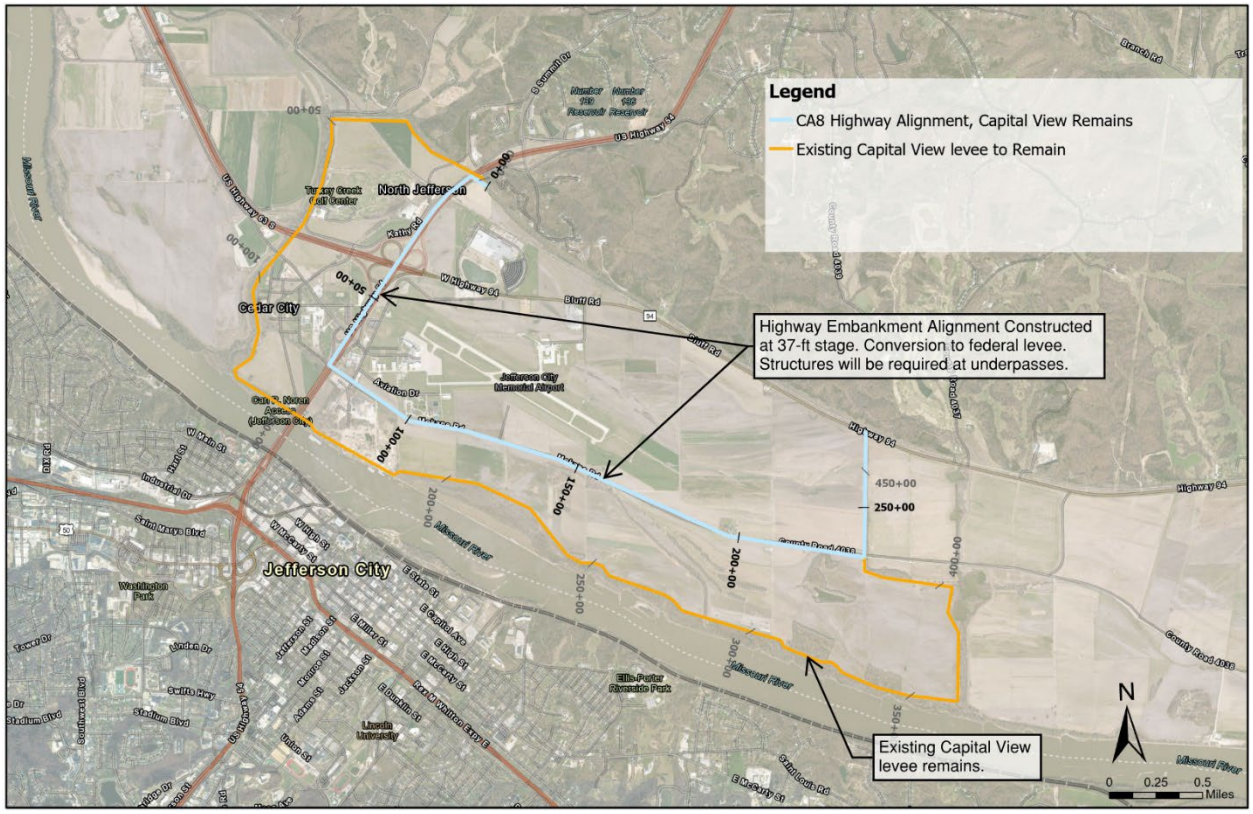
3.2.9 CA8 Highway Alignment, 37-ft Stage, Capital View Remains

CA8 (**Figure 11**) was developed as a new levee built to the elevation that correlates to a 37-foot stage. The alignment utilizes the existing U.S. Highway 54 embankment as the line of protection. It then turns and is follows along the existing ROW and property owned by the City of Jefferson and along Mokane Road. It connects to high ground at the bluff by turning north along the existing Capital View levee station 430+00 to 464+22.

The highway embankment alignment levee would be constructed from station 0+00 to 272+30 meeting federal standards for material composition and compaction. The portions of the existing Capital View levee that overlaps the proposed alignment for this alternative would be degraded and reconstructed meeting federal standards to the proposed elevations. The remaining existing Capital View levee would go on unchanged. Borrow material is required to complete the proposed alternative.

CA8 would reduce occurrence of flooding for approximately 1,700 acres of Missouri River floodplain in Callaway County, Missouri. The Capital View levee would remain protecting 1,500 acres between the existing levee and the proposed federal levee footprint, though a lower level of protection.

Figure 11 CA8 Highway Alignment, 37-ft Stage, Capital View Remains



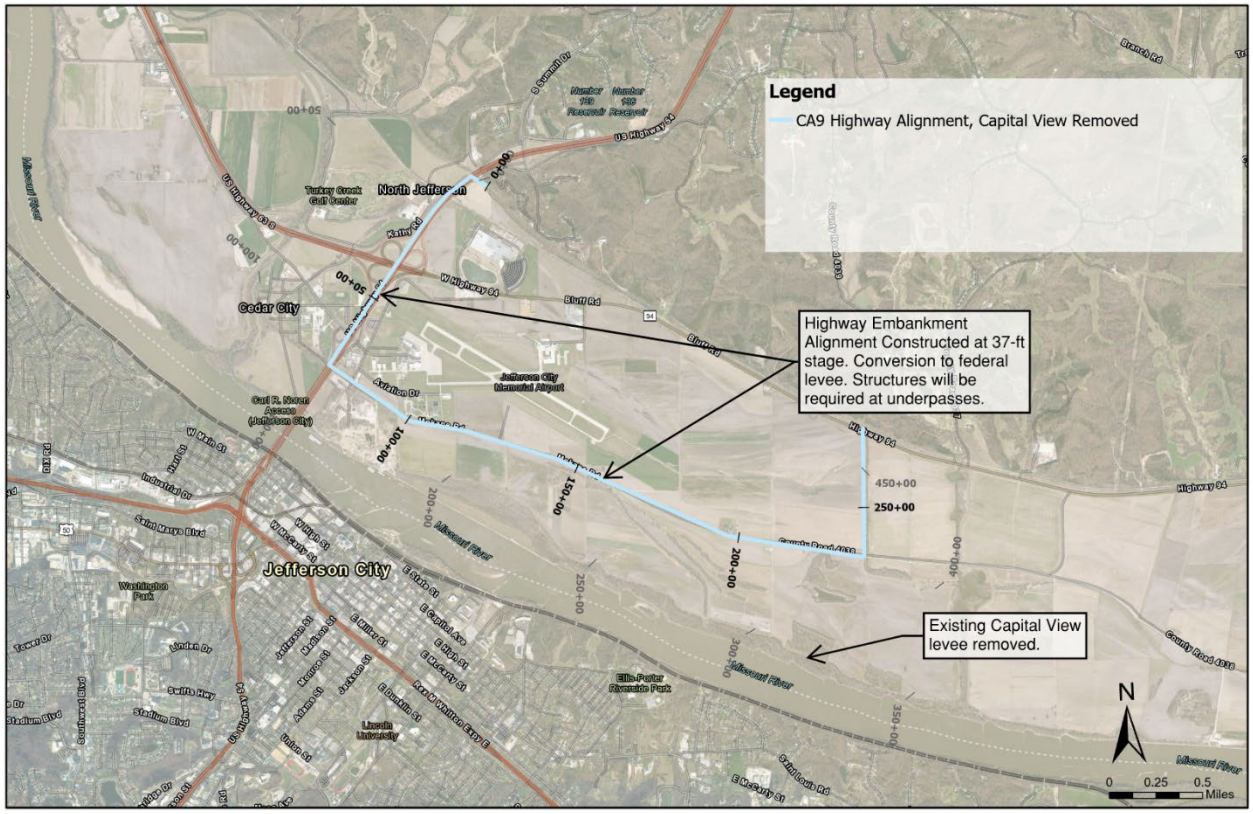
3.2.10 CA9 Highway Alignment, 37-ft Stage, Capital View Removed

CA9 (**Figure 12**) was developed as a new levee built to the elevation that correlates to a 37-foot stage. The alignment utilizes the existing U.S. Highway 54 embankment as the line of protection. It then turns and is follows along the existing ROW and property owned by the City of Jefferson and along Mokane Road. It connects to high ground at the bluff by turning north along the existing Capital View levee station 430+00 to 464+22.

The highway embankment alignment levee would be constructed from station 0+00 to 272+00 meeting federal standards for material composition and compaction. The portions of the existing Capital View levee that overlaps the proposed alignment for this alternative would be degraded and reconstructed meeting federal standards to the proposed elevations. The remaining existing Capital View levee would be fully deconstructed and used for borrow material to construct the setback levee. Additional borrow material is required to complete the proposed alternative.

CA9 would reduce occurrence of flooding for approximately 1,700 acres of Missouri River floodplain in Callaway County, Missouri.

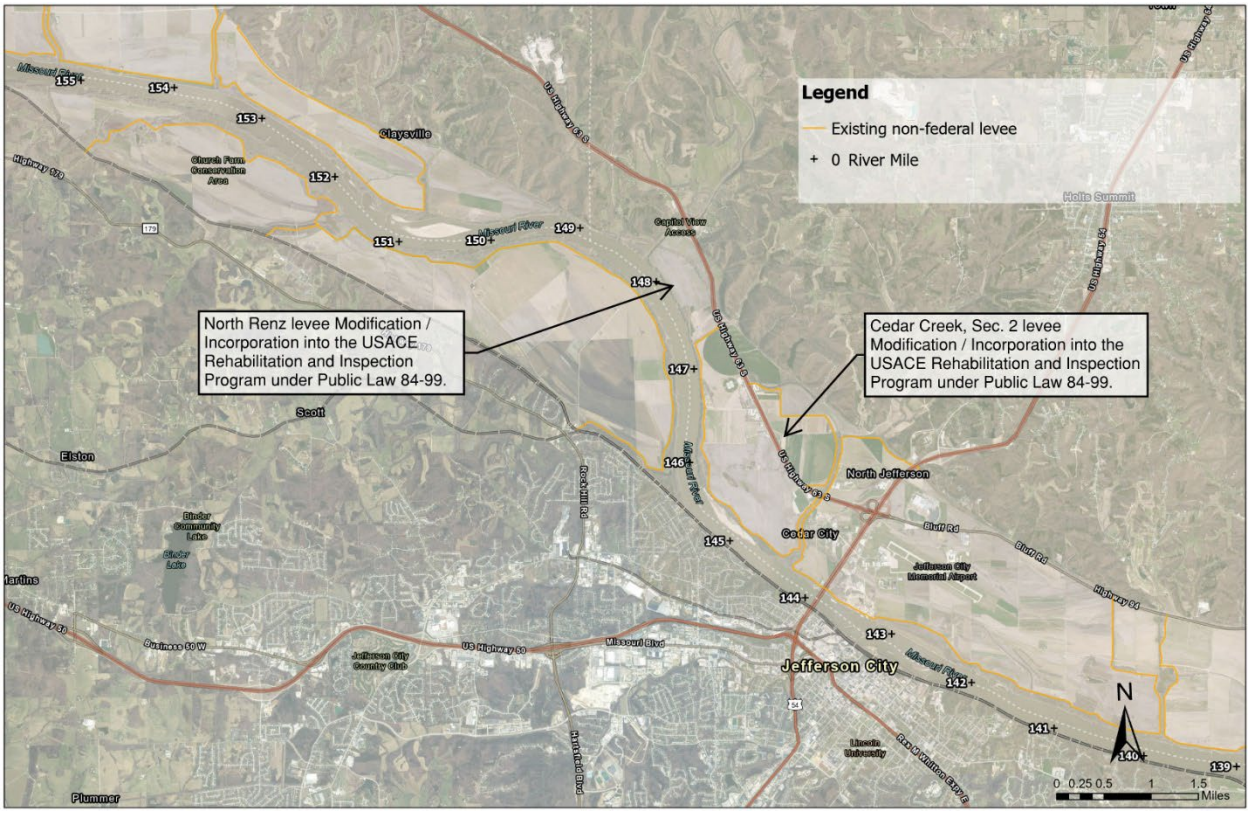
Figure 12 CA9 Highway Alignment, 37-ft Stage, Capital View Removed



3.2.11 CA10 Limited Resiliency Measures Outside of Capital View Footprint

CA10 (**Figure 13**) considers modification and incorporation of the North Renz levee into the P.L. 84-99 program. The North Renz levee is located along the left bank of the Missouri River between Cedar Creek (river mile 148.2) and 147.3 This alternative also considers the modification of and incorporation of the Sod Farm levee into the P.L. 84-99 program. The Sod Farm levee is located along the left bank of the Missouri River between river mile 146.8 and Turkey Creek (river mile 144.5).

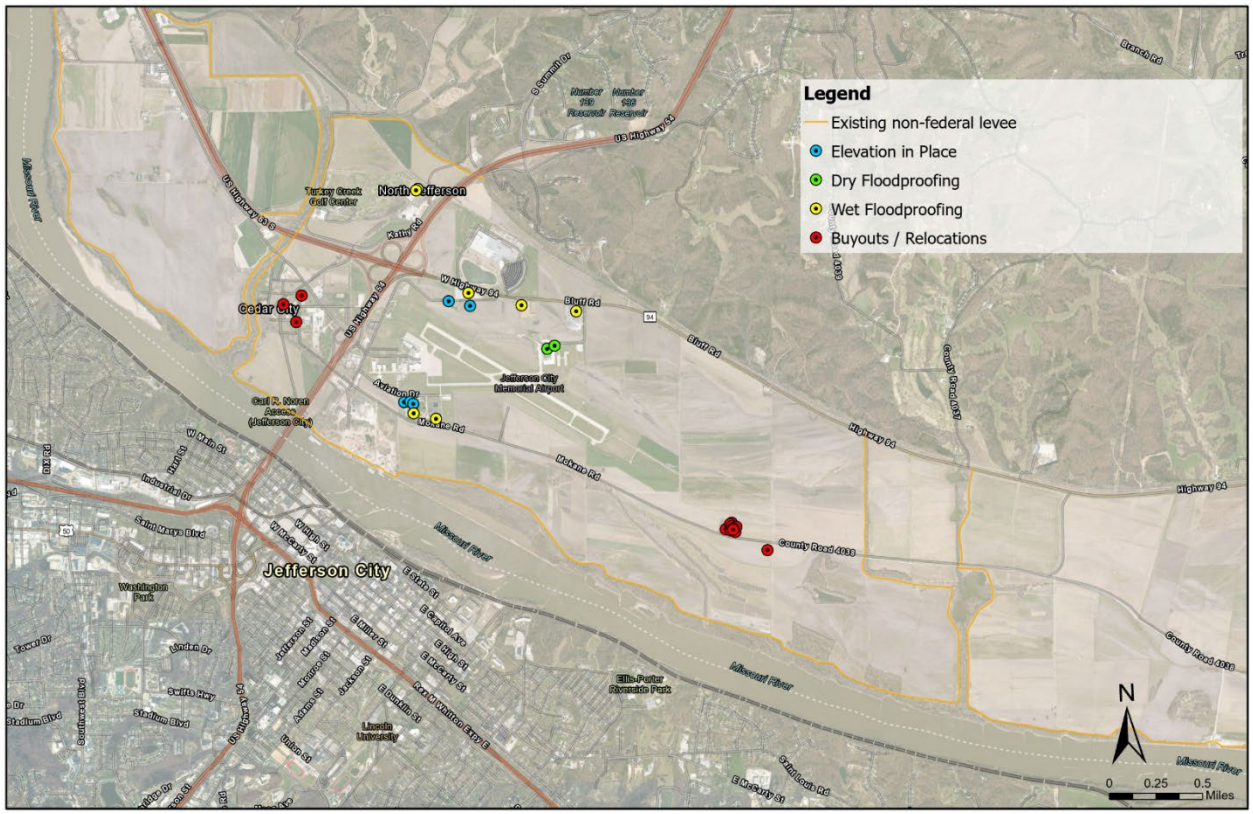
Figure 13 CA10 Limited Resiliency Measures Outside of Capital View Footprint



3.2.12 CA11 Nonstructural

CA11 (**Figure 14**) includes consideration of incorporating various non-structural measures such as flood-proofing (wet or dry), elevate in place, and buyouts or relocations. These measures are considered within the area of the existing Capital View levee. See 3.2.1 for descriptions of this protected area.

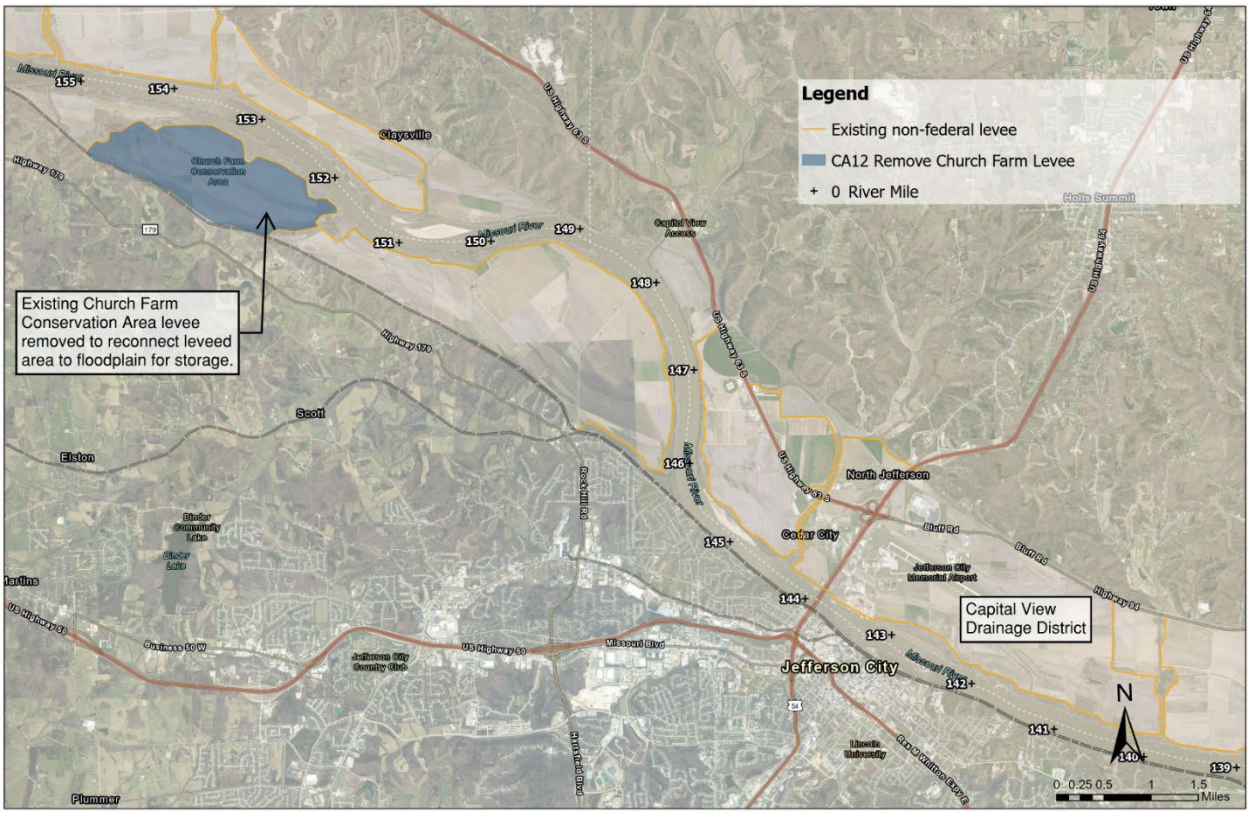
Figure 14 CA11 Nonstructural



3.2.13 CA12 Remove Church Farm Levee

CA12 (**Figure 15**) considers the removal of the existing Church Farm Conservation Area levee located along the right bank of the Missouri River upstream of the study area. The existing Church Farm levee is located between river mile 151.7 to 154.8.

Figure 15 CA12 Remove Church Farm Levee



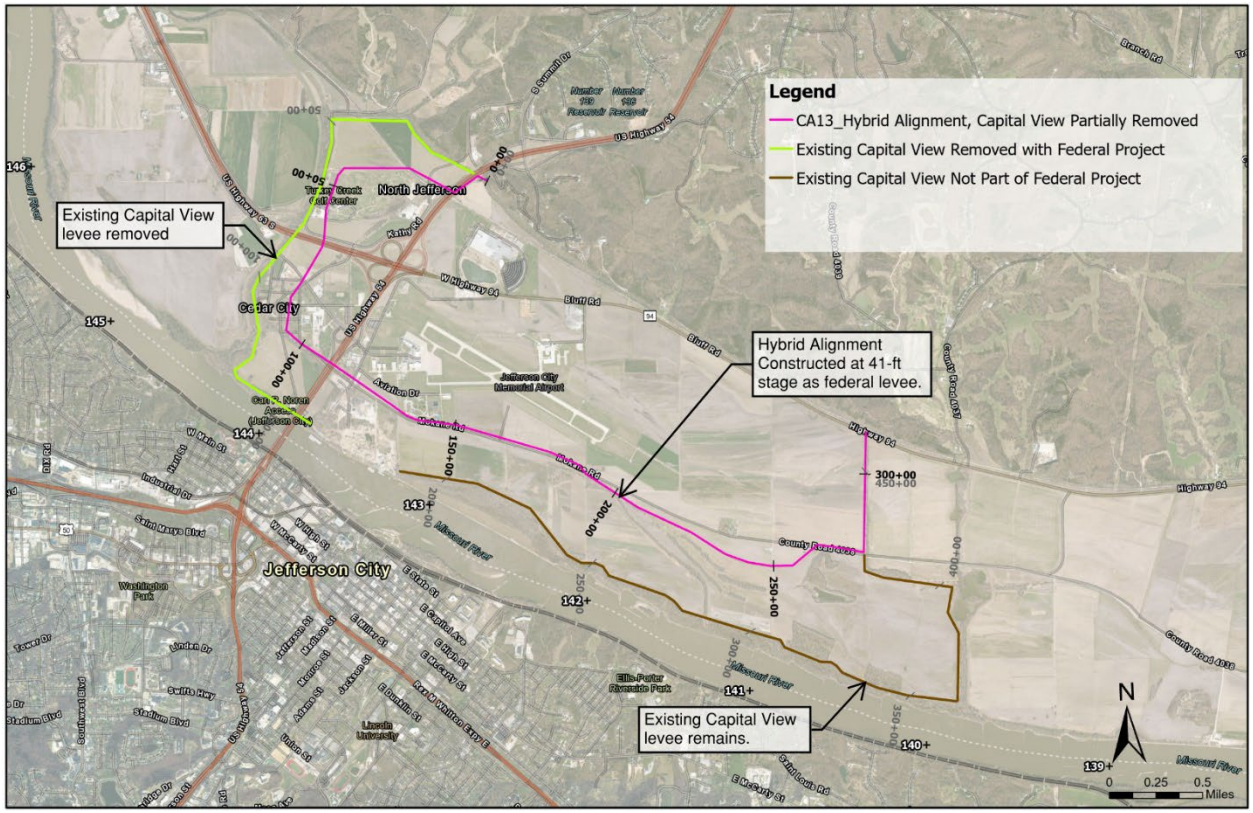
3.2.14 CA13 Hybrid Alignment, 41-ft Stage, Partial Capital View Removal

CA13 (**Figure 16**) was developed as a new levee built to the elevation that correlates to a 41-ft stage (1% AEP). This alignment is a hybrid of CA2 and CA4 and 5. The alignment follows along the embankment for U.S. Highway 54. Then continues along the north and west side of the golf course. It connects to high ground crossing over U.S. Highway 63 and continues through Old Cedar City tying into the U.S. Highway 54 embankment near the bridge abutment. The alignment follows East along Sandstone Drive and Mokane Road before a slight turn south to follow the natural drainage path along a farm levee. It connects to high ground at the bluff by turning north along the existing Capital View levee station 430+00 to 464+22.

The hybrid alignment levee would be constructed from station 0+00 to 313+32 meeting federal standards for material composition and compaction. The portions of the existing Capital View levee that overlaps the proposed alignment for this alternative would be degraded and reconstructed meeting federal standards to the proposed elevations. The portion of existing Capital View levee from station 0+00 to 160+00 would be deconstructed and used for borrow material to construct the setback levee. The remaining existing Capital View levee would go on unchanged. Additional borrow material is required to complete the proposed alternative.

CA13 would reduce occurrence of flooding for approximately 2,100 acres of Missouri River floodplain in Callaway County, Missouri. The Capital View levee would remain with 1,000 acres between the existing levee and the proposed federal levee footprint.

Figure 16 CA13 Hybrid Alignment, 41-ft Stage, Partial Capital View Removal



3.3 EVALUATION OF ALTERNATIVES

Combined alternative alignments and reaches are evaluated and refined to incorporate project specific needs. This section is not all inclusive of the design process but does focus on methods used at various locations and areas to ensure the project meets design criteria moving forward.

3.3.1 Levee Alignment

Developing the levee alignment for each alternative was a coordinated effort utilizing the hydraulic model and the existing conditions. The alignments were adjusted taking into consideration the full footprint of all components and real estate associated with the designed cross section for each reach of the system. See the Alternative Components Discussion of Part 5.4 in this appendix for more information regarding what is included in each.

3.3.2 Highway Embankment

Utilizing the highway embankment as a portion of the protection would reduce the material and real estate required for the proposed project. Although the material composition and compaction of the highway embankment is unknown, further investigations will occur as alternative development progresses. The assumption moving forward is a clay cap on the riverside of the embankment will be required to ensure impervious material is present to reduce water seepage. The embankment is also much wider than the typical 10-food wide top of levee which also decreases the opportunity of seepage during high water events.

3.3.3 Utilities

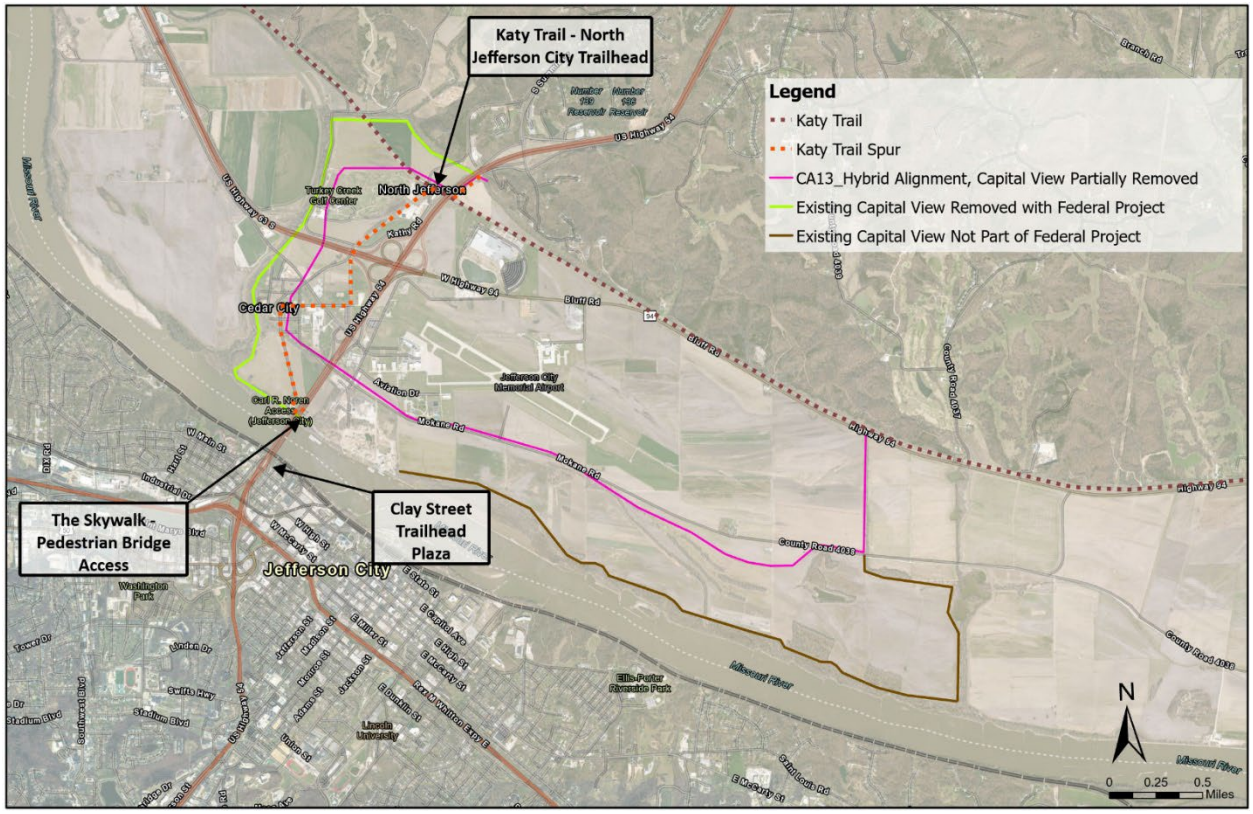
All the alternative alignments considered have significant utility impacts. The areas impacted by the proposed alignments are previous developed and have an established utility grid system. In accordance with Engineering Manual 1110-2-2902, non-essential pipes generally serve as utility crossings for water mains, sanitary sewers, liquid petroleum products, natural gas, or electrical, fiber optic and other services. Non-essential pipes within, beneath, or adjacent to federally authorized projects require review and approval per Section 408 requirements. Traditionally, the most cost-effective method in meeting the requirements within the manual, is to relocate utilities up and over the levee embankment. Without taking proper action on utilities impacted by the levee alignment there is an increase in possible pipe-related issues contributing to project risk. Utilities are discussed in more detail in part 3.8 in this appendix.

3.3.4 Katy Trail and other Recreational Considerations

The Katy Trail – North Jefferson City Trailhead is located along the north side of the study area. Considerations were taken to minimize impacts to the existing trail both in horizontal positioning and elevation. Design of project features impacting the public trailhead will be closely coordinated with the trailhead stakeholders. Many of the alternative alignments impact the trail in one way or another. The design will incorporate ADA standards for an up-and-over access ramp to maintain access and crossing of the federally constructed project at both the eastern and western end of the study area.

The City of Jefferson City expressed interest in incorporating a trail access spur that is easier to navigate than the current connection from the Katy Trail to the North Jefferson City Recreational Area, the Carl R. Noren Access Boat Ramp, and The Skywalk connecting downtown to North Jefferson City. Incorporation of this feature along the levee alignment utilizes trail surfacing in lieu of the traditional aggregate surfacing used on top of the levee embankments for maintenance access. This trail surfacing is utilized successfully on other federally constructed projects to encourage recreational use and community interest. **Figure 17** shows a map of the recreational areas considered during evaluation.

Figure 17 Katy Trail and Other Recreational Areas



3.3.5 Current Land Use – Golf Course

The Turkey Creek Golf Center and Capital Bluffs Event Center in the northwestern part of the Study Area. Both attract Jefferson City residents to north of the river and are established businesses. The alignment configurations vary in incorporating these businesses into the protected area. The alignments that protect both businesses impact the parking lot and entrances.

3.3.6 Current Land Use – Old Cedar City

Previous efforts by the City of Jefferson City after floods have changed the usage of properties in the Cedar City area. Majority of the area is utilized as parks and recreation properties. The City agreed to reconfiguration of the roadway system throughout this area to use the land more efficiently as most of the alignments modify various properties through this area.

3.3.7 Jefferson City Regional Wastewater Treatment Plant

The Jefferson City Regional Wastewater Treatment Plant is located along Mokane Road near the center of the study area. Most of the structures have been raised to a higher elevation to decrease impact by more frequent flooding. The alignments presented allow for a higher level of protection to allow access to remain open for longer to the treatment facility so it can stay operational as long as possible. Access points along Mokane Road will likely be revised to tie into the relocated Mokane Road.

3.3.8 Jefferson City Memorial Airport

The Master Pan of the Jefferson City Memorial Airport was provided for coordination during alignment development. Information related to runway expansion was incorporated into the location of the alignments to ensure distance requirements were met.

3.3.9 Current Roadway Infrastructure

Mokane Road is along the alignment of most proposed alternatives. Relocation of the roadway from its current position to on top of the stability berm or underseepage berm may be required. The roadway would be removed and reconstructed on top of the levee component meeting all state and local roadway design requirements.

The road layout in Old Cedar City may be reconfigured to provide an efficient use of space and more direct access to both landside businesses and the riverside boat ramp.

Throughout the study area are private access roads off main roads to access businesses, farm fields, and other properties. Continued access will be provided post-construction of the proposed alignment. Ramps from the levee alignment will be included to allow access to businesses, farm fields, and other properties.

3.4 ALTERNATIVE COMPONENTS

3.4.1 Levee Embankment

The levee embankment is designed to be zoned using both impervious material and random material. Pervious sand drains are included as required. See part 2.0 of this appendix for additional design discussion. The levee embankments for the proposed alternatives is a 10-foot wide top with 1V to 3H side slopes. The top of the levee will be surfaced with aggregate pavement for use by the non-federal sponsor to operate and maintain the project as well as use during flood fight monitoring. Public vehicular access is not allowed on the top of the levee unless specially designed, and access will be gated or blocked in some manner to prevent damage to the levee top and embankment. **Table 12** shows the length of levee embankment for each combined alternative. The levee embankment will be capped with 4 inches of topsoil and turf vegetation. No vegetation will be installed on the embankment where riverside riprap is installed for erosion protection.

Table 12 Levee Embankment

Combined Alternative	Station Range	Length Linear Feet (LF)	Length Miles (mi)
CA1	0+00 to 464+22	46,422	8.79
CA2	0+00 to 314+82	31,482	5.96
CA3	0+00 to 464+22	46,422	8.79
CA4 & 5	0+00 to 337+05	33,705	6.38
CA6 & 7	0+00 to 247+27	24,727	4.68
CA8 & 9	0+00 to 272+30	27,230	5.16
CA13	0+00 to 314+18	31,418	5.95

3.4.2 Stability Berm

Stability berms are adjacent to the levee embankment and provide additional stability to the embankment during high water. **Table 13** below shows a summary of stability berms for each structural alternative. Stability berm design is discussed in pat 2.6 of this appendix. The stability berms will be capped with 4 inches of topsoil and turf vegetation.

Table 13 Stability Berms

Combined Alternative	Length Linear Feet (LF)	Height (Ft)	Width (Ft)
CA1	NA	NA	NA

Combined Alternative	Length Linear Feet (LF)	Height (Ft)	Width (Ft)
CA2	NA	NA	NA
CA3	NA	NA	NA
CA4 & 5	18,700	5	20
CA6 & 7 Landside Berm	7,000	30	10
CA6 & 7 Riverside Berm	7,000	20	10
CA8 & 9	NA	NA	NA
CA13	6,200	10	15

3.4.3 Underseepage Berm

Underseepage berms extend varying distances from the levee embankment. **Table 14** below shows a summary of underseepage berms for each structural alternative. See part 2.5 in this appendix for detailed design discussion of underseepage for each consideration. The underseepage berms will be capped with 12 inches of topsoil and temporarily seeded to accommodate farming.

Table 14 Underseepage Berms

Combined Alternative	Length Linear Feet (LF)	Height (Ft)	Width (Ft)
CA1	16,100	3	50
CA2	NA	NA	NA
CA3	NA	NA	NA
CA4 & 5	31,000	3	150
CA6 & 7	22,800	4	250
CA8 & 9	5,230	3.5	150 to 250
CA13	20,600	3	150

3.4.4 Relief Wells

Relief wells are considered in areas where underseepage berms are required but may not be feasible due to existing conditions. Examples include established structures or complicated utility configurations. Relief wells are more expensive than underseepage berms and require additional costs associated with operation and maintenance. Minimizing the number of relief wells on a project is preferred because it decreases long-term maintenance required by non-federal sponsors. As indicated in Part 2.5.6 of this appendix, and in **Table 15**, CA13 requires three relief wells in the area of the wastewater treatment plant.

Table 15 Relief Wells

Combined Alternative	Number of Wells
CA1	0
CA2	0
CA3	0
CA4 & 5	0
CA6 & 7	0
CA8 & 9	0
CA13	3

3.4.5 Riverside Riprap Erosion Protection

Riverside riprap armoring is required in designated places along the riverside of the levee embankment to protect the levee from damage. Armoring is focused along the reaches of embankments which parallel the Missouri River. Riprap design typically requires a 4-foot-thick layer of rock. **Table 16** includes the length of embankment for each alternative which riprap protection is required.

Table 16 Riprap Erosion Protection

Combined Alternative	Length Linear Feet (LF)
CA1	24,000
CA2	17,700
CA3	24,000
CA4 & 5	18,700
CA6 & 7	8,000
CA8 & 9	16,400
CA13	18,500

3.4.6 Access Ramps

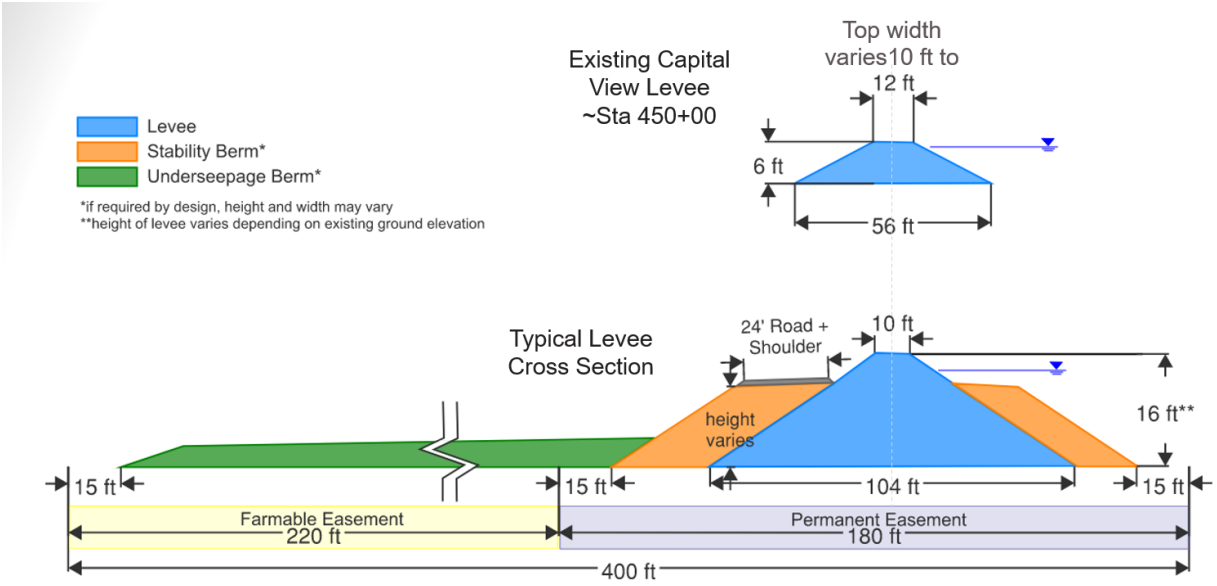
Typical access ramps are required at points to allow for operation and maintenance of the project by the non-federal sponsor. The ramps have a minimum width of 10 feet wide and a maximum slope of 10 percent. Typical access ramps are not designed to meet roadway criteria as it's use is for O&M purposes. Ramps located to provide continued access to properties on both the landside and riverside of the line of protection will be constructed at a width required to meet the needs of vehicles and equipment using the access.

Roadway relocations of existing access points are required along the proposed alignments. Roads relocated will be up and over the levee to cross the line of protection and meet roadway design requirements.

3.5 REAL ESTATE

Various easement types are considered for this study. Each alternative includes easements for the type of project feature required and dimensions of easements will vary from other alternatives.

Figure 18 Typical Levee Cross Section



Permanent Easement or Right(s)-of-Way

Permanent easement or Right(s)-of-Way (ROW) areas include levee embankments and stability berms plus 15 feet +/- from the toe of the levee embankment or stability berms to allow for the non-federal sponsor necessary space to properly perform operation, maintenance, repair to the project. Although not depicted in the typical levee section (see **Figure 18**), it also includes closure structures, ramps, relief wells, storm drainage structures, storm piping and other features required for the project to operate.

Permanent Easement - Farmable

Permanent easement – farmable areas is a permanent easement that include underseepage berms plus 15 feet +/- from the toe of the underseepage berm to allow for the non-federal sponsor necessary space to properly perform operation, maintenance, repair to the project. The purpose of this easement is to allow the landowner to continue to utilize the property above the required underseepage berm elevations as dictated by design. See **Figure 18** for a typical levee section.

Temporary Easement

Temporary easements include areas to allow for construction activities such as staging areas for contractor equipment and materials, borrow areas, and 30-50 feet beyond the Permanent and permanent farmable easements to allow for construction of project features. Temporary access roads and haul routes may also be included in temporary easement areas. Temporary easements have an expiration date and once it expires the land will be restored to the original condition. Temporary borrow sites will be left in a condition agreed up on by the owner.

3.6 BORROW SOURCES

Feasibility level design requires the non-federal sponsor to identify sites available for borrow use. The proximity of the project to the airport has additional FAA requirements associated with not increasing bird strikes by airplanes. Borrowing within boundaries set by the FAA require concurrence from the agency to proceed with borrow areas within 10,000 feet of the runway. This led to investigation of a variety of borrow area possibilities including areas further from the study area than typically used. The area of the

existing Church Farm Conservation levee and southwest of the boat ramp in Old Cedar City are two areas currently identified as borrow sources, pending subsurface investigations.

3.6.1 Identified Borrow Areas

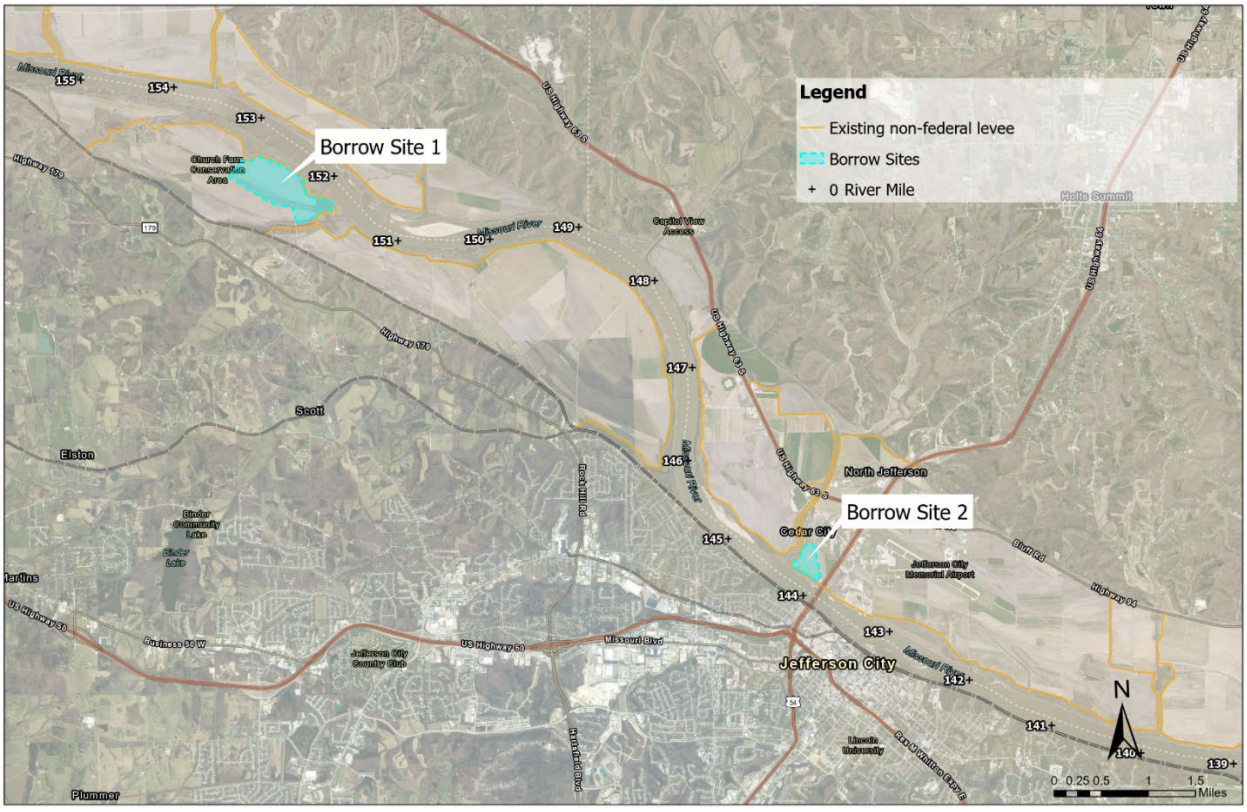
Two sites have been identified, shown in **Figure 19**, as possible borrow areas to use for construction.

Borrow Site 1 area in the **Figure 19** consists of approximately 215 acres within the existing Church Farm Conservation leveed area. The land is currently farmed, and a variety of final borrow configurations would be ideal for maximizing borrow material at this site.

Borrow Site 2 near the confluence of Turkey Creek and the Missouri River in **Figure 19** consists of approximately 42 acres. While this is within the 10,000-foot boundary, there are various finish grade configurations that will likely be approved by the FAA through proper review processes.

Additional borrow areas may be identified as the design progresses. Haul distance is a contributing factor of the cost of material. The haul distance for Borrow Site 1 shown is approximately 15 miles. Identifying borrow closer to the project area will increase efficiency of construction and potentially decrease the cost of material.

Figure 19 Identified Borrow Areas



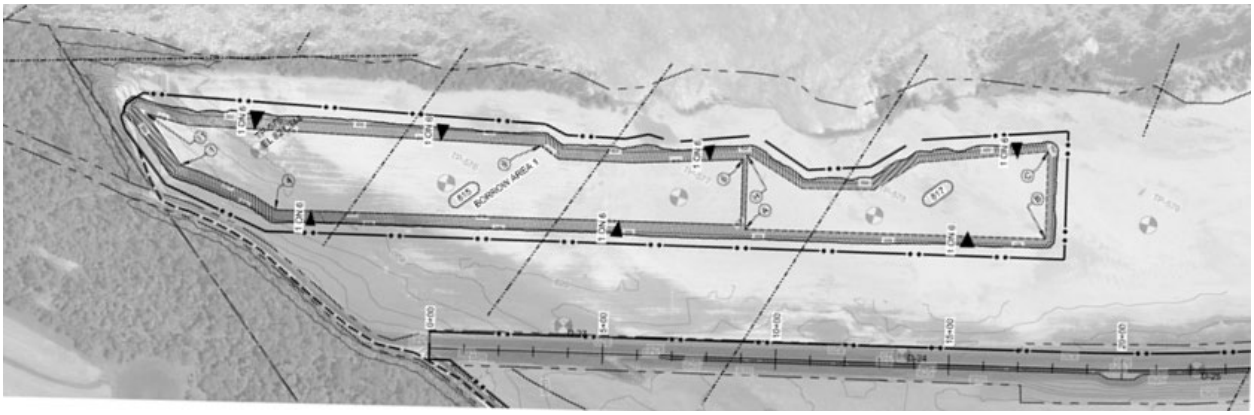
3.7 TYPES OF BORROW AREAS

Various types of borrow areas are considered effective in maximizing volume from site. While every identified site produces a unique design, examples of previously designed borrow areas for levee construction projects have been compiled for reference. Borrow areas associated with this study may be similar to components included in one or more of the examples below.

3.7.1 Example 1 – Riverside Borrow Area

The riverside borrow area (**Figure 20**) in this example has 6H:1V side slopes down to a depth of 7 to 8 feet below existing grade. The pros of a design like this are that the area will remain farmable, and it will silt in over time from material during inundation periods. The cons to a design like this are that it is not graded to drain out and could hold water until it fills in when inundated.

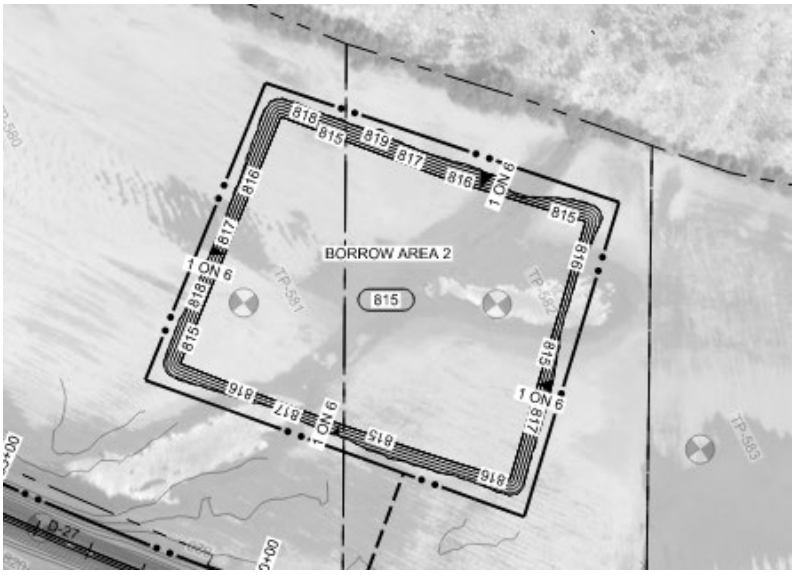
Figure 20 Borrow Area Example 1 - Riverside Borrow



3.7.2 Example 2 – Riverside Borrow Area

The riverside borrow area (**Figure 21**) in this example has 6H:1V side slopes down to a depth of 2 to 4 feet below existing grade. The pros of example 2 design that the area will remain farmable and due to its shallow depth, it will silt in over a shorter time from material during inundation periods. The cons to a design like this are that it is not graded to drain out and could hold water until it fills in when inundated.

Figure 21 Borrow Area Example 2 - Riverside Borrow Area

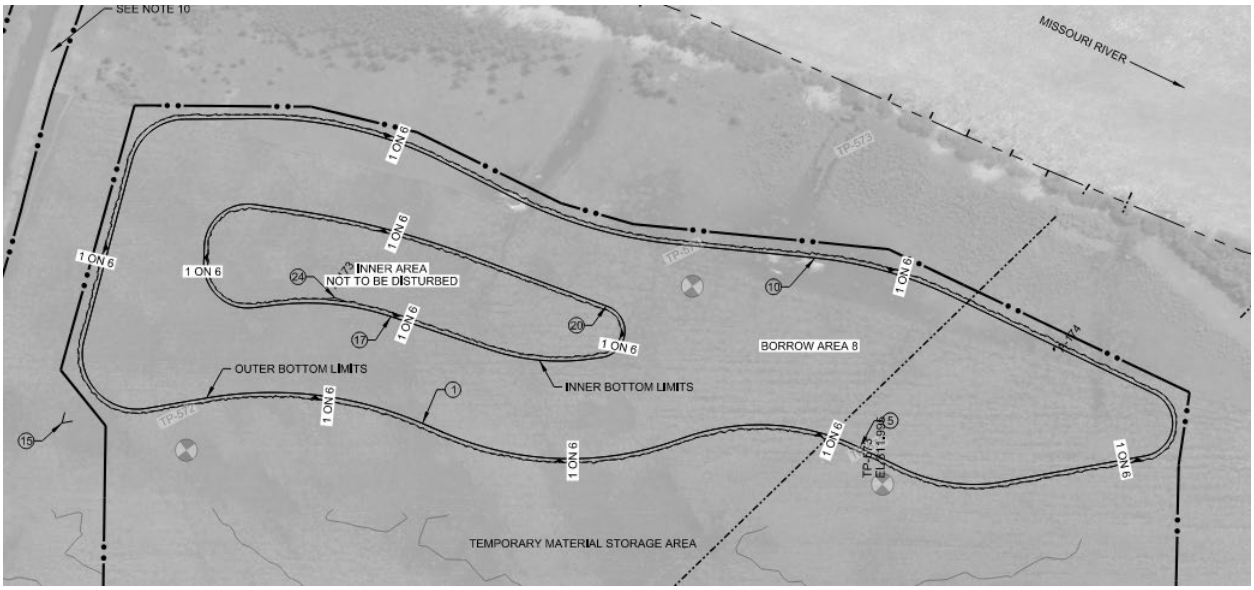


3.7.3 Example 3 – Shallow Borrow Area

The shallow borrow area (**Figure 22**) in this example has 6H:1V side slopes down to a depth of 18 inches below existing grade. The pros of example 3 design that the area will remain farmable. This could be

located either landside or riverside of the levee. The cons to a design like this are that it is less efficient use of acreage for maximizing quantity available.

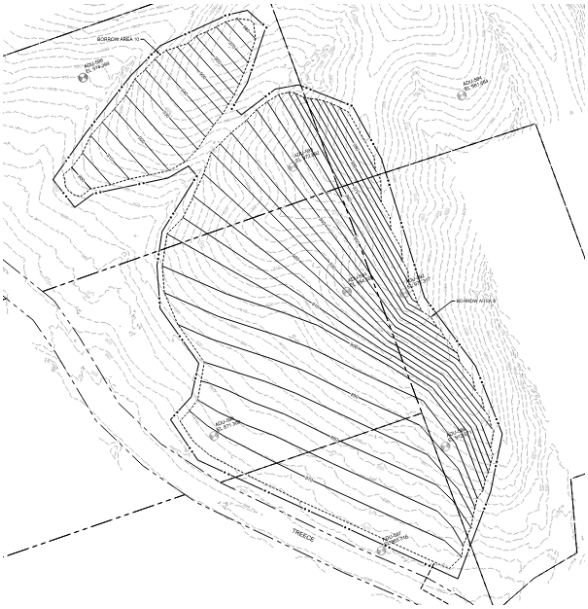
Figure 22 Borrow Area Example 3 - Shallow Borrow Area



3.7.4 Example 4 – Hillside Borrow Area

Hillside borrow area (**Figure 23**) in this example has varying slope with a maximum of 3H:1V side down to a depth of 20+ feet below existing grade. The pros of example 4 design that the area maximizes the borrow quantity and can be designed to a finish grade where the land remains usable. The cons to a design like this are that it is more ideal in areas already cleared of trees to reduce required mitigation and due to varying geomorphology along river channels, bedrock elevations cannot accurately be mapped and may be encountered.

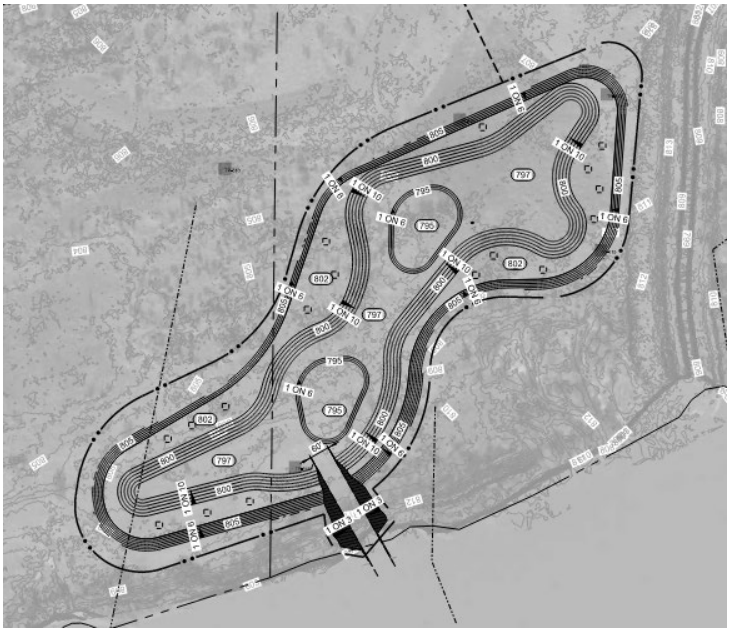
Figure 23 Borrow Area Example 4 - Hillside Borrow Area



3.7.5 Example 5 – Deeper Borrow Area

Deeper borrow area (**Figure 24**) in this example has a maximum of 6H:1V side slopes down to a depth of 8 to 12 feet below existing grade. The pros of example 5 design that the area maximizes the borrow quantity and can be designed to connect to the river for natural draining. It will also silt in overtime but would be expected to take longer due to the size. The cons to a design like this are that the outlet may get clogged if not maintained and water could accumulate unable to drain out. This is less desirable due to the proximity to the airport and runway.

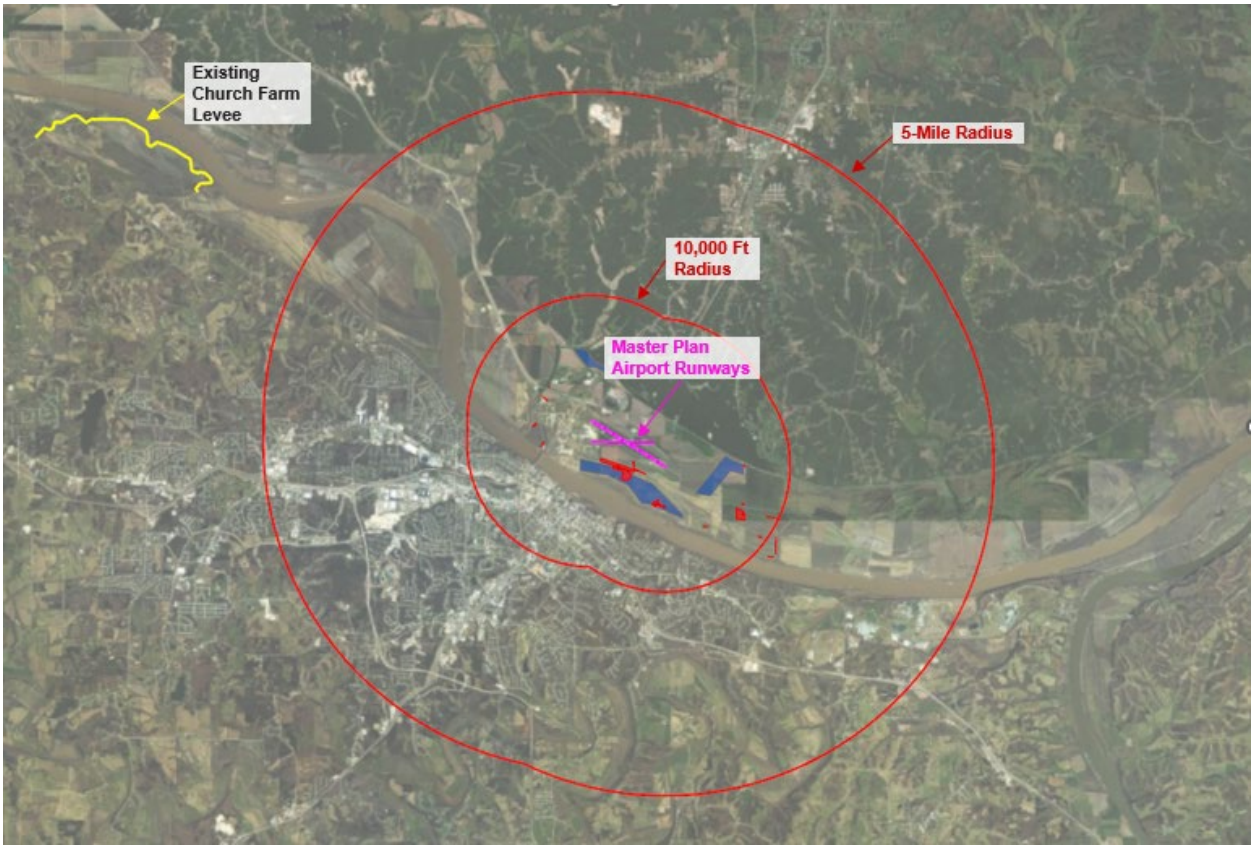
Figure 24 Borrow Area Example 5 - Deeper Borrow Area



3.7.6 Jefferson City FAA Boundaries

Jefferson City FAA Boundaries shown in **Figure 25** are based on the future runways included in the airport master plan. Majority of the previously identified borrow areas shown in blue and red on the map are within the 10,000-foot radius of FAA restriction. Note that the existing Church Farm Conservation leveed area is outside of the 5-mile radius.

Figure 25 Jefferson City FAA Boundaries



3.8 UTILITY RELOCATIONS

Each alternative has unique considerations for utility relocations. The levee alignments cross buried telephone lines, fiber optic lines, sanitary sewer force mains, sanitary sewer gravity pipes, storm pipes, water force mains, gas pipes, electric lines, and copper lines, as well as overhead electric lines, fiber optic lines, copper lines, and telephone lines. Utility relocations would be required for construction and to avoid utilities passing under the levee. Many utility locations were sent by the utility companies during the research phase of the project, but there were some companies that did not provide their information. Ameren, most notably the electric and gas supplier of the area, did not furnish updated utility locations. The electric and gas information found at this stage is from utility information found in the GRR from 1999 and 2002. The locations of most of these utilities should be expected to change when a utility survey is performed during the design phase of the project. It is likely the additional utilities will be discovered as design progresses.

Non-gravity line relocations are typically up-and-over the levee. See Figure 26 for the details of a typical utility crossing. Figure 27 and Figure 28 are additional details of a utility crossing through the levee crest and levee slope.

Figure 26 Typical Utility Up-And-Over Crossing

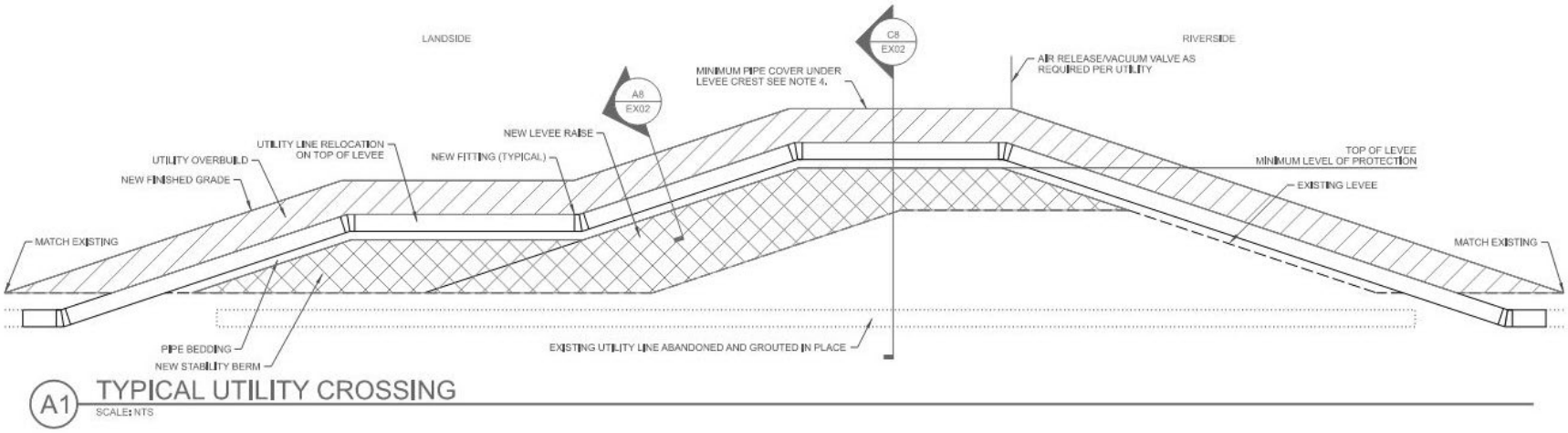


Figure 27 Typical Utility Crossing Section Through Levee Crest

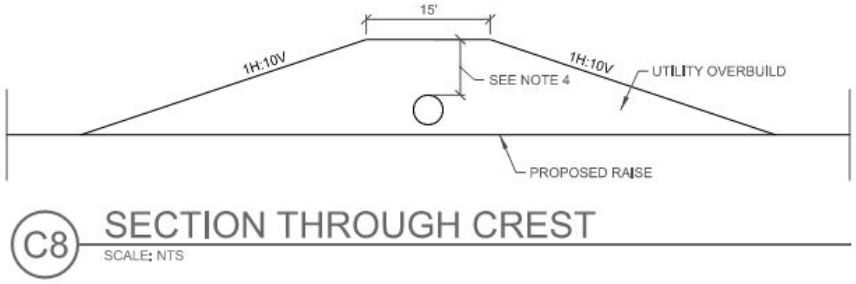
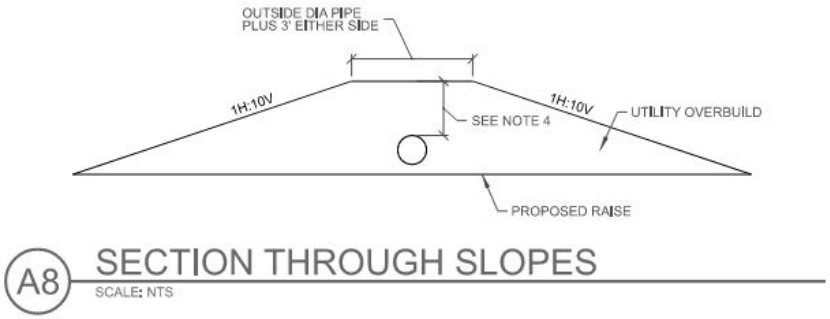


Figure 28 Typical Utility Crossing Section Through Levee Slope



3.8.1 CA1 Existing Capital View Alignment, 34-ft Stage

The Capital View levee Stage 34 Combined Alternative 1 (CA1) would raise the existing Capital View levee. Because it is not a new alignment, the utility relocations would be minimal for this alternative. There were no utilities that were found to run parallel underneath this alternative.

Electric poles within the footprint of the levee and adjacent to the levee were considered for removal and relocation. During plans and specifications, a comprehensive review will have to be made to determine the extent of relocations required in this area. Overhead electrical relocation would be required along U.S. Highway 63, the Katy Trail, Oilwell Road, Mokane Road, Renz Farm Road, and Cedar City Road. Adjustments to pole location and sag height clearances need to be investigated in these locations.

There is a substantial amount of fiber optic lines that cross the levee. Most of the fiber is concentrated around Capital Sands, between stations 155+00 to 183+00. A levee raise would impact the fiber and it would need to be relocated. Special design considerations would need to be considered where the levee crosses the buried cable.

There are some telephone lines that run along Renz Farm Road and Cedar City Road that would need to be relocated. Adjustments to pole location and sag height clearances need to be investigated in this area.

There was one sanitary sewer force main identified around station 179+10. It runs across the Missouri River. Additional information is needed about closure devices. Considerations need be made about pipe strength due to increased overburden and overall pipe condition.

There was one wastewater sewer main identified around 178+50; it runs across the Missouri River. Additional information is needed pertaining to its capacity, stability, bedding requirements, and strength due to increased overburden and overall pipe condition.

There are 16” water lines at the northernmost end of the alignment. The lines that run parallel will need to be relocated. Considerations need to be made about proper closure devices as well as overall pipe condition.

Gas main lines are located at the northernmost end of the alignment, and there are two which run across the river through Capital Sands. Further development of relocations or removals would need to be explored during the design phase.

3.8.2 CA2 Turkey Creek and Riverside Setback, 34-ft Stage, Capital View Removed

This alignment involves moving Capital View levee landward by 1,000 feet and making it tall enough for the 34-foot stage. It also involves setbacks at Turkey Creek. This alignment has a significant number of utilities that cross or run parallel to it.

Electric poles within the footprint of the levee and adjacent to the levee were considered for removal and relocation. During plans and specifications, a comprehensive review will have to be made to determine the extent of relocations required in this area. Overhead electrical relocation would be required along U.S. Highway 63, the Katy Trail, Oilwell Road, Mokane Road, Sandstone Drive, and Cedar City Road. Adjustments to pole location and sag height clearances need to be investigated in these locations. This alternative follows Sandstone Drive under the bridge and onto Mokane Road. The poles located along this street would all need to be relocated out of the levee footprint, which may be a substantial effort considering the infrastructure along this route.

There is a substantial amount of both overheard and buried copper and fiber optic lines that currently cross or run parallel along this alternative. A lot of the fiber is concentrated around the Mokane Road and Hibernia Road intersection. A levee raise would impact the fiber and it would need to be relocated.

Special design considerations would need to be made where the levee crosses or runs along the buried cable.

There are some telephone lines that run along Cedar City Road that would need to be relocated. There are telephone lines that run along Sandstone Drive on the electric poles that would need to be relocated out of the alignment footprint. Adjustments to pole location and sag height clearances need to be investigated in these areas. Coordination between the phone company and electric company would have to be arranged.

A 54-inch RCP gravity sewer outfall exits the wastewater treatment plant and outfalls into the Missouri River. Two 24-inch force mains enter the treatment plant perpendicular to Mokane Road and the proposed alignment. Considerations will need to be made for pipe strength and stability for all these pipes. Structural evaluations will need to be made for these pipes. There is a sanitary sewer line with manholes that runs along Sandstone Drive, parallel to the alignment. Special design considerations would need to be made to relocate this pipe out of the proposed levee footprint. There is also a sanitary sewer line at the northernmost part of the alignment that will need to be relocated out of the levee footprint.

There are 16-inch water lines at the northernmost end of the alignment. The lines that run parallel will need to be relocated. There are water lines that follow Sandstone Drive and run parallel through the alignment to the intersection with Mokane Road. They cross again around the wastewater treatment plant. Considerations need to be made about proper closure devices as well as overall pipe condition.

Gas main lines are located at the northernmost end of the alignment, and there this one which runs across the river through Capital Sands and up along Hibernia Road. There is a crossing at Cedar City Road and there is a gas line that runs along Sandstone Drive. Further development of relocations or removals would need to be explored during the design phase.

3.8.3 CA4 & 5 Optimization Alignment, 37-ft Stage

This alignment involves following the existing alignment until it hits the east tieback of this alignment roughly 4,000 feet eastward of the Historic Alignment. This alignment has many utilities that cross or run parallel to it.

Electric poles within the footprint of the levee and adjacent to the levee were considered for removal and relocation. During plans and specifications, a comprehensive review will have to be made to determine the extent of relocations required in this area. Overhead electrical relocation would be required along U.S. Highway 63, the Katy Trail, Oilwell Road, Mokane Road, Renz Farm Road, and Cedar City Road. Adjustments to pole location and sag height clearances need to be investigated in these locations. This alternative follows Sandstone Drive under the bridge and onto Mokane Road. The poles located along this street would all need to be relocated out of the levee footprint, which may be a substantial effort considering the infrastructure along this route.

There is a substantial amount of both overheard and buried copper and fiber optic lines that currently cross or run parallel along this alternative. A lot of the fiber is concentrated around the Mokane Road and Hibernia Road intersection, with many of those lines running parallel to the levee along Sandstone Drive and Mokane Road. A levee raise would impact the fiber and it would need to be relocated. Special design considerations would need to be made where the levee crosses or runs along the buried cable.

There are some telephone lines that run along Mokane Road that would need to be relocated. Adjustments to pole location and sag height clearances need to be investigated in these areas.

A 54-inch RCP gravity sewer outfall exits the wastewater treatment plant and outfalls into the Missouri River. Two 24-inch force mains enter the treatment plant perpendicular to Mokane Road and the proposed alignment. Considerations will need to be made for pipe strength and stability for all these pipes. Structural evaluations will need to be made for these pipes. There is also a sanitary sewer line at the northernmost part of the alignment that will need to be relocated out of the levee footprint.

There are 16-inch water lines at the northernmost end of the alignment. The lines that run parallel will need to be relocated. There are water lines that follow Sandstone Drive under the overpass and run parallel through the alignment all the way to the wastewater treatment plant. Considerations need to be made about proper closure devices as well as overall pipe condition.

Gas main lines are located at the northernmost end of the alignment, and there this one which runs across the river through Capital Sands and up along Hibernia Road. Further development of relocations or removals would need to be explored during the design phase.

3.8.4 CA6 & 7 Historic L-142 Alignment, 45-ft Stage

The Historic L-142 Alternative matches the design presented in the 2001 General Reevaluation Report & Environmental Assessment for Unit L-142. This alignment has a significant number of utilities that cross or run parallel to it.

Electric poles within the footprint of the levee and adjacent to the levee were considered for removal and relocation. During plans and specifications, a comprehensive review will have to be made to determine the extent of relocations required in this area. Overhead electrical relocation would be required along Mokane Road and the intersection of Mokane Road and Sandstone Drive. Adjustments to pole location and sag height clearances need to be investigated. Relocation of these poles needs to be investigated further during design phase.

There is a substantial amount of both overheard and buried copper and fiber optic lines that currently cross or run parallel along this alternative. A lot of the fiber is concentrated around the Mokane Road and Hibernia Road intersection, with many of those lines running parallel to the levee along Sandstone Drive and Mokane Road. A levee raise would impact the fiber and it would need to be relocated. Special design considerations would need to be made where the levee crosses or runs along the buried cable.

There are some telephone lines that run across Oilwell Road and Cedar City Road that would need to be relocated. There is one that runs along Sandstone Drive. Adjustments to pole location and sag height clearances need to be investigated in these areas. There is also a telephone line that runs along Mokane Road, but it should be out of the levee footprint starting at Hibernia. Relocation of these lines needs to be investigated further during design phase.

A 54-inch RCP gravity sewer outfall exits the wastewater treatment plant and outfalls into the Missouri River. Two 24-inch force mains enter the treatment plant perpendicular to Mokane Road and the proposed alignment. Considerations will need to be made for pipe strength and stability for all these pipes. Structural evaluations will need to be made for these pipes. There is also a sanitary sewer line at the northernmost part of the alignment that will need to be relocated out of the levee footprint.

There are 6-inch water lines at the northernmost end of the alignment. The lines that run parallel will need to be relocated. There are water lines that follow Sandstone Drive under the overpass and run parallel around the alignment all the way to the wastewater treatment plant. The water pipe relocation needs to be investigated further during the design phase. Considerations need to be made about proper closure devices as well as overall pipe condition.

Gas main lines are located at the northernmost end of the alignment, along Sandstone Drive, one at the wastewater treatment plant, and there this one which runs across the river through Capital Sands and up along Hibernia Road. Further development of relocations or removals would need to be explored during the design phase.

3.8.5 CA8 & 9 Highway Alignment, 37-ft Stage

This proposed alternative extends from the bluffs to the Historic L-142 Alignment along U.S. Highway 54, then follows the Historic L-142 Alignment. This alignment has many utilities that cross or run parallel to it.

Electric poles within the footprint of the levee and adjacent to the levee were considered for removal and relocation. During plans and specifications, a comprehensive review will have to be made to determine the extent of relocations required in this area. Overhead electrical relocation would be required along Mokane Road and the intersection of Mokane Road and Sandstone Drive. Adjustments to pole location and sag height clearances need to be investigated. Relocation of these poles needs to be investigated further during design phase.

There is both overheard and buried copper and fiber optic lines that currently cross or run parallel along this alternative. Most of the copper and fiber is concentrated around the Mokane Road and Hibernia Road intersection, with many of those lines running parallel to the levee along Sandstone Drive and Mokane Road. A levee raise would impact the fiber and it would need to be relocated. Special design considerations would need to be made where the levee crosses or runs along the buried cable.

There are some telephone lines that run along Sandstone Drive onto Mokane Road. Adjustments to pole location and sag height clearances need to be investigated in these areas. Relocation of these lines needs to be investigated further during design phase.

A 54-inch RCP gravity sewer outfall exits the wastewater treatment plant and outfalls into the Missouri River. Two 24-inch force mains enter the treatment plant perpendicular to Mokane Road and the proposed alignment. Considerations will need to be made for pipe strength and stability for all these pipes. Structural evaluations will need to be made for these pipes. There is also a sanitary sewer line at the northernmost part of the alignment that will need to be relocated out of the levee footprint.

There is a 16-inch water line at the northernmost end of the alignment. There are water lines that follow Sandstone Drive under the overpass and run parallel around the alignment all the way to the wastewater treatment plant. The water pipe relocation needs to be investigated further during the design phase. Considerations need to be made about proper closure devices as well as overall pipe condition.

A gas main line is located at the northernmost end of the alignment, and there this one which runs across the river through Capital Sands and up along Hibernia Road. Further development of relocations or removals would need to be explored during the design phase.

3.8.6 CA13 Hybrid Alignment, 41-ft Stage, Partial Capital View Removal

This alignment has many utilities that cross or run parallel to it.

Electric poles within the footprint of the levee and adjacent to the levee are considered for removal and relocation. During the engineering and design phase, a comprehensive review will occur to determine the extent of relocations required. Overhead electrical relocation will be required along U.S. Highway 63, the Katy Trail, Oilwell Road, Mokane Road, Renz Farm Road, and Cedar City Road. Adjustments to pole location and sag height clearances need to be investigated in these locations. This alternative follows Sandstone Drive under the bridge and onto Mokane Road. The poles located along this street would all need to be relocated out of the levee footprint, which may be a substantial effort considering the infrastructure along this route.

There is a substantial amount of both overheard and buried copper and fiber optic lines that currently cross or run parallel along this alternative. A lot of the fiber is concentrated around the Mokane Road and Hibernia Road intersection, with many of those lines running parallel to the levee along Sandstone Drive and Mokane Road. A levee raise would impact the fiber and it would need to be relocated. Special design considerations would need to be made where the levee crosses or runs along the buried cable.

There are some telephone lines that run along Mokane Road that would need to be relocated. Adjustments to pole location and sag height clearances need to be investigated in these areas.

A 54-inch Reinforced Concrete Pipe gravity sewer exits the wastewater treatment plant and outfalls into the Missouri River. Two 24-inch force mains enter the treatment plant perpendicular to Mokane Road and the proposed alignment. Considerations will be made for pipe strength and stability for all these pipes.

Structural evaluations will need to be made for these pipes. There is also a sanitary sewer line at the northernmost part of the alignment that will need to be relocated out of the levee footprint.

There are 16-inch water lines at the northernmost end of the alignment. The lines that run parallel will need to be relocated. There are water lines that follow Sandstone Drive under the overpass and run parallel through the alignment all the way to the wastewater treatment plant. Considerations need to be made about proper closure devices as well as overall pipe condition.

Gas main lines are located at the northernmost end of the alignment, and there this one which runs across the river through Capital Sands and up along Hibernia Road. Further development of relocations or removals would need to be explored during the design phase.

3.9 QUANTITY METHODOLOGY

3.9.1 Existing Ground Elevations

Existing ground elevations were developed using the same LiDAR used in the Hydraulic Model as existing ground elevations. See Appendix A1 for LiDAR information.

3.9.2 Earthwork Quantities – Levee Embankment

Proposed top of levee elevations were provided by the hydraulic engineer for each alternative. Using the proposed top elevations and existing ground elevations, the average height of levee embankment for each alternative was estimated. A cross-sectional volume was calculated using a 10-foot-wide levee crown top with 3H:1V side slopes and includes the topsoil, impervious, and random material required. The cross-sectional volume and length of levee embankment were multiplied to determine the total levee embankment volume.

3.9.3 Earthwork Quantities – Underseepage and Stability Berms

Underseepage and stability berm dimensions were provided by the geotechnical engineer. See part 2.5 and 2.6 of this appendix for dimensions. Using the provided dimensions, a cross-sectional area was calculated topsoil and random material required to construct the berms. The cross-sectional area and required berm length were multiplied to determine the total underseepage and stability berm volumes.

3.9.4 Material Quantities – Roadway Surfacing

The volume of aggregate surfacing required on the top of the levee was calculated to be 10-feet wide and 0.5-feet thick for the length of the levee embankment.

Access ramps vary in roadway surfacing material. The length of roadway improvements were calculated using the average levee embankment height and a maximum slope of 10%. Each alternative considered all ramps and up and over roadway relocations and determined an average width. The minimum width of roadways is 22-feet. Volume calculations varied for various surfacing materials but were generally the length of roadway improvements times the road width times thickness of roadway materials.

3.9.5 Utility Relocations

Due to the developed nature of the project area. A considerable number of utilities require relocation with each alternative. Required utility relocations were broken up into three groups for cost determination: low cost, medium cost, and high cost. Placing the utilities required for relocation into groups allowed the PDT to apply cost values of an average relocation of each type to the number of relocations in the group. The low cost group includes relocation of power poles, guy wires, overhead electric lines, overhead telephone lines, and other minor utilities features. The medium cost group includes underground communication lines and similar utilities. The high cost group includes relocations of gravity storm lines, gas lines, water lines, sanitary sewer gravity mains, sanitary sewer force mains, and other utilities requiring complex

relocations. Future refinements will require more detailed evaluation of each utility to be relocated. See 3.10.2 for utility refinement post-TSP.

3.9.6 Drainage Structures

The number of proposed storm drainage pipes were determined based off installing the same number as the existing system. The proposed pipes are 48-inch RCP with an estimated length of 100 feet. Each storm pipe through the levee will have a gatewell structure. Structural quantities including concrete, pipe cradles, inlets, and outlets for a single gatewell structure were calculated using the average levee height and applied to the number of proposed gatewells for each alternative.

3.9.7 Closure Structures

The Structural Engineer and Hydraulic Engineer determined the height and length required for each proposed closure structure. Quantities for a full structure length along the closure area were calculated for each alternative.

3.9.8 Seeding

All areas which are estimated to be disturbed by construction, including borrow areas will be seeded. The acreage to be seeded was measured by drawing the construction limits required for each alternative. The construction limits include permanent and temporary easements described in part 3.5 of this report.

3.9.9 Borrow Areas

Borrow area sizes were estimated using the required borrow volumes. The volume of material required to construct each alternative is measured as compacted cubic yard (CCY) quantities. To determine the volume of borrow required, the quantity must be converted to bank cubic yards (BCY) by multiplying the CCY by 1.15 to account for compaction of the material during placement. At this stage of design, the borrow depth is estimated and will change with design refinement.

For alternatives where some or all of the existing Capital View levee is removed, the volume was calculated by using the average levee height and length of removal.

The size of additional borrow sources is determined by balancing the required volume with the available volume. The available volume is calculated by multiplying the surface area by an assumed excavation depth.

3.10 OPPORTUNITIES FOR REFINEMENT POST-TSP

Post-TSP refinement of CA13 will occur to further develop the design of the tentatively selected plan.

3.10.1 Levee Alignment

The levee alignment will be refined to create a centerline of the levee that has the proper geometry and curves to allow for vehicular traffic for operation and maintenance of the project. Refinement would keep in mind the goal of maximizing the use of existing public owned property and existing ROW to minimize the permanent easements required on private property.

3.10.2 Utilities

Additional investigation of existing utilities will continue. Data will be requested from utility owners for to continue development of accurate existing conditions. With more accurate information, assumptions made during this phase for relocations can be better evaluated for their impact by the project. The project maya require utility relocation up and over the line of protection accounting in the design for riverside loading on the levee. The utility may be required to be relocated outside of the levee embankment and

stability berm footprint. Other options for relocation could include installing features on an existing utility to provide resiliency.

3.10.3 Katy Trail and other Recreational Considerations

The slope of the levee top will be designed to meet ADA requirements. Levee surfacing will be adjusted for the safety of pedestrian and bicycle trails. Incorporating these features and adding signage will provide a more established and marked connection from the Katy Trail to The Skywalk near U.S. Highway 63/54 and the Missouri River. The Skywalk is a pedestrian and bicycle trail that allows easy connection between downtown Jefferson City at the Clay Street Trailhead Plaza across the Missouri River to the North Jefferson Trailhead of the Katy Trail State Park.

3.10.4 Current Land Use – Golf Course

Design development of the alignment in the vicinity of the Turkey Creek Golf Center and Capital Bluffs Event Center will refine the final conditions of the business access and restoration of disturbed parking areas.

3.10.5 Current Land Use – Old Cedar City

Future refinement in Old Cedar City will include revising the layout of the roadway systems to use the properties and provide access to remaining landowners in the area more effectively.

3.10.6 Jefferson City Regional Wastewater Treatment Plant

Future development of the design in the areas surrounding the Jefferson City Regional Wastewater Treatment Plant is required to ensure features such as stability berms and underseepage berms are properly integrated to the operations of the plant. Utility relocations and modifications to piping in and out of the plant may be required.

3.10.7 Jefferson City Memorial Airport

Continued coordination with the airport will identify any FAA requirements the project is required to meet.

3.10.8 Interior Drainage

Interior drainage will be conveyed through the levee embankment using pipes and drainage structures. Existing drainage paths will be used with potential grading to minimize structures required.

3.10.9 Roadway Infrastructure

The proposed alternatives have varying alignments that affect a variety of existing roadways. Mokane Road is heavily used by Capital Sand Company and provides access to the wastewater treatment plant and private residences. Relocation of this roadway to the protected side of the levee is critical in providing continued access during high water events. The roadway will be constructed in accordance with required horizontal and vertical curves meeting local, state, and federal requirements. Additional up-and-over ramps will be included to provide access to non-leveed areas.

4.0 Structural Requirements

4.1 GENERAL

The Structural support to the Lower Missouri Jefferson City L-142 focused on the CA13 Hybrid Alignment, Profile at 1% AEP (1/100 year) tentatively selected plan (TSP). Structural input was also provided for alternative screening. Alternative screening is addressed in more detail within the main body of the study report. The documentation as follows provides a structural overview and summary for CA13, which is the plan with federal interest and would be the plan implemented if action is taken.

4.2 FUNCTIONAL DESIGN REQUIREMENTS AND TECHNICAL DESIGN CRITERIA

4.2.1 Strength Design Criteria

The structures were evaluated with the new levee loads and load factors were required to meet EM 1110-2-2104 (dated 30 November 2016). **Table 17** summarizes these load factors for design. The comparison is for the unusual loading condition only which was the basis of the study recommendations. The return period for both is greater than 10 years but less than 750 years for critical structures as discussed in EM 1110-2-2104. This is an unusual loading category for critical structures per Table 3-1 of EM 1110-2-2104 and these load factors must be applied during design to levees, gatewells, floodwalls, and closure structures.

Table 17 Top of Levee Loading Strength Criteria

	Design (Critical)
Load Factors (LF)	1.6

4.2.2 Stability

Criteria was partially based on EM 1110-2-2100 available at the time. The current design requirements for local stability are defined in EM 1110-2-2100. Section 3-2 of EM 1110-2-2100 (2005) load condition categories. **Table 18** shows a comparison of the local stability criteria currently required by design. The comparison is for the unusual loading condition only which was the basis of the recommendations. The return period for both is greater than 10 years but less than 750 years for critical structures as discussed in EM 1110-2-2502 (2022). This is an unusual loading category for critical structures per Figure 6.1 of EM 1110-2-2502 and the load combination of Table 6.1 of EM 1110-2- 2502 must be applied during the floodwall design.

Table 18 Top of Levee Loading Stability Criteria

Flotation Min (FS)	1.2
Sliding Min (FS)	1.3[2]
Rotation (Percent Base in Compression)	75 percent
Bearing	Min FS=3.0[2]

4.2.3 Drainage Structures

Kansas City District published draft guidance entitled, Piping Systems, with recommendations for construction of a piping system through a levee embankment or its foundation. This guidance will be used as criteria for drainage structure design during the PED Phase. In all instances, Reinforced Concrete Pipe

(RCP) with a minimum size of 48-inches, should be used whenever possible to perform required pipe inspections and ease of maintenance.

4.2.4 Closure Structures

Two stoplog closure structures are necessary, one at Oilwell Road and one at Old 63 U.S. Highway. Based on the 2001 Historic L-142 design each structure would have a total structure length of approximately 135 feet. Each would have an approximate height of 15 feet. In addition, 14 gatewell structures with sluice gates on the riverside of levee are needed to avert floodwaters from entering the protected area of levee. Further refinement will be conducted during design to lower height of stoplogs or use an alternative method to close these areas from floodwaters. It is assumed that a building to house the stoplogs will not be required. The non-federal sponsor has sufficient notification on a pending flood event and has the ability to bring the logs from an offsite location and stage them onsite when needed.

4.3 TECHNICAL BASIS FOR SELECTION OF TYPE AND CONFIGURATION OF MAIN AND MAJOR APPURTENANT STRUCTURES

Closure type requirements based on pipe diameter and flood rise are prescribed in EM 1110-2-2902, Conduits Pipes and Culverts Associated with Dams and Levee Systems. The closure type requirements are for new construction but are also highly recommended for retrofitting existing pipes. **Table 19** summarizes the active closure requirements.

Table 19 Closure Type Requirements[1]

Flood Rise[1]	Pipe Diameter (inches)	Closure Configuration
Fast	< 36	(1) Passive
Fast	≥ 36	(1) Passive AND (1) Active
Slow	< 36	(1) Passive OR (1) Active
Slow	≥ 36	(1) Passive and (1) Active -OR- (2) Active

1. Table 9-1 of EM 1110-2-2902
2. Fast flood rise refers to floods capable of rising to a flood stage with less than 12 hours prediction time.

4.4 EVALUATION AND SELECTION OF SUBSTRUCTURE ALTERNATIVES

A new pile foundation and concrete sill is to be placed across the stoplog gap and new gatewells to provide bearing and load transfer down to the foundation. Further refinement will be conducted during design to evaluate alternative foundation methods.

4.5 INITIAL SEISMIC EVALUATIONS OF KEY ELEMENTS AND MONOLITHS

According to the FEMA Earthquake Hazard Maps, Jefferson City, Missouri is considered a Seismic Design Category of B, which is relatively low risk but “could experience shaking of moderate intensity”. What’s more, its proximity to the New Madid fault zone warrants a review during design of the seismic stability of structural features of the levee.

5.0 Construction Procedures and Materials

5.1 FOUNDATION PREPARATION AND TREATMENT

The levee foundation will be striped of vegetation to a depth of 12 inches. A 5-foot deep by 3-foot-wide trench will be excavated along the length of the levee foundation to intercept any potential sandy natural deposits or sandy fill deposits. If pervious material is found it shall be over excavated to a depth matching the surrounding clay blanket, back filled with impervious fill composed of CL soils (per the Unified Soil Classification System) and compacted in 8-inch lifts to 95% of maximum density as defined by the standard proctor test. Compaction moisture requirements will be set during final design.

5.2 EMBANKMENT

Levee embankments will be composed of construction materials noted below. At this stage it is assumed that the main body of the levee will be constructed in 8-inch lifts and compacted to 95% density. At this stage it is assumed that stability and seepage berms will be compacted in 8-inch lifts via truck compaction to 90% density. Where levee new levee ties into existing roadway or levee the existing roadway and levee slope will be stripped and benched prior to placement of new fill.

5.3 JUNCTION OF LEVEE STRUCTURES

Short floodwall tie-ins will be required on either side of every closure structure. These junctions will be designed in accordance with levee EM 1110-2-1913 and Floodwall Manual EM 1110-2-2502. At locations where the levee will be tied into U.S. Highway 54, the highway slopes will be striped to a depth of 6 inches, scarified, and the levee embankment fill will be placed and compacted on these existing highway slopes that will act as part of the levee protection.

5.4 WATER CONTROL

The existing Capital View Levee is approximately 6 feet in height and overtops at a 30.5-foot stage (elevation 550.7 feet NAVD88) on the Jefferson City gage. This existing levee will be used to provide protection during much of the construction of the site. When this material is used to construct new levee tiebacks, the contractor will have to construct temporary dikes around the construction site to protect it when water reaches a set river elevation, to be determined during final design. These temporary dikes will serve to provide flood risk reduction any structures under construction (gatewells, flood wall, closure structures) as well as to the inside of the TSP, CA 13.

5.5 CONSTRUCTION MATERIALS

Proposed levee sections will be composed of coarse-grained sands, fine-grained impervious fill, and fine-grained Random Fill. Coarse-grained sands will have less than 3% fines and will have a gradation close to ASTM C33 fine-grained aggregate. The final acceptable gradation will be determined during the final design. Fine grained impervious fill consists of CL material as defined by the Unified Soil Classification System (USCS). Random Fill can be composed of clay, silt, and sand. Fine-grained portions of the embankment may be composed of USCS CL and ML soils. USCS CH material may be allowed in portions of levee depending on soils found in borrow areas that are to be later identified. The main body of the levee and stability berms will be topped with six inches of topsoil. Levee seepage berms will be topped with 12 inched of topsoil. The levee crest will be topped with six inches of well graded aggregate.

6.0 Reference List

Reference included may not be all inclusive but are meant to be a list of standards applicable to the project through construction completion.

6.1 USACE ENGINEERING MANUALS

Reference #	Title	Date
EM 1110-2-1413	Hydrologic Analysis of Interior Areas	24 Aug 2018
EM 1110-2-1416	River Hydraulics	15 Oct 1993
EM 1110-2-1417	Flood-Runoff Analysis	31 Aug 1994
EM 1110-2-1601	Hydraulic Design of Flood Control Channels	30 Jun 1994
EM 1110-1-1804	Geotechnical Investigations	01 Jan 2001
EM 1110-2-1902	Slope Stability	31 Oct 2003
EM 1110-2-1906	Laboratory Soils Testing	20 Aug 1986
EM 1110-2-1913	Design and Construction of Levees	30 Apr 2000
EM 1110-2-1914	Design, Construction, and Maintenance of Relief Wells	29 May 1992
EM 1110-2-2100	Stability Analysis of Concrete Structures	01 Dec 2005
EM 1110-2-2104	Strength Design for Reinforced Concrete Hydraulic Structures	30 Nov 2016
EM 1110-2-2902	Conduits, Culverts and Pipes	01 Dec 2020
EM 1110-2-2107	Design of Hydraulic Steel Structures	01 Aug 2022

6.2 USACE ENGINEERING REGULATIONS

Reference #	Title	Date
ER 1110-1-1807	Drilling and Invasive Activities at Dams and Levees	01 Jun 2023

6.3 USACE ENGINEERING TECHNICAL LETTER

Reference #	Title	Date
ETL 1110-2-569	Design Guidance for Levee Underseepage	01 May 2005

6.4 USACE ENGINEERING AND CONSTRUCTION BULLITEN

Reference #	Title	Date
ECB 2017-2	Revision and Clarification of EM 1110-2-2100 and EM 1110-2-2502	27 Jan 2017
ECB 2019-8	Managed Overtopping of Levee Systems	24 Apr 2019

6.5 OTHER REFERENCES

Reference Source	Title	Date
State of Missouri	Missouri Standard Specifications for Highway Construction, 2024, Second Edition	Oct 2024
AASHTO	Policy on Geometric Design of Highways and Street (Green Book), 7th Edition	2018
ASTM D2487-17	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soils Classification System)	25 Aug 2020