CIRBY CREEK HAZARD MITIGATION STUDY

CITY OF ROSEVILLE

DECEMBER 2024

Prepared For: City Of Roseville
Prepared By: R&F Engineering, Inc.

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1. INTRODUCTION

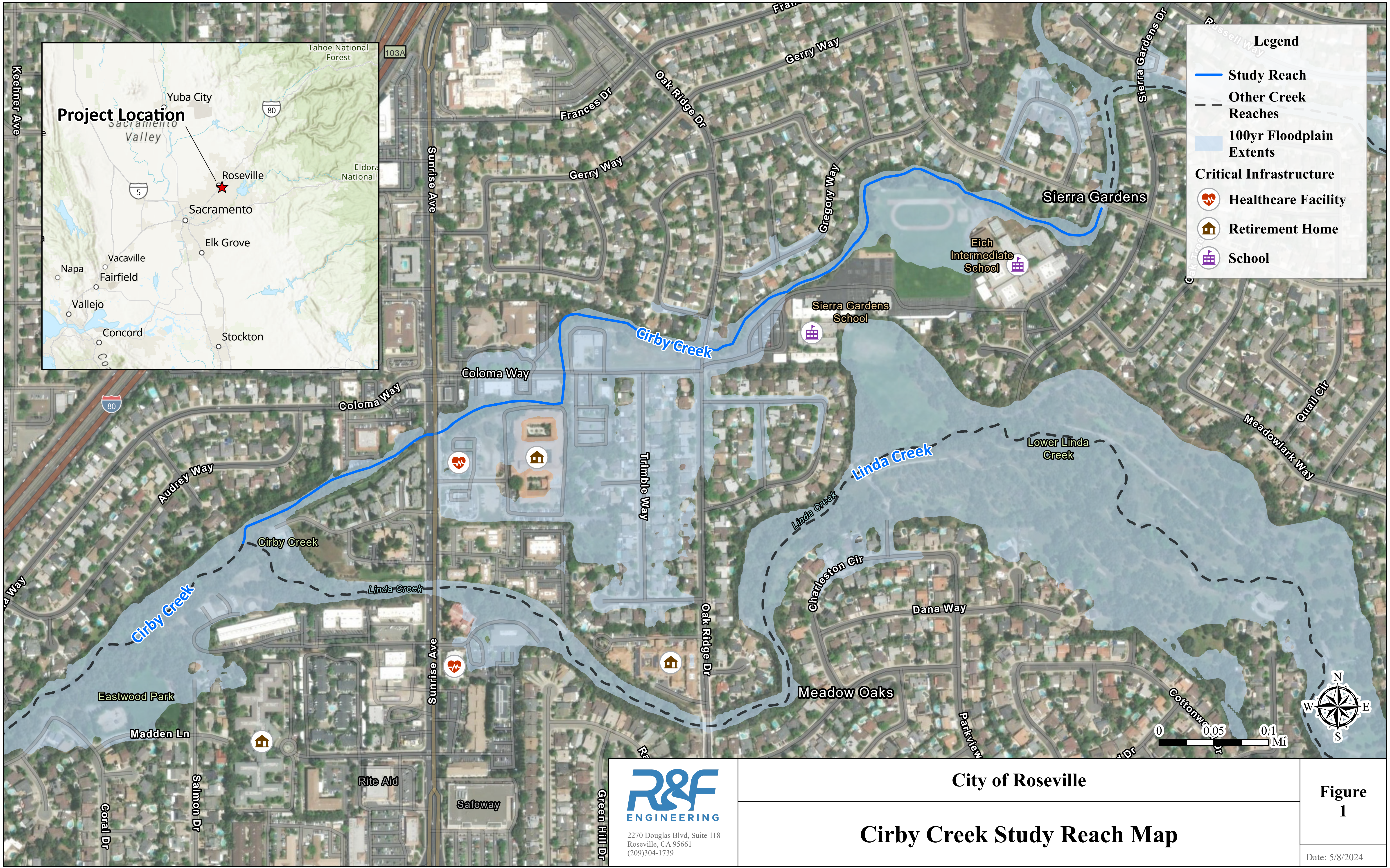
R&F Engineering, Inc. (R&F) was retained by the City of Roseville (City) to conduct the Cirby Creek Hazard Mitigation Actions Study (Study) aimed at mitigating flood risk for the developed areas along Cirby Creek upstream of Sunrise Avenue in Roseville, California. The Study includes a feasibility-level analysis of potential structural and non-structural flood risk reduction alternatives for this area of the creek.

This report identifies the flooding issues along Cirby Creek, formulates potential flood risk reduction alternatives, evaluates these alternatives, and recommends a preferred alternative for the City to consider advancing towards implementation. The purpose of this Study is to provide the City with a strategic and actionable plan to mitigate the hazards associated with flooding in the Cirby Creek area, specifically the reach of Cirby Creek upstream of Sunrise Avenue, which is 1,000 feet upstream of the confluence with Linda Creek.

1.1. Community Profile

1.1.1. Location

Cirby Creek is located within the Dry Creek watershed which covers an area of approximately 101.4 square miles primarily within Placer County (County). Cirby Creek is a perennial stream that is approximately 2.7 miles long with a watershed area of approximately 3.4 square miles. It is located almost entirely within the urbanized area of the City of Roseville, with headwaters located near the intersection of Strauch Drive and Rocky Ridge Drive. Cirby Creek has a main tributary which joins the main channel immediately downstream of Rocky Ridge Drive. The upstream reach of this tributary extends east where it begins near the intersection of Douglas Blvd and E Roseville Pkwy. Linda Creek converges with Cirby Creek just downstream of Sunrise Avenue. Cirby Creek then continues and terminates at the confluence with Dry Creek just upstream from Riverside Avenue. Figure 1 provides an overview of the Cirby Creek study area. This Study is focused on investigating improvements on Cirby Creek upstream of its confluence with Linda Creek. See Appendix A for a figure showing the full extents of Cirby Creek.



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City of Roseville

Cirby Creek Study Reach Map

Figure 1

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1.1.2. History

The Dry Creek watershed has a history of flooding, including damaging floods in 1955, 1958, 1962, 1964, 1983, 1986, 1995, and 2005. The most significant flood events for Cirby Creek occurred in 1986, 1995, and 1997. High flow events on Cirby Creek typically occur from October through April due to prolonged rainfall and saturated soils followed by short periods of intense precipitation and runoff. Below are summaries of the notable flood events along Cirby Creek:

- The **February 1986** flood is the historic flood of record and was estimated to be between a 50- and 100-year event, depending on the specific location within the Dry Creek watershed, and resulted in Placer County being designated as a Federal Disaster Area. Nearly all bridges and culverts were overtopped and around 209 structures in Roseville, including along Cirby Creek, experienced some degree of flooding. Total damages within Placer County were estimated at $7.5M (approximately $17.9M in 2024 dollars). This flood initiated the Cirby-Linda-Dry Creek Flood Control Project, which is discussed further in Section 1.2.1.
- The **January 1995** flood was estimated to be close to a 100-year event and Placer County was again designated as a Federal Disaster Area. The flooding resulted from an approximately 10-year storm event followed by an even higher intensity storm about 12 hours later. Within smaller watersheds in Roseville, these events remained temporally distinct, but within larger watersheds, the events merged and created the estimated 100-year event. Numerous bridges were again overtopped, 358 structures were flooded, and damages were estimated at $15.4M in 2024 dollars, with $7.8M estimated damages within Roseville alone. This flood accelerated the implementation of the recently approved Cirby-Linda-Dry Creek Flood Control Project. Figure 2 below shows the flooding observed on Oak Ridge Dr between Cirby Creek and Linda Creek.

Figure 2. Oak Ridge Drive near Cirby Creek during 1995 flood event. (City, 1995)

- The **January 1997** flood was a result of a typical storm event for the Roseville area on top of soils already saturated from preceding storm events, leading to a flash flood. Twenty-one (21) structures were inundated with floodwaters, however further damages were mitigated by the partially-completed Cirby-Linda-Dry Creek Flood Control Project.

1.1.3. Current Conditions

The Cirby Creek area is urbanized with a mix of residential, public, and commercial land uses. Multiple critical facilities are located in the area including an urgent care facility, a retirement facility, and multiple schools. The City became the first community in the nation to receive the highest rating (Class 1) offered by the Federal Emergency Management Agency's (FEMA) Community Rating System (CRS). However, despite the progress made through the Cirby-Linda-Dry Creek Flood Control Project and the FEMA CRS program, 37 structures along Cirby Creek remain within the 100-year floodplain.

The City owns and maintains an ALERT flood warning response system including approximately 30 rain and stream gauges that are tied to a computer monitoring system. The City also participates in an annual streambed maintenance program lead by the City's Open Space crews with input from the City Floodplain Management. This includes up to 2 miles per year of stream channel work at critical locations to maintain channel capacity, reduce debris and potential blockages, and reduce invasive species.

1.2. Background Studies and Programs

A number of past efforts related to Cirby Creek provided background information, analysis, and tools that were used to inform this Study. The following sections provide summaries of these past efforts.

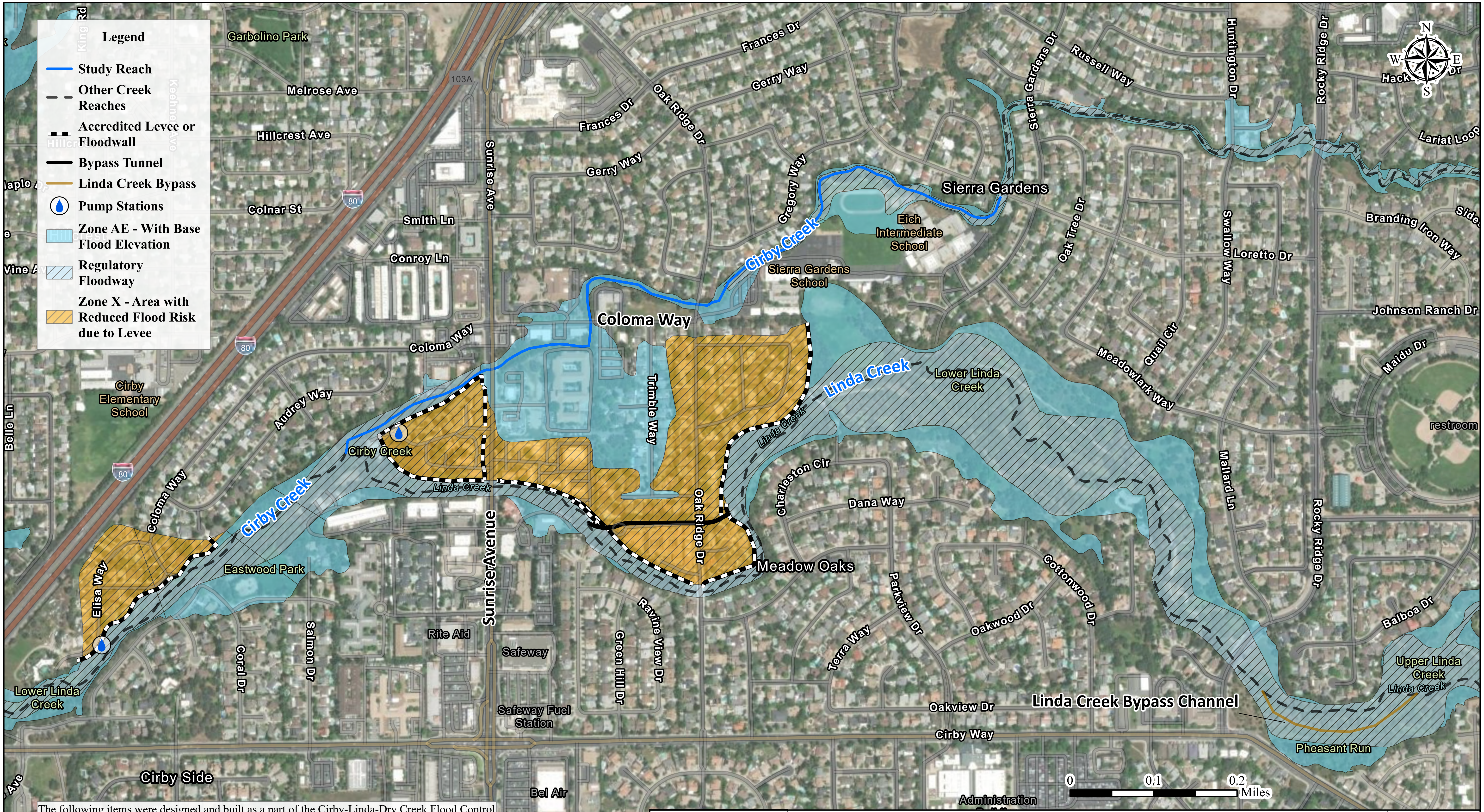
1.2.1. City of Roseville, Cirby-Linda-Dry Creek Flood Control Project Conceptual Design Report – 1991

The City initiated the Cirby-Linda-Dry Creek Flood Control Project (CLD FCP) conceptual design in 1989 to increase channel capacities and reduce backwater constrictions along Cirby, Linda, and Dry Creeks. A conceptual design report was drafted in 1991 and the project was approved in 1992. It included seven work packages involving streambed and channel excavation, open bypass channels and bypass tunnels, flood walls and retaining walls, improvements at bridges and road crossings (including a new Sunrise Avenue bridge at Linda Creek), concrete channels, installation of flap gates, drainage pump stations, and bank protection measures. The specific work package numbers and descriptions are as follows:

- Work Package 1 – SPRR Bridge Approach and Bypass Channel Formulation
- Work Package 2 – Riverside/Vernon Bypass Channel (bypass channel from Vernon to Riverside Streets)

- Work Package 3 – Interstate 80 Channel and Bank Protection (bypass culvert, bank protection, and stream excavation and regrading)
- Work Package 4 – Tina-Elisa Way Works (stream excavation and regrading, embankment, foot bridge reconstruction, and floodwalls)
- Work Package 5 – Sunrise Ave Works (bridge replacement and levee)
- Work Package 6 – Oakridge Bypass (bypass channel)
- Work Package 7 – Rocky Ridge/Champion Oaks/Lexington Green (build floodwalls from Rocky Ridge to Old Auburn Road)

These improvements were primarily structural in nature. The January 1995 flood spurred accelerated pursuit of the project, and as mentioned previously, components of the partially-completed project reduced flood impacts during the January 1997 flood. Six of the seven work packages have been completed to date with a cost of $29.9M; Work Package 2 was not completed because the benefit/cost ratio was not high enough. Upon completing construction of CLD FCP facilities in 2001, flood protection was improved for 262 structures in Roseville, CA. Floodwalls and levees along the right bank of Linda Creek (totaling 0.9 miles) significantly reduced flood risk for structures at and around the Cirby-Linda Creek confluence. However, the extents of the improvements on Cirby Creek were primarily limited to downstream of the confluence with Linda Creek. The City of Roseville's CLD FCP comprises most facilities within its Flood Risk Reduction Facilities (FRRF). Figure 3 provides an overview of the CLD FCP.



Legend

- Study Reach
- Other Creek Reaches
- Accredited Levee or Floodwall
- Bypass Tunnel
- Linda Creek Bypass
- Pump Stations
- Zone AE - With Base Flood Elevation
- ▨ Regulatory Floodway
- ▨ Zone X - Area with Reduced Flood Risk due to Levee

The following items were designed and built as a part of the Cirby-Linda-Dry Creek Flood Control Project in this region of Roseville:

>FEMA-accredited floodwalls and levees built
>Replaced the culvert-crossing of Linda Creek at Sunrise Ave with a bridge crossing
>Added twin 9-foot diameter bypass tunnels on Linda Creek to alleviate pressure on Linda Creek
>Channel excavation to lower water surface and improve flow characteristics

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Cirby-Linda-Dry Creek Flood Control Project
Overview of Work in this Area

Figure 3

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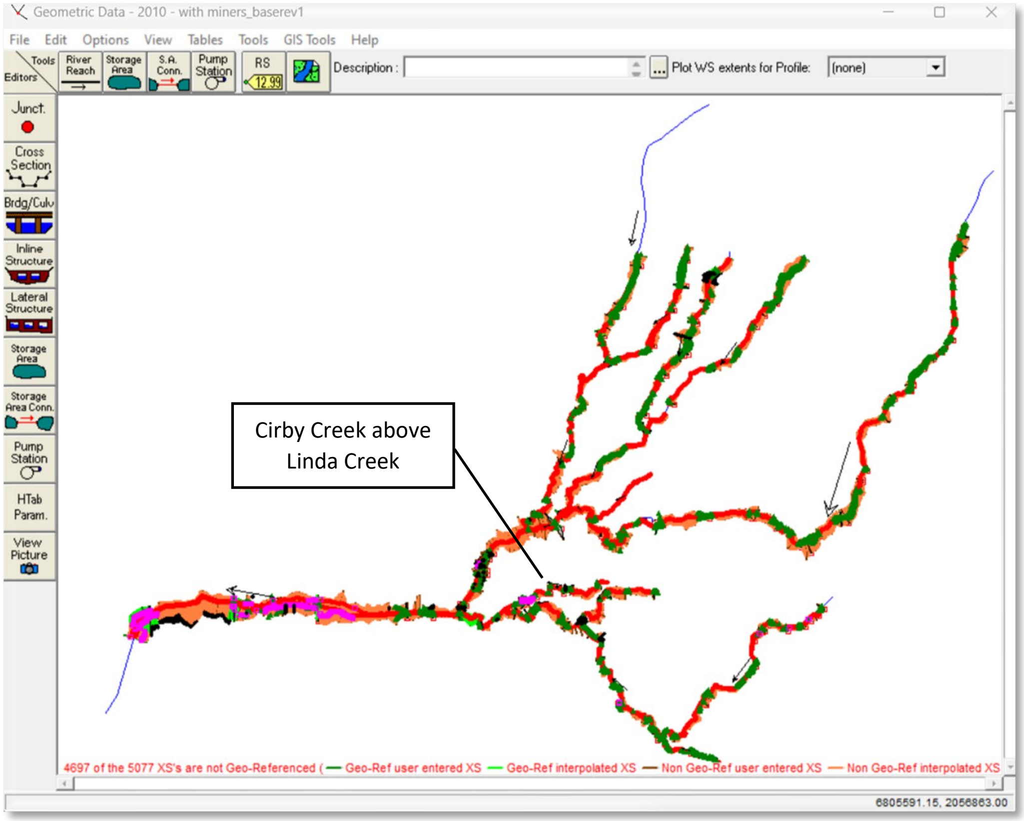
1.2.2. City of Roseville, Dry Creek Watershed Plan Update – 2011

In 2011, Placer County Flood Control & Water Conservation District (District) prepared an update to the 1992 Dry Creek Watershed Flood Control Plan to renew the hydrologic analysis of the watershed, provide recommendations for feasible means to reduce future flood damages, identify possible means to mitigate development impacts on flooding, and recommend an updated funding plan. Some of the recommendations from the 1992 Dry Creek Watershed Flood Control Plan had been implemented by 2011, though many were not due to environmental and/or economic constraints. The 2011 Plan Update evaluated the hydrology and hydraulics of the watershed and provided new recommendations. It included the development of a HEC-HMS model, a one-dimensional (1D) HEC-RAS v4.1 model, and a report with technical appendices. The hydrologic and hydraulic models simulated the 10-, 25-, 50-, 100-, 200-, and 500-year events and included Cirby Creek upstream of Linda Creek (see Figure 4 below). However, because the model was primarily used for hydraulic routing purposes, it was not fully geospatially rectified and did not utilize terrain data necessary for flood mapping. The Dry Creek Watershed Plan looked at structural and non-structural improvements to mitigate flood risk. Recommendations included bridge and culvert improvements to improve conveyance, implementing projects and strategies to mitigate for development impacts, and supporting building elevation and floodplain property buy-outs.



Description :

Plot WS extents for Profile: (none)

Cirby Creek above Linda Creek

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Figure 4. 2011 Dry Creek Watershed Plan Update hydraulic model overview.

1.2.3. City of Roseville, Dry Creek Stream Group Floodplains – 2016

In 2016, the City updated the models from the 2011 Dry Creek Watershed Plan Update to include State and federal terrain data and used the updated models to produce new baseline floodplain mapping. The primary terrain data used was from the California Department of Water Resources (DWR) Central Valley Flood Evaluation and Delineation (CVFED) Program which was flown in 2009. Some of the eastern limits of the mapped area extended beyond the CVFED LiDAR coverage, so FEMA and United States Geological Survey (USGS) topographic data from 2011 was used in those areas. The model geometry was also geo-rectified to align cross sections, stream centerlines, and bridge and culvert elements. The hydrology used in the modeling remained unchanged from the 2011 Plan Update.

The flood mapping products from this effort were used to support the planning efforts associated with the Urban Level of Flood Protection (ULOP) requirements instituted by Senate Bill 5 (SB5).

1.2.4. California Department of Water Resources, Central Valley Flood Protection Plan Update, Non-structural Actions in the Central Valley Non-Urban Areas Cost Estimation Technical Memorandum – 2017

As part of the Central Valley Flood Protection Plan (CVFPP) 2017 Update, a technical memorandum (TM) was produced which outlined how the application of certain non-structural actions could ideally be applied in high-residual risk areas of the Central Valley. It identified what some basic benefits might be and the associated planning-level costs. The primary purpose of the TM was to look at the theoretical use of non-structural actions within non-urban areas. Some potential non-structural actions evaluated in this TM include:

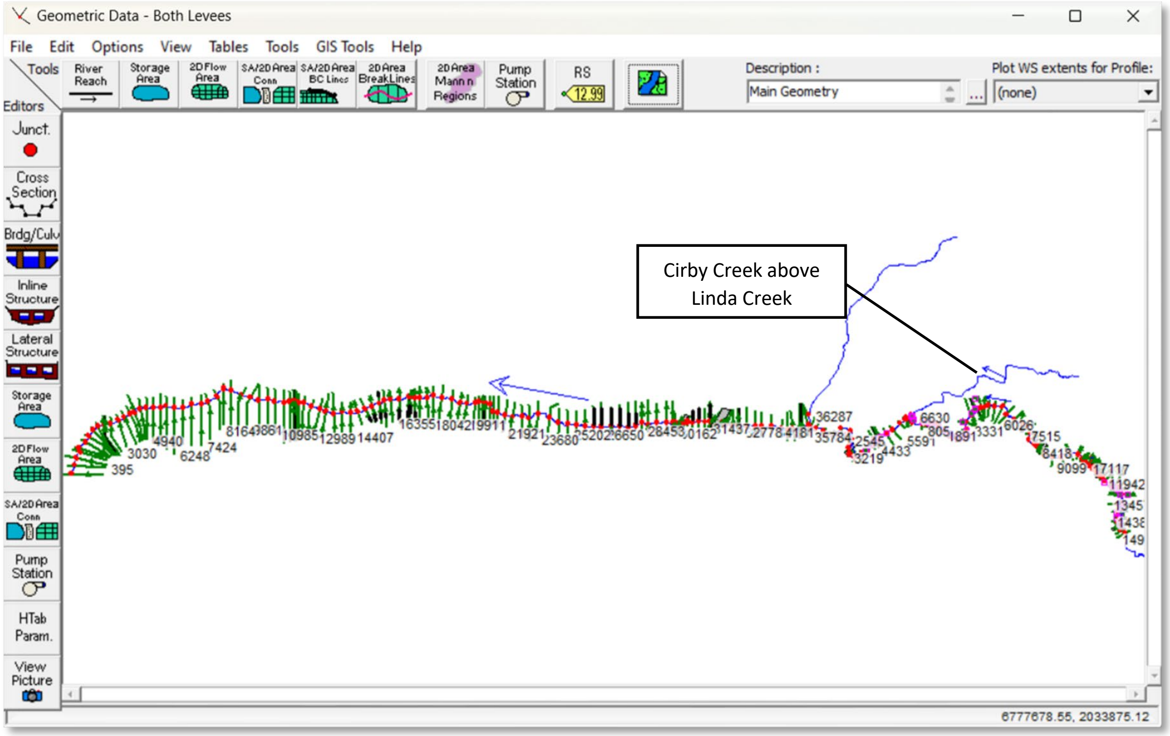
- Elevating/Raising Structures
- Acquisition/Buyout
- Wet Floodproofing
- Dry Floodproofing
- Ring Levees/Non-structural Berms

Although the TM focused non-structural solutions in non-urban areas, and the Cirby Creek area is heavily urbanized, the evaluation of potential non-structural actions and their effectiveness to reduce flood risk and residual risk may still prove helpful in this analysis of the Cirby Creek area.

1.2.5. Placer County Flood Control and Water Conservation District, Cooperating Technical Partners, and DFIRM Creation – 2018

The Placer County Flood Control and Water Conservation District (District) entered a Cooperating Technical Partners (CTP) Partnership Agreement with FEMA to conduct a Risk Map Project within Placer County; this was the 3rd CTP contract between FEMA and the District as was initiated in April of 2018. The objective was to ensure flood hazard maps remained reliable and up-to-date by leveraging local knowledge and resources. Updated flood hazard data for the Linda-Cirby-Dry Creek system and Pleasant Grove South Branch was developed to aid the revision of existing FIRM panels to better reflect flood risk in the City of Roseville. The first CTP effort was completed in 2013 and included Bear Creek, Squaw Creek, Linda Creek, Pleasant Grove Creek, Auburn Ravine, Orchard Creek and Curry Creek. The second CTP effort (i.e., CTP2) consisted of public outreach for the release of the Placer County FEMA Digital Flood Insurance Rate Maps (DFIRMs) and supporting documentation.

In 2021, as a part of FEMA CTP3, the District developed updated flood hazard data for various flooding sources within the County, including portions of Cirby Creek. This included hydrologic and hydraulic analysis of the 10-, 25-, 50-, 100-, and 500-year events. The hydrology for all study streams was developed using methodology prescribed in the Placer County Stormwater Management Manual (SWMM) and software from the Army Corps of Engineers Hydrologic Engineering HEC-1 software. The hydraulics analysis was performed in a 1D HEC-RAS v5.0.7 model and incorporated the updated flows obtained in the hydrologic analysis, updated modeling parameters, and new topographic data collected for FEMA and the CVFPP in 2008. The Cirby-Linda-Dry Creek Flood Control Project was also incorporated into the model geometry. However, the model extents do not include this project's study reach, which is Cirby Creek upstream of the confluence with Linda Creek (see Figure 5 below).



Geometric Data - Both Levees

Description : Main Geometry

Plot WS extents for Profile: (none)

Cirby Creek above Linda Creek

Figure 5. District CTP3 model overview.

1.3. Study Limitations

The Cirby Creek Hazard Mitigation Actions Study was conducted at a feasibility-level of detail to inform decision makers on potential flood risk reduction options for Cirby Creek. As such, more detailed investigations will be required for design, permitting, and financing of any actions recommended out of this Study.

The study was conducted using available existing information. No, geotechnical borings, test pits or other physical field investigations were conducted. No environmental or cultural resources field studies were conducted.

The study does not consider flooding impacts from Linda Creek, which are mitigated by existing floodwalls, and does not consider floodwall failure scenarios.

No field property surveying was conducted. Most of Cirby Creek and its embankments are located on lands owned in fee or easements controlled by City.

Estimates of study costs associated with flood risk reduction alternatives identified in this Study were made at a feasibility-level of detail and are suitable for broad financial planning and comparison of prospective study alternatives. Actual project costs will ultimately depend on results of additional geotechnical/environmental/real estate investigations, conditions existing when the project is constructed, the bidding climate, potential project phasing, permitting and mitigation costs that evolve over time, and conditions in the field during construction that were undetected during planning and design.

This study is limited to improvements to reduce flood risk due to flooding coming from Cirby Creek and does not include improvements to resolve any interior drainage issues.

2. PROBLEMS AND OPPORTUNITIES

This chapter of the Study further identifies the flooding problems along Cirby Creek, the goals and objectives of the Study, as well as opportunities and constraints to review as a flood risk reduction study is considered for the Cirby Creek study area.

2.1. Problem Identification

The Cirby Creek area is exposed to potential flood risk and, while several projects have been completed over the past 30 years to reduce flood risk to the area, there are still structures along Cirby Creek upstream of Sunrise Avenue that remain within the FEMA 100-year floodplain (AE and A Zones) that is identified as a Special Flood Hazard Area (SFHA). The City has a Regulatory Floodplain that is a composite floodplain of three data sources: (1) FEMA 1% annual chance (100-year) floodplains (AE and A Zones), (2) the City-developed 1 percent annual chance (100-year) floodplains with the modeling condition that the Pleasant Grove/Curry Creek and Dry Creek watersheds have been fully developed (e.g., at estimated build-out) without mitigation, and (3) the City-developed 0.5 percent annual chance (200-year) floodplains with flood depths 3.0-foot and greater meeting the State's ULOP criteria. The delineated floodplain boundary of the Regulatory (composite) Floodplain is the most conservative floodplain boundary of the three boundaries. Since the Cirby Creek study area is within a FEMA SFHA, it is also within the City's Regulatory Floodplain. For clarity, any mention of the "floodplain" or "100-year floodplain" in this report will be in reference to the FEMA 100-year floodplain SFHA.

2.1.1. Hydraulic Deficiencies

The developed portion of Cirby Creek is currently prone to overbank flooding from Cirby Creek upstream of Sunrise Avenue. Overbank flooding inundating residential parcels has been observed during flow conditions as low as the 10-year event. While past flood control projects in the area have focused on maintaining flows in-channel along Linda Creek and Cirby Creek downstream of Sunrise Ave, limited improvements have been made to the portion of Cirby Creek upstream of Sunrise Ave (e.g., Loretto Dr bridge replacement in 1992). Insufficient in-channel capacities paired with relatively low-lying, flat topography surrounding the channel has resulted in the flood risk posed to the existing structures along Cirby Creek. Figure 6 shows FEMA's effective flood map in the study area. As mentioned previously, 37 properties are inundated by the 100-year floodplain in this area including residential and commercial properties, an assisted living facility, and an urgent care facility.

Figure 7 shows the stage and flow hydrograph from the 2016 ULOP HEC-RAS model for Cirby Creek between the Sunrise Ave and Coloma Way crossings (HEC-RAS RS 7736.899, location shown in Figure 8). For the 100-year event, the stage and flow within Cirby Creek peaks at approximately 137.4 ft-NGVD29 and 554 cubic feet per second (cfs), respectively. It is also notable that the hydrographs are relatively "flashy", where the peak of the event occurs over approximately four hours.

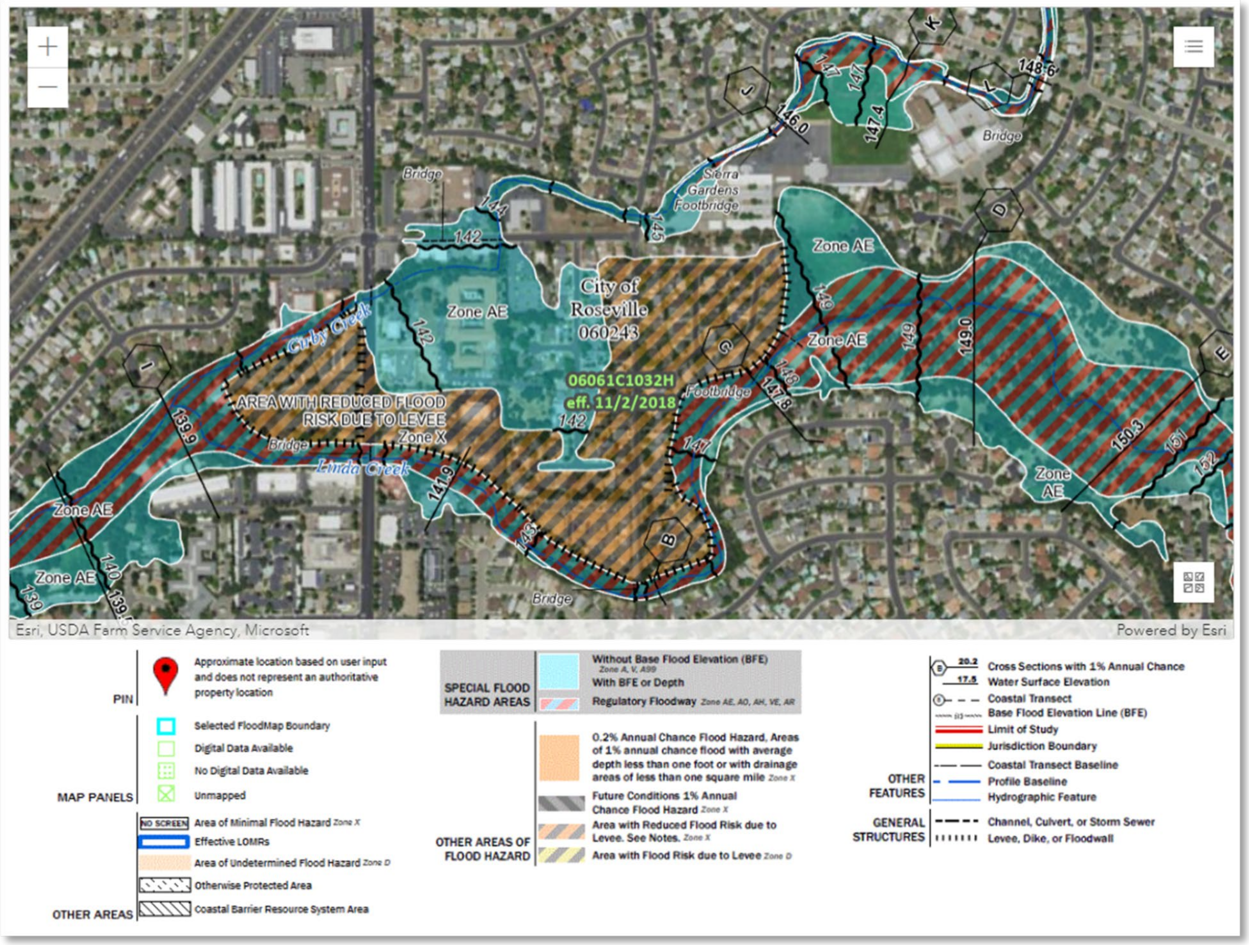


Figure 6. Effective FEMA Flood Map along Cirby Creek upstream of Sunrise Ave (FEMA, 2018).

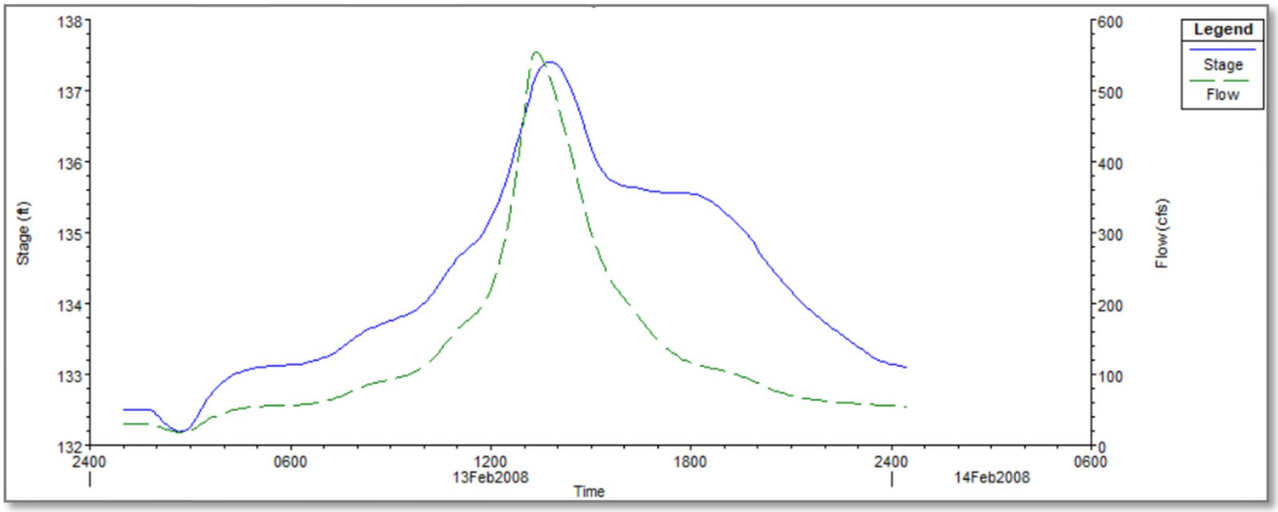


Figure 7. 100-year Stage and Flow Hydrograph - Cirby Creek bet. Sunrise Ave & Coloma Wy (HEC-RAS RS 7736.899) (CES Inc., 2013).

Figure 8. HEC-RAS Cross Section at RS 7736.899 location (shown in pink).

The cross-section plot at this same location (RS 7736.899) is shown in Figure 9 below. Water is seen overtopping the channel embankments and inundating the overland areas and structures (represented by the hatched green ineffective flow areas). The left side of the cross-section is bounded by Oak Ridge Drive and the right side is bounded by Coloma Way.

This cross-section plot in Figure 9 is a good representation of what many of the cross sections look like in the study area of the existing RAS model. It is unknown what the high elevation points on the left end of the cross section represent. Similar discrepancies are assumed with the observed elevation dip (~STA 4800ft) and various undulations throughout the cross section. However, with the goal of the study to eliminate overbank flooding and keep flows within the main channel banks, the discrepancies that are present outside the channel banks should not be a major concern in this analysis. As mentioned in Section 1.3, this study is limited to using existing information and modeling, and no extensive model improvements were completed as part of this study.

Referring back to Figure 9, the channel embankment elevation is approximately 136.4 ft-NGVD29, which is only one foot below the peak stage at this location. Reducing peak flows through upstream storage or elevating the embankments of the creek with levees/floodwalls could be examined as options to reduce or eliminate overbank flooding. Further, non-structural actions such as channel clearing and improvement maintenance may result in stage reductions with the channel.

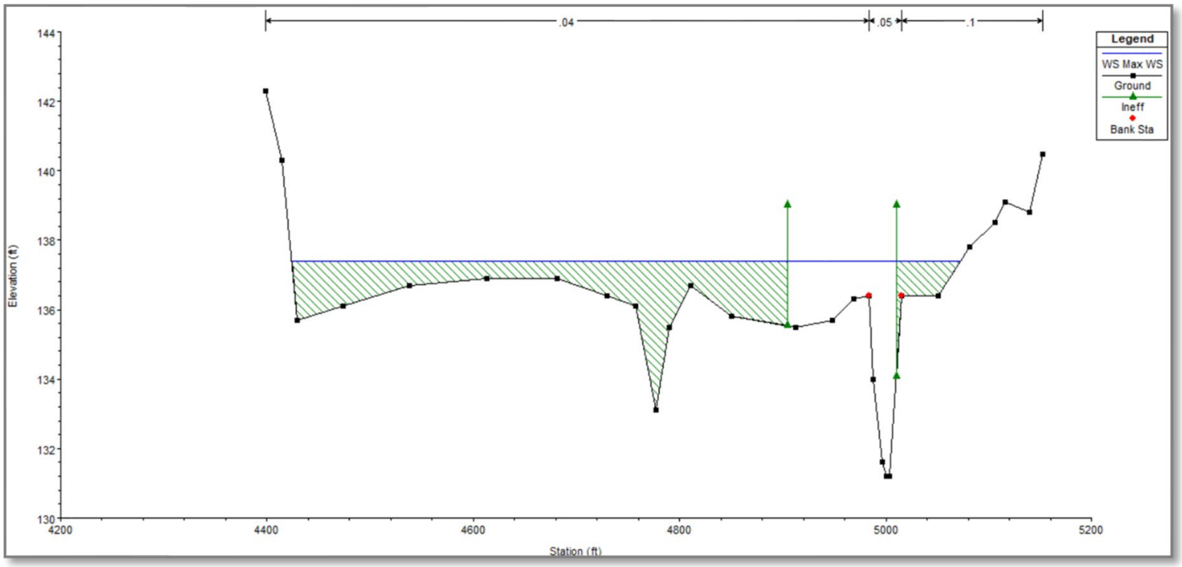


Figure 9. HEC-RAS Cross Section at Cirby Creek – Above Linda RS 7736.899 (CES Inc., 2013).

Figure 10 below shows the existing flood control infrastructure in the study area. The floodwalls and levees shown were primarily constructed as part of the Cirby-Linda-Dry Creek Flood Control Project discussed previously. Note there is no existing flood control infrastructure along Cirby Creek upstream of Sunrise Avenue.

Figure 10. Existing Flood Control Structures in the Study Area.

Finally, the 100-year floodplain shown in Figures 3 and 6 is primarily upstream of the Sunrise Avenue crossing. This would suggest that there may be insufficient capacity at culverts that run though the Sunrise Avenue crossing which would have the potential to cause backwater effects and embankment overtopping upstream. Figure 11 below shows the modeled Sunrise Ave crossing where both culverts are at maximum capacity and overtopping is observed during the 100-year flow event.

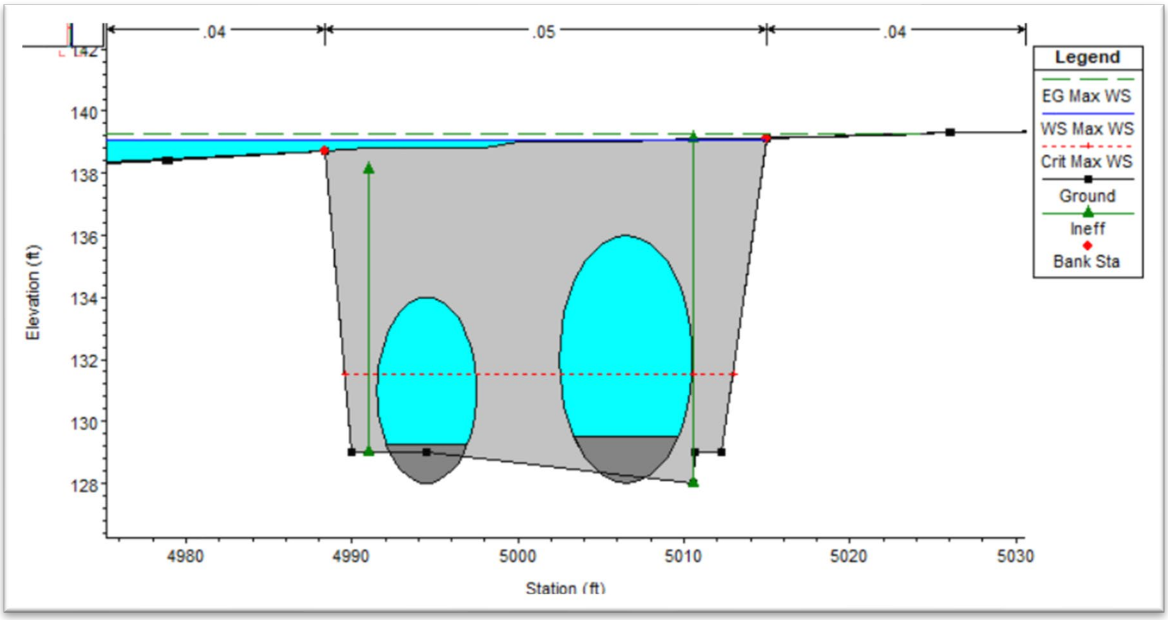


Figure 11. HEC-RAS Cross Section at Sunrise Ave Crossing for 100-year event (CES Inc., 2013).

2.1.2. Other Considerations within the Study Area

Several other considerations to note within the Study area include:

- **Critical Facilities at Risk** – A number of critical facilities are currently in the 100-year floodplain (see Figure 1). While the finish floor elevations (FFE) of these structures are elevated above the base flood elevation (BFE), they are still at risk from larger storms such as the 200- and 500-year events or if issues cause creek blockages. FEMA and USACE standards strive for a 500-year level of protection for critical facilities. Further, even if the 100-year flooding event does not flood these particular facilities, it would still present issues during potential evacuation and emergency response activities.
- **Limited Open Space –** Because Cirby Creek runs through an urbanized area of Roseville, there is limited space along the creek corridor to construct large flood management structures. Right-of-way acquisition may be required prior to implementation of a project. The selected project can also look to take advantage of land on properties that are already in public ownership.
- **Channel Vegetation Maintenance** – As seen in the aerial images of previous figures and in Figure 12 below, there is dense vegetation in the creek beds throughout the study

area. Ongoing maintenance is necessary to maintain sufficient channel capacities will inevitably be a continuous effort in perpetuity following implementation of a project.

Figure 12. View looking upstream on Cirby Creek from Sunrise Ave (R&F, March 2024).

2.2. Study Goals

The planning goals for the Cirby Creek Hazard Mitigation Study seek to improve flood risk management while also improving operations and maintenance and promoting multi-benefit projects.

Primary Goal

- **Improve Flood Risk Management** – Reduce the chance of flooding and damages once flooding occurs and improve public safety, preparedness, and emergency response through the following:
    - Identifying, recommending, and implementing structural and non-structural projects and actions that benefit lands currently exposed to flood risk.
    - Formulating standards, criteria, and guidelines to facilitate implementation of structural and non-structural actions for protecting flood prone areas.

Supporting Goals

- **Promote Multi-Benefit Projects** – To the extent practical, work towards flood management projects and actions that also contribute to broader, programmatic objectives including ecosystem restoration and recreational amenities.
- **Operations and Maintenance Efficiency** –Any modifications to the flood management systems should be made in ways that maximize operations and maintenance (O&M) efficiency, including features that improve the ability of the City to maintain flood infrastructure and perform maintenance and emergency management activities, especially during high water events.

2.3. Study Objectives

The objectives for the Study provide more detailed descriptions needed to achieve or advance towards the goals. As a developed, urbanized, and densely populated area, the objectives reflect the history, culture, land use, hydrology, and economic needs of the area.

- **100-year Flood Protection** – Provide 100-year flood protection for developed areas of the community and reduce the FEMA 100-year floodplain footprint where possible.
- **Flood System Resiliency** – Improve the flexibility and sustainability of the flood management system, the FRRF, in light of future climate change projections and potential regulatory constraints.
- **Residual Risk Management** – Manage and address residual risk through improved emergency preparedness, evacuation plans, and public outreach.
- **Willing Sellers** – Land acquisition, rights-of-ways, and easements should occur with willing sellers.

2.4. Opportunities

The primary opportunities for the Cirby Creek area are improvements to the existing conveyance system. Structural improvements along the creek embankments, off-channel, or at crossings could keep flows within the channel, reduce flows in-channel, or eliminate backwater effects, all of which present the opportunity to remove properties from the 100-year floodplain.

Non-structural measures such as wet or dry floodproofing, or elevating or relocating structures, could reduce flood risk to properties and improve residual risk.

Opportunities for habitat restoration could be created, as well as new recreational opportunities such as walking or biking paths could be incorporated into structural improvements.

2.5. Constraints

Constraints hinder implementation of potential improvements. In some cases, constraints will cause potential improvements to be unfeasible.

- **Funding** – The City is limited in what it could spend for a large-scale flood infrastructure project, and because much of the existing flooding is shallow and may not inundate structures, would likely be unable to cost-share potential improvements. Furthermore, non-structural actions are typically done on-site at private properties and typically require a 25% grant cost-share by the willing seller or owner of the property, rather than a public sponsor. Because the non-structural actions are not considered a city infrastructure project, City funding is typically severely limited.
- **Permitting and Regulations** – There are numerous State and federal agencies, programs, policies, and procedures which profoundly affect how future flood management features are designed, permitted, financed, constructed, operated, and maintained.
- **Transfer of Risk** – Any structural measures that are recommended in this Study need to be completed in a way such that flood risk does not get transferred to other developed areas of the community.
- **Maintenance Resources** – Recommended projects may require additional maintenance. Maintenance of vegetation, sedimentation, and scour in and around flood management facilities and the maintenance of the actual facility (e.g., floodwall) may be necessary in perpetuity.
- **Environmental** – Threatened or protected species of flora and fauna in the area could restrict or eliminate potential flood management work that could take place.
- **Future Climate Change** –Future climate change may result in increases to the magnitude and frequencies of flows in the system. Uncertainty in this magnitude and timing of climate change impacts calls for flexibility in flood management planning.

An array of alternatives for the Study were formulated and evaluated with these goals, objectives, opportunities, and constraints in mind.

3. ALTERNATIVE FORMULATION

The study team, with input from the City, formulated four alternative plans for reducing flood risk in the developed area along Cirby Creek. The process for formulating these alternatives as well as a description of the selected array of alternatives is provided in this chapter.

3.1. Formulation Approach

The alternative formulation approach for the Study began with an identification of existing problems and opportunities. A range of alternatives was developed using engineering judgement to identify potential solutions to the identified problems. Specifically, the approach considered the following:

- Define the study area to include all areas currently inundated due to overbank flooding on Cirby Creek during the 100-year flood.
- Define flood related problems for the area.
- Consider recommendations from past studies.
- Identify potential opportunities (structural and non-structural) to address or contribute to the primary study goal of improving flood risk management.
- Look for opportunities to combine multiple features into a single, more comprehensive alternative.
- Supplement alternatives with additional features that provide opportunities that address or contribute to the supporting goals of the study.
- Discard potential alternatives that are impractical, unfeasible, or essentially duplicate the performance of other alternatives, but at a higher cost. Retain four or less alternatives for further analysis.

Components of the final array of alternatives are defined as either structural or non-structural features. For the purposes of this study, structural features are defined as any proposed improvement that modifies the hydraulics or the physical characteristics of the Cirby Creek system. Non-structural features are defined as any proposed improvements that do not directly modify the hydraulics or physical characteristics of the existing creek system.

3.2. Array of Alternatives

The following subsections include brief descriptions of the final array of alternatives that were selected for further evaluation. Four (4) alternatives that reduce flood risk to the developed area along Cirby Creek were identified and considered for additional evaluation.

3.2.1. Alternative A - Floodwalls

This alternative would involve construction of a floodwall along the north and south bank of Cirby Creek upstream of the Sunrise Ave crossing. This alternative would essentially expand upon the already implemented Cirby-Linda-Dry Creek Flood Control Project which installed floodwalls and levees along Linda Creek and downstream portions of Cirby Creek (see Figure 10).

The floodwall would be designed with sufficient height and length upstream to contain the flows within the banks of the creek during the 100-year event. The floodwall could be one continuous structure, or segments of a floodwall in areas, as needed. This alternative would effectively increase the available channel capacity in Cirby Creek such that structures between Cirby Creek and Linda Creek would be removed from the FEMA SFHA.

To get the floodwall accredited by FEMA and remap the floodplain in the study area, the floodwall would need to be designed with at least three feet of freeboard above the 100-year WSE throughout the system with an additional foot of freeboard within 100 feet of bridge crossings. The floodwall would likely be cast-in-place reinforced concrete and would tie into existing structures (such as the Sunrise Ave crossing), similar to what was completed for the Cirby-Linda-Dry Creek Flood Control Project.

The City owns portions of the embankment along Cirby Creek, but there are portions that are privately owned. To construct and maintain the floodwall, the City would likely need to obtain land rights in the form of easements in areas where the floodwall and its access would not be on City property. Geotechnical and environmental conditions along the proposed floodwall alignment would be important considerations during the design and implementation phases.

Figure 13 shows an example of an existing floodwall in Roseville. Figure 14 shows a potential floodwall alignment to protect the structures in the study area, which will be further refined during the hydraulic evaluation of the alternatives.

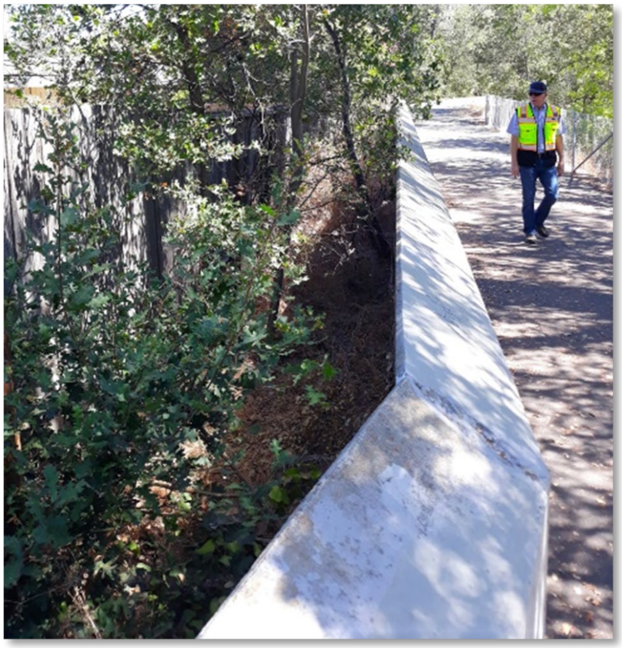
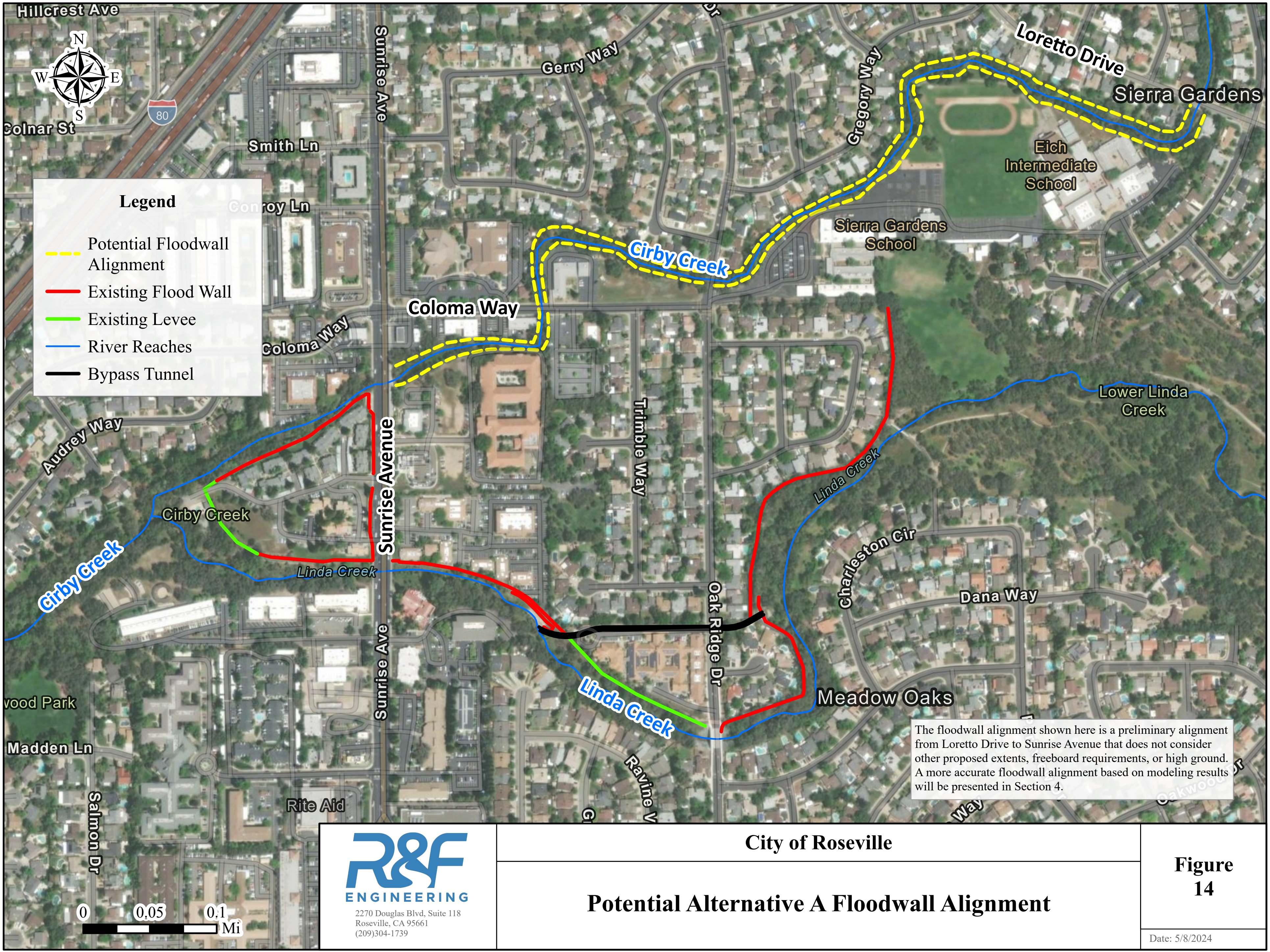


Figure 13. Example Existing Floodwall in Roseville (City of Roseville, 2023).



Legend

🟨	Potential Floodwall Alignment
🟥	Existing Flood Wall
🟩	Existing Levee
🟦	River Reaches
⬛	Bypass Tunnel

The floodwall alignment shown here is a preliminary alignment from Loretto Drive to Sunrise Avenue that does not consider other proposed extents, freeboard requirements, or high ground. A more accurate floodwall alignment based on modeling results will be presented in Section 4.

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Potential Alternative A Floodwall Alignment

Figure 14

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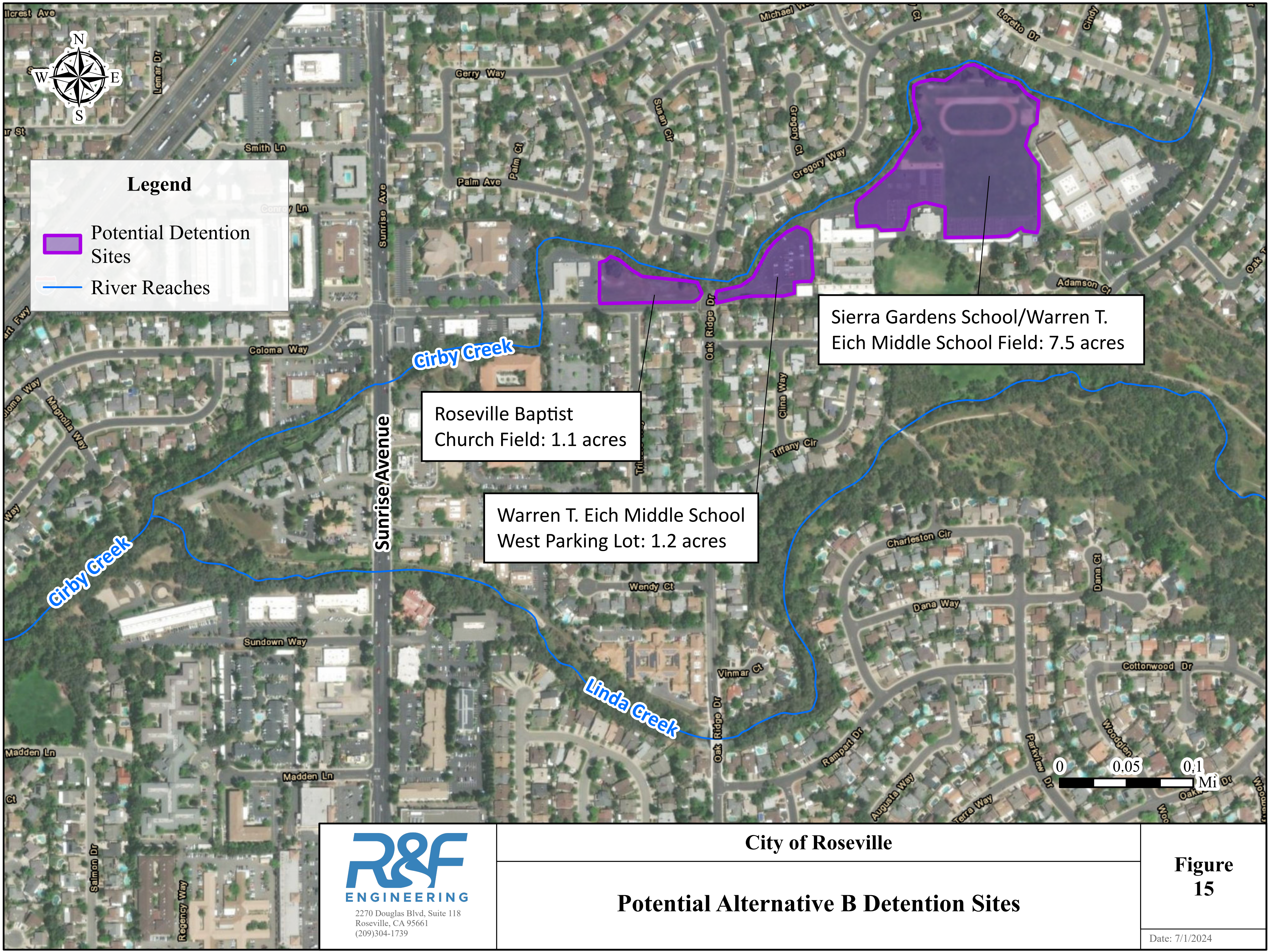
3.2.2. Alternative B – Off-Channel Storage

This alternative would involve construction of at least one off-channel detention basin along the south bank of Cirby Creek. The detention basin(s) would provide temporary storage of peak flows from Cirby Creek, effectively lowering the peak stage with the goal of eliminating overbank flooding in downstream areas during the 100-year event.

The detention basin(s) would be located within existing undeveloped or open areas (e.g., open space, turf fields, vacant parcels, etc.). The south bank of Cirby Creek would likely be re-graded and a weir would be constructed to divert flows out of the channel during peak stages. The identified land would be excavated to create sufficient storage capacity for the flows removed from Cirby Creek. For the purposes of evaluating basin storage capacities in this study, it was assumed that the maximum depth of a potential detention basin would be limited to 8 feet. The embankments of the basin would be sloped appropriately per hydraulic, safety, and geotechnical requirements. Geotechnical evaluations would need to be performed to understand local soil conditions of the detention site. Depending on the soil conditions, the water stored in the basin(s) could be allowed to infiltrate and drain naturally, or outfall pump stations could be implemented to return the water to Cirby Creek once the peak stage had sufficiently subsided. Depending on the size and location of the detention basin site, the interior of the basin could be a multi-use space and potentially incorporate a parking lot or recreational components (playground, sports field, dog park, etc.).

Ideally, the detention basin would be located on public land already owned and maintained by the City. Figure 15 below shows three potential detention basin sites. The two most eastern sites are on City-owned (by the Roseville City School District) land associated with the Warren T. Eich Middle School and the Sierra Gardens Elementary School and total approximately 8.75 acres. An additional site was identified further downstream on private land owned by the Roseville Baptist Church totaling approximately one acre. Should private land be utilized for the basin, conversations and agreements with the current landowner would be needed to acquire easements or purchase the land. The potential detention basin sites will be further refined during the hydraulic evaluation of the alternatives.



Roseville Baptist Church Field: 1.1 acres

Warren T. Eich Middle School West Parking Lot: 1.2 acres

Sierra Gardens School/Warren T. Eich Middle School Field: 7.5 acres

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Potential Alternative B Detention Sites

Figure 15

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3.2.3. Alternative C – Sunrise Ave Crossing Retrofit

This alternative would involve retrofitting the Sunrise Avenue culvert crossing over Cirby Creek to expand the conveyance capacity through the structure. Visual examination of the 100-year floodplain near the Sunrise Ave crossing appears to show that the conveyance capacity of the culverts is limiting flow and resulting in a backwater effect, causing water to overtop the channel banks upstream and contributing to inundation within the study area (see Figure 6). Further, during the 100-year event, the Sunrise Ave crossing is shown to overtop by approximately 0.25 feet (see Figure 11). Increasing the conveyance capacity of the culvert crossing could alleviate the constriction and backwater ponding that may be contributing to the upstream flooding, as well as eliminate or reduce the overtopping of the roadway, maintaining safe road conditions and evacuation routes. However, these modifications also have the potential to exacerbate flooding conditions further downstream due to the increased conveyance and modified timing of peak flows. These changes would require further hydraulic modeling to verify and quantify impacts during the design phase.

Currently, the crossing is constructed with two corrugated steel culverts with vertical headwalls 90-degree wingwalls (see Figures 16 & 17 below). One is a circular culvert with a diameter of 7 feet and the other culvert is roughly elliptical measuring 10.5 feet by 7 feet. The existing total cross-sectional area of the culverts is 96.2 square feet. The existing model assumes 1.25 feet and 1.5 feet of sedimentation at the bottom of these culverts, so the effective flow area is roughly 87.3 square feet. This alternative would potentially include removing the two culverts and replacing the crossing with a full span bridge. Assuming a 5-foot-thick, single span bridge deck, the cross-sectional area under the bridge could be increased to approximately 136.6 square feet, or an approximate 56% increase from existing conditions. Retrofits to the edges of the bridge and abutments could also be made to include a floodwall-type design, providing extra freeboard to protect against potential overtopping, and offer improved hydraulic efficiencies.

The bridge retrofit would be completed in close collaboration with CalTrans and would likely require temporary closure of the bridge. The bridge is only 26 feet long and a full span bridge should be feasible without the need for piers. In addition to providing flood mitigation benefits, the removal of the culverts would also likely reduce culvert maintenance costs for the City. Figures 16 and 17 below shows the existing conditions of the culvert crossing.

Figure 16. Sunrise Ave Culvert Crossing (looking downstream) at Cirby Creek (R&F, March 2024).

Figure 17. Sunrise Ave Culvert Crossing (looking upstream) at Cirby Creek (R&F, March 2024).

3.2.4. Alternative D – Non-Structural Improvements

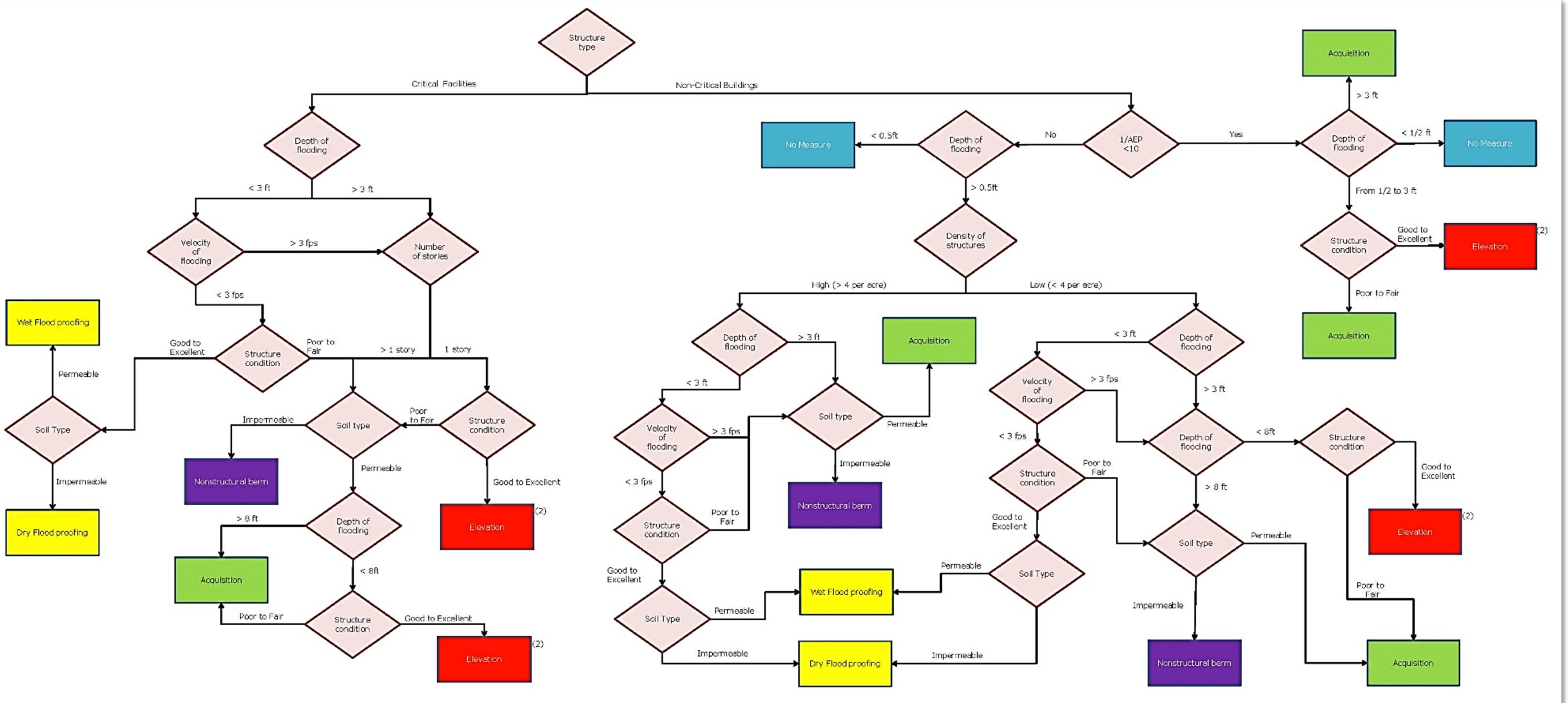
This alternative considers ways to improve flood protection and resiliency through non-structural improvements. As discussed in Section 1.2.4, a technical memorandum (TM) was produced as part of the CVFPP 2017 Update, which outlined how the application of certain non-structural actions could ideally be applied in non-urban areas with high residual risk. Although the TM focused on non-structural solutions in non-urban areas, and the Cirby Creek area is heavily urbanized, the evaluation of potential non-structural actions and their effectiveness to reduce flood risk and residual risk may still prove applicable for the Cirby Creek study. Some potential non-structural actions evaluated in the CVFPP TM include:

- Elevating/Raising Structures
- Acquisition/Buyout
- Wet Floodproofing
- Dry Floodproofing
- Ring Levees/Non-structural Berms

Due to the density of the structures in the Cirby Creek study area, implementation of ring levees or non-structural berms is likely infeasible to consider for this study. Further, acquisition and buyout are typically very costly and would likely be less preferable actions to improve flood protection. Thus, elevating/raising structures and wet/dry floodproofing remain as potentially viable non-structural options for this study. That said, it is important to note that regardless of the most suitable non-structural action chosen, the decision to implement the action belongs to each property owner. That is, implementation of non-structural actions is contingent upon voluntary, willing participants and in some cases can be a large financial burden for those participants. These factors will be considered during the alternatives evaluation process. DWR developed a decision process by which to identify the most suitable non-structural action for individual structures in a flood prone area, depicted by the flowchart presented in Figure 18. This flowchart and process will be utilized during the evaluation of Alternative D. Key data inputs are required for the use of the flowchart including:

- Structure Information
    - Location / Density
    - Ground Elevation
    - Structure Condition
    - Foundation
    - Structure Footprint
    - Number of Stories
    - Structure Type
- Hydraulics Information
    - AEP / Flood Frequency
    - Water Surface Elevation
    - Maximum Water Velocity
    - Soil Type

The amount of vegetation in the channel directly influences in-channel velocities and stages. This alternative will also look at the sensitivity and potential flood risk impacts of different streambed conditions (Manning’s n roughness values)within the channel.



Notes:

(1) Three key assumptions effecting outcomes noticeably are (a) the year built is used to inform what state structure is in, (b) the current model assumes "Good" structural condition if no "year built" data; this often leads to Elevation, (c) if "Fair" were assumed for condition with no "year built" data, Acquisition would be more common. Preliminary results were based on this.

(2)
- Only buildings with ≤2,500 s.f. on the ground floor are considered eligible for physical elevation.
- If buildings which were recommended for elevation persuant to this nonstructural action selection-assistance flowchart do not meet this criteria, they re-entered the decision tree.
- Assume 2 stories have 60% of total building area on the ground floor.
- Assume 3+ stories have 40% of total building area on the ground floor.

Figure 18. Non-Structural Action Selection-Assistance Flowchart (DWR, 2017).

4. ALTERNATIVES EVALUATION

The following alternatives, as identified in Section 3, were further evaluated for this study:

- Alternative A – Floodwalls
- Alternative B – Off-Channel Storage
- Alternative C – Sunrise Ave Crossing Retrofit
- Alternative D – Non-Structural Improvements

Alternative evaluations considered the following as discussed in the following sections:

- Hydraulic Analysis
  - Model Background and Setup
  - Modeling Approach for Each Alternative
  - Results
- Other Considerations
  - Geotechnical
  - Environmental
  - Cultural Resources
- Land Rights
- Preliminary Cost Estimates

Ultimately, the evaluations of the alternatives are summarized in an alternatives matrix for comparison and ranking of alternatives.

4.1. Hydraulic Analysis

4.1.1 Model Background & Setup

The base model used for the hydraulic evaluation of the alternatives was the 1D HEC-RAS v4.1.0 model developed as part of the 2011 Dry Creek Watershed Flood Control Plan and then updated in 2016 as part of the Dry Creek Stream Group Floodplains work (see Section 1.2.3 for more information on the base model). As part of this analysis, the model was up-versioned to the most recent HEC-RAS v6.4.1 for better usability and visualization using RAS Mapper, which is not available in HEC-RAS v4.1.0. A comparison of the original model and up-versioned model existing conditions results were reviewed and differences were considered negligible. No changes were made to the existing conditions geometry or model parameters. Refer to the 2011 Dry Creek Watershed Control Plan for more information on the hydraulic development for the base model.

The referenced horizontal projection for the model is the North American Datum 1983, California State Plane Coordinate System, Zone II. The referenced vertical datum is the National Geodetic Vertical Datum of 1929 (NGVD 29). All units are in U.S. Survey feet. The terrain data in the model utilizes LiDAR data flown by the USGS in 2019.

The hydrology of the base model was also left unchanged. The 2011 and 2016 analyses utilized seven (7) different 100-year design storms (with varying storm centerings) to determine peak flow conditions at key locations. Because this analysis is for Cirby Creek, the “CC5G” hydrology was used, which correlates to the design storm centered in the Cirby Creek watershed and produces the controlling peak flows within Cirby Creek. The 100-year peak flow in Cirby Creek through the study reach ranges from approximately 780 to 1,100 cfs. Refer to the 2011 *Dry Creek Watershed Control Plan* for more information on the hydrology development for the base model.

The hydraulics of each alternative were evaluated primarily using the resulting 1D maximum water surface elevation and extent of inundation south of Cirby Creek between Loretta Drive and Sunrise Avenue. Effects on the water surface elevation downstream of Sunrise Avenue, upstream of Loretta Drive, and along Linda Creek were also observed to help identify potential transfer of risk impacts outside of the study reach.

When plotting the modeled water surface profiles (WSPs), left and right elevations at the creek banks were also extracted to compare the WSPs to the existing bank elevations. However, the bank elevations pulled out of the model cross sections had poor resolution and were not accurate enough to properly estimate the required floodwall heights. Therefore, new bank elevation profiles were created by drawing bank lines in ArcPro over the LiDAR data. Figures 19 and 20 present the updated bank elevation profiles along the study reach compared to the bank elevation profiles pulled from the model. As seen, the updated profiles generally follow the model profiles, but are much higher resolution which was beneficial for the evaluation of the alternatives, particularly the floodwall alternatives.

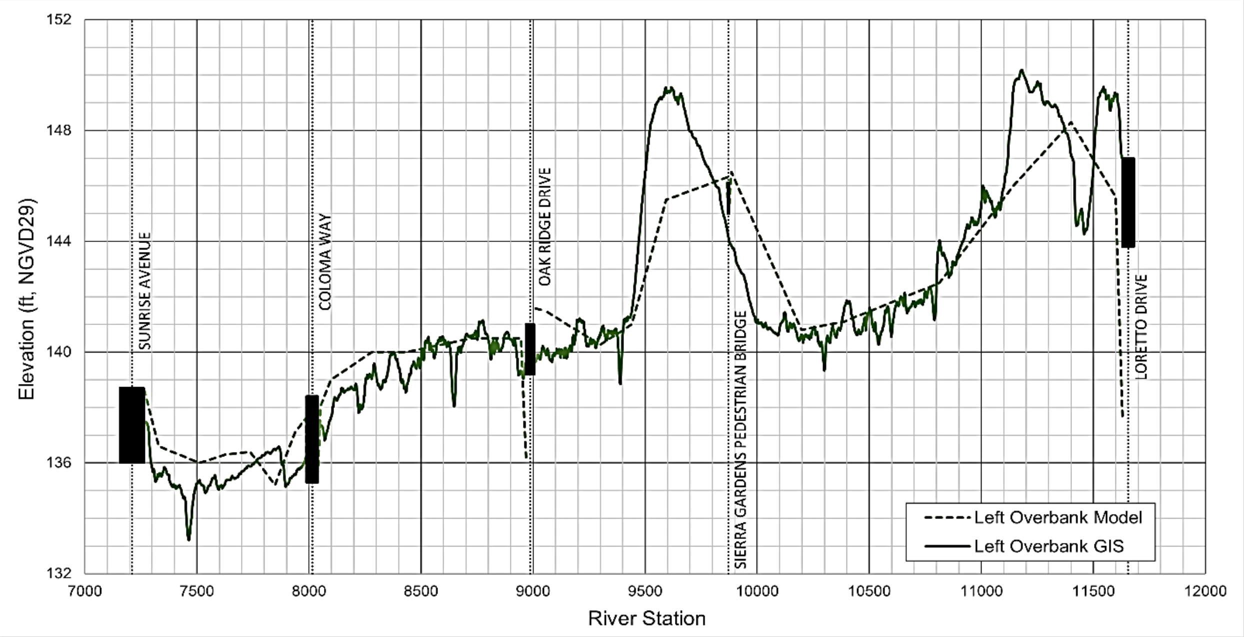


Figure 19. Left bank elevation profile comparison between HEC-RAS and GIS LiDAR data.

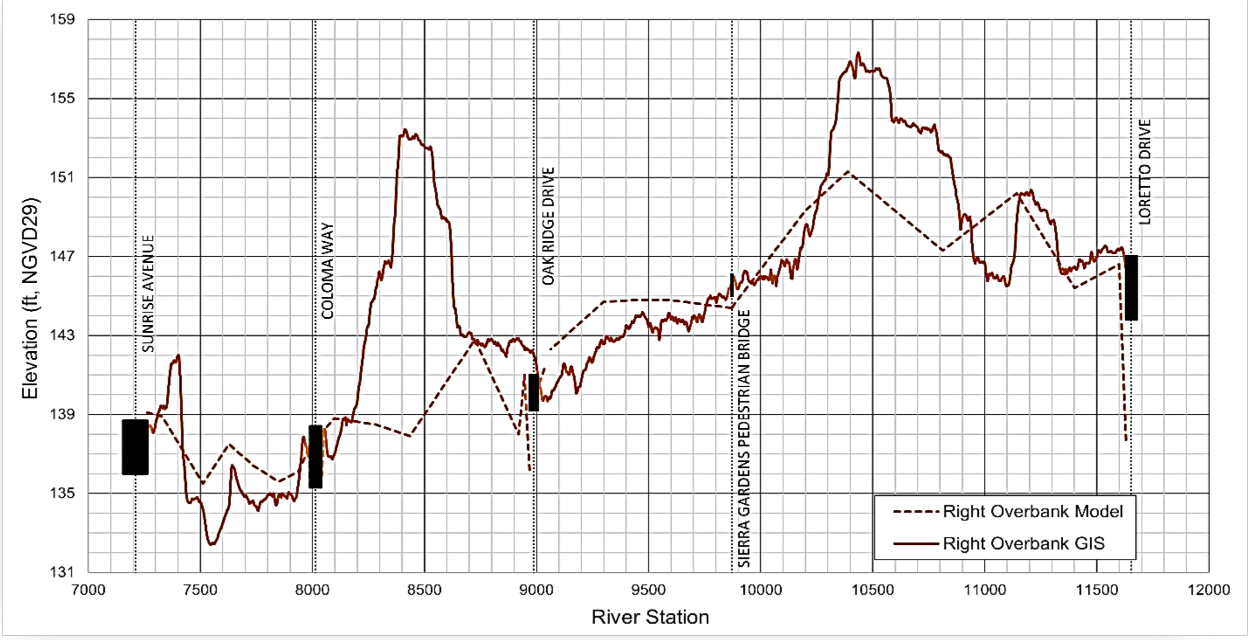


Figure 20. Right bank elevation profile comparison between HEC-RAS and GIS LiDAR data.

4.1.1 Alternative A – Floodwalls

Modeling Approach

Two different extents of left bank and right bank floodwalls were evaluated: (1) Loretto Drive to Sunrise Avenue and (2) Oak Ridge Drive to Sunrise Avenue (see Figure 14 for reference). To determine the floodwall height required to contain the Cirby Creek flows within the channel embankments, HEC-RAS levee points were coded into the model cross sections along the entire reach where floodwalls are proposed. The model was run with "infinite" height levees to determine the max floodwall height required (see Figure 21 below). FEMA criteria requires that levees and floodwalls have at least 3 feet of freeboard above the 100-year water surface elevation, along with an additional foot of freeboard within 100 feet of flow constrictions such as bridges. Once the peak WSE with infinite floodwalls was estimated in HEC-RAS, the FEMA freeboard requirements were added to the peak WSE to identify a final estimate for the proposed floodwall heights.

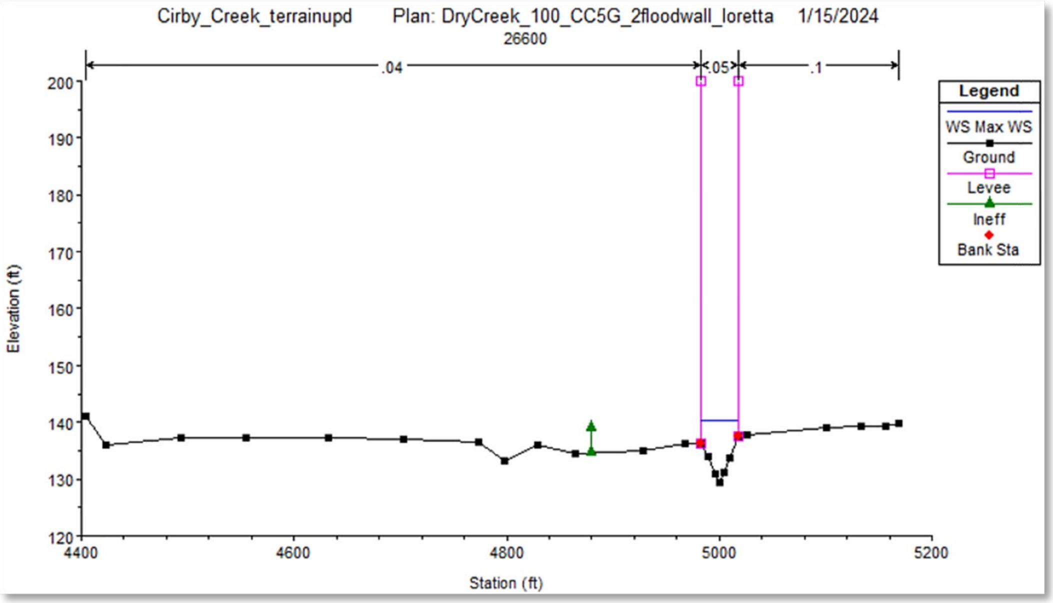


Figure 21. Example cross section with infinite levee points to determine required floodwall height.

Results

As expected, implementation of floodwalls along the study reach results in WSE increases as the floodwalls contain flows within the channel and do not permit excess flows to spill out of the channel. There were also minor WSE increases observed upstream and downstream of the study reach. The bridges at Oak Ridge Drive, Coloma Way, and Sunrise Avenue are already overtopped under existing conditions and the implementation of floodwalls further increases the depth of flooding over these bridges, resulting in the need for bridge retrofits with floodwalls along the bridge decks. Lastly, implementation of floodwalls along the left bank of Cirby Creek requires the concurrent implementation of floodwalls along the right bank to prevent induced flooding of areas on the other side of the creek.

To contain the 100-year event within Cirby Creek between Loretto Drive and Sunrise Boulevard, the required length of floodwalls is approximately 3,400 on the left bank and 4,100 feet on the right bank with average heights of approximately 8 feet and 6 feet, respectively. The maximum floodwall height is estimated to be roughly 13 feet.

If the floodwalls were implemented only from Oak Ridge Drive to Sunrise Boulevard, the required length of floodwalls would be approximately 1,700 feet on the left bank and 1,400 feet on the right bank with average heights of approximately 8 feet and 7 feet, respectively. The maximum floodwall height is estimated to be roughly 12 feet.

The scenario with floodwalls constructed up to Loretto Drive increases the WSE by 0.6 feet just downstream of Sunrise Avenue, as compared to the scenario with floodwalls constructed up to Oak Ridge Drive which increases the WSE by 0.1 feet at the same cross section. Both floodwall scenarios minimally increase the WSE downstream of the Cirby Creek-Linda Creek confluence by about 0.02 feet. Similarly, both floodwall scenarios increase the WSE upstream of Oak Ridge Drive or Loretto Drive by a maximum of 0.6 and 1.5 feet, respectively.

The 100-year WSPs are provided in Figure 22 which includes the scenarios of (1) floodwalls from Loretto to Sunrise, and (2) floodwalls from Oak Ridge to Sunrise. Extents of the proposed floodwalls are presented in Figure 23.

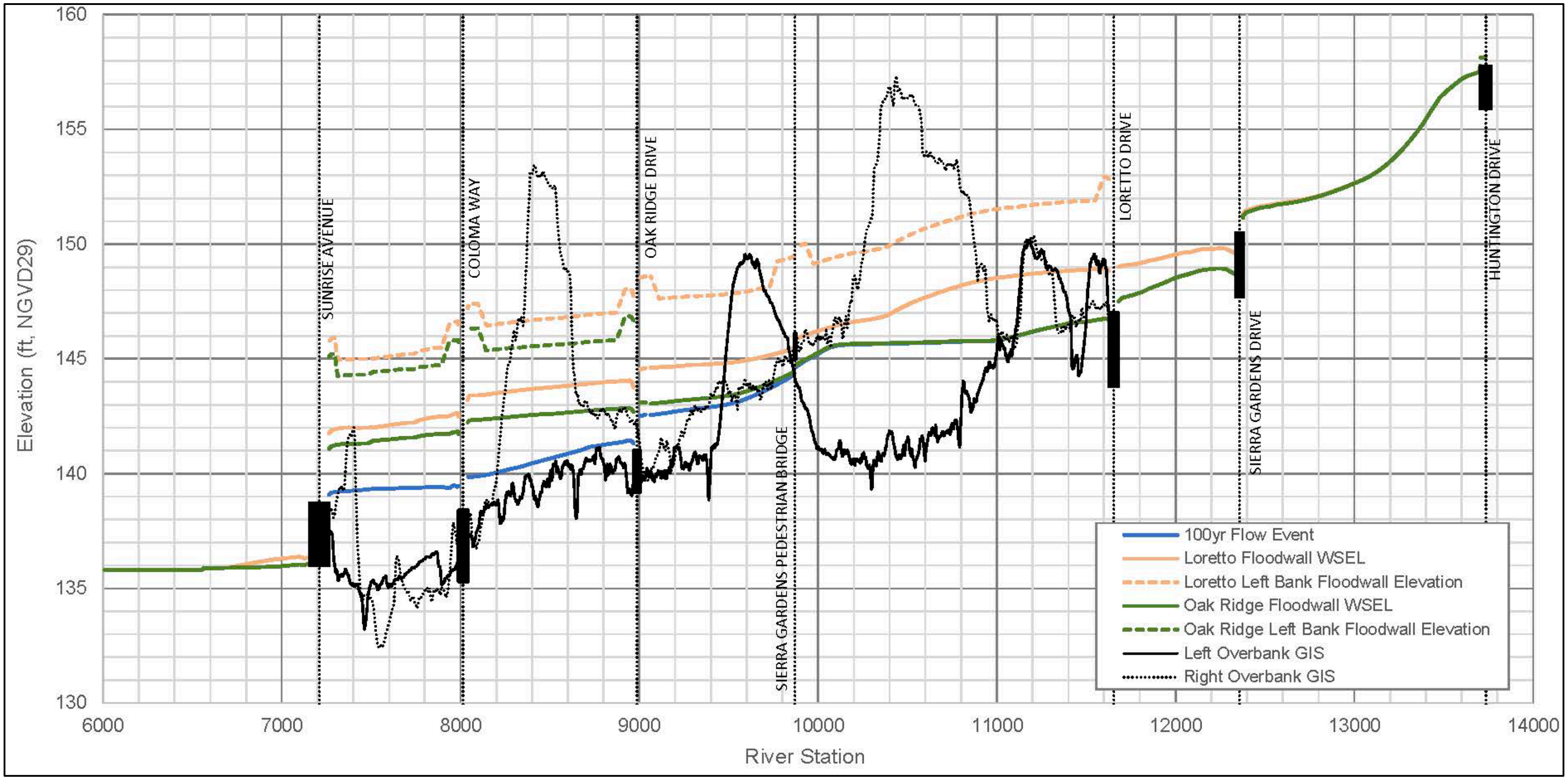
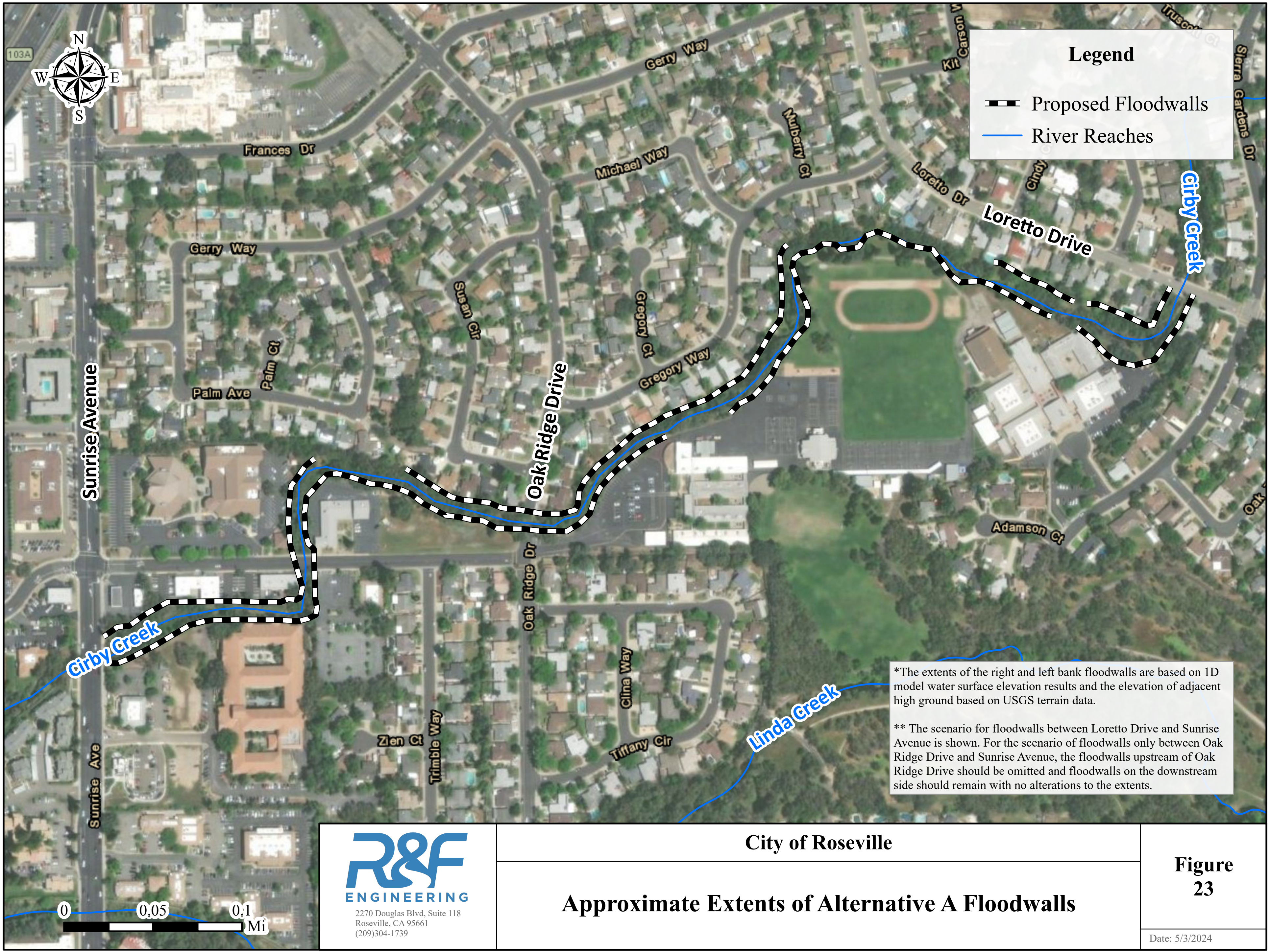


Figure 22. Water Surface Profiles for Potential Floodwalls.



*The extents of the right and left bank floodwalls are based on 1D model water surface elevation results and the elevation of adjacent high ground based on USGS terrain data.

** The scenario for floodwalls between Loretto Drive and Sunrise Avenue is shown. For the scenario of floodwalls only between Oak Ridge Drive and Sunrise Avenue, the floodwalls upstream of Oak Ridge Drive should be omitted and floodwalls on the downstream side should remain with no alterations to the extents.

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Approximate Extents of Alternative A Floodwalls

Figure 23

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4.1.2 Alternative B – Off-Channel Storage

Modeling Approach

Three sites along Cirby Creek were evaluated as potential off-channel storage opportunities. The three sites are (1) the Warren T. Eich Middle School field/Sierra Gardens Park ("MSF"), (2) the Warren T. Eich Middle School parking lot ("MSPL"), and (3) the Roseville Baptist Church field ("CF") (see Figure 15 for reference). The implementation of a detention basin at each site was modeled in HEC-RAS by connecting a storage area with the specified acreages to the nearest adjacent model cross section along Cirby Creek. A simple notch weir was created in the channel embankment to divert water out of the channel. A sensitivity analysis was performed on the three potential sites by varying the simulated depth of each basin to estimate the flood reduction benefits of varying sized storage areas at each location. The sites were analyzed both individually and collectively, resulting in multiple storage area scenarios along Cirby Creek.

Results

Table 1 presents the different scenarios evaluated, the storage capacities for each scenario, and the resultant stage reductions within Cirby Creek.

Table 1. Off-Channel Storage Alternatives Evaluated

Scenario	Detention Basin[a]	Area (acres)	Depth (ft)	Available Storage (ac-ft)	Volume Detained (ac-ft)	Flooding in SFHA?	WSE Decrease [b] (feet)
1	MSF	7.5	8	60	58.7	Yes	2.27
2	MSPL	1.2	8	9.6	9.6	Yes	0.26
3	CF	1.1	8	8.8	8.3	Yes	0.25
4	MSF, MSPL, CF	9.8	4	39.2	39.2	Yes	1.55
5	MSF, MSPL, CF	9.8	6	58.8	53.7	Yes	2.23
6	MSF, MSPL, CF	9.8	8	78.4	59.3	Yes	2.27
7	MSF, MSPL, CF	9.8	4, 8[c]	48.4	44.8	Yes	1.81
8	MSF	7.5	4	30	27.7	Yes	1.01
9	MSF	7.5	6	45	45	Yes	1.90

a: Naming convention of the potential storage areas are as follow:
MSF: Warren T. Eich Middle School Field/Sierra Gardens Park
MSPL: Warren T. Eich Middle School Parking Lot
CF: Roseville Baptist Church Field
b: Water surface elevation decrease is taken as the average decrease between Coloma Way and Sunrise Avenue compared to the existing conditions in Cirby Creek
c: Depth at MSF set to 4 feet and depths at MSPL and CF set to 8 feet

As seen in Table 1, each scenario lowers the water surface elevation of the 100-year event, but none of them eliminate all flooding in the FEMA floodplain. To take all structures out of the

FEMA floodplain and keep flow within Cirby Creek using only detention storage, it is estimated that over 230 acre-feet of storage would be required. If the City were to utilize all the available area to implement potential detention basins, the maximum area would be approximately 9.8 acres. To achieve 230 acre-feet of storage, these basins would need to be approximately 23 feet deep, which was considered infeasible from an implementation perspective. It was assumed that an 8-foot-deep detention basin was the maximum feasible depth for implementation.

While there is not enough available storage areas to eliminate flooding with the use of detention basins alone, these storage scenarios and resulting water surface profiles were still evaluated to judge the effectiveness of using storage areas as *part* of a flood risk reduction alternative.

Scenarios 1, 2, and 3 evaluated the performance of each basin individually to reduce the peak WSE of the 100-year event if the basin was excavated to depths of 8 feet. MSF has the largest potential for detention since it is roughly six times larger than the other two detention sites. With a maximum area of 7.5 acres, MSF is able to store nearly 60 acre-feet and decreases the peak WSE by approximately 2.3 feet between Coloma Way and Sunrise Avenue. Scenarios 2 and 3 detained nearly 10 acre-feet of water each and only decreased WSEs by approximately 0.25 feet between Coloma and Sunrise. The water surface profiles for these three scenarios are presented in Figure 24.

Scenarios 4 through 6 explore using a combination of the three storage areas to depths of 4 feet, 6 feet, and 8 feet, respectively. If MSF is the only storage area used and it is excavated to 4-feet-deep (30 acre-feet), the average WSE decrease between Coloma and Sunrise is approximately 1.1 feet. If the smaller MSPL and CF basins are added with depths of 4 feet, the WSE decrease is another 0.5 feet (1.6 ft total stage reduction). If all three storage areas were excavated to a depth of 8 feet, the basins could theoretically retain a maximum of approximately 78 acre-feet. However, once the larger MSF basin is excavated to a depth of 8 feet, it lowers the stage in Cirby Creek upstream of the other two basins such that the smaller MSPL and CF basins do not divert any more flow out of the channel via weirs. In this case, further measures like culverts or degraded weirs would need to be considered. Therefore, the theoretical maximum amount of storage volume from off-channel storage is approximately 60 acre-feet, which is only about 26% of the storage volume needed to eliminate flooding in the Study area.

Additional scenarios that utilized culverts for MSPL and CF were modeled to evaluate how effective the additional storage would be in reducing WSEs. However, due to the flashy nature of Cirby Creek, culverts could not divert enough water to create a significant impact on downstream WSEs (about 0.03 feet). The hydraulic performance of the culverts could potentially be optimized by changing diameters, barrels, and invert elevations, but this would need to be evaluated in a future design phase and would not likely provide a significant benefit to flood risk reduction.

Scenario 7 shows that even if the smaller MSPL and CF basins are excavated at twice the depth (8 ft) of the MSF basin (4 ft), there is minimal increased storage or WSE reduction benefit as compared to other options.

Regardless of the basin depths, over 75% of the achievable storage capacity comes from the MSF basin due to its size. Due to the minimal effect that the two smaller basins have on channel WSEs and the challenges associated with hydraulically connecting them to Cirby Creek, it is recommended that the primary focus be held on utilizing the MSF basin if off-channel storage is selected as part of the preferred alternative.

Scenarios 8 and 9 evaluated utilizing the MSF basin to depths of 4 feet (30 acre-ft) and 6 feet (45 acre-ft) respectively. Like the other scenarios, flooding is still observed within the SFHA, but the WSE decrease between Coloma Way and Sunrise Avenue is 1.0 feet with 30 acre-ft of storage and 1.9 feet with 45 acre-ft of storage.

The resulting water surface profiles of each scenario can be viewed in Figure 25.

Removal of Structures from the SFHA Using Storage Basins

Thirty-seven (37) structures reside in the existing SFHA based on survey data provided by the City. Each structure’s lowest floor elevation was compared to resulting water surface elevations to estimate how many structures could be removed from the floodplain. Roughly 17 structures could be removed from the SFHA in the most effective detention scenarios (#1 and #6).

It should be noted that four (4) of the 37 structures did not have elevation data associated with them and could not be evaluated for flood reduction. The survey data was also collected over 20 years ago, so the reported elevations may not reflect the current state of these structures. There are also possible errors that could result from outdated or low-resolution bathymetry in the model that was used to conduct this hydraulic evaluation. Estimates of how many structures could be removed from the floodplain are rough approximations, and another study with new survey data and an updated hydraulic model with 2D areas would be required to make more accurate estimates.

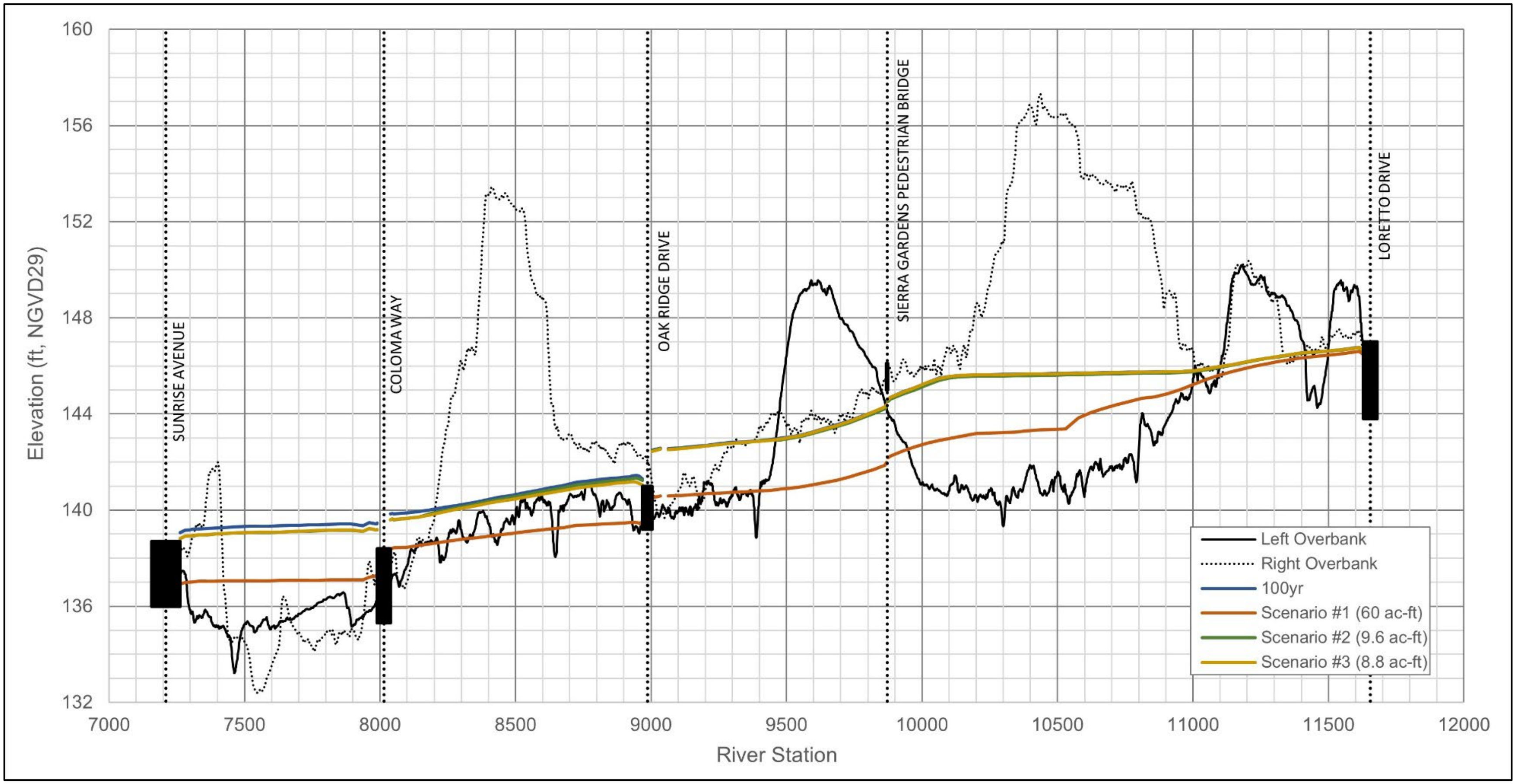


Figure 24. Water Surface Profiles for Potential Individual Detention Basins.

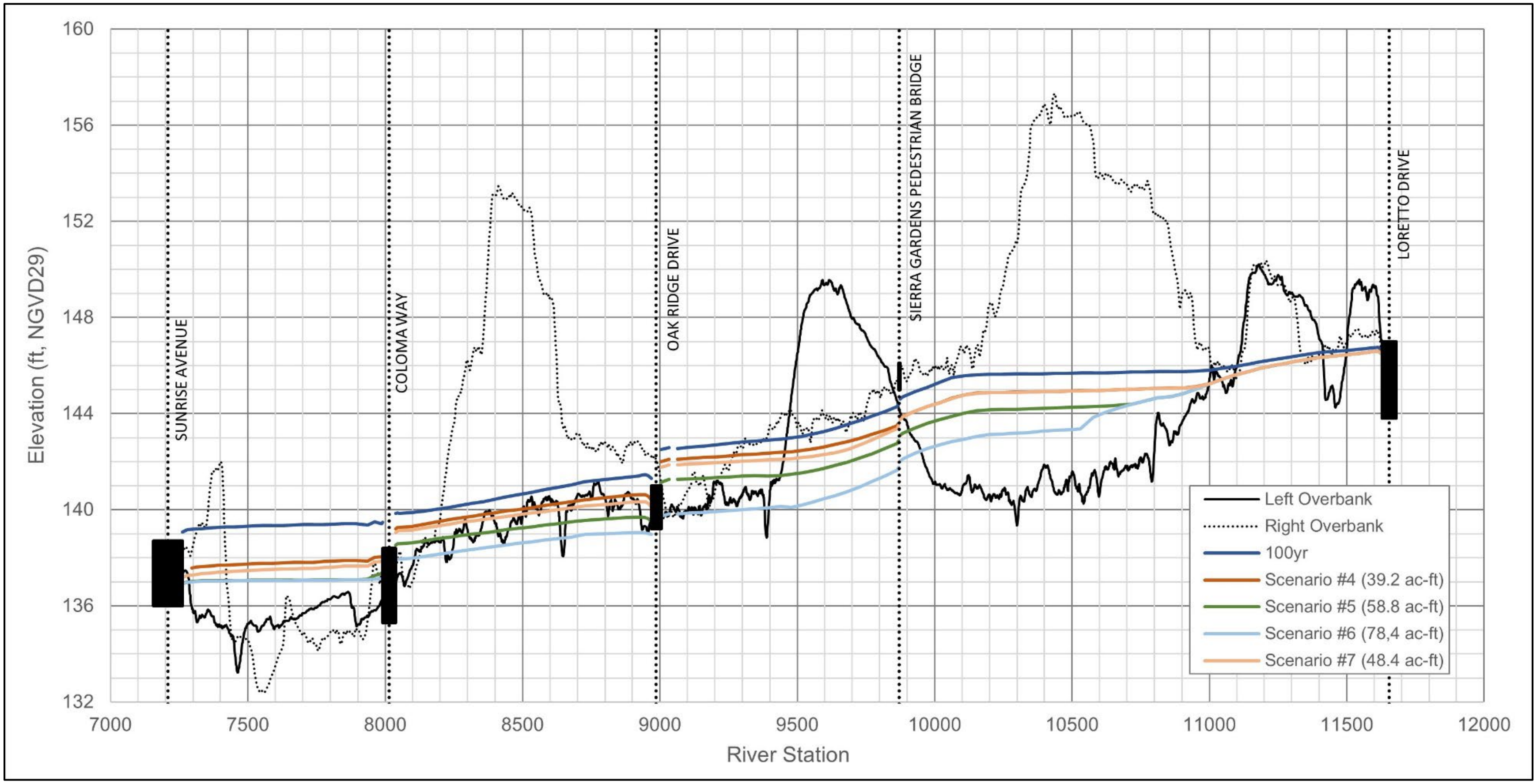


Figure 25. Water Surface Profiles for Potential Combined Detention Basins.

4.1.3 Alternative C – Sunrise Ave Crossing Retrofit

Modeling Approach

The existing Sunrise Avenue bridge crossing includes two culverts (a 7-foot circular culvert and a 10.5-foot x 7-foot arched pipe culvert) to convey Cirby Creek flows. In the 100-year event, the current bridge is overtopped by roughly 0.25 feet. When examining the existing FEMA floodplain (refer to Figure 6), the majority of the flooding occurs upstream of the Sunrise Ave crossing, suggesting that the crossing is potentially undersized and creating a backwater effect.

Alternative C proposes to retrofit the crossing to an open span bridge to relieve any backwater impacts that the current bridge crossing may be having on Cirby Creek during the 100-year flow event. For the purposes of analyzing this alternative, the open span bridge would be assumed to have a 5-foot-thick bridge deck, which is based on similar bridge deck depths seen at Eureka Road, East Roseville Parkway, and Sierra College Boulevard, which have similar lane capacities as Sunrise Avenue. Final bridge deck thickness would need to be determined during potential project design. This would increase the effective flow area through the Sunrise Ave crossing by approximately 27%. Figure 26 shows how Alternative C is represented in the HEC-RAS model.

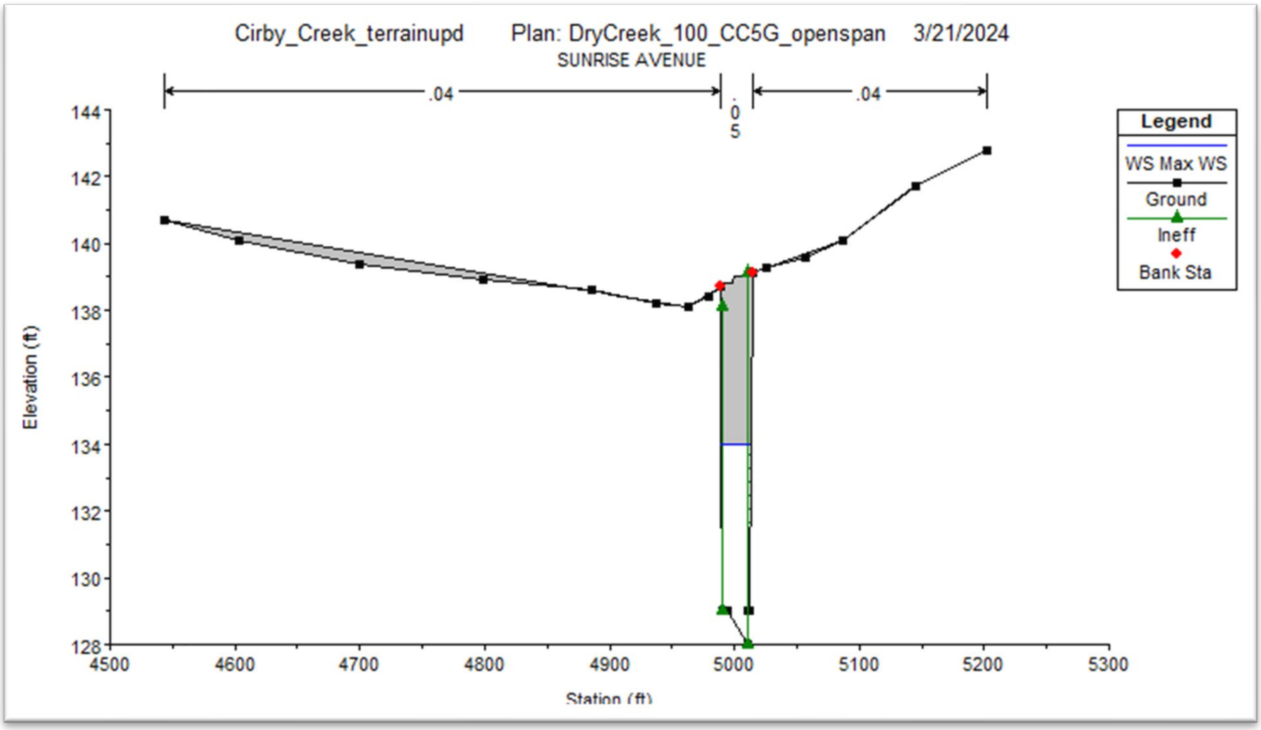


Figure 26. Proposed Alternative C Sunrise Ave Crossing Retrofit in RAS model.

Results

Retrofitting the bridge crossing resulted in a 0.8-foot decrease in the 100-year WSE between Coloma and Sunrise. It does not eliminate flooding in the FEMA floodplain, but it does prevent Sunrise Avenue from overtopping and could remove an estimated 3 structures from the SFHA.

Downstream of Sunrise Avenue, the WSE in Cirby Creek increases slightly as a result of increasing the conveyance capacity through the crossing. The WSE increases in the downstream areas range from approximately 0.03’ just downstream of the Sunrise Ave crossing to less than 0.02’ at the Cirby-Linda confluence. The water surface profile for Alternative C is presented in Figure 27.

This bridge retrofitting scenario was constrained to keeping the roadway elevation constant to minimize the construction necessary for the proposed retrofit. The 100-year WSE remains above the low chord and continues to push up against the bridge deck, but does not overtop the bridge. Increasing the flow area by conducting channel excavation or raising the low chord of the bridge deck could provide more benefit if this alternative is pursued.

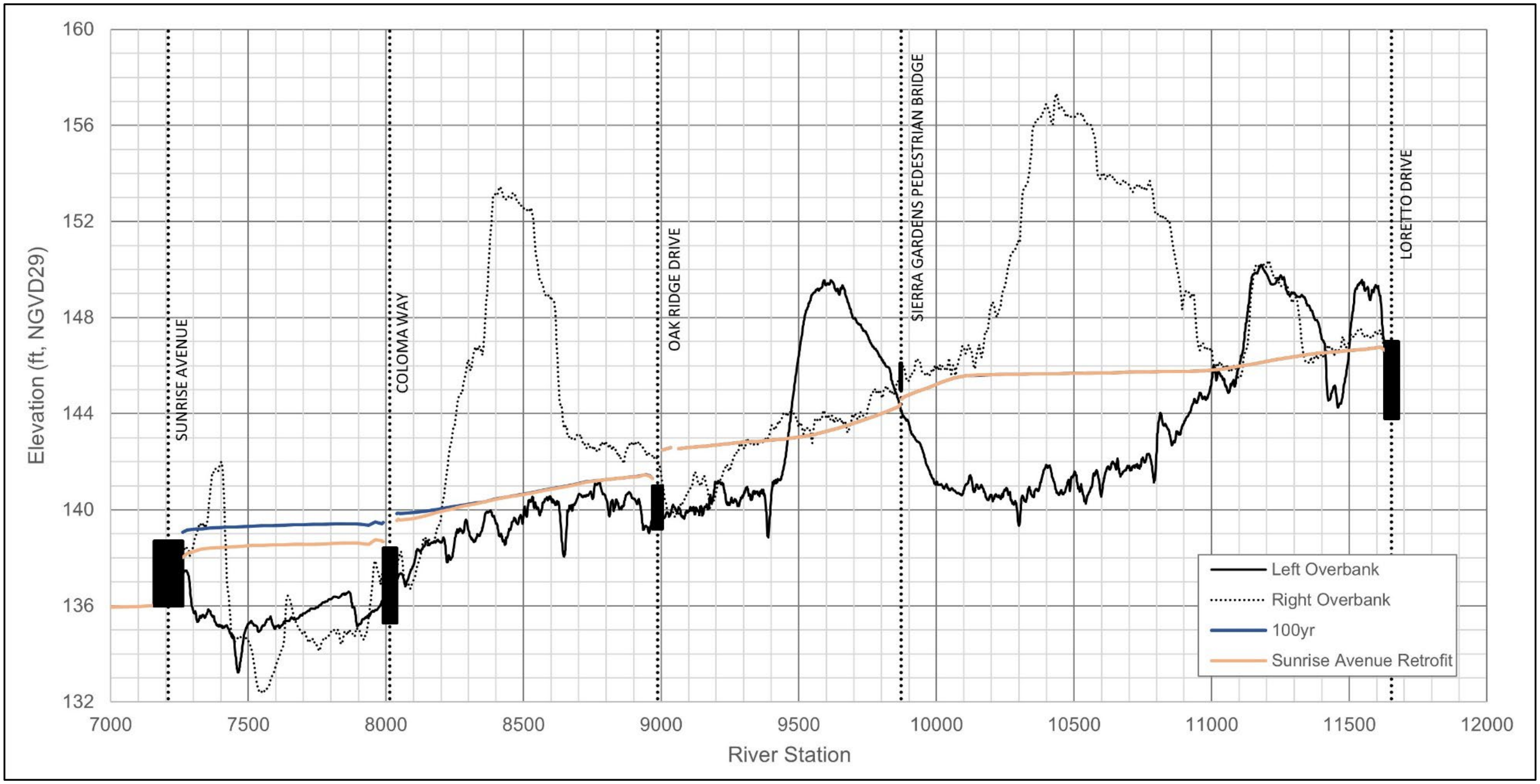


Figure 27. Water Surface Profiles for Potential Bridge Retrofit.

4.1.4 Alternative D – Non-Structural Improvements

Two types of non-structural measures were considered: (a) O&M activities to reduce channel vegetation, and (b) floodproofing or elevating of structures within the SFHA.

O&M Activities to Reduce Channel Vegetation

To evaluate the impact of in-channel conditions on velocities, stages, and potential flood risk in the Study area, a sensitivity analysis was conducted on the reach between Loretto Drive and Sunrise Avenue where the Manning’s n roughness values were varied and the results were compared.

The current model assumes that Cirby Creek between Loretto and Sunrise has a Manning’s n roughness value of 0.05 which is representative of a sinuous channel with stones, pools, and some weeds (Chow 1959). For this evaluation, two other scenarios were considered to analyze the impact of varying in-channel roughness. The first scenario assumed more aggressive vegetation clearing in Cirby Creek by lowering the Manning’s n to 0.035 which is representative of a winding channel with minimal stones and weeds. The second scenario assumed less vegetation clearing by raising the Manning’s n to 0.07 which is representative of a sluggish channel with weedy, deep pools. The reaches upstream of Loretto Drive and downstream of Sunrise Avenue were not altered from the existing conditions present in the model.

For the in-channel roughness sensitivity analysis, the Sunrise Avenue bridge crossing controls the WSE between Coloma Way and Sunrise Avenue in both the n = 0.035 and n = 0.07 scenarios. No changes in peak WSE are observed in this section so the FEMA floodplain would likely not be affected. However, WSEs between Sierra Gardens Drive and Coloma Way vary by up to +/- 0.6 feet depending on if vegetation is cleared (n = 0.035) or left to grow without maintenance (n = 0.07). The water surface profiles for each scenario are presented in Figure 28.

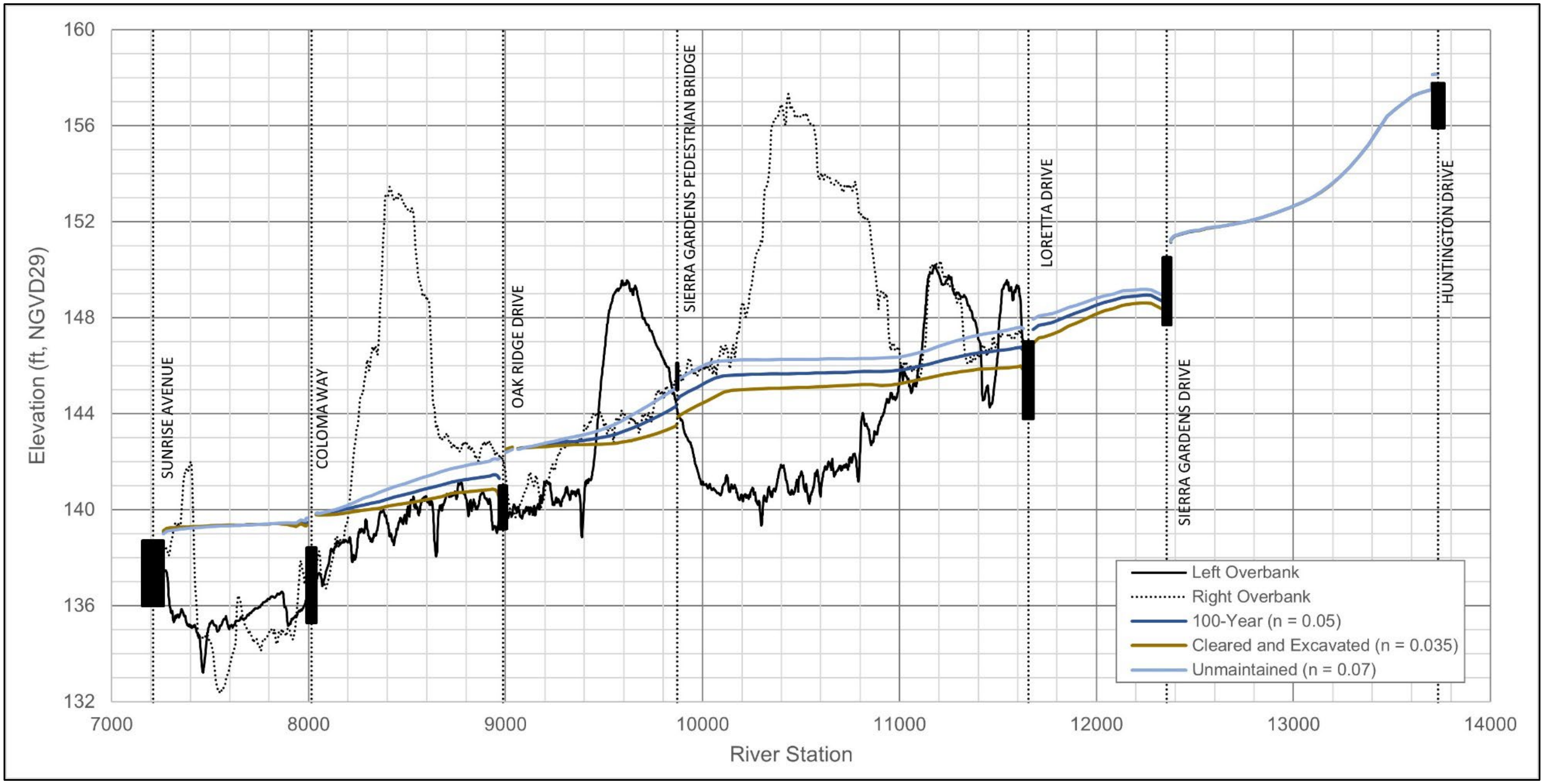


Figure 28. Water Surface Profiles with Varying Channel Roughness.

Other Non-Structural Measures

The DWR flowchart shown in Figure 18 was used to evaluate potential non-structural improvements that could be implemented at the properties currently in the FEMA floodplain. An Excel spreadsheet was created to track the selected action for each property based on the DWR flowchart and the existing structure and property data provided by the City.

Each of the 37 properties in the FEMA floodplain were evaluated through the DWR flowchart to identify the preferred non-structural improvement. Note that due to the density of the properties in the urban Study area, levees and berms around individual structures were not considered feasible for the purposes of this Study. It was assumed that elevating/raising structures and wet/dry floodproofing were the likely non-structural options, but potential buy-out and acquisition was also considered even though it may be too cost-prohibitive to implement.

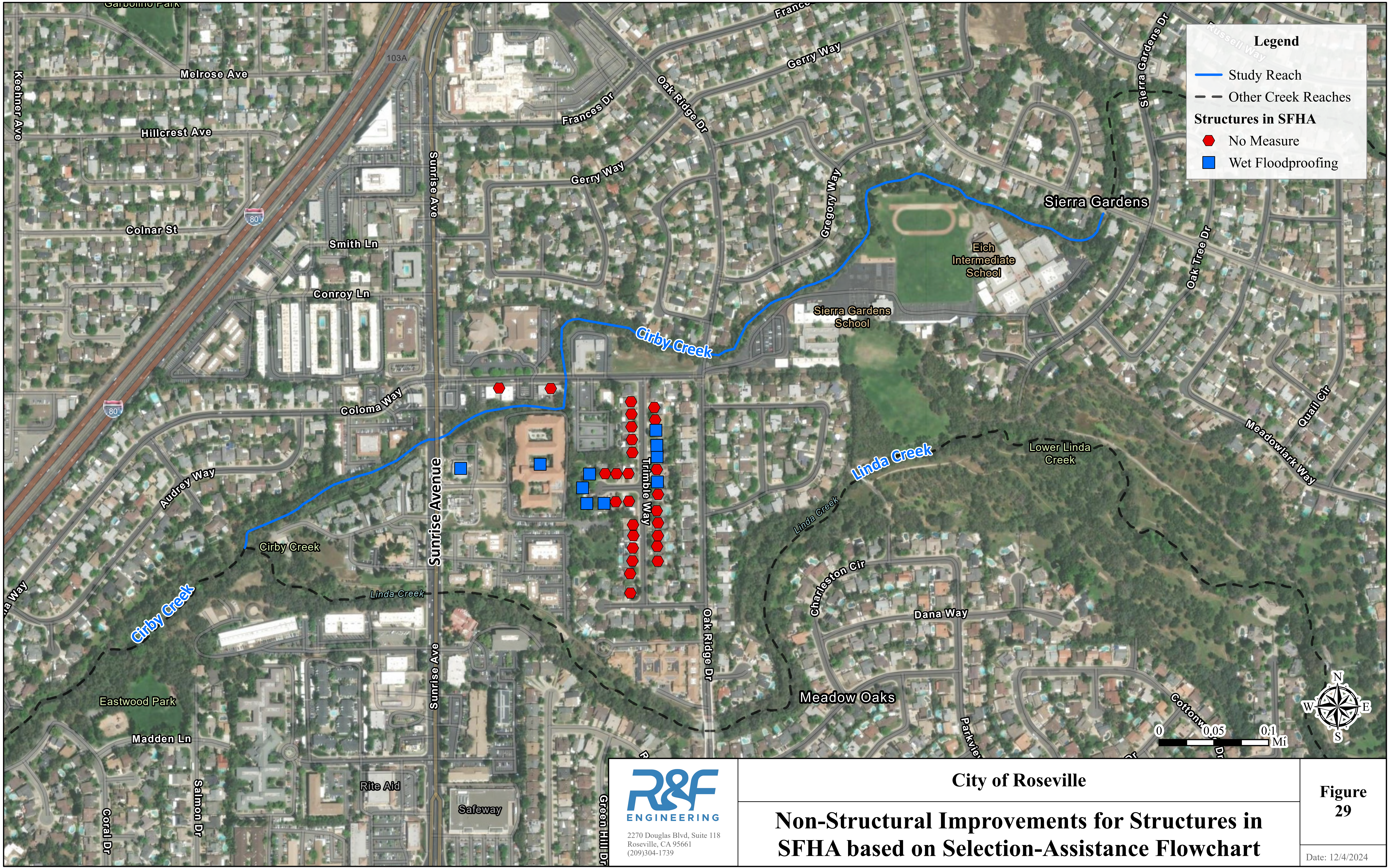
Out of the 37 structures, six (6) structures were confirmed to have existing elevation certificates and lowest floor elevations above the BFE and were therefore determined to require “No Measure”. Of the remaining 31 structures, 21 structures were identified as having minimal depth of flooding (<0.5 feet) and were therefore also determined to require “No Measure”. The remaining ten (10) structures were determined to best suited for “Wet Floodproofing”. Zero structures were determined to be best suited for “Elevation” or “Acquisition” based on the DWR flowchart. Figure 29 presents the properties included in the analysis and their recommended non-structural improvements. Appendix B presents a tabulated summary of the non-structural improvements analysis.

While wet floodproofing is a viable non-structural measure to protect flood-prone structures, FEMA does not typically provide grant funding to wet floodproof residential structures. Therefore, this alternative would come with a significant financial burden on property owners. Therefore, a separate analysis was conducted where “Wet Floodproofing” was considered a non-viable measure in the DWR flowchart, leaving “No Measure”, “Elevation”, or “Acquisition” as potential measures. There were still 27 of the 37 structures that were determined to require “No Measure” based on minimal depth of flooding. Two (2) of the remaining ten (10) structures were deemed “Critical” (urgent care office and retirement facility) and are multi-story. Therefore, they are not candidates for “Elevation” and would be best suited for “Acquisition” (without “Wet Floodproofing” as a viable option). The remaining eight (8) structures all followed the same path through the flowchart, depending on how the analysis was modified. The possible recommended measures for the eight (8) remaining structures based on the DWR flowchart (without “Wet Floodproofing” as a viable option) are detailed below:

- Based on the data available for this analysis, it was estimated that the depth of flooding on the ten structures was less than three (3) feet. If a more refined analysis were to find that the depth of flooding was greater than three (3) feet, the eight properties would be best suited for “Acquisition”.

- Similarly, if a more refined analysis were to find that the velocity of flooding was greater than 3 feet-per-second, the eight properties would be best suited for “Acquisition”.
- For the purposes of this analysis, all the properties were assumed to be in “Good to Excellent” condition. If the properties were assumed to be in “Poor to Fair” condition, the eight properties would be best suited for “Acquisition”.
- Should the high density (> 4 per acre) structures be ignored, as well as the condition of the structures be assumed as “Poor to Fair”, the eight properties would be best suited for “Acquisition”.
- Should the high density (> 4 per acre) structures be ignored, the condition of the structures be assumed as “Poor to Fair”, and the depth of flooding be greater than three (3) feet, then the eight properties would be best suited for “Acquisition”.
- Lastly, should the high density (> 4 per acre) structures be ignored and the depth of flooding be greater than three (3) feet, but the condition remains “Good to Excellent”, then the eight properties would be best suited for “Elevation”.

As seen, under most circumstances in the alternative analysis where “Wet Floodproofing” was eliminated as a viable measure, “Acquisition” as found to be the best suited measure based on the DWR flowchart. In practice, the best suited measure for each structure would likely be determined on a case-by-case basis after field investigations, further analyses, discussions with property owners and stakeholders, and identification of funding opportunities.



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Non-Structural Improvements for Structures in SFHA based on Selection-Assistance Flowchart

Figure 29

Date: 12/4/2024

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4.2. Right-of-Way and Land Acquisition

Any structural improvements pursued as part of this study would require use of available land, either publicly- or privately-owned. The need to use private land would result in acquisition or agreement between the owner and the City which would directly impact the cost to implement the Project, as well as potentially impact the ability to maintain the Project once constructed. The City provided parcel data and ownership information to evaluate the alternatives for the land that would be required to implement them. Figure 30 shows the parcels in the Study area denoted by whether they are publicly- or privately-owned.

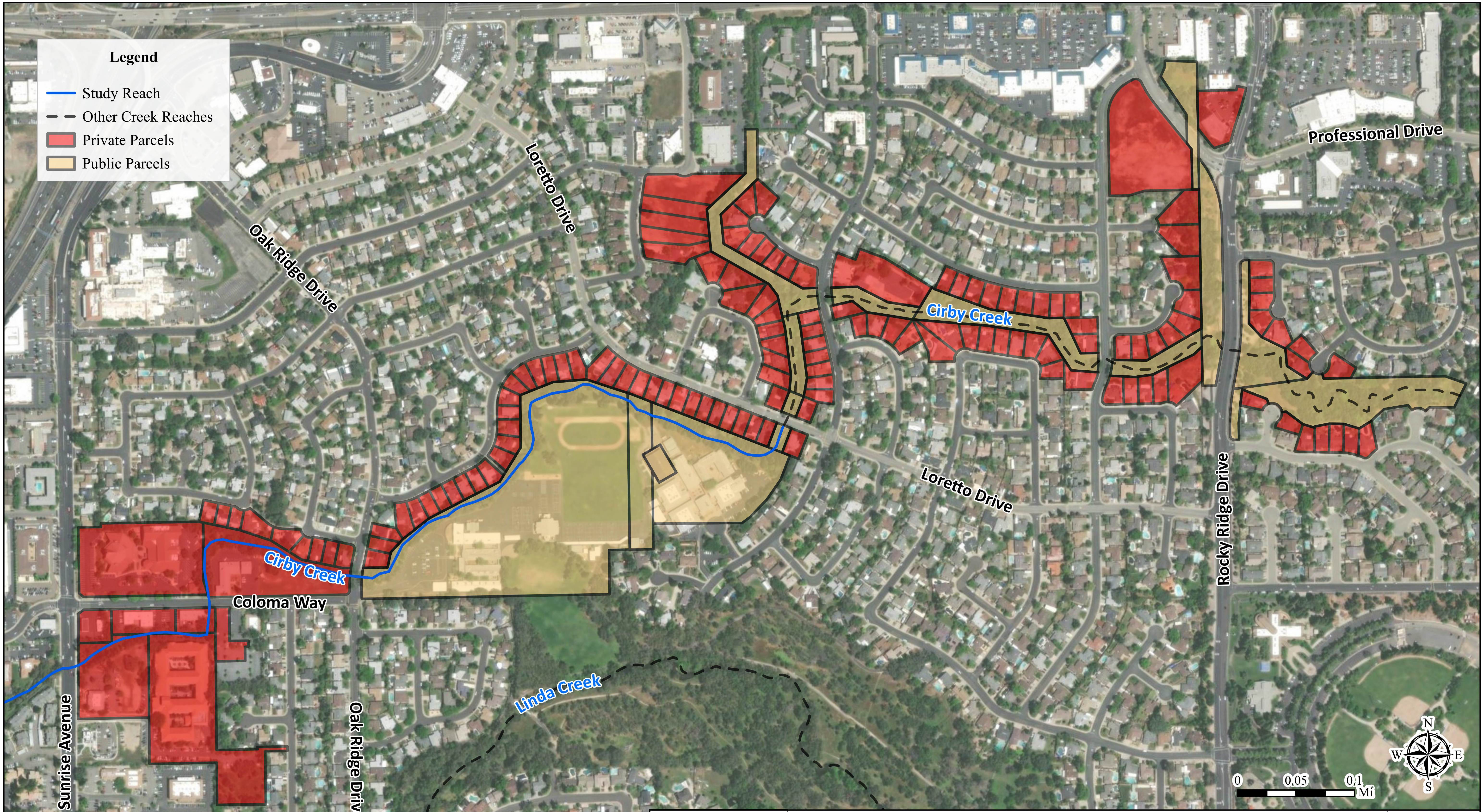
Implementation of the floodwall alternative **(Alternative A)** along the left and right bank of Cirby Creek would need to accommodate the construction and maintenance of the floodwalls. A 15-foot maintenance easement on the landside of the floodwall is typically required (for example by USACE), which would likely require public and private land acquisitions to achieve, dependent on the final floodwall alignment. This maintenance corridor can sometimes be reduced with approval of variances, however rarely can it be less than 10-12 feet.

The current floodwall alignments were developed at a conceptual level of detail. Based on the conceptual floodwall alignment, which follows the top of bank elevation all along Cirby Creek from Loretto Drive to Sunrise Avenue, the required land to implement the alternative would be up to 1.2 acres (53,000 sq ft) of public land and up to 1.6 acres (68,000 sq ft) of private land. From Oak Ridge Drive to Sunrise Avenue, no public land and up to 1.0 acres (43,000 sq ft) of private land would be required to implement the alternative. *It should be emphasized that there is very limited space on the banks along some parts of the creek and the required land acquisition for the floodwalls could create significant impacts on some parcels of private property.* The final alignment should be further refined based on topography and impacts to local residents if floodwalls are pursued as part of the preferred alternative.

Implementation of the off-stream storage options **(Alternative B)** is currently proposed in open space and on a mixture of public and private land. The larger potential MSF basin is located completely on public land and would require up to 7.5 acres. Similarly, the smaller MSPL basin is located on public land, but would only require up to 1.2 acres to implement. Lastly, the smaller CF basin is located on private land and would require up to 1.1 acres to implement.

The retrofit of Sunrise Avenue bridge **(Alternative C)** is located completely on public land and the existing crossing is managed by CalTrans. Implementation of this alternative would require less than half an acre to implement but would require close coordination and approval from CalTrans.

The implementation of non-structural measures **(Alternative D)** would not require land acquisition or additional right-of-way.



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Private and Public Parcel Ownership around Cirby Creek

Figure
30

Date: 5/21/2024

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4.3. Other Considerations

The scope of this Study was limited to a high-level evaluation of potential hazard mitigation alternatives to reduce flood risk in the Cirby Creek area, primarily focused on hydraulic evaluations. However, it is important to consider other factors that would impact an alternative's ability to perform and/or be implemented. Below are a few other factors that were qualitatively evaluated to inform the preferred alternative selection for this Study. It should be noted that these factors should be more comprehensively evaluated in additional detail during the potential next phases of the Study.

- **Geotechnical** – Based on soil data from the National Resources Conservation Service (NRCS) Web Soil Survey, the soil group in the study area is predominantly flooded xenofluvents. This corresponds to moderately-high to high draining soils with low runoff generation. For implementing potential floodwalls, this could indicate possible seepage concerns. For implementing potential detention basins, this could indicate a potential for infiltration and groundwater recharge. The soil conditions would not likely have any impact on potential implementation of a bridge retrofit or non-structural improvements other than impacts to footing depths.
- **Environmental** – Based on the California Natural Diversity Database (CNDDB) and the Biogeographic Information and Observation System (BIOS), Cirby Creek is suitable habitat for vernal pool fairy shrimp, steelhead trout, valley elderberry longhorn beetle, Swainson's hawk, and bank swallow. There is also known suitable western pond turtle habitat in the area. The presence of these habitats would be further evaluated within the environmental regulatory setting (such as CEQA, NEPA, or an ITP) and potential mitigation would be needed if any structural improvements were made in the Study area that impact sensitive species. Lastly, should any structural work be conducted within or along the banks of Cirby Creek, environmental permits for in-water work through entities such as USACE and/or CDFW could be required.
- **Cultural Resources** – Cultural resources information is confidential in nature and would need to be investigated by a licensed contractor during the next phases of the Study. However, the Study area is known to have historical significance with the Nisenan Maidu people and any groundbreaking work associated with structural improvements would need to be preceded with a cultural assessment of the Study area.

4.4. Preliminary Cost Estimates

Preliminary estimates of project costs for implementation of each alternative and several possible build-out scenarios are provided in Table 2. These estimates were completed at a conceptual/feasibility level of detail with the primary purpose of providing comparisons of alternatives. The estimates include construction costs, mobilization/demobilization, contingencies, land rights, mitigation, permitting, engineering, services during construction, and administration. More details on these preliminary cost estimates are contained in Appendix C.

Table 2. Conceptual Estimates of Capital Cost for Study Alternatives.

Alternative	Construction Totals ($M)	Land Acquisition ($M)	Admin, Engineering, and Other Soft Costs ($M)[1]	Total Estimated Project Cost ($M)[2]
A (Loretto-Sunrise)	11.0	0.1	10.5	21.6
A (Oak Ridge-Sunrise)	4.7	0	4.4	9.1
B (All Basins)	9.2	0.1	8.8	18.0
B (Single 7.5-AC Basin)	8.0	0	7.5	15.5
C	6.2	-	5.9	12.2
D	0.3	-	0.3	0.6

Notes:

1. Includes administration, permitting, engineering, services during construction and mitigation (ecosystem and cultural resources)
2. See Appendix C for more detail on preliminary cost estimates

While any of these alternatives could be constructed in its entirety at one time, funding limits will likely result in incremental construction over several years as funding becomes available. Since there is no way of knowing how many construction increments there may be, or how far into the future they may occur, the costs in this table represent constructing an entire project at one time. In reality, costs will increase over time – remediating a specific levee reach will cost more in ten years than it does now. Costs escalate over time, each incremental construction requires another mobilization and demobilization of equipment, and other factors such as environmental mitigation requirements may become more restrictive. Lastly, the actual costs will depend on the contractor bidding climate which cannot be predicted.

Costs will be compared with performance of each alternative and with community/political support to help inform selection of a preferred alternative.

4.5. Evaluation Metrics and Alternatives Comparison

Evaluation metrics were developed which ultimately lead to a numerical scoring and ranking of Study alternatives. The metrics are directly tied to the primary and supporting Study goals that were identified in Section 2.2 of this report. Each metric is described below, along with an accompanying narrative evaluation for each alternative.

Scoring for each of the metrics that are associated with the Study's Primary Goals is based on a scale from 1 to 15, with 15 being the strongest score. Scoring for each of the metrics that are associated with the Study's Supporting Goals is based on a scale from 1 to 5, with 5 being the strongest score.

The scoring can be considered subjective, however the primary purpose is to provide a means of comparison of alternatives. The final scores for each alternative are summarized in Table 3.

- **Property Protected** – The portion of the Study area within the FEMA floodplain is urban and primarily residential, with some commercial properties as well. There is also a retirement facility and an urgent care facility. This metric is primarily evaluated on whether the alternative provides 100-year flood protection to properties.
    - **Alternative A** provides 100-year flood protection for the entire Study area, removing all 37 structures from the FEMA floodplain. There is some transfer of risk as WSEs and slightly raised upstream and downstream of the potential floodwalls, however this is considered inconsequential. For these reasons, Alternative A receives a score of 15.
    - **Alternative B** removes up to 17 structures from the 100-year floodplain and lowers the WSE by up to 2.3 feet in Cirby Creek. Therefore, Alternative B receives a score of 12.
    - **Alternative C** removes approximately 3 structures from the 100-year floodplain and lowers the WSE in Cirby Creek by 0.8 feet in the area between Sunrise Avenue and Coloma Way. Therefore, Alternative C receives a score of 6.
    - **Alternative D** does not provide 100-year flood protection for any of the Study area, but would reduce flood damage to structures within the FEMA floodplain via non-structural improvements. Therefore, Alternative D receives a score of 12.
- **Reduced Risk to Lives** – In general, the risk to lives from flooding in the Study area is minimal. While the area is urban and densely populated, there are only 37 structures in the FEMA floodplain, the flooding is relatively shallow, and there are good egress options for those properties. There is a multi-story retirement facility located within the floodplain which has approximately 200 units. Most of the units are on elevated floors and are not at risk for life loss due to flooding. However, the lower floor would likely need to be evacuated during a flood event. Regardless, the flooding depths for the 100-year event are only estimated to reach up to 4 feet at the facility, so risk of life loss is still minimal.
    - **Alternative A** provides 100-year level of protection for the entire Study area, so it receives a score of 12.
    - **Alternative B** removes up to 17 structures from the 100-year floodplain and lowers the WSE by up to 2.3 feet in Cirby Creek. Therefore, Alternative B receives a score of 9.
    - **Alternative C** removes approximately 3 structures from the 100-year floodplain and lowers the WSE in Cirby Creek by 0.8 feet in the area between Sunrise Avenue and Coloma Way. The main benefit of this alternative is that it keeps Sunrise Ave bridge from overtopping, providing reliable egress and emergency response during a flood event, however this is considered in the scoring of the 'Floodplain Management' metric. Therefore, Alternative C receives a score of 6.

- **Alternative D** does not provide 100-year flood protection for any of the Study area, but would reduce flood damage to structures within the FEMA floodplain via non-structural improvements. However, raising and floodproofing structures is primarily for the reduction of potential flood damage rather than a life-saving measure. Therefore, Alternative C receives a score of 3.

- **Floodplain Management** – Elements of floodplain management may include land use planning, emergency preparedness and response activities, and residual risk management. With the Study area already being highly urbanized, land use planning was not considered as a major factor in the scoring of this metric and more emphasis was put on an alternative's contribution to improving emergency preparedness/response and residual risk management.
    - **Alternative A** removes all properties in the Study area from the FEMA floodplain which is why it received high scores for protecting property and lives. However Alternative A does not necessarily address residual risk management. Therefore, it receives a score of 3.
    - **Alternative B** removes up to 17 structures from the 100-year floodplain and lowers the WSE by up to 2.3 feet in Cirby Creek which is why it received high scores for protecting property and lives. However Alternative B does not necessarily address residual risk management. Therefore, it receives a score of 3.
    - **Alternative C** keeps the Sunrise Ave bridge from overtopping, providing reliable egress and emergency response during a flood event which increases its score for residual risk management. Therefore, it receives a score of 9.
    - **Alternative D** identifies non-structural measures that would reduce flood damage to structures that are left in the floodplain. This is a key element of residual risk management and, therefore, it receives a score of 15.
- **Improved Maintenance** – Impacts to maintenance efforts vary throughout the alternatives, with some elements of alternatives increasing the maintenance needs within Cirby Creek and others elements providing for more efficient maintenance when compared to existing conditions.
    - **Alternative A** would come with increased maintenance requirements as the City would need to inspect and maintain the new floodwalls. It would at least marginally improve maintenance in the sense that it would reduce or eliminate cleanup needed in the overbank areas following a high flow event. Therefore, Alternative A receives a score of 2.
    - **Alternative B** would also increase maintenance requirements as the City would need to inspect and maintain the vegetation in the detention basins as well as the potential outfall pump station and inflow weir. The alternative would lower the stage in Cirby Creek which could reduce maintenance needs from high flow

events, but this benefit would be minor as there would still be the potential for overbank flow. Therefore, Alternative B receives a score of 1.

    - **Alternative C** would likely improve maintenance as it would replace the culverts with a full span bridge. Culvert inspections and clearing would be eliminated. There would still be some maintenance and inspection associated with the bridge undercrossing, although minimal. Therefore, Alternative C receives a score of 4.
    - **Alternative D** would not impact maintenance as it would primarily involve non-structural improvements on private property. It would not increase or decrease maintenance efforts, therefore, Alternative D receives a neutral score of 2.
- **Promote Ecosystem/Habitats** – The opportunities to promote ecosystem and habitats is limited in the Study area.
    - **Alternative A** would likely have a negative impact on ecosystem and habitats as it would involve vegetation clearing along the Cirby Creek embankments and replace it with a floodwall and easement. Therefore, Alternative A receives a score of 1.
    - **Alternative B** would also do little to promote ecosystem or habitat and may have a negative impact associated with the construction and maintenance of the outfall pump station and inflow weir. However, the impacts to existing riparian habitat would be less than that of Alternative A. Therefore, Alternative B receives a score of 2.
    - **Alternative C** would potentially provide benefits to the fish and salmonid populations as the full span bridge would eliminate potential entrapment and improve the navigability of Cirby Creek. Therefore, Alternative C receives a score of 4.
    - **Alternative D** would not contribute to promoting ecosystem or habitat, however it would also not make it worse. If vegetation clearing was increased as part of the alternative, it could potentially have some negative impacts to existing habitat. Therefore, Alternative D receives a score of 2.
- **Promote Multi-Benefit Components** –Multi-benefit components can be incorporated into flood control projects and may include enhancement of recreation opportunities (bike/walking trails, parks, etc.) or open space, improving water quality, and/or improving water supply reliability. It can also include habitat enhancement, but that benefit was tracked separately for the purposes of this evaluation matrix.
    - **Alternative A** provides opportunities for recreation components to be added to the final design such as a walking/biking trail adjacent to the floodwall and within the ROW easement that would be established. This would require more land be acquired than if just the floodwall was implemented but would provide up to 1.3 miles of trails that would connect Loretto Drive to Coloma Way.

Further, by eliminating all flooding in the Study area, it would also improve water quality by preventing the release of toxic substances and oil that are commonly stored at residences and businesses and released during flooding. Lastly, it would maintain safe egress and evacuation routes for residents. Therefore, Alternative A receives a score of 4.

  - **Alternative B** also provides opportunities for recreation by having the proposed detention sites be multi-use. The smaller CF detention basin site could be converted from a relatively unused open field to a sports field or a park. The larger MSF detention basin is already a sports field and would be maintained as such if the alternative was implemented. The other small MSPL detention basin site is a parking lot and would likely be maintained as such. Therefore, Alternative B receives a score of 4.
  - **Alternative C** does not have the multi-benefit opportunities that Alternatives A and B have. There are already sidewalks on the existing crossing so there would be no improvements to recreation. There could be a minor increase in habitat for fish and salmonids as passage may be improved with a full span bridge, however this was already considered in a separate metric.. Therefore, Alternative C receives a score of 1.
  - **Alternative D** would do very little to promote multi-benefit components. There may be a slight improvement in water quality if structures are raised and toxic substance releases are reduced during floods, however this benefit is likely minimal. Therefore, Alternative D receives a score of 1.
- **Improve Institutional Support** – Institutional support is a measure of consistency with local agency goals and objectives, consistency with the community's General Plan goals and objectives, consistency with other local/regional/State planning, and ease of approval for implementation of the alternative.
  - **Alternative A** is consistent with City and other agency goals and objectives of improving flood protection for the community. The City just implemented a similar flood protection project with floodwalls on adjacent streams and could follow a similar design and plan to achieve approval and institutional support. The need for land acquisition for floodwall implementation and the hurdle of environmental permitting slightly lower the score for this alternative. Therefore, Alternative A receives a score of 3.
  - **Alternative B** is also consistent with City and other agency goals and objectives of improving flood protection for the community. Two of the detention basin sites are on public property at Warren T. Eich Middle School. This would likely require coordination and approval from the school board and may face hurdles in reaching an agreement. Therefore, Alternative B receives a score of 3.

- **Alternative C** would provide some flood risk reduction and would improve the reliability of a main roadway bridge. While this would likely be a desirable project, it would require close coordination with and approval from CalTrans. It would also involve potential traffic implications on a busy street during construction, which may decrease institutional support. Therefore, Alternative C receives a score of 3.
- **Alternative D** implements non-structural measures that would minimize flood risk and flood damage. This is consistent with City of Roseville goals that are outlined in various City documents. For example, the City's Multi-Hazard Mitigation Plan emphasizes non-structural strategies and the City's floodplain management goals aim to minimize flood risk. In addition, California DWR actively promotes non-structural flood management measures as cost-effective and sustainable solutions. The main roadblock to implementation of this alternative is lack of funding that is available for non-structural measures. Therefore, Alternative D receives a score of 4.

- **Sensitivity to Climate Change** – The sensitivity to climate change is a measure of the alternative's flexibility and resiliency/adaptability if, for example, hydrologic conditions were to change on Cirby Creek in the future.
    - **Alternative A** is resilient to climate change as the floodwalls would be built with extra freeboard throughout (100-year flood + 3 feet). However, there is limited capability to raise a floodwall significantly once constructed; major raises would likely require rebuilding or significantly modifying the floodwall to have sufficient footing capacity and structural integrity. Therefore, Alternative A receives a score of 3.
    - **Alternative B** is less resilient to climate change as the detention basins would not be able to be upsized significantly if at all once built. The off-channel storage would provide flood risk reduction under potential future climate conditions, however those benefits would continue to be diminished as high flow events grew larger over time. Therefore, Alternative B receives a score of 2.
    - **Alternative C** is even less resilient to climate change as there are no improvements that could be made to the crossing to increase conveyance capacity once the bridge was made to be full span. The increased capacity will help reduce flooding and overtopping during progressively higher flow events, however even with the retrofitting there is no freeboard for the current climate 100-year event. Therefore, Alternative C receives a score of 2.
    - **Alternative D** would reduce risk to individual structures for future climate change events, however these improvements would be site-specific on private property and would not make the entire Cirby Creek system more resilient. Therefore, Alternative D receives a score of 2.

- **Community Support** –Community support is critical to implementation of any alternative. Land acquisition, local cost-sharing, and other factors rely on strong community support. This metric attempts to estimate whether there might be strong support or opposition for an alternative, but this would ultimately need to be reevaluated through community meetings and public outreach activities during subsequent CEQA phases of a project and during future planning and design efforts.
    - **Alternative A** would likely have mixed support from the community. The floodwalls would protect property throughout the Study area and would potentially provide recreation trails along its alignment. However, they would also create somewhat of a "fence" in the backyards of those properties along Cirby Creek and would potentially require land acquisition in certain reaches which may not garner support from those community members. Therefore, Alternative A receives a score of 3.
    - **Alternative B** would likely have positive community support. The storage areas are mostly proposed on public land and would not require acquiring large amounts of private land. The storage areas would provide mixed use sites where existing school fields, playgrounds, and parking lots could maintain their functions. However, it's also a potentially expensive alternative that would not completely eliminate the flood problem along Cirby Creek on its own. Therefore, Alternative B receives a score of 4.
    - **Alternative C** would likely have mixed community support. Completing the bridge project would improve the conveyance capacity and would provide more reliability as it would not overtop during high flow events. However, it would also require significant traffic control and would greatly impact transportation and traffic on a main thoroughfare in the City during construction. Therefore, Alternative C receives a score of 3.
    - **Alternative D** may receive limited community support if there is not substantial financial assistance to implement non-structural measures that is provided to participating residents. There is currently limited State and federal funding available to help residents with these efforts. Raising residences and flood-proofing structures can be considered a large hassle to people. Participation in a non-structural program would not be mandatory and, while it's unknown if there would be string support for a non-structural program, it is unlikely to have strong opposition. Therefore, Alternative D receives a score of 2.

The scoring for each metric for Alternatives A, B, C, and D is summarized in Table 3 along with the total scores and costs of each alternative.

Table 3. Alternatives Evaluation Matrix and Scoring

Alternatives Evaluation Matrix				
Metric	**Alternatives**			
	A	**B**	**C**	**D**
Primary Goal – Improve Flood Risk Management	**-----Scoring (1-15)-----**			
Property Protected	15	12	6	12
Reduced Risk to Lives	12	9	6	3
Floodplain Management	3	3	9	15
Supporting Goals	**-----Scoring (1-5)-----**			
Improved Maintenance	2	1	4	2
Promote Ecosystem/Habitats	1	2	4	2
Promote Multi-Benefit Components	4	4	1	1
Improve Institutional Support	3	3	3	4
Other Factors	**-----Scoring (1-5)-----**			
Sensitivity to Climate Change	3	2	2	2
Community Support	3	4	3	2
	Compare costs with total scores			
Total Score (out of 75)	**46**	**40**	**38**	**43**
Project Cost Estimate ($ Million)	**21.6[a] / 9.1[b]**	**18.4[c] / 15.5[d]**	**12.2**	**0.6**

[a] *Sunrise-Loretto*
[b] *Sunrise-Oak Ridge*
[c] *All Basins*
[d] *Single 7.5-ac Basin*

5. PREFERRED ALTERNATIVE

The matrix in Table 3 includes the total scoring and estimated project costs for each alternative. Below is a brief comparison of the alternatives and their performance when considering the scoring metrics and project costs:

- Alternative A (Floodwalls) – Alternative A scored the highest of all the alternatives. However, floodwalls from Sunrise Avenue to Loretto Drive had the highest cost of all the alternatives. In comparison, floodwalls from Sunrise Avenue to Oak Ridge Drive was a lower cost alternative and still provided most of the same benefits. Alternative A with floodwalls from Sunrise Avenue to Oak Ridge Drive was therefore retained as the preferred alternative.
- Alternative B (Off-Channel Storage) – As currently configured, Alternative B scored high in its evaluation, however it would not be a stand-alone solution to the flood issues along Cirby Creek and would need to be implemented alongside other measures. It carries a relatively high cost of implementation which may make it less desirable, but it does show promising stage reduction potential. Therefore, Alternative B was dropped as a stand-alone preferred alternative, but could be considered for implementation as part of a more comprehensive preferred alternative. It could potentially be a supplemental component to Alternative A and could reduce the needed floodwall heights that are currently prescribed with Alternative A.
- Alternative C (Sunrise Ave Crossing Retrofit) – As currently configured, Alternative C scored the lowest of all alternatives. It also carries a relatively high cost which makes it less desirable. Therefore, Alternative C was dropped from consideration as the preferred alternative, but could be considered in future City projects as it has potential to improve the reliability of the Sunrise Avenue bridge crossing during high flow events in Cirby Creek.
- Alternative D (Non-Structural Improvements) – Alternative D scored high in its evaluation, but mostly because it was a low-cost and relatively benign option to reduce risk of flood damage at targeted structures. Alternative D was dropped as a stand-alone preferred alternative, however with its low cost and voluntary involvement of property owners, it could be considered for implementation as part of a more comprehensive preferred alternative.

5.1. Selected Preferred Alternative

The Preferred Alternative for the Cirby Creek Hazard Mitigation Study is Alternative A where floodwalls are proposed from Sunrise Avenue to Oak Ridge Drive. This selected alternative comes with the option of also including components of Alternative B (off-channel storage) and Alternative D (non-structural improvements) as supplemental and complementary features. The following describes the features of the Preferred Alternative and the reasons for refining Alternative A and incorporating components of the other alternatives to improve performance.

Due to the high estimated capital cost of the full floodwall option of Alternative A (approx. $21.6M), the extents of the proposed floodwalls were reconsidered to better optimize flood protection benefits in a more cost effective manner. As shown in Section 4.1.1, a floodwall that terminates at Oak Ridge Drive was much more cost effective, but may still result in overbank flooding upstream of Oak Ridge Drive. Therefore, Alternative A was refined to extend the floodwalls upstream on both banks of Cirby Creek to tie-in to high ground located just upstream of Oak Ridge Drive. This refinement would: (1) still protect the Study Area from overbank flooding from Cirby Creek; (2) eliminate the potential flanking around the floodwall at Oak Ridge Drive; and (3) allow the existing high ground to contain any potential surcharge upstream of the floodwall within the banks of Cirby Creek and not induce flooding upstream. The Preferred Alternative floodwalls would begin at Sunrise Avenue bridge and would terminate upstream of Oak Ridge Drive at roughly RS 9638.99 and RS 10245.4 on the left and right banks, respectively. It would also likely be necessary to retrofit the Sunrise Ave, Coloma Way, and Oak Ridge Drive bridges to include floodwalls along the upstream and downstream edges of the bridge decks so that they tie-in with the embankment floodwalls to keep the flows within the channel. The additional length of floodwalls to tie into high ground and the additional length of floodwalls along the bridge decks were incorporated in the final Preferred Alternative and estimated project costs. Implementation of the Preferred Alternative provides 100-year flood protection for the entire Study area, removing all 37 structures from the FEMA floodplain.

Figures 31, 32 and 33 show the proposed extent of the floodwalls following refinements to the Preferred Alternative.

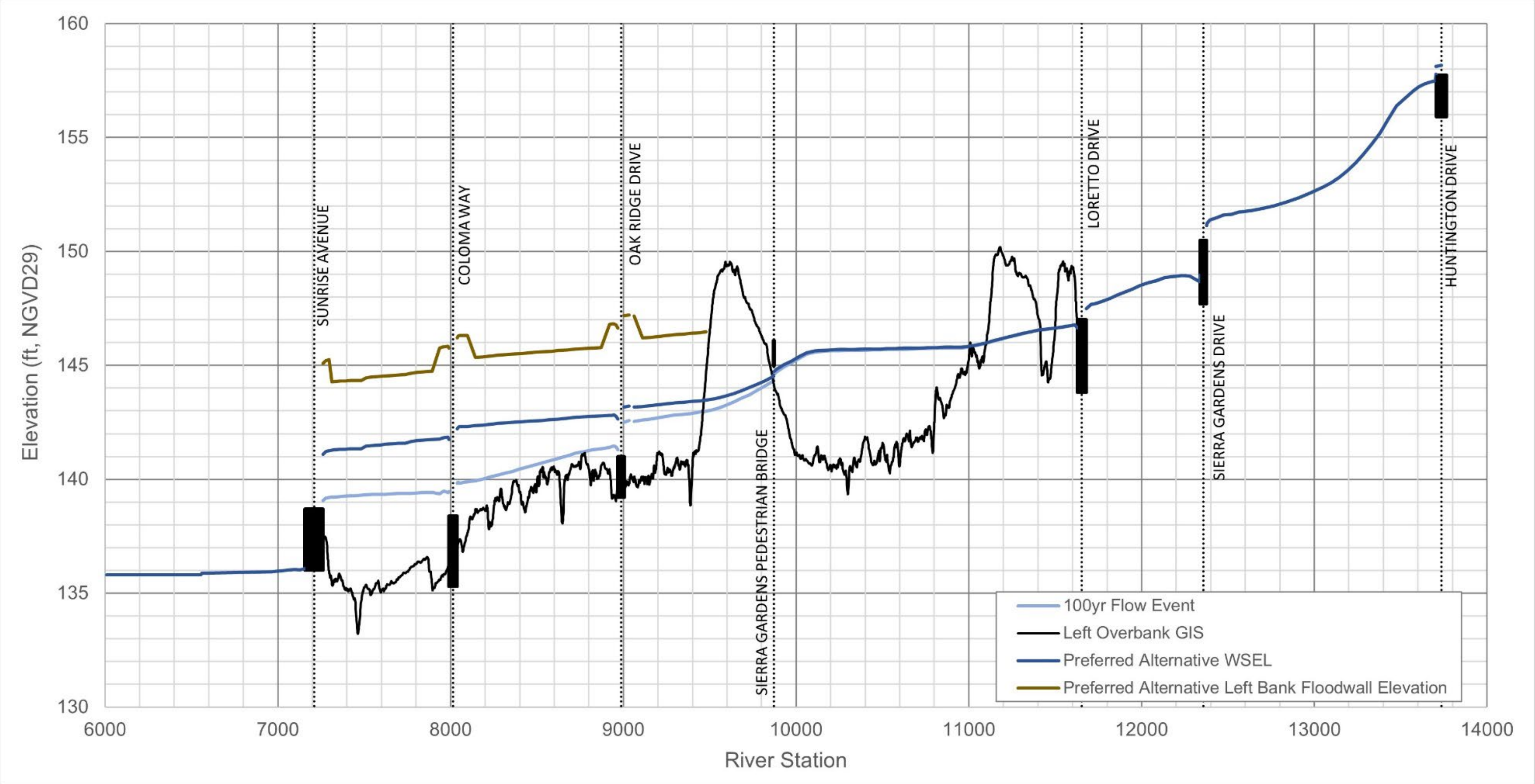


Figure 31. Preferred Alternative Left Bank Floodwall Extent and Water Surface Profile.

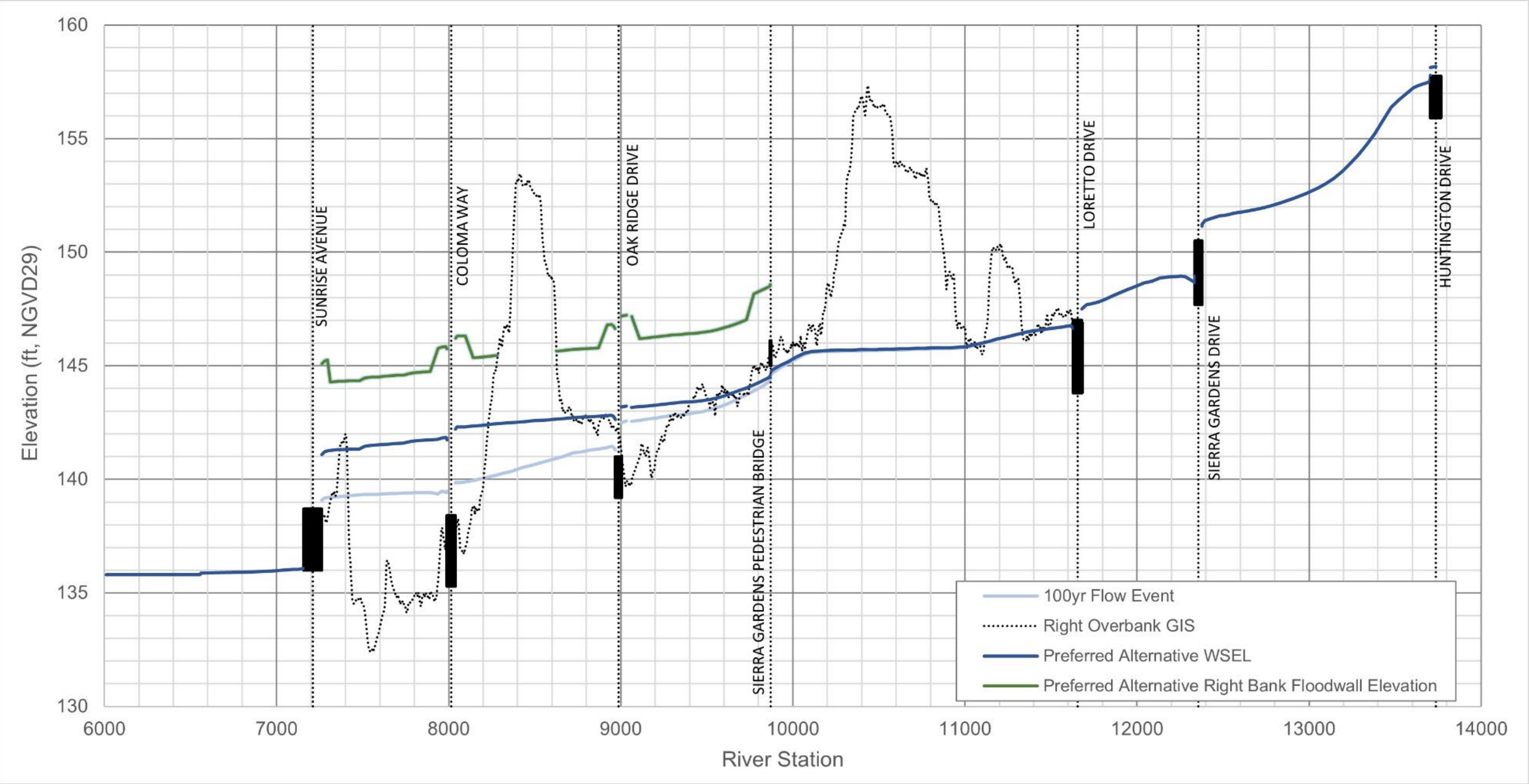
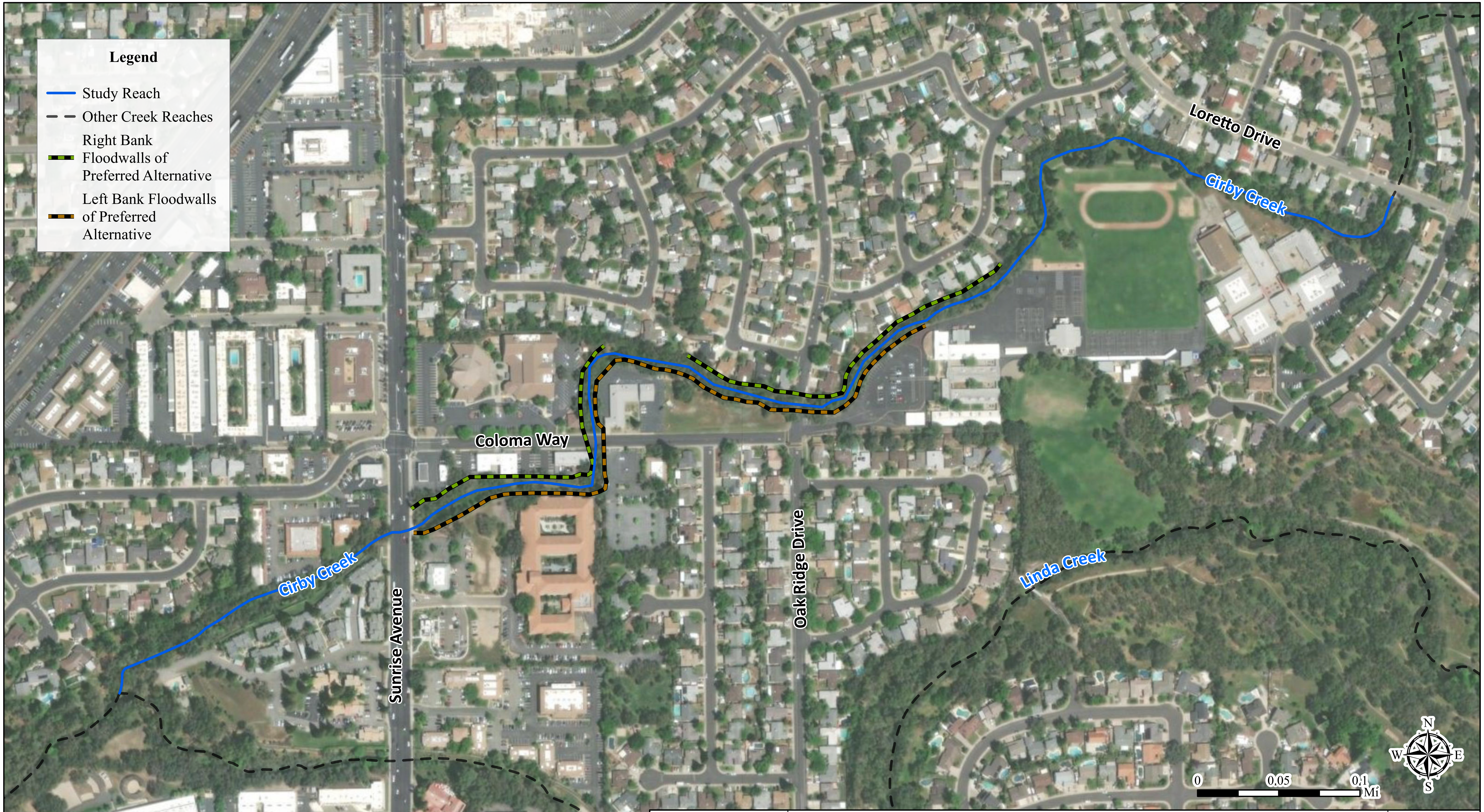


Figure 32. Preferred Alternative Right Bank Floodwall Extent and Water Surface Profile.



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Roseville, CA 95661
(209)304-1739

City of Roseville

Preferred Alternative for Cirby Creek Hazard Mitigation Study

Figure 33

Date: 7/15/2024

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Another approach to eliminate the potential flanking and surcharge associated with implementing a floodwall from Sunrise Avenue to Oak Ridge Drive would be to implement a configuration of Alternative B (Off-Channel Storage) at the Middle School Field (MSF). This would effectively lower the WSE in Cirby Creek, which would alleviate the induced flooding issues that Alternative A may cause, while also potentially reducing the height and/or length of floodwall needed between Sunrise Avenue and Oak Ridge Drive. This would inherently come with increased costs due to the implementation of two alternatives, but there may be cost savings with the reduction in floodwall height/length. The exact required storage volume required to eliminate flanking and surcharge from the floodwall would need to be determined in a future, more-refined analysis. However, based on preliminary modeling, a conservative estimate of 60 acre-feet of storage would provide an average of 1.9 feet of stage reduction in Cirby Creek between Sunrise Avenue and Oak Ridge Drive. It was assumed with the high cost of this approach that floodwall extensions into high ground would be the preferred approach. Therefore, this off-channel storage approach was not pursued further, however it is presented here as a potential option and could be analyzed in a future study.

Lastly, components of Alternative C and D could also be incorporated into the flood risk reduction efforts by the City at any time should funding become available. As discussed in previous sections, there are benefits associated with potential bridge retrofitting and/or non-structural measures. The results of this Study can be used to inform future decisions with CalTrans and/or property owners on the flood risk reduction benefits associated with pursuit of those measures.

5.2. Sensitivity to Climate Change

As mentioned in Section 4.5, the sensitivity to climate change is a measure of the Preferred Alternative’s flexibility and resiliency/adaptability if, for example, hydrologic conditions were to change on Cirby Creek in the future. The Preferred Alternative is resilient to climate change as the floodwalls would be built with extra freeboard throughout (100-year flood + 3 feet). However, there is limited capability to raise a floodwall significantly once constructed; major raises would likely require rebuilding or significantly modifying the floodwall to have sufficient footing capacity and structural integrity. Further, as potential increases in WSE occur within Cirby Creek, additional reaches of floodwalls may need to be constructed. The Preferred Alternative is aligned with Executive Order 13690 which sets to improve resilience of communities and Federal assets against the impacts of flooding by considering future climate change and incorporating sufficient freeboard into planning and design. It is also aligned with the City’s and State’s initiatives to consider future climate change in flood risk reduction projects.

5.3. Preferred Alternative Preliminary Cost Estimate

The elements of the preferred alternative discussed in Section 5.1 differ from those described in Section 3.2. Table 4 shows the estimated costs for the preferred alternative. See Appendix C for a more detailed breakdown of the Preferred Alternative cost estimate.

Table 4. Preferred Alternative Estimated Capital Costs

Item	Estimated Cost
Opinion of Total Construction Cost (includes construction contract, contingencies, land rights, permitting, mitigation, engineering/design, services during construction, and administration costs for remediation of critical levee reaches)	**$7,276,400**
Opinion of Total Soft Costs (includes all remaining elements)	**$6,963,800**
Estimated Total Project Cost	**$14,240,200**
Notes: *These costs are for implementation of all features at one time in the near future – construction of several sub-projects over many years will add costs. Since timing of this incremental construction is unknown at this time, more accurate estimates cannot be made.* *The opinion of costs above is based on available information for this study before more detailed investigations, designs, and contractor bidding. Even after detailed designs are completed, the engineer has no control over the sourcing method, cost of labor, materials, equipment, the contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from the opinion of cost due to bidding climate, competition, and materials escalation by the time the project is let out for bid and construction. The engineer does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.*	

As shown above, by refining Alternative A the Preferred Alternative cost is estimated to be reduced to $14.2M. While the Preferred Alternative could be constructed in its entirety at one time, funding realities may result in incremental construction over several years as funding becomes available. Since there is no way of knowing how many construction increments there may be, or how far into the future they may occur, the costs in Table 4 represent constructing an entire project at one time in 2024 dollars. Costs escalate over time, each incremental construction requires another mobilization and demobilization of equipment, and other factors such as environmental mitigation requirements may become more restrictive. Lastly, the actual costs will depend on the contractor bidding climate that cannot be predicted into the future.

Again, the incorporation of a configuration of Alternative B would likely increase overall project costs as a result of construction off-channel storage. However, it would likely reduce the costs of the floodwall components by lowering the stage and required height/length of the floodwall. The exact size of the potential storage basin, revised floodwall sizing, and overall project cost could be analyzed further in a future study.

Additional maintenance efforts would be required for the new structural components of the Preferred Alternative. However, there will be some reduction in need for flood fighting and post-flood cleanup, resulting in some annual cost savings. The City’s maintenance budget would need to be further evaluated with the implementation of the Preferred Alternative.

6. RECOMMENDATIONS AND NEXT STEPS

This Study defines the feasibility of flood hazard mitigation options for the City of Roseville in the Cirby Creek area. This Study is a preliminary step towards selecting and implementing a preferred flood risk reduction solution for the Cirby Creek study area.

The next step is for the decision makers to review the Study information, preliminary analyses, and estimated costs to evaluate the flood risk reduction options for the Study area and how they fit into the overall flood management planning vision for the City. The recommendations are intended to provide preliminary insights and guidance for decision makers to consider when deciding on the course of action for Cirby Creek Flood Mitigation.

Recommendations

1. The existing hydraulic model was sufficient for preliminary evaluations, however an updated 1D/2D hydraulic model should be developed for the study area prior to moving forward with any alternative. The existing model used for this analysis was limited to 1D, was developed in a now outdated version of HEC-RAS, did not include updated land use or terrain data, and would be insufficient for design purposes. It was outside of the scope of this Study to do major model improvements or build a new model. An updated model would be necessary to properly evaluate the Preferred Alternative and inform design. Further, an updated model would provide the City with a robust tool for future analyses and could be expanded upon to include other areas of the City's watersheds, as needed.
2. Due to the vegetation and sedimentation present within Cirby Creek, it would be preferrable to obtain a more recent site survey along the Study Reach to obtain accurate channel invert, geometry, and embankment elevations. This would also help inform the City on potential sedimentation and channel capacity issues over time if surveys were completed on a recurring basis.
3. As part of the future analysis, additional geotechnical, financial, environmental, and cultural evaluations would be critical in identifying potential opportunities and constraints associated with the Preferred Alternative.
4. Preliminary stakeholder outreach could be conducted to gauge interest in the Preferred Alternative, as well as potentially incorporating components of the other alternatives. Reaching out to CalTrans, the Warren T. Eich Middle School, and the public would inform potential future decisions. Additionally, beginning discussions with applicable regulatory agencies and understanding permitting requirements would help inform needs and feasibility of the Preferred Alternative.

Appendix A
Full Cirby Creek Extents Figure

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City of Roseville

Cirby Creek Reach Extents

Figure 1

Date: 5/16/2024

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Appendix B
Nonstructural Improvements Analysis

ADDRESS	Structure Type	1/AEP	100YR BFE (ft-NGVD29)	LAG ELEV (ft-NGVD29)	FIRST FLOOR ELEV (ft-NGVD29)	SLAB/CRAWLSPACE ELEV (ft-NGVD29)	Depth (vs First Floor El)	Depth <0.5ft?	Low or High Density	Soil Type*	Slope**	Velocity of Flooding	Structure Condition***	IMPROVEMENT	IGNORE CONDITION?	IGNORE DEPTH?	IGNORE DENSITY AND CONDITION?	IGNORE DENSITY, DEPTH, AND CONDITION?	IGNORE DENSITY AND DEPTH?
911 TRIMBLE WAY	Non-Critical	NO	139	138.1	139.64	138.15	-0.6	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
909 TRIMBLE WAY	Non-Critical	NO	139	137.6	139.03	137.67	0.0	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
908 TRIMBLE WAY	Non-Critical	NO	139	138.8	140.27	138.88	-1.3	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
907 TRIMBLE WAY	Non-Critical	NO	139	137.3	138.91	137.55	0.1	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
906 TRIMBLE WAY	Non-Critical	NO	139	138.7	140.27	138.84	-1.3	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
905 TRIMBLE WAY	Non-Critical	NO	139	137.2	138.73	137.34	0.3	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
904 TRIMBLE WAY	Non-Critical	NO	139	138.6	140.21	138.72	-1.2	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
903 TRIMBLE WAY	Non-Critical	NO	139	139.1	139.88	139.36	-0.9	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
902 TRIMBLE WAY	Non-Critical	NO	139	138.6	140.05	138.67	-1.1	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
900 TRIMBLE WAY	Non-Critical	NO	139	138.8	140.27	138.75	-1.3	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
816 TRIMBLE WAY	Non-Critical	NO	139	138.2	139.68	138.19	-0.7	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
814 TRIMBLE WAY	Non-Critical	NO	139	137.7	138.31	137.71	0.7		HIGH	PERMEABLE	0.01%	0.2	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ELEVATION
812 TRIMBLE WAY	Non-Critical	NO	139	137.6	139.13	137.63	-0.1	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
811 TRIMBLE WAY	Non-Critical	NO	139	138.3	138.98	138.46	0.0	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
810 TRIMBLE WAY	Non-Critical	NO	139	137.4	138.02	137.41	1.0		HIGH	PERMEABLE	0.01%	0.2	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ELEVATION
809 TRIMBLE WAY	Non-Critical	NO	139	138.8	139.51	138.95	-0.5	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
808 TRIMBLE WAY	Non-Critical	NO	139	137.3	138.04	137.34	1.0		HIGH	PERMEABLE	0.04%	0.4	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ELEVATION
807 TRIMBLE WAY	Non-Critical	NO	139	138.9	139.43	138.93	-0.4	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
806 TRIMBLE WAY	Non-Critical	NO	139	137.4	138.28	137.59	0.7		HIGH	PERMEABLE	0.19%	0.9	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ELEVATION
805 TRIMBLE WAY	Non-Critical	NO	139	139.3	139.98	139.42	-1.0	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
804 TRIMBLE WAY	Non-Critical	NO	139	137.9	138.56	137.97	0.4	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
803 TRIMBLE WAY	Non-Critical	NO	139	140.1	140.74	140.15	-1.7	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
802 TRIMBLE WAY	Non-Critical	NO	139	138.1	138.56	138.08	0.4	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
707 SUNRISE AVE	Critical	NO	139	135.4	141.9	135.6	-2.9		-	PERMEABLE	0.20%	0.9	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION
701 SUNRISE AVE	Critical	NO	139	-	137.3	-	1.7		-	PERMEABLE	-	-	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION
1309 WENDY CT	Non-Critical	NO	139	139.3	139.81	139.45	-0.8	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
1224 COLOMA WAY	Non-Critical	NO	139	134.9	139.1	135.7	-0.1	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
1212 COLOMA WAY	Non-Critical	NO	139	136.6	139	139	0.0	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
108 ZIEN CT	Non-Critical	NO	139	136.7	138.31	138.86	0.7		HIGH	PERMEABLE	1.61%	2.6	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ELEVATION
107 ZIEN CT	Non-Critical	NO	139	136.9	138.38	136.94	0.6		HIGH	PERMEABLE	0.04%	0.4	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ELEVATION
106 ZIEN CT	Non-Critical	NO	139	136.5	138.11	136.61	0.9		HIGH	PERMEABLE	0.11%	0.7	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ELEVATION
105 ZIEN CT	Non-Critical	NO	139	137.5	139.02	137.51	0.0	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
104 ZIEN CT	Non-Critical	NO	139	136.7	138.29	136.89	0.7		HIGH	PERMEABLE	0.19%	0.9	GOOD	**WET FLOODPROOFING**	ACQUISITION	ACQUISITION	ACQUISITION	ACQUISITION	ELEVATION
103 ZIEN CT	Non-Critical	NO	139	137.2	138.95	137.45	0.1	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
102 ZIEN CT	Non-Critical	NO	139	137.2	138.96	137.33	0.0	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
101 ZIEN CT	Non-Critical	NO	139	137.5	138.85	137.48	0.2	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE
100 ZIEN CT	Non-Critical	NO	139	137.4	138.81	137.48	0.2	Yes : NO MEASURE	-	-	-	-	-	**NO MEASURE**	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE	NO MEASURE

Appendix C
Preliminary Cost Estimates

PROJECT: CIRBY CREEK HAZARD MITIGATION
OWNER: CITY OF ROSEVILLE
LOCATION: ROSEVILLE, CA

Estimator: BFL
Reviewed By: BMC

DESCRIPTION **Floodwall Alternative Feasibility Estimate**

DATE: 4/25/2024

CONSTRUCTION SERVICES

Item	Description	Units	Unit Cost	Estimated Quantity	Subtotal Rounded
1	Mobilization	%	10%	1	$ 1,003,990
2	Floodwall Excavation	BCY	$ 9.19	6,776	$ 62,300
3	Haul	LCY	$ 10.00	8,131	$ 81,300
4	Disposal	LCY	$ 10.00	8,131	$ 81,300
5	Reinforced Concrete Floodwall	CY	$ 1,400.00	6,776	$ 9,486,500
6	Floodwall Backfill	LCY	$ 8.08	4,359	$ 35,200
7	Clearing and Grubbing	AC	$ 8,063.60	1	$ 7,500
8	Hydroseed	SF	$ 1.00	114,346	$ 114,300
9	Hydromulch	SF	$ 1.50	114,346	$ 171,500
CONSTRUCTION SUB TOTALS					**$ 11,043,890**
10	ENVIRONMENTAL MONITORING & MITIGATION	%	15%		$ 1,656,584
11	UNALLOCATED COSTS - LOW	%	5%		$ 552,195
12	DESIGN AND ENGINEERING	%	15%		$ 1,656,584
13	PERMITTING AND LEGAL	%	5%		$ 552,195
14	ENGINEERING DURING CONSTRUCTION	%	5%		$ 552,195
15	CONSTRUCTION MANAGEMENT/SITE INSPECTION	%	15%		$ 1,656,584
16	EASEMENTS	AC	$ 50,000.00	1.75	$ 87,500
17	CONTINGENCY	%	35%		$ 3,865,362
OPINION OF PROBABLE COSTS					**$ 21,623,086**

Note: The Opinion of Probable Cost above is based on Feasibility study level design. R&F has no control over the sourcing method, cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from the opinion of cost due to bidding climate, competition, and materials escalation by the time the project is let out for bid and construction. R&F does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.

All estimates were completed at a conceptual/feasibility level of detail with the primary purpose of providing comparisons of alternatives..

R&F
ENGINEERING

PROJECT: CIRBY CREEK HAZARD MITIGATION
OWNER: CITY OF ROSEVILLE
LOCATION: ROSEVILLE, CA

Estimator: BFL
Reviewed By: BMC

DESCRIPTION **Detention Basin Alternative Feasibility Estimate**

DATE: 4/25/2024

CONSTRUCTION SERVICES

Item	Description	Units	Unit Cost	Estimated Quantity	Subtotal Rounded
1	Mobilization	%	10%	1	$ 837,510
2	Basin Excavation	BCY	$ 10.14	126,485	$ 1,282,600
3	Haul	LCY	$ 10.00	151,782	$ 1,517,800
4	Disposal	LCY	$ 5.59	151,782	$ 848,800
5	Clearing and Grubbing	AC	$ 8,063.60	10	$ 80,600
6	Hydroseed	SF	$ 1.00	458,136	$ 458,100
7	Hydromulch	SF	$ 1.50	458,136	$ 687,200
8	Pump and Pump Install	LS	$ 2,200,000	1	$ 2,200,000
9	Process Piping and Valves	LF	$ 1,500.00	200	$ 300,000
10	Structural Components	LS	$ 500,000	1	$ 500,000
11	Electrical Components	LS	$ 500,000	1	$ 500,000
CONSTRUCTION SUB TOTALS					**$ 9,212,610**
12	ENVIRONMENTAL MONITORING & MITIGATION	%	15%		$ 1,381,892
13	UNALLOCATED COSTS - LOW	%	5%		$ 460,631
14	DESIGN AND ENGINEERING	%	15%		$ 1,381,892
15	PERMITTING AND LEGAL	%	5%		$ 460,631
16	ENGINEERING DURING CONSTRUCTION	%	5%		$ 460,631
17	CONSTRUCTION MANAGEMENT/SITE INSPECTION	%	15%		$ 1,381,892
18	EASEMENTS	AC	$ 50,000.00	9.26	$ 463,100
19	CONTINGENCY	%	35%		$ 3,224,414
OPINION OF PROBABLE COSTS					**$ 18,427,690**

Note: R&F has no control over the sourcing method, cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from the opinion of cost due to bidding climate, competition, and materials escalation by the time the project is let out for bid and construction. R&F does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.

All estimates were completed at a conceptual/feasibility level of detail with the primary purpose of providing comparisons of alternatives..

R&F ENGINEERING

PROJECT: CIRBY CREEK HAZARD MITIGATION
OWNER: CITY OF ROSEVILLE
LOCATION: ROSEVILLE, CA

Estimator: BFL
Reviewed By: BMC

DESCRIPTION **Bridge Retrofit Alternative Feasibility Estimate**

DATE: 4/25/2024

CONSTRUCTION SERVICES

Item	Description	Units	Unit Cost	Estimated Quantity	Subtotal Rounded
1	Mobilization	%	10%	1	$ 567,100
3	Bridge Modification	SF	$ 699.00	8,000	$ 5,592,000
4	Traffic Control	LS	$ 60,000.00	1	$ 60,000
5	Paving	SY	$ 20.33	933	$ 19,000
6				1	$ -
7				1	$ -
8				1	$ -
9				1	$ -
10				1	$ -
11				1	$ -
12				1	$ -
CONSTRUCTION SUB TOTALS					**$ 6,238,100**
	ENVIRONMENTAL MONITORING & MITIGATION		15%		$ 935,715
	UNALLOCATED COSTS - LOW		5%		$ 311,905
	DESIGN AND ENGINEERING		15%		$ 935,715
	PERMITTING AND LEGAL		5%		$ 311,905
	ENGINEERING DURING CONSTRUCTION		5%		$ 311,905
	CONSTRUCTION MANAGEMENT/SITE INSPECTION		15%		$ 935,715
	CONTINGENCY	%	35%		$ 2,183,335
OPINION OF PROBABLE COSTS					**$ 12,164,295**

Note: R&F has no control over the sourcing method, cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from the opinion of cost due to bidding climate, competition, and materials escalation by the time the project is let out for bid and construction. R&F does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.

All estimates were completed at a conceptual/feasibility level of detail with the primary purpose of providing comparisons of alternatives..

PROJECT: CIRBY CREEK HAZARD MITIGATION
OWNER: CITY OF ROSEVILLE
LOCATION: ROSEVILLE, CA

Estimator: BFL
Reviewed By: BMC

DESCRIPTION **Non-Structural Alternative Feasibility Estimate**

DATE: 4/25/2024

CONSTRUCTION SERVICES

Item	Description	Units	Unit Cost	Estimated Quantity	Subtotal Rounded
1	Mobilization	%	10%	1	$ 28,000
2	Structure Buyout	EA	$ 621,000	0	$ -
3	Structure Raise	EA	$ 256,371	0	$ -
4	Acre of Land Acquisition	AC	$ 382,427	0	$ -
5	Improved Evacuation Planning and Coordination	LS	$ 50,000.00	1	$ 50,000
6	Wet Floodproofing	EA	$ 10,000.00	23	$ 230,000
7				1	$ -
8				1	$ -
9				1	$ -
10				1	$ -
11				1	$ -
12				1	$ -
CONSTRUCTION SUB TOTALS					**$ 308,000**
	ENVIRONMENTAL MONITORING & MITIGATION	%	15%		$ 46,200
	UNALLOCATED COSTS - LOW	%	5%		$ 15,400
	DESIGN AND ENGINEERING	%	15%		$ 46,200
	PERMITTING AND LEGAL	%	5%		$ 15,400
	ENGINEERING DURING CONSTRUCTION	%	5%		$ 15,400
	CONSTRUCTION MANAGEMENT/SITE INSPECTION	%	15%		$ 46,200
	CONTINGENCY	%	35%		$ 107,800
OPINION OF PROBABLE COSTS					**$ 600,600**

Note: R&F has no control over the sourcing method, cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from the opinion of cost due to bidding climate, competition, and materials escalation by the time the project is let out for bid and construction. R&F does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.

All estimates were completed at a conceptual/feasibility level of detail with the primary purpose of providing comparisons of alternatives..

PROJECT: CIRBY CREEK HAZARD MITIGATION
OWNER: CITY OF ROSEVILLE
LOCATION: ROSEVILLE, CA

Estimator: BFL
Reviewed By: BMC

DESCRIPTION **Preferred Alternative Feasibility Estimate**

DATE: 7/12/2024

CONSTRUCTION SERVICES

Item	Description	Units	Unit Cost	Estimated Quantity	Subtotal Rounded
1	Mobilization	%	10%	1	$ 661,490
2	Floodwall Excavation	BCY	$ 9.19	3,964	$ 36,400
3	Haul	LCY	$ 10.00	4,757	$ 47,600
4	Disposal	LCY	$ 10.00	4,757	$ 47,600
5	Reinforced Concrete Floodwall	CY	$ 1,400.00	4,498	$ 6,296,900
6	Floodwall Backfill	LCY	$ 8.08	1,817	$ 14,700
7	Clearing and Grubbing	AC	$ 8,063.60	1	$ 4,400
8	Hydroseed	SF	$ 1.00	66,900	$ 66,900
9	Hydromulch	SF	$ 1.50	66,900	$ 100,400
CONSTRUCTION SUB TOTALS					**$ 7,276,390**
10	ENVIRONMENTAL MONITORING & MITIGATION	%	15%		$ 1,091,459
11	UNALLOCATED COSTS - LOW	%	5%		$ 363,820
12	DESIGN AND ENGINEERING	%	15%		$ 1,091,459
13	PERMITTING AND LEGAL	%	5%		$ 363,820
14	ENGINEERING DURING CONSTRUCTION	%	5%		$ 363,820
15	CONSTRUCTION MANAGEMENT/SITE INSPECTION	%	15%		$ 1,091,459
16	EASEMENTS	AC	$ 50,000.00	1.02	$ 51,200
17	CONTINGENCY	%	35%		$ 2,546,737
OPINION OF PROBABLE COSTS					**$ 14,240,161**

Note: The Opinion of Probable Cost above is based on Feasibility study level design. R&F has no control over the sourcing method, cost of labor, materials, equipment, the Contractors' methods of determining bid prices, or other competitive bidding markets. Prices may vary from the opinion of cost due to bidding climate, competition, and materials escalation by the time the project is let out for bid and construction. R&F does not assume responsibility for the use of these costs in budget analysis and will not be held liable for capital improvement cost increases associated with the development of this project.