DRAFT EXECUTIVE SUMMARY

EVALUATION OF CHANNEL CAPACITY IMPROVEMENT OPTIONS

FIELD GEOMORPHOLOGY & HYDRAULIC MODELING

EAST CREEK & WEST CREEK

FLOOD ZONE 4

Marin County Flood Control and Water Conservation District

OCTOBER 2022

INTRODUCTION

Recommendations for channel capacity improvements and other flood risk reduction measures are made based on historical and field geomorphic assessment and simulations of East Creek and West Creek flow conditions using existing hydraulic models.

HISTORICAL GEOMORPHIC ASSESSMENT

Readily available historical USGS maps show natural, pre-development creeks flowed from steep canyon-confined reaches into a broad salt marsh spanning the entire width of the valley floor. Salt marsh lands were drained or partially drained for ranching during the first part of the 1900s by ditching creek flows along the east and west edges of the valley. Residential development during the middle of the 1900s made the ditch channels permanent and narrowed them in places. Despite channelization and grading for residential development, National Hydraulic Dataset digital elevation model-computed creek flow paths match the historical pre-development creek alignments.

According to late 1800s maps, the entire width of the valley floor – from Blackfield Drive to Leland Way – was salt marsh habitat with sinuous meandering channels fed by narrow valley-confined ephemeral "canyon" streams. By the late 1940s natural channel incision and/or ditching and drainage improvements for the ranch property (Lands of John Reed) had reduced the salt marsh extents. East Creek was ditched along the east edge of the valley floor. By the 1950s, West Creek had been ditched along the west edge of the valley floor and residential lots on Blackfield Drive, Cecilia Way, and Pamela Court were graded in forming a border on the east side of the West Creek ditch. Residential lots on Leland Way and Cecilia Way were graded in forming the west side of the East Creek ditch.

Today's overbank flow patterns match the original natural creek flow directions: West Creek tends to overflow to the east and East Creek tends to overflow to the west. As they did under natural pre-development conditions, both creeks have the potential to overflow beginning just downstream from the narrow valley-confined "canyon" reaches.

EXISTING CONDITIONS – WEST CREEK

West Creek was ditched in an efficient flow configuration. The nearly 2%-sloped canyon reach gives way to a 0.8%-sloped ditch (Upper West Creek) sloping down to a 2-3' bed elevation at Cecilia Way. Lower West Creek slopes 0.5% from the Cecilia Way culvert floor to the double-barrel metal arch culvert invert at State Route 131 (Tiburon Blvd). The Cecilia Way culvert is a 12' wide, 5' high rectangular box with a concrete floor.

West Creek is prone to overflow to the east as soon as it enters the ditch downstream from the canyon reach -- along nearly the entire length of Blackfield Dr and Pamela Ct. However, under existing conditions, it nearly contains the estimated 10-year to 25-year flood flow. It appears that minor top of bank flood barriers (e.g., solid waterproof lower fence units, earthen levees, or other barrier types) would prevent damaging overflows during similar flood flows.

There are a number of hydraulic constrictions that cumulatively act to increase flood water surface elevations and overflow potential:

- The deteriorated metal arch culverts passing under State Route 131 (Tiburon Blvd) are restricting flow.

- The 90-degree right-turning bend required upstream from the Tiburon Blvd culverts ("sackrete" transition structure) is not efficient because of the severity of the turn required by the residential development pattern.

- The sackrete transition structure has a sackrete drop structure that would be a constriction if the downstream culverts were upgraded and not restrictive.

- The 90-degree right-turning bend causes repeat sedimentation at the inside bend of the transition structure. Vegetation establishes on the sediment bar and creek flows will not erode the bar. It's not clear if the vegetated bar increases the constriction caused by the transition structure or not. Repeat dredging this area probably does not reduce upstream water surface elevations during high flows.

- Concrete rubble originating from failed bank erosion protection revetments on Pamela Ct properties lines the channel bed between 80 Rancho Dr and 55 & 65 Pamela Ct. The rubble increases the channel bed elevation and roughness, and prevents natural channel bed downcutting potential indicated this reach. The rubble induces mid-channel bar deposition of coarse bedload material on the bed between 90 Rancho Dr and 75 Pamela Ct.

- The cumulative effect of the above-listed constrictions reduces the channel slope and narrows the channel dimensions bordering 85 Pamela Ct and 242 Cecilia Way and, among other things (explained below), conflicts with sediment transport through the Cecilia Way culvert.

- Upstream from the Cecilia Way culvert inlet, the Upper West Creek channel is encroached by large trees rooted on the mid- and lower creek banks – trees that should be removed, including several Lombardy poplar trees, one Eucalyptus tree, and one Black willow tree. The tree trunks block flow and the tree roots raise the channel bed elevation by entangling large broken concrete rubble pieces and other large foreign material. All concrete rubble and loose rock rip-rap pieces larger than 4" diameter should be removed from West Creek to promote self-maintaining channel bed elevations and channel width.

- The storm drain originating at the intersection of Cypress Hollow Dr and Rancho Dr discharges onto a poured concrete apron spanning the West Creek channel between 160 and 170 Rancho Dr. District should explore the feasibility of removing the apron.

EXISTING CONDITIONS – EAST CREEK

East Creek was ditched in a less efficient configuration than West Creek. The steeper sloped canyon reach gives way to a relatively gradual 0.3%-sloped ditch (Upper East Creek) running along the rear of Leland Way properties. Upper East Creek slopes down to a 6-7' bed elevation at Cecilia Way – 4 feet higher than the bed elevation of West Creek at the other end of Cecilia Way. It appears that the historical East Creek ditch was not excavated to a low enough elevation where it was pinned against bedrock outcrops along the east canyon wall.

Then, downstream from Cecilia Way, Lower East Creek slopes 0.8% from the Cecilia Way culvert floor down to elevation 0' at double-barrel arch culvert inlet at State Route 131 (Tiburon Blvd). Under existing conditions, historical sedimentation upstream from the sanitary sewer crossing reduces the channel bed slope to about 0.2%, which encourages sedimentation and vegetation encroachment downstream from the culvert.

The Cecilia Way culvert is represented in the hydraulic model as a 10' wide, 5' high rectangular concrete box with a concrete floor. The SR 131 culverts are not represented in the HEC-RAS model. The culverts were analyzed in HY-8 by Schaaf & Wheeler for the design of the pump station. Schaaf & Wheeler noted that a future project could be a floodwall along the creek bank in the vicinity of the pump station to increase the creek capacity.

East Creek is prone to overflow to the west as soon as it enters the ditch downstream from the canyon reach, along the length of Leland Way. Under existing conditions, Upper East creek nearly contains the estimated 5-year to 10-year flood flow. The most flood prone reach appears to be immediately upstream from the Cecilia Way culvert including adjacent to 100 Way and 106 Leland Way. It appears that minor top of bank flood barriers (e.g., solid waterproof lower fence units, earthen levees, or sandbags) would prevent damaging overflows during similar flood flows.

Initiation of overflow occurs immediately upstream from the Cecilia Way culvert implies that the culvert may be undersized or that channel sedimentation downstream from the culvert is causing the overflows. However, there are a number of hydraulic constrictions downstream from

the culvert apparently stemming from the historical, awkward ditch configuration that cumulatively act to increase flood water surface elevations and overflow potential:

- The high elevation and narrow width at the elevated sanitary sewer (SS) crossing about 200 feet upstream from Tiburon Boulevard culvert inlets, combined with the similarly narrow constriction about 50 feet upstream from the SS crossing caused by historical ditch grading and/or residential development at 50 Harriet Way caused historical channel bed sedimentation upstream, possibly during a historical extreme flood flow occurring during high tide level (e.g., possibly 1955, 1983, 1986).

- East Creek flows have gouged pools in the historical sedimentation fill but the fill appears stabilized in place due to hydraulic conditions forced by the downstream constrictions (listed above) and large concrete rubble lodged in the sediment fill (likely transported by historical flood that emplaced the broader sediment fill). All pieces of concrete rubble and loose rock rip-rap larger than 4" diameter should be removed from East Creek to promote self-maintenance of more efficient channel bed slopes and channel dimensions.

- The historical sediment fills described above reduce the channel bed slope downstream from Cecilia Way culvert. Considering there are also channel width constrictions imposed by the relatively close proximity of the 80 Harriet Way lot and steep bedrock outcrops on the toe of the east canyon wall, slow creek flows allow for fine sediment deposition and emergent vegetation establishment within 300-350 feet downstream from the culvert.

<u>FINDINGS – WEST CREEK</u>

1. Removing channel bed sediment from within the Cecilia Way box culvert and only from within the Right-of-Way (R.O.W.) immediately upstream and downstream from the culvert reduces the model-computed 100-year flood water surface elevation (WSE) about 0.5 feet upstream from the culvert. However, the WSE reduction only extends about 100 feet upstream because the channel upstream is constricted by large trees and tree root entangled concrete rubble on the channel bed. And the benefit is temporary because fine sediment redeposits quickly within the culvert/R.O.W. The Cecilia Way culvert is adequately sized and configured, but existing conditions upstream and downstream from the culvert cause the culvert to transport sediment inefficiently (like a fine sediment washing machine).
2. Implementing a complete channel bed dredging to remove a lag of broken concrete rubble, loose rock rip-rap, and trapped natural creek sediment between the Cecilia Way culvert outlet at the Tiburon Blvd culvert inlet would increase the 100-year WSE reduction upstream from Cecilia Way from 0.5' to 0.8', but the WSE reduction still only extends about 100 feet upstream from the culvert because of the tree and rubble related narrow channel constrictions. The 100-year WSE reduction downstream from Cecilia Way is limited to 0.2' because the culverts under Tiburon Blvd restrict flow. The benefit is semi-permanent.

3. If Caltrans were to replace the deteriorated double-barrel metal-arch culverts under Tiburon Blvd with a 12′ wide by 5.5′ high concrete box culvert (or similar size) (with alignment and new inlet and outlet transition works for optimizing sediment transport continuity through the 90-degree bend) would make the potential 100-yr WSE reduction benefits greater – 0.7′ downstream from Cecilia Way and 0.9′ upstream from Cecilia Way – as well as more permanent and self-maintaining.
4. The above-listed channel capacity improvements would not reduce flood water surface elevations and overflow potential along Upper West Creek bordered by Blackfield Dr residences, unless additional channel capacity improvements are implemented upstream from the Cecilia Way culvert. A combination of selective tree removal, channel bed lowering, channel bed widening, removal of broken concrete rubble and loose rock rip-rap would "unlock" 100-year WSE reductions extending 700-800′ upstream from Cecilia Way up to and exceeding 1.2′. Natural channel adjustments anticipated to result from replacing a concrete storm drain apron with a standard rock rip-rap energy dissipator may increase and extend these model-computed 100-year WSE reductions.
5. Implementing all of the above-listed measures would produce a restored channel that contains the estimated 75-year to 100-year peak flood flow without top of bank flood barriers such as solid waterproof lower fence units, sand bags, etc. Installing top of bank flood barriers along the most flood-prone channel segments would either: (a) provide a higher level of flood protection; or (b) achieve the same level of protection with fewer of the above-listed measures being implemented.
6. Considering it is not known if and when Caltrans will replace the SR 131 culverts, top of bank flood barriers should be considered along Lower West Creek as an interim measure.
7. Top of bank flood barriers should also be considered along Upper West Creek as an interim or permanent measure. Reliance of top of bank flood barriers on Upper West Creek could be reduced by implementing a suite of tree removal, debris removal, channel widening, and storm drain outfall improvements.

FINDINGS – EAST CREEK

1. Removing vegetation-covered channel bed sediment within 300-350 feet downstream from the Cecilia Way box culvert reduces the model-computed 100-year flood water surface elevation (WSE) about 0.6 feet downstream and upstream from the culvert. The WSE benefit extends upstream along the length of Upper East Creek bordered by Leland Way. The WSE benefit is not enough to prevent overflows to the west through backyard fences along the rear of Leland Way residential lots, but any potential property damage would be significantly reduced. Escapement of flow from the culvert inlet onto Cecilia Way toward the lower-elevation Leland Way and Harriet Way intersections would also be reduced but not eliminated without other measures. The benefit is more than temporary but not semi-permanent because fine sediment will redeposit downstream from the culvert within a small number of winter rainy seasons owing to downstream constrictions.

2. Although narrower and higher elevated than the Cecilia Way culvert on West Creek, the Cecilia Way culvert on East Creek is adequately sized and configured. The culvert can convey the estimated 100-year peak flow without substantial backwater so long as downstream conditions are manually- or self-maintained clear.
3. A number of downstream constrictions may need to be removed to create self-maintaining clear conditions downstream from the Cecilia Way culvert: (a) Lower and wider channel section at the elevated Sanitary Sewer (SS) crossing about 200 feet upstream from Tiburon Blvd; (b) Lower and wider channel at the constriction about 50 feet upstream from the SS crossing; (c) Dredge channel to remove historical sedimentation between those constrictions and within 300-350 feet from Cecilia Way culvert; (d) Potentially detail-designed channel bed lowering and widening at potential other constrictions revealed by sediment removal along East Creek bordered by 80 Harriet Way and 300 Cecilia Way; (e) permanent evergreen vegetation establishment to limit emergency vegetation growth on the channel bed.
4. It is not known at this time if replacing the existing double-barrel culverts under Tiburon Blvd would improve self-maintenance of clear channel conditions on East Creek. It appears unlikely to make a difference unless the channel constriction at the SS crossing is relieved. If the Tiburon Blvd culverts on East Creek are deteriorated like the Tiburon Blvd culverts on West Creek, they are probably candidates for replacement, and should be replaced with (minimum) 12′ wide by 5.5′ high rectangular box culvert.
5. Owing to the awkward historical East Creek ditch configuration compared to West Creek, and greater drainage area with higher peak flows, it is more difficult to optimize channel flow capacity to entirely contain peak flows greater than the estimated 25-year peak flow. It appears that some top of bank flood barriers extending upstream from the Cecilia Way culvert would be cost effective for increasing the level of protection, for existing conditions or improved conditions.
6. Top of bank flood barriers should also be considered along Upper East Creek as an interim or permanent measure. Reliance of top of bank flood barriers on Upper East Creek could be reduced by implementing a suite of sediment, vegetation, and debris removal work.

RECOMMENDATIONS

1. SR 131 (Tiburon Blvd) Improvements – Advise Caltrans to Replace West Creek and East Creek culverts as part of next upcoming corridor overlay. Consider preparing an investigation report showing the deteriorated condition of the culverts and documenting hydraulic restriction. Requesting culverts be replaced based on study demonstrating optimized hydraulic conveyance for current conditions and future sea level conditions, as may require realignment of the culvert crossings compared to the existing culvert crossings.

2. Channel Maintenance Dredging – Perform sediment and vegetation removal on East Creek downstream from Cecilia Way culvert this year, extending to about 300-350 ft downstream from the culvert. Consider extending the dredging farther downstream as needed, and/or removing concrete rubble from the channel downstream to reduce the potential for rapid re-deposition of sediment and vegetation encroachment.

   It does not appear helpful to remove sediment from West Creek within the R.O.W. limits at Cecilia Way culvert.

3. Improvement options – To the extent that channel maintenance dredging can also be performed on Upper East Creek and Upper West Creek, certain activities would reduce flood water surface elevations:

   Upper West Creek – Removal of certain trees, removal of concrete rubble pieces from the channel bed, sediment removal to widen and deepen the channel in narrow constrictions, and replacing a concrete apron storm drain outfall with a rock rip-rap outfall would cumulatively act to reduce flood water surface elevations along Upper West Creek.

   Upper East Creek – Removal of fine sediment and encroached emergent vegetation, removal of concrete rubble pieces exposed on the channel bed or expose by sediment dredging would reduce flood water surface elevations somewhat along Upper East Creek. More detailed evaluation might show that certain tree removals and other obstructions are indicated.

   Top of bank flood barriers (sandbags, solid waterproof fence panels, etc.) should be considered along flood-prone channel segments. The most complete, reliable and long-lasting flood risk reduction program would include a combination of top of bank barriers and cost-effective channel capacity improvements.