

## ES.1 INTRODUCTION AND PURPOSE

Eight people are reported to have drowned in the Walnut Creek Flood Control Channel System (WCFCCS), which includes Drop Structure 2 (shown in Figure ES-1) since the WCFCCS was constructed in the 1960s and 1970s. Additionally, one fire fighter was injured in 2010 while rescuing a victim from the channel.

The overall purpose for preparing this study is to identify how Drop Structure 2 could potentially be made safer, while still achieving its flood control requirements and benefits. This study was commissioned by the Contra Costa County Flood Control and Water Conservation District (FC District) to provide information regarding improving the safety of the WCFCCS and Drop Structure 2 to guide future management decisions.



Figure ES-1. Drop Structure 2 at a Relatively Low Flow

At Drop Structure 2, just downstream of Bancroft Road, the water flows from the upstream concrete channel over a 20-foot drop, flows through a stilling basin (to slow the water down) and then up-wells by about 8 feet into the downstream earthen and rock lined channel. This results in an overall drop of 12 feet. In the stilling well, the water is very turbulent, and swirls around in a vertical loop, but it eventually leaves the stilling well and enters the downstream channel. The swirling of the water in the stilling well is called a submerged hydraulic jump or simply a hydraulic. The water flowing through this hydraulic can flow through the vertical loop several times before it is pushed out of the stilling well and flows downstream. This vertical flow loop can also entrain a person and hold them underwater for a dangerously long time.

The WCFCCS conveys the 100-year peak flow from the upper watershed through Walnut Creek and Concord quickly and efficiently. This system of channels has greatly reduced the potential for flooding within the low-lying areas of Walnut Creek and Concord. Prior to the construction of the WCFCCS in the 1960s and 1970s, flooding was relatively common, with major floods occurring in 1938, 1952, 1955, 1958, 1962, and 1963.

### **ES.2 PUBLIC COMMENTS, CONCERNS, AND SAFETY IMPROVEMENT IDEAS**

The public expressed concern about the safety of the WCFCCS and Drop Structure 2. Many verbal and written comments were provided by the public in response to the FC District's 2011 outreach effort requesting input on the safety of the WCFCCS. The public's ideas to improve safety generally included the following: improved signage, barriers and fencing, channel modifications, drop structure modifications, and public outreach and education.

### **ES.3 EXISTING FLOOD CONTROL SYSTEM OVERVIEW**

The WCFCCS is a system of flood control channels that quickly conveys stormwater water from the cities of San Ramon, Danville, Alamo, Lafayette, Walnut Creek, Pleasant Hill, and Concord, and unincorporated areas of Contra Costa County to Suisun Bay. The Walnut Creek watershed is the largest in Contra Costa County, draining over 145 square miles, and is home to over 300,000 residents. The Walnut Creek Channel is the largest of the channels in the watershed, and conveys flow from Bollinger, San Ramon, Green Valley, Tice, and Las Trampas Creeks.

The design flow rate for the Walnut Creek channel is 18,000 cubic feet per second, which is the estimated peak flow in a 100-year storm. At the design flow rate, the flow in the concrete channel upstream of Drop Structure 2 is supercritical (ie: high speed, high energy) with a velocity of about 28 feet per second, or about 19 miles per hour. The original design of the channel and drop structures required extensive engineering evaluations, including physical, scale model testing of the drop structures.

During the planning and design of the WCFCCS, the FC District requested that a safer type of drop structure be used rather than the type that was ultimately constructed at Drop Structure 2. However, the request was not implemented by the US Army Corps of Engineers because of the limited right-of-way width for the channel upstream of Drop Structure 2 and because of the higher cost of the requested type of drop structure. The USACE design documents concluded that the climb-proof fencing and the warning signs would provide an appropriate level of safety.

### ES.4 SAFETY BARRIERS AND DEVICES AND POTENTIAL CHANNEL AND DROP STRUCTURE MODIFICATIONS

In addition to the discussions with the public and FC District staff members, numerous other flood control districts and agencies were contacted to identify potential improvements to be evaluated to improve the safety of the WCFCCS and drop structure. The agencies contacted include: Iowa Department of Natural Resources, Denver Urban Drainage and Flood Control District, Santa Clara Valley Water District, Los Angeles County Public Works Department, Los Angeles City Fire Department (LAFD) Disaster Preparedness Section. Several relevant, recent publications and studies were reviewed.

The above process led to the following safety barriers/devices and channel/drop structure modifications being identified for potential use in the WCFCCS and/or at Drop Structure 2.

- Increased Inspection and Repair of Existing Fencing
- Public Awareness and Outreach.
- Additional Warning Signs
- Additional Escape Ladders
- Safety Racks
- Safety Nets
- Safety Cables
- Tension Diagonals
- Thermal Imaging
- Sloped Baffle Chute Drop
- Grouted Sloping Boulder Drop
- Multiple Vertical Drop Structure (3-Foot Maximum Drop)
- Stream Channel Restoration

These potential improvements were evaluated for use in the WCFCCS or at Drop Structure 2. Each potential improvement was evaluated and scored using numerous criteria as presented in Table ES-1. The scores could range from – 160 to +160 points, and positive, high point scores are better than low or negative point scores. Improvements with overall scores less than zero should not be considered for implementation. Improvements with scores between 0 and 20 should be considered marginally feasible. Improvements with scores greater than 20 would provide a meaningful increase in safety and should be further evaluated for implementation.

Table ES-1. Comparison Matrix

Safety Item	Relative Safety Enhancement		Potential for Decreased Floodwater Conveyance or Increased Flooding		Storm Period O&M Requirements		Routine O&M Requirements		Private Property and Housing Impacts		Community Impacts		Environmental Impacts		Proven Technology		Capital Cost		Useful to CCFPD Rescuers		Fatal Flaw		Total Score (160 Points)
	Discussion	Score (20 points)	Discussion	Score (10 points)	Discussion	Score (5 points)	Discussion	Score (5 points)	Discussion	Score (10 points)	Discussion	Score (5 points)	Discussion	Score (5 points)	Discussion	Score (20 points)	Estimated Cost	Score (25 points)	Discussion	Score (5 points)	Discussion	Score (50 points)	
<b>Safety Devices and Barriers</b>																							
Escape Ladders	Provides very minimal increase in safety, but provides unauthorized channel entry	2	No Change	0	Would not require storm period O&M	0	Would require periodic inspections and repairs, would require minor clearing of debris	-1	No impacts	0	No impacts	0	No impacts	0	Minimal use in supercritical flow channels	-4	\$20,000	0	Rescuers would install their own ladders	0	None	0	-3
Safety Rack	Could provide some increase in safety, but could also be an attractive nuisance that could lead to injuries	0	Great risk of causing a hydraulic jump, which would result in increased flooding	-5	Could require some storm period O&M	-3	Would require periodic inspections and repairs, would require minor clearing of debris	-5	No impacts	0	Minor construction period impacts	-1	Visually obtrusive facility	-2	Not used in supercritical flow channels	-20	\$2.4 million	-3	Not useful during a rescue	0	Risk of hydraulic jump	-40	-79
Safety Net	Provides no increase in safety and could trap a victim in the net, could also be an attractive nuisance that could lead to injuries	-15	Risk of causing a hydraulic jump, which would result in increased flooding	-3	Could require some storm period O&M	-3	Would require periodic inspections and repairs, would require minor clearing of debris	-5	No impacts	0	Minor construction period impacts	-1	Visually obtrusive structure	-2	Not used in supercritical flow channels	-20	About \$1.6 million	-3	Not useful during a rescue	0	Great risk of causing a victim to drown	-50	-102
Safety Cables	Could provide some potential for self-rescue, but only downstream of Drop Structure 2	2	If used downstream of Drop Structure 2, it would not change floodwater conveyance or increase risk of flooding	0	Would not require storm period O&M	0	Would require periodic inspections and repairs, would require minor clearing of debris	-1	No impacts	0	No impacts	0	No impacts	0	Proven technology in subcritical flow channels like downstream of Drop Structure 2	10	\$8,000	0	Not useful during a rescue	0	None	0	11
Tension Diagonal	Would provide two locations where a victim could be rescued. Does not rely on self-rescue. Very difficult catch and retain a victim in the supercritical flow. Could put rescuers at risk if they enter the flowing water.	10	Would not change floodwater conveyance or increase risk of flooding	0	Would not require storm period O&M	0	Would require periodic inspections and repairs, would require minor clearing of debris	-1	Minimal impacts	-2	Minor construction period impacts	-1	No impacts	0	Successfully used in supercritical flow channels but difficult to implement on vertical walled channels	5	\$50,000	0	Not useful during a rescue	0	None	0	11
Thermal Imaging	Could detect a victim trapped in the channel and notify rescue personnel	10	Would not change floodwater conveyance or increase risk of flooding	0	Would not require storm period O&M	0	Would require periodic inspections and repairs	-1	No impacts	0	No impacts	0	No impacts	0	The technology may not work if victim has been in the water for several minutes.	-5	\$240,000	0	Not useful during a rescue	0	None	0	4
<b>Channel and Drop Structure Improvements</b>																							
Baffle Chute Drop Structure	Eliminates the submerged hydraulic jump, but could cause victim to impact against baffles	-5	Not for upstream supercritical flow channels, could cause some water to jump out of channel.	-10	Would not require storm period O&M	0	Would require periodic inspections and significant clearing of debris	-3	Requires demolition of 11 houses and reconstruction of Bancroft Road Bridge	-3	Significant construction period impacts	-1	Could include fish passage improvements	2	Not for use with upstream supercritical flow channel	-20	\$8.3 million	-10	Not useful during a rescue	0	Not for upstream supercritical flow channels	-40	-90
Multiple Vertical Drop Structure	Would eliminate existing submerged hydraulic jump, but could result in another submerged hydraulic jump.	0	Great risk of causing a hydraulic jump, which would result in increased flooding	-10	Would not require storm period O&M	0	Would require periodic inspections and repairs, would require minor clearing of debris	-1	No impacts	0	Minor construction period impacts	-1	Could include fish passage improvements	2	Used in some supercritical flow channels	10	\$6.3 million	-8	Not useful during a rescue	0	Would cause water level to exceed channel top	-50	-58
Grouted Sloping Boulder Drop Structure	Would eliminate existing submerged hydraulic jump, but a nonsubmerged hydraulic jump would remain	5	Should not decrease floodwater conveyance or increase risk of flooding, but unanticipated problems could occur.	-3	Would not require storm period O&M	0	Would require periodic inspections and some clearing of debris	-2	No impacts	0	Minor construction period impacts	-1	Ideal for improving fish passage	3	Not a proven technology for supercritical flow channels	-10	\$3.8 million	-4	Not useful during a rescue	0	Not a proven technology for supercritical flow channels	-30	-42
Stream Channel Restoration Project	Would eliminate existing submerged hydraulic jump, but would result in many trees and bushes in which a victim could be trapped and drown	0	Would not decrease floodwater conveyance or increase risk of flooding	0	Would not require storm period O&M	0	Would require periodic inspections, significant clearing of debris, and major vegetation maintenance efforts	-5	Requires demolition of about 700 houses/condominiums and 24 buildings. Major transportation impacts.	-10	Major construction period impacts	-5	Would generate significant stream and riparian habitat and would improve fish passage	5	Stream restoration of channels has been used in many urban environments, but infrequently with channels the size of Walnut Creek	5	\$1.2 billion	-25	Not useful during a rescue	0	Extreme impacts to the community (residential and business) and disruption of transportation system streets and bridges)	-40	-75
<b>CCFPD Rescuer Requested Facilities</b>																							
CCFPD Rescuer Requested Facilities	Increases the ability of CCFPD rescuers to save a victim trapped in the channel.	10	Would not change floodwater conveyance or increase risk of flooding	0	Would not require storm period O&M	0	Would require periodic inspections and maintenance of improvements	-1	No Impacts	0	No impacts	0	No impacts	0	Gates, anchor points and high point attachments are all items that have been used by rescuers in other locations	20	\$38,000	0	Very useful during a rescue	5	None	0	34
<b>Other Approaches</b>																							
Public Awareness and Outreach	Helps prevent people from entering the channel and precludes the need to rescue a victim from the channel	5	Would not change floodwater conveyance or increase risk of flooding	0	Would not require storm period O&M	0	Would require ongoing public outreach and education program	-2	No Impacts	0	Educate community about creeks and channels	1	No impacts	0	People may still enter the channels	5	\$50,000	0	Not useful during a rescue	0	None	0	9
Fence Inspections and Repairs	Helps prevent people from entering the channel and precludes the need to rescue a victim from the channel	3	Would not change floodwater conveyance or increase risk of flooding	0	Would not require storm period O&M	0	Would require periodic inspections and repair efforts	-1	No Impacts	0	No impacts	0	No impacts	0	Highly effective where installed, but fencing is not installed upstream of the concrete channels	10	\$20,000	0	Not useful during a rescue	0	None	0	12
Additional Signage	Helps prevent people from entering the channel and precludes the need to rescue a victim from the channel	5	Would not change floodwater conveyance or increase risk of flooding	0	Would not require storm period O&M	0	Would require very infrequent sign replacement	0	No Impacts	0	No impacts	0	No impacts	0	People may still enter the channels	5	\$20,000	0	Not useful during a rescue	0	None	0	10

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None of the potential improvements listed above scored above 20 points. The primary reason these improvements did not score higher is because the flow in the concrete channel upstream of Drop Structure 2 is supercritical, and the high costs to modify the channel configuration to make it subcritical. The supercritical flow at a velocity of 28 feet per second precludes the use of improvements that could improve the safety of the WCFCCS and Drop Structure 2 if the WCFCCS flow was subcritical (slower than 22 feet per second). No examples of supercritical channels with safety racks or nets, sloped baffle chutes drops, grouted sloping boulder drops, and multiple vertical drops were located.

### ES.5 COUNTY COORDINATION MEETING

A coordination meeting was held with the Contra Costa County Fire Protection District (CCCFPD) and staff from other County departments on June 7, 2012. The purpose of the meeting was to review the alternative potential improvements, receive input on these potential improvements from several County departments, and identify the feasible improvements that would provide a meaningful increase in the safety of WCFCCS and Drop Structure 2. A summary of the meeting is presented below:

- Tim Jensen (FC District) opened the meeting and provided a brief introduction and background for the project.
- Doug Moore (West Yost Associates) gave the presentation the potential improvements, including noting that the thermal imaging and tension diagonals appeared to be the most promising potential improvements.
- The CCCFPD stated that they already have portable thermal imaging cameras, but have not had success with thermal imaging because a person's body temperature drops quickly when exposed to cold water like would be present in the Walnut Creek Channel.
- The CCCFPD expressed concern that even with a tension diagonal, it would be very difficult to catch and rescue a victim being swept down the channel in the supercritical flow.
- The discussion shifted to identifying the facilities which would be helpful to CCCFPD staff for rescuing a victim trapped in the WCFCCS. The facilities identified are described in the following section.

### ES.6 CCCFPD RECOMMENDED IMPROVEMENTS

The following facilities would be the most helpful for CCCFPD staff to effectively rescue a victim trapped in the Walnut Creek Channel. Two sets of improvements would be constructed; a primary set where the initial rescue attempt would be made and a secondary/redundant set downstream. Both of the sites would be the just upstream of the Bancroft Road Bridge on property owned by the CCCFCWCD. The recommended improvements include the following items:

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- Access gates in the existing fencing along the top of the channel walls.
- Strong anchor points located 15 to 20 feet back from the channel top. The rescuers would be connected to the anchor points with ropes to prevent them from falling into the channel.
- A high point attachment (basically a structure with a horizontal bar 6 to 8 feet above the ground). The high point attachment would be used to attach webbing or rope to in order to provide the leverage necessary to lift someone (rescuer or victim) up and over the channel wall and onto the channel bank.

The CCCFPD Recommended Improvements were incorporated into Table ES-1, and received a score of 34 points, resulting in the CCCFPD Recommended Improvements having the highest score of any of the potential improvements.

### ES.7 CONCLUSION AND RECOMMENDATIONS

The conclusions and recommendations include:

- The supercritical flow in the WCFCCS limited the extent of potential safety improvements that could be implemented in the WCFCCS. The supercritical flow prevents the effective use of escape ladders, safety racks, safety nets, safety cables, Baffle Chute Drop Structure, Grouted Sloping Boulder Drop Structure, and Multiple Vertical Drop Structure. Examples of all these features are used by other agencies, but only in subcritical flow channels.
- Public awareness and outreach, fence inspection and repair, and additional signage reduce the likelihood of people entering the channels and thereby prevent the need to rescue victims from the channel. Also, the costs of these programs are low compared to the costs of most of the other safety improvements. Consequently, these programs should be continued.
- The CCCFPD Recommended Improvements appear feasible and should be further evaluated for implementation.
- The marginally feasible safety improvements include safety cables (downstream of Drop Structure 2 only), and tension diagonals. These should be considered further for implementation.
- Safety nets, safety racks, baffle chute drops, grouted sloping boulder drop, multiple vertical drops, and the stream channel restoration project create new, significant safety hazards or would cause major community impacts, and consequently are not considered feasible to implement.