City of Sacramento, Department of Utilities, Existing Conditions and Channel Improvements Modeling, South Sacramento Streams Group, Sacramento, CA

City of Sacramento

FINAL

January 2013

WOOD RODGERS

DEVELOPING INNOVATIVE DESIGN SOLUTIONS

WOOD RODGERS

January 28, 2013

Ms. Connie Perkins
City of Sacramento
Department of Utilities
1395 – 35th Avenue
Sacramento, California 95822

Dear Ms. Perkins,

Subject: City of Sacramento, Existing Conditions and Channel Improvements Modeling Report

Enclosed is the final report (five sets) entitled, "Existing Conditions and Channel Improvements Modeling, South Sacramento Streams Group, Sacramento, California", dated January 2013, which was prepared by Wood Rodgers, Inc. for the City of Sacramento.

As there were no comments received on the draft version of this report, the content of this final report is identical to the draft version of January 2012.

If you have any questions, please do not hesitate to call me at (916) 326-5294.

Sincerely,

Jonathan Kors, P.E., PMP
Principal

Chris Ferrari, P.E.
Associate

Enclosures

Corporate Office: 3301 C Street, Bldg. 100-B · Sacramento, CA 95816 · Tel: 916.341.7760 · Fax: 916.341.7767
Offices located in California, Nevada
www.woodrodgers.com

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INTRODUCTION

In March of 2011, the City of Sacramento (City) contracted with Wood Rodgers, Inc. (Wood Rodgers) to develop an unsteady flow hydraulic model for portions of Morrison, Unionhouse, Elder, and Florin Creeks. These streams are collectively known as the "South Sacramento Streams Group." The modeling was performed for the purpose of understanding existing flooding conditions within the South Sacramento area and the potential benefits of proposed improvements along Unionhouse Creek. The modeling incorporates recently completed storm hydrology developed by the Sacramento County Department of Water Resources (County), recently completed topographic mapping collected by the California Department of Water Resources (DWR), and as-built information from recent levee and floodwall improvements constructed at Elder, Florin, and Unionhouse Creeks by the Sacramento Area Flood Control Agency (SAFCA), the City, and the U.S. Army Corps of Engineers (USACE).

The study reaches total approximately 23.4 miles and are located in both the City and County of Sacramento, California, east of the Sacramento River as presented on **Figure 1**.

This report presents the methodology employed for development of the model and the results for the existing 500-, 200-, 100-, 50-, and 10-year frequency floodplains and water surface elevation profiles (WSP). These results will be reviewed with the City, the County, SAFCA, and the USACE. After review and approval by the City, a Letter of Map Revision (LOMR) will be submitted to the Federal Emergency Management Agency (FEMA) to update the effective Flood Insurance Rate Maps (FIRM), dated December 8, 2008, to reflect the results of the analyses. Similarly, once the results of the proposed improvements at Unionhouse Creek are reviewed and approved, a Conditional Letter of Map Revision (CLOMR) will be prepared to coordinate the future improvements with FEMA.

REFERENCES

1. Sacramento County Department of Water Resources, Morrison Creek Watershed Hydrologic Model, December 2011.

2. HDR, "San Joaquin River Basin South Sacramento County Streams Flood Damage Reduction Project Design Documentation Report for Final Hydraulic Design," June 2009.

3. FEMA, Effective FIRMs for Sacramento County and the City of Sacramento, California.

4. USACE (Parsons Brinkerhoff, Quade & Douglas), South Sacramento County Streams Project, Sacramento, California, Section 1B1: Morrison Creek, Franklin Boulevard to the Union Pacific Railroad, Construction Plans, August 1999.

5. USACE (Parsons Brinkerhoff, Quade & Douglas), South Sacramento County Streams Project, Sacramento, California, Section 1B2: Florin, Elder & Unionhouse Creek, Franklin Boulevard to the Union Pacific Railroad, As-Built Construction Plans, June 2008.

6. Andregg, Inc., Aerial Mapping of South Sacramento Streams Project, Phase 1, City of Sacramento, Sacramento County, June 1999.

7. USACE, San Joaquin River Basin, South Sacramento County Streams Investigation, California, Final Feasibility Report Appendices, March 1998.

8. DWR, Central Valley Floodplain Evaluation and Delineation Program LiDAR, October 2010.

9. DWR, State Plan of Flood Control Database.

10. City of Sacramento pump station data.

11. County of Sacramento pump station data.

STUDY AREA AND SCOPE OF WORK

Description of Study Area

The Morrison Creek watershed is approximately 100 square miles, and extends from El Dorado County to Beach Lake, which is located in Sacramento County east of the Sacramento River. Presented on **Figure 2** are the watershed boundaries of Morrison, Unionhouse, Elder, and Florin Creeks, which were used to produce the hydrology for the modeling conditions.

Morrison Creek is approximately 21 miles in length between Mather Lake and Interstate 5. The modeled study reach of 9.6 miles extends from Power Inn Road to the Union Pacific Railroad (UPRR), located upstream of Beach Lake. The reaches for most of the channels in this evaluation have been engineered with levees, floodwalls, or trapezoidal channels. Morrison Creek includes certified levees at its east bank from Beach Lake to Franklin Boulevard, and from the UPRR to Franklin Boulevard These improvements are outlined in Reference 4

above. Unionhouse, Elder, and Florin Creeks are tributaries to Morrison Creek. These creeks, from Franklin Boulevard to their confluence with Morrison Creek, were improved in 2009 and 2010 as outlined in Reference 5. The modifications made to the streams as part of these projects are reflected in the channel geometry definitions contained within the hydraulic model. Of particular note is the reduced elevation of the Unionhouse Creek left bank downstream of the UPRR tracks, which allows more water to be released into the Beach Lake area during high flow stages.

It is noted that Florin Creek contains earthen embankments above the elevation of adjacent ground between Franklin Boulevard and Center Parkway. The treatment of these embankments within the model is discussed further within the Model Development Section of this report.

Presented in **Table 1** are the study stream reach lengths.

Table 1: Study Stream Reach Lengths

Stream Name	Estimated Reach Length (mi)	Study Limits
Morrison Creek	9.6	Beach Lakes to Power Inn Road
Unionhouse Creek	4.3	Morrison Creek Confluence to Power Inn Road
Elder Creek	4.1	Morrison Creek Confluence to UPRR
Florin Creek	4.1	Morrison Creek Confluence to UPRR
Strawberry Creek	0.7	Unionhouse Creek Confluence to East of State Route Highway 99
Pump 33 Morrison Creek Tributary Channel	0.6	Morrison Creek Confluence to Pump 33
TOTAL	**23.4**	

Figure 3 provides the location of the levees for Morrison, Elder, Florin, and Unionhouse Creeks that are included in the study. The State Plan of Flood Control database (Reference 9) provided the approximate levee locations along the study area. The line work provided by the database required adjustments to correctly align the left and right bank levee locations to the LiDAR topographic data of Reference 8.

Scope of Work

The primary approach and work tasks are summarized below and described in greater detail in subsequent sections of this report. The tasks include:

- Developing a hydraulic model to review the existing condition 200- and 100-year floodwater surface floodplain and profiles for the study streams. Additional storm frequencies for 500-, 50-, and 10-years were included for the future FEMA LOMR submittal.

- Utilizing the best available topographic, survey, and base mapping data to determine the appropriate application and whether it satisfies FEMA's criteria for updating the FIS.

- Developing new hydraulic models using LiDAR collected from DWR, for the detailed mapping. The following parameters were created for the hydraulic models:

    - Stream Channel Geometry
    - Peak Discharges
    - Hydraulic Structures
    - Starting Water Surface Elevations
    - Energy Losses
    - Ineffective Flow Locations

- Adjusting the LiDAR to incorporate channel modifications to Unionhouse, Florin, and Elder Creeks in 2009.

- Incorporating the storage available from the Retention Basin constructed on Morrison Creek near Mayhew Drive (Aspen 6 Project).

- Verifying model reasonableness by comparing the model results with previous mapping.

- Determining floodplain boundaries for the 1-percent annual chance of exceedence event and developing work maps showing the resulting floodplains.

- Determining and summarizing model limitations.

- Reviewing proposed alternatives for Unionhouse Creek, between Franklin Boulevard and Center Parkway, to increase channel capacity and reduce overbank flooding.

EFFECTIVE FEMA FIRMS

The effective FEMA FIRMs dated 2008 were reviewed by Wood Rodgers and incorporated into the modeling effort, where appropriate. The effective FEMA FIRMs reference a FEMA A99 designation for the study area after the levees were decertified in 1998. FEMA designation A99 indicates areas that are protected by a Federal Flood Protection system under construction. Improvements to portions of the Morrison, Unionhouse, Florin, and Elder Creeks channel capacities and levee embankments (including floodwalls) will allow the City to certify and remove the A99 FEMA designation.

Presented on **Figure 4** is the effective FEMA floodplain for the study streams.

MODEL DEVELOPMENT

The USACE Hydrologic Engineering Center River Analysis System (HEC-RAS) modeling software, Version 4.1.0, using a one-dimensional unsteady flow application was utilized for the combined model. Twelve hydraulic models were developed representing existing and proposed conditions using two model geometries. The following sections provide a description of the methodology for the detailed hydraulic model development.

Existing Condition Model Scenarios:

1. 500-, 200-, 100-, 50-, and 10-year 24-hour storm frequencies, using DWR LiDAR (Reference 8) for existing conditions geometry. The LiDAR was modified to incorporate channel/floodwall improvements at lower Florin, Elder, and Unionhouse Creeks constructed after the LiDAR was produced.

2. 100-year 10-day and 100-year 5-day storm frequencies, using existing conditions geometry as described above.

Proposed Unionhouse Creek Alternative Evaluations:

Two alternatives were reviewed for improving channel capacity at Unionhouse Creek as described below.

Alternative B2 – From Franklin Boulevard to Center Parkway, no concrete channel lining (n=.025). From Franklin Boulevard to Center Parkway, widen bottom 8.0 feet to a total bottom width of 20' with a channel top width of approximately 69'. From Center Parkway to Strawberry Creek, utilize existing channel dimensions, but channel sides will be lined with concrete (n=.02).

Alternative D2 – From Franklin Boulevard to Center Parkway, concrete line channel (n=.025). From Franklin Boulevard to Center Parkway, widen bottom 8.0 feet to a total bottom width of 20' with a channel top width of approximately 69'. From Center Parkway to Strawberry Creek, utilize existing channel dimensions, but channel sides will be lined with concrete (n=.02).

The alternative channel improvements noted above were evaluated with the following storm recurrence intervals and durations:

1. 200-year and 100-year, 24-hour storm.

2. 100-year, 24-hour storm.

Channel Geometry

Cross sections reflective of the existing channel geometry (including modifications made the channel by recent projects) were pre-processed using HEC-RAS and HEC-GeoRAS Version 4.3.93. The HEC-GeoRAS is a GIS application that allows topographic data to be integrated into the hydraulic modeling software. No breakline data was available for these study stream reaches. The standard HEC-GeoRAS input was developed for river, reach, and station identifiers; cross-sectional cut lines; cross-sectional surface lines; cross-sectional bank stations; downstream reach lengths for the overbank, main channel, and right overbank; and cross-sectional roughness coefficients. Additional geometric data defining riverine hydraulic structures, levee alignments, ineffective flow areas, and blocked obstructions were added as needed.

At Florin Creek, between Franklin Boulevard and Center Parkway, there are existing mounds adjacent to the channel top of bank that appear to be the remnants of spoil material generated during the channel's construction. There has been some correspondence between Wood Rodgers, the City, SAFCA, and FEMA Region 9 regarding how the mounds should be represented in the model. It is noted that whether or not the embankments are modeled in place, Florin Creek spills overbank for the 100-year flood event. Because the channel does not contain adequate capacity for the 100-year flow, the raised embankments have the effect of forcing

additional water overbank at the upstream portions of Florin Creek, just downstream of Persimmon Ave. This overbank flow increases the floodplain at the lower end of Florin (upstream of Franklin Boulevard) as the water is prevented from returning to the channel by the raised embankments. In Wood Rodgers' opinion, as the Florin Creek channel is not natural, and the material adjacent to the top of bank was not deposited by way of overbank flow, the embankments should be removed in the model as if they were an uncertified levee.

Manning's "n" Values

Manning's "n" values for the study streams were assigned to the model based upon values previously approved by FEMA and Wood Rodgers' field observations. **Table 2** presents the roughness coefficient ranges that were selected for each channel reach.

Table 2: Manning's Roughness Coefficients

Stream Reach/ Location	Upstream Cross-Section Location	Downstream Cross-Section Location	Left Overbank Range	Channel Range	Right Overbank Range
Morrison Creek	Power Inn Road	UPRR	.035-.05	.035-.05	.035-.05
Florin Creek	UPRR	Elder Creek	.035-.05	.035-.05	.035-.05
Elder Creek	UPRR	Morrison Creek	.035-.05	.035-.05	.035-.05
Unionhouse Creek	UPRR	Morrison Creek	.035-.05	.035-.05	.035-.05

Pump Stations

Figure 5 provides the pump stations located in the City and County that were included in the hydraulic model.

In-line Structures

There are 58 in-line structures along the study reaches, as summarized in **Table 3.** Back-up documentation including field forms, photographs, survey documentation, and record drawings was collected for each structure. The locations of the in-line structures are presented on the work maps.

Table 3: In-line Structures

Stream Location	Description	Structure Type				No. of Overtopping Structures for 100-Year	Data Source
		Bridge	Culvert	Pedestrian Crossing	R/R		
Morrison Creek	Power Inn to UPRR	19	---	1	1	0	FEMA Models, Record Dwgs., and Field Review
Florin Creek	Elder Creek to UPRR	14	1	---	1	7	FEMA Models, Record Dwgs., and Field Review
Elder Creek	Morrison Creek to UPRR	11	---	---		1	FEMA Models, Record Dwgs., and Field Review
Unionhouse Creek	Morrison Creek to UPRR	6	1	0	0	2	FEMA Models, Record Dwgs., and Field Review
Strawberry Creek	Unionhouse to Hwy 99	0	0	0	4	0	Field Review

Lateral Structures

Lateral structures are defined at locations where channel capacity is exceeded and flow is exchanged to the overbank floodplain. At areas where the top of bank or the top of levee would act as a lateral structure, 3-dimensional polylines were generated from the LiDAR dataset using LP360 and imported into HEC-GeoRAS. LP360 is a GIS software application which allows LiDAR generated topography to be imported into GIS applications.

The lateral structure coefficients used in the analysis are presented in **Table 4**. These values are based upon the recommendations provided by Mr. Gary Brunner of the USACE on June 30, 2011, to consultant modeling teams working on the DWR's Central Valley Floodplain Evaluation and Delineation Program (CVFED). Coefficients for lateral structures will vary depending upon weir shape, angle of weir to flow, velocity/Froude number of the main channel of flow, and depth of water. Weir coefficients as low as 1.0 for levees and embankments are considered if momentum of flow in the channel is perpendicular to the lateral structure. Lateral structures for CVFED were identified in two categories:

1. Levees or levee-like feature: C = 1.0 – 2.6.
2. Natural Ground/Channel Overbank: C = .4 – 1.0.

Table 4: Lateral Structures

Stream Location	Structure Description	No. of Lateral Structures	Lateral Weir Station		Data Source	Weir Coefficient Range
			From	To		
Morrison Creek	Levees and Embankment	24	29434	48972	DWR LiDAR	.5 - 1.0
Elder Creek	Levees and Embankment	9	3978	8334	DWR LiDAR	.5 - 1.0
Florin Creek	Levees and Embankment	40	2219	21336	DWR LiDAR	.5 - 1.0
Unionhouse Creek	Levees and Embankment	27	726	21993	DWR LiDAR	.5 - 1.0
Strawberry Creek	Embankment	4	966	3381	DWR LiDAR	.5 - 1.0
D33 Channel	Embankment	3	11	3976	DWR LiDAR	.5 - 1.0

Contraction and Expansion Coefficients

In the latest version of HEC-RAS (Version 4.1), the release notes indicate that HEC-RAS may not be capturing all of the contraction and expansion losses in unsteady flow, particularly at sharp contractions and expansions. The 4.1 Release notes state:

> "In general, contraction and expansion losses are not used in unsteady flow, and therefore the default coefficients are 0.0. Forces due to contractions and expansions are handled in the momentum equation through pressure force differences. However, because HEC-RAS is a 1-dimensional unsteady flow model, the 1-dimensional momentum equation does not always capture all of the forces acting on the flow field at a sharp contraction and/or expansion zone. In order to better approximate the forces acting on the water, and the resulting water surface elevation, at a contraction and/or expansion, the user can enter empirical contraction and expansion coefficients for unsteady flow modeling. These coefficients will be multiplied by a change in velocity head, just like in steady flow modeling, but the resulting energy loss gets converted to an equivalent force for placement into the momentum equation."

Where contraction and expansion coefficients were entered, the appropriate coefficients were determined based upon the values presented in **Table 5**.

Table 5: Subcritical Flow Contraction and Expansion Coefficients

Coefficient	Contraction	Expansion
No Transition Loss Computed	0.0	0.0
Gradual Transitions	0.1	0.3
Typical Bridge Sections	0.3	0.5
Abrupt Transitions	0.6	0.8

Ineffective Flow Areas

Ineffective flow locations are generally used to define portions of the channel cross section that describe water that will pond, where the velocity of that water, in the downstream direction, is close to or equal to zero. Wood Rodgers delineated polygons to identify portions of the channel that would be subject to these conditions and used them to define ineffective flow areas in the model.

Blocked Obstructions

Blocked obstructions are generally used to define areas of the channel where cross sections will permanently block flow. There were no blocked obstructions applied to the study streams.

Upstream Boundary Conditions

Wood Rodgers obtained the Morrison Creek watershed hydrologic models from the County and incorporated the hydrographs into the hydraulic models. It is noted Wood Rodgers was only able to provide a limited review of the County's hydrology model based on the limited supporting documentation received from the County. Any change to the hydrology that may occur due to its refinement is likely to impact the results of the hydraulic modeling as outlined within this report.

Downstream Boundary Conditions

The downstream boundary condition elevations were initially developed by the USACE in Reference 7, and reiterated in the HDR report (Reference 2). Wood Rodgers adopted elevations from the 1998 and 2009 reports for the downstream boundary conditions within the unsteady flow models. The elevations were presented in 1929 datum and converted to 1988 datum using a conversion factor of 2.5 feet. **Table 6** provides the downstream boundary elevations for each storm frequency.

Table 6: Downstream Boundary Elevations

Storm Frequency	Stage 1929 Datum (ft)	Stage 1988 Datum (ft)
10-Year	9.4	11.9
25-Year	10.3	12.8
50-Year	10.8	13.3
100-Year	11.2	13.7
200-Year	11.7	14.2
500-Year	12.9	15.4

RESULTS

Morrison Creek

The updated hydrology produced by the County reduces water surface elevations between Stockton Boulevard and Power Inn Road. However, further downstream the impact of tributary flows becomes more substantial and a reduction in peak flow resulting from the updated hydrology is less pronounced.

The recently constructed retention basin on Morrison Creek, upstream of Mather Airfield (Aspen 6) provides a reduction in peak flow of approximately 25 percent. This reduction in peak flow reduces the 100-year water surface elevation by approximately 1.5 feet compared to pre-basin conditions. The available future mitigation from this basin may be reduced depending on ongoing negotiations between mining interests and Sacramento County.

The existing floodplain for Morrison Creek is shown on the Work Maps section of this report. The floodplain assumes the Aspen 6 retention basin is in place.

Table 7 provides a summary of the flows and water surfaces elevations for Morrison Creek. The table provides flow and water surface elevations with and without considering the Aspen 6 Project's retention basin. The effect of the basin on peak flow and volume reduction was not previously reflected in the effective FEMA FIRMs. The hydrologic models provided by the County, however, do reflect this basin. The basin will not provide a reduction along Elder, Florin, and Unionhouse Creeks.

Table 7: Morrison Creek Flows and Water Surface Elevations

Morrison Creek Location	Shed Area (sq mi)	100-Year Peak Flow With Aspen 6 Basin (cfs)	Est. 100-Year WSEL With Aspen 6 Basin (ft)	100-Year Peak Flow Without Aspen 6 Basin (cfs)	100-Year WSEL Without Aspen 6 Basin (ft)
Power Inn Road	28.4	2253	33.67	3241	35.52
Stockton Boulevard	32.8	3070	26.68	3839	28.17
Mack Road (Upstream of Confluence)	40.3	4113	16.66	4579	17.15
Unionhouse Creek Confluence	73.4	8279	14.43	8357	14.47
Interstate 5	125.7	9149	13.79	9874	13.80

Unionhouse Creek

Existing conditions modeling of Unionhouse Creek indicates that the embankment lowering which was completed by the USACE downstream of Franklin Boulevard has reduced flooding along Unionhouse Creek downstream of Strawberry Creek compared to the current FEMA effective FIRM. However, there is a location of the channel upstream of Franklin Boulevard where 100-year flows exceed the channel. The existing floodplain is as shown in the Work Maps section of this report. It is noted that the floodplain as shown is dependent on overbank flow which occurs upstream of Stockton Boulevard during the 100-year event. If the County elects to improve the channel upstream of Stockton Blvd., additional flow currently stored upstream will be routed to Unionhouse Creek, potentially worsening the existing flood conditions. Accommodation of the upstream storage should be evaluated with the proposed Alternative B2 and D2 channel improvements.

For alternatives modeling at Unionhouse Creek, both alternatives B2 and D2 contains the 100-year and 200-year water surfaces with the channel improvements and potential floodwalls along the channel at isolated locations. The exact length and location of the potential floodwalls will need to be confirmed in final design. **Figure 6A** and **Figure 6B** provide a comparison of Alternative B2 versus existing conditions for the 100-year and 200-year event, respectively. **Figure 7A** and **Figure 7B** provide a comparison of Alternative D2 versus existing conditions for the 100-year and 200-year event, respectively. **Figure 8A** and **Figure 8B** provide a comparison of the two alternatives (B2 and D2) for the 100-year and 200-year event, respectively.

Appendix A provides the Unionhouse Creek cross sections for each of the alternatives compared to existing conditions.

The figures indicate that for Alternative B2, the 100- and 200-year flood profiles will be reduced by up to 2 feet compared to existing conditions. For Alternative D2, the 100- and 200-year flood profiles will be reduced by up to 4 feet compared to existing conditions.

Florin Creek

Channel improvements, which included a floodwall in 2009 from Elder Creek to Franklin Boulevard, improved channel capacity to contain the 100- and 200-year floodplains.

Florin Creek exhibits significant overbank flooding between Franklin Boulevard and State Highway 99 regardless of how the mounded embankments are depicted in the model as discussed under the Model Development above.

The modeling indicates that upstream storage can be used to reduce the amount of overbank flow between State Highway 99 and Franklin Blvd.; however, due to the internal drainage amount at the lower end of the channel, channel capacity must be improved to fully contain the 100-year flow.

Figure 9 provides the hydraulic profile of Florin Creek for the 100-year and 200-year events. The existing floodplain for Florin Creek is shown on the Work Maps in this report.

Elder Creek

The evaluation of Elder Creek indicates the existing channel has capacity to contain the 100- and 200-year floodplains except at isolated locations between Franklin Boulevard and Center Parkway.

The existing floodplain for Elder Creek is shown on the Work Maps in this report.

Work Maps

Included in **Appendix B** are Work Map 1 through Work Map 13, which show the existing channel and overbank floodplain conditions for Morrison, Florin, Elder, and Unionhouse Creeks. Elevations were based upon NAVD88 datum. These maps provide the 1-percent annual chance floodplains, stream centerlines, model cross sections locations, and topographic sources. The 0.2 percent annual chance floodplain will be included as part of the LOMR that is submitted to FEMA, but is currently not shown on the Work Maps.

FIGURES

CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING

LOCATION MAP
JANUARY 2012

NORTH

0 2,000 4,000

Feet

- Railroad
- Study Stream Limits
- Levee
- County Boundary
- City Boundary

PRELIMINARY

WOOD RODGERS
DEVELOPING INNOVATIVE DESIGN SOLUTIONS
3301 C Street, Bldg. 100-B Tel: 916.341.7760
Sacramento, CA 95816 Fax: 916.341.7767

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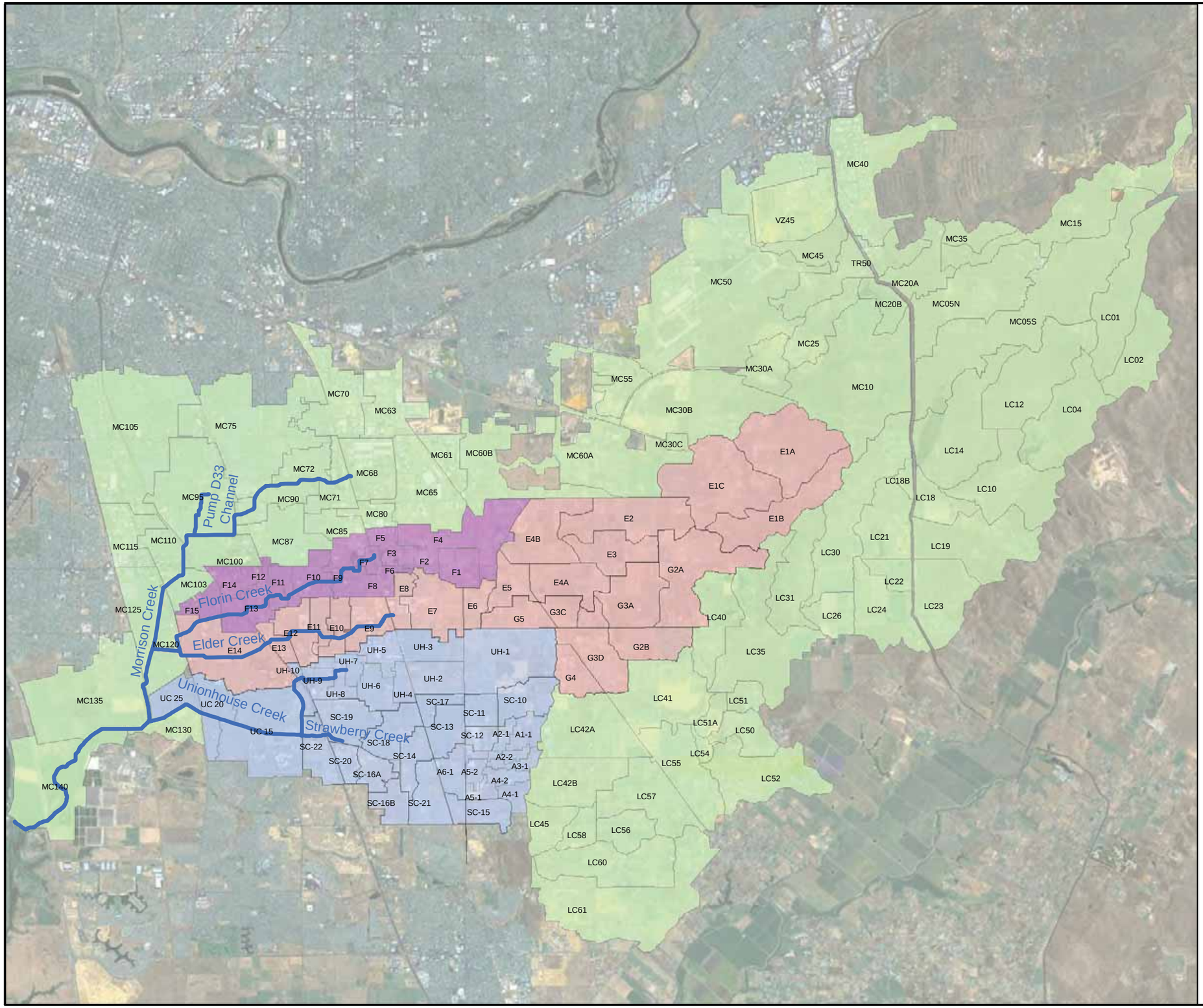
FIGURE 1

CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING

WATERSHED MAP
JANUARY 2012



NORTH

0 4,000 8,000

Feet

- Study Stream Limits
- Watersheds Morrison Creek
- Watersheds Florin Creek
- Watersheds Elder Creek
- Watersheds Unionhouse Creek

PRELIMINARY

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Sacramento, CA 95816 Fax: 916.341.7767

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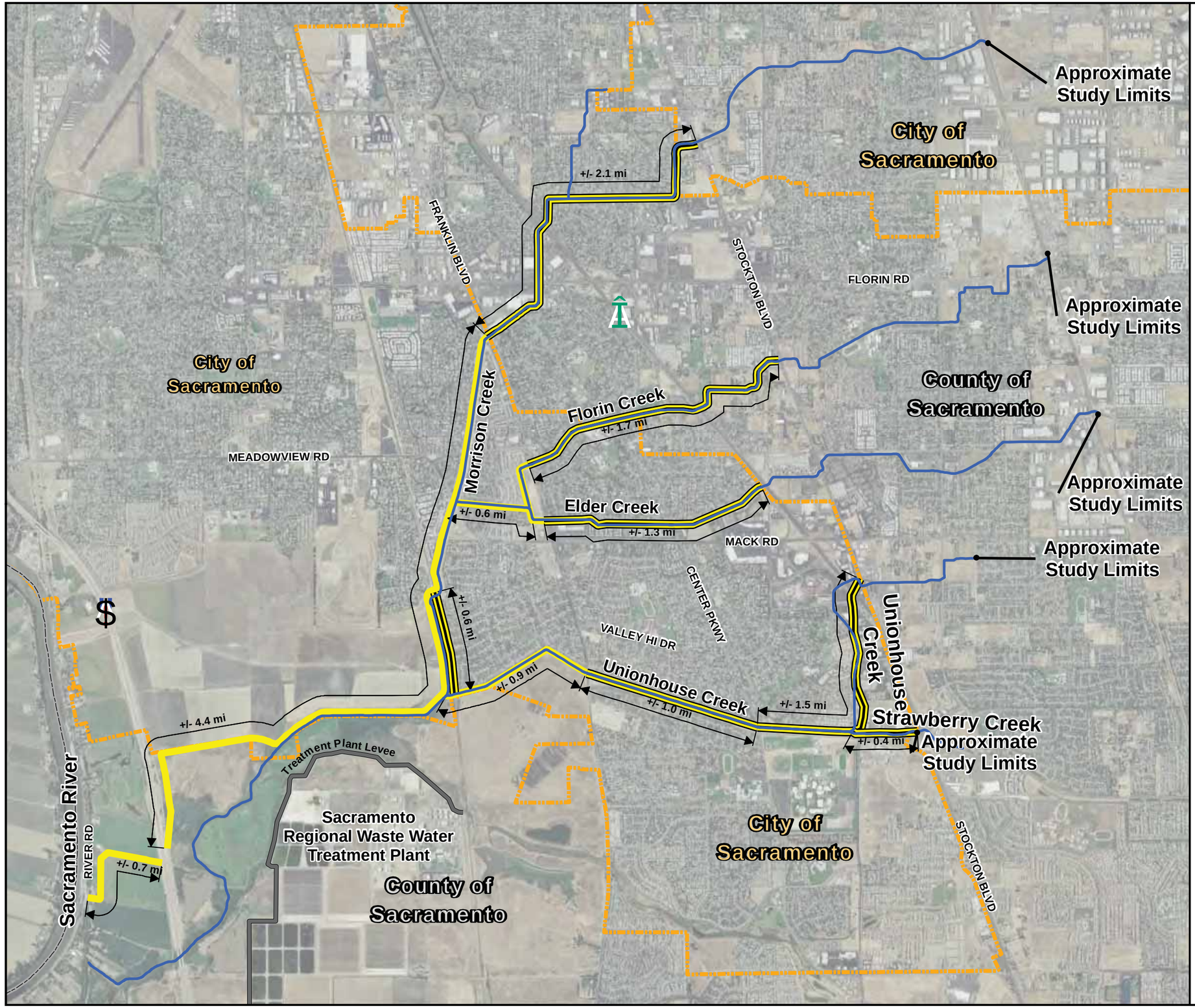
FIGURE 2

CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING

LEVEE LOCATION MAP
JANUARY 2012



NORTH

0 1,500 3,000

Feet

- Study Stream Limits
- Future Levee Work
- Completed Levee Work
- Treatment Plant Levee
- City Boundary
- County Boundary

PRELIMINARY

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FIGURE 3

CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING

PRELIMINARY DFIRM
JANUARY 2012

- Railroad
- Channel Centerlines
- Base Flood Elevation, NAVD88

Flood Zone:

- A
- AE
- AH
- AO
- A99
- X PROTECTED BY LEVEE
- 0.2 PCT ANNUAL CHANCE FLOOD HAZARD
- X

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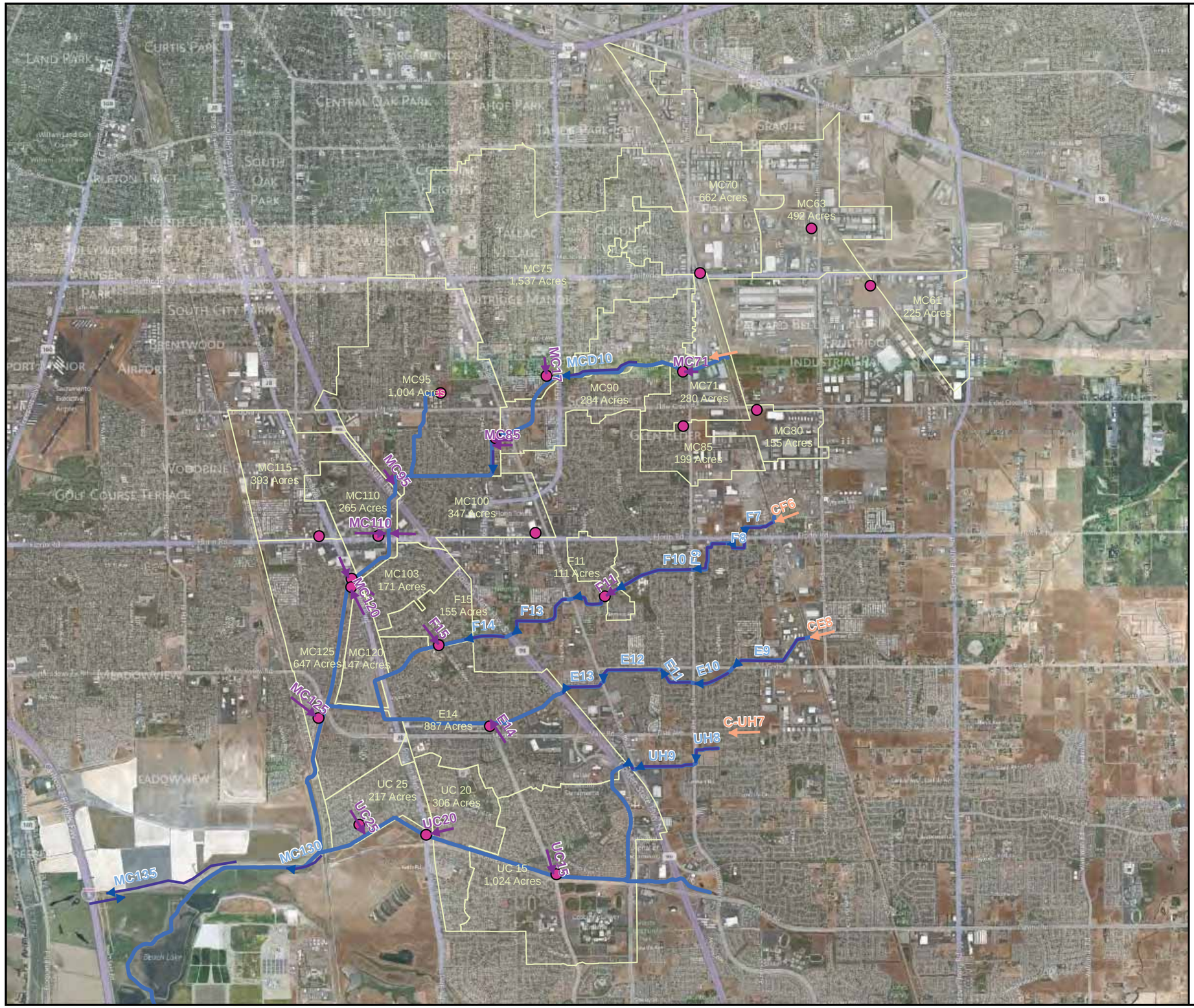
FIGURE 4

CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING

PUMP STATION AND SHED BOUNDARY LOCATION MAP

JANUARY 2012



0 0.75 1.5

Miles

NORTH

- Pump Station

Inflow Type

- Pump Station/Storage Area
- Uniform Lateral Inflow Hydrograph
- Upstream Boundary Hydrograph
- Study Stream Limits
- Watershed Boundary

PRELIMINARY

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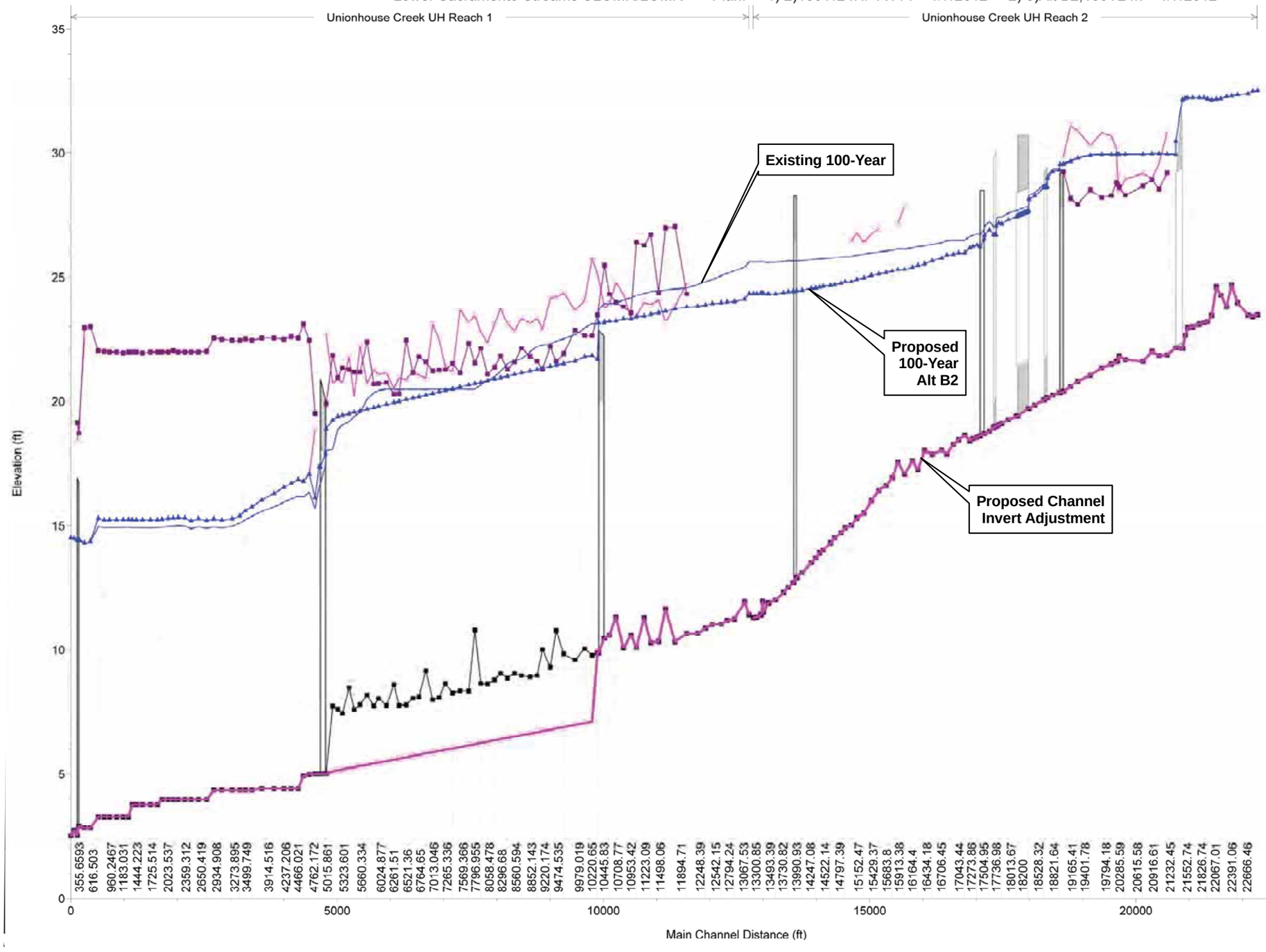
FIGURE 5

Lower Sacramento Streams CLOMR/LOMR Plan: 1) 2)100Yr24Hr TW14 1/7/2012 2) 8)Alt B2;100Y24h 1/7/2012



CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING
UNIONHOUSE CREEK 100-YEAR
EXISTING CONDITIONS VS. PROPOSED ALT. B2
JANUARY 2012

NORTH

WS Max - Proposed Alt. B2
WS Max - Existing Conditions
Ground
Left Levee
Right Levee
Ground

PRELIMINARY

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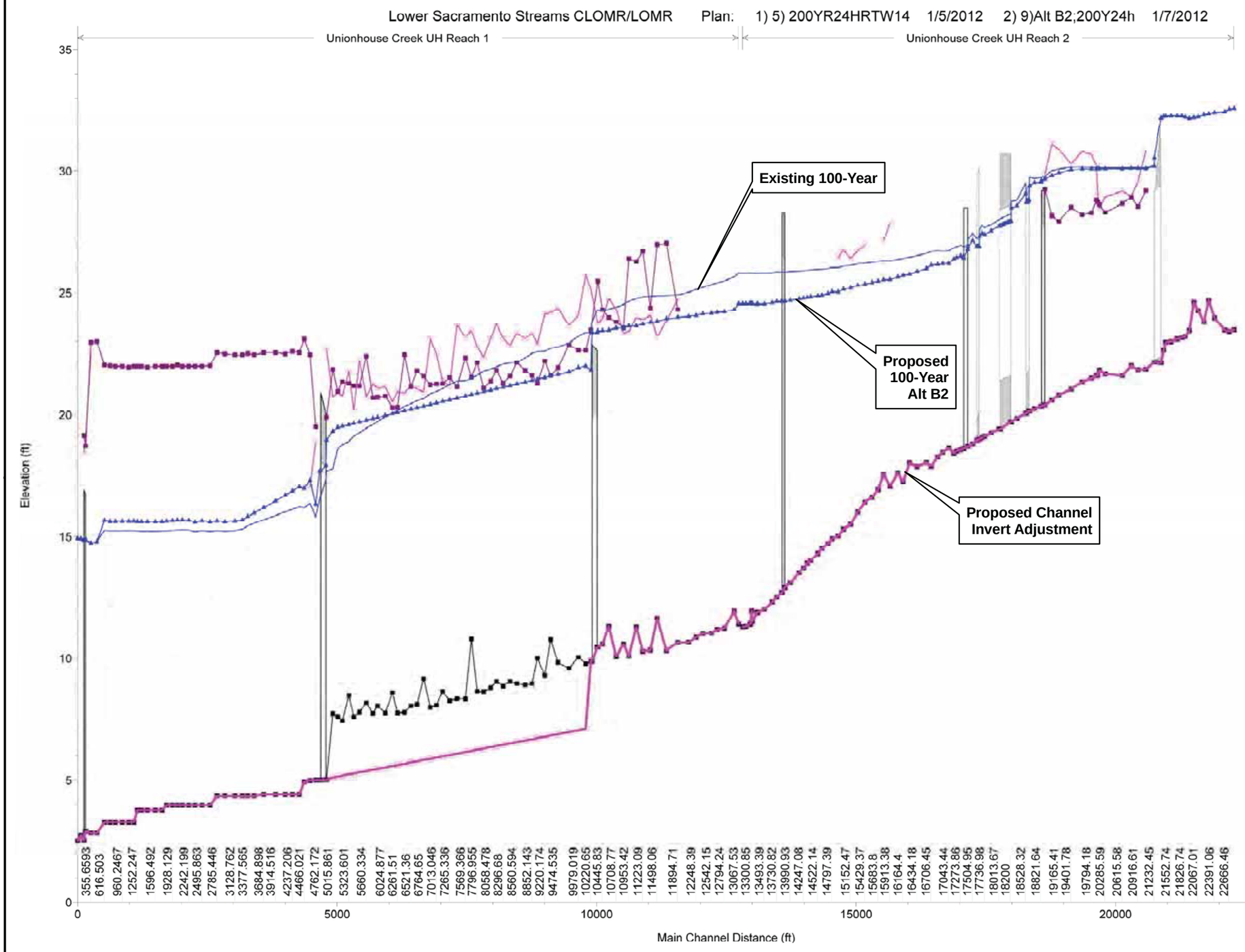
FIGURE 6A



CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING
UNIONHOUSE CREEK 200-YEAR
EXISTING CONDITIONS VS. PROPOSED ALT. B2
JANUARY 2012

NORTH

WS Max - Proposed Alt. B2
WS Max - Existing Conditions
Ground
Left Levee
Right Levee
Ground

PRELIMINARY

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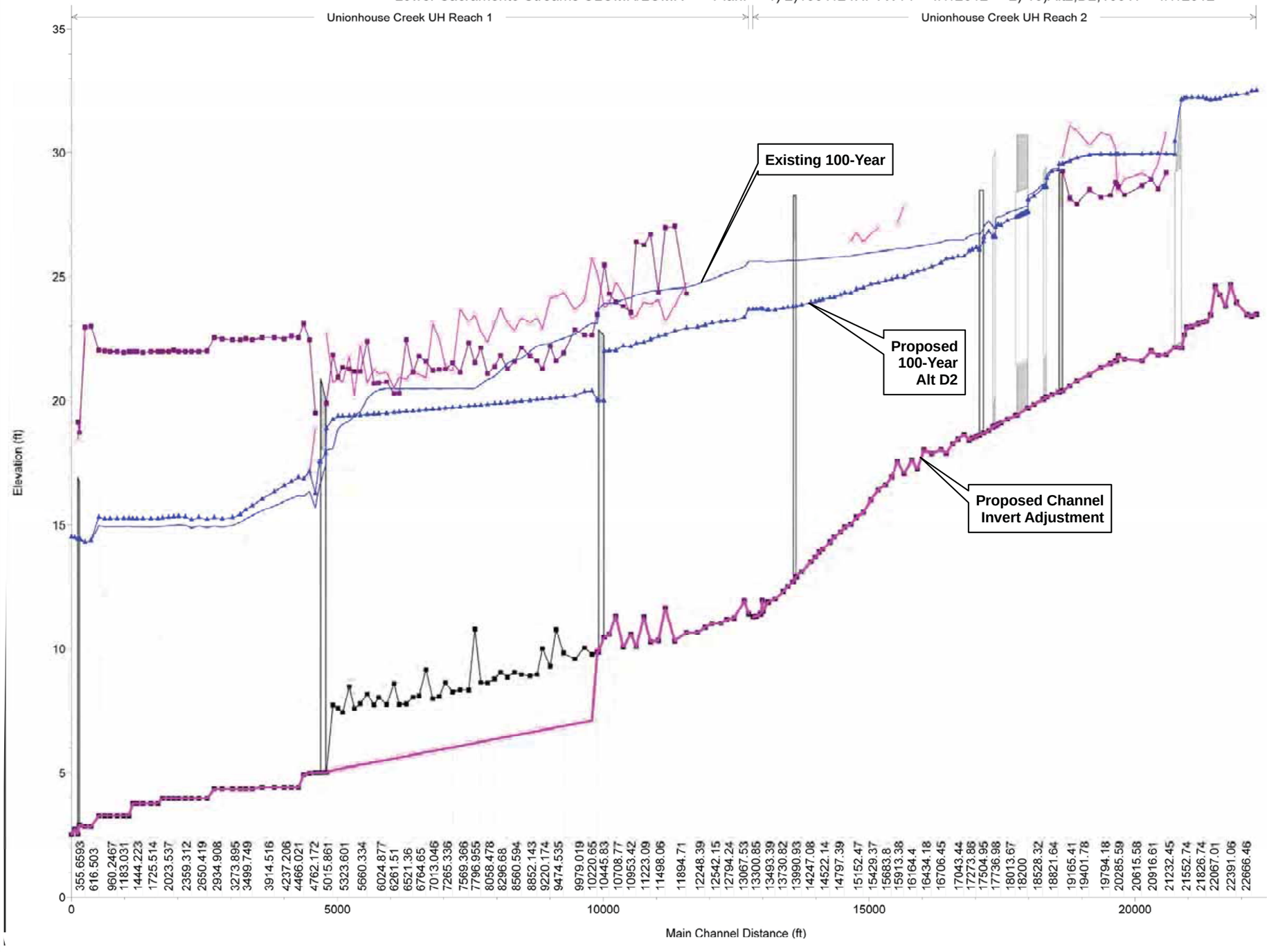
FIGURE 6B

Lower Sacramento Streams CLOMR/LOMR Plan: 1) 2)100Yr24Hr TW14 1/7/2012 2) 10)Alt2;D2;100Yr 1/7/2012



CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING
UNIONHOUSE CREEK 100-YEAR
EXISTING CONDITIONS VS. PROPOSED ALT. D2
JANUARY 2012

NORTH

WS Max - Proposed Alt. D2
WS Max - Existing Conditions
Ground
Left Levee
Right Levee
Ground

PRELIMINARY

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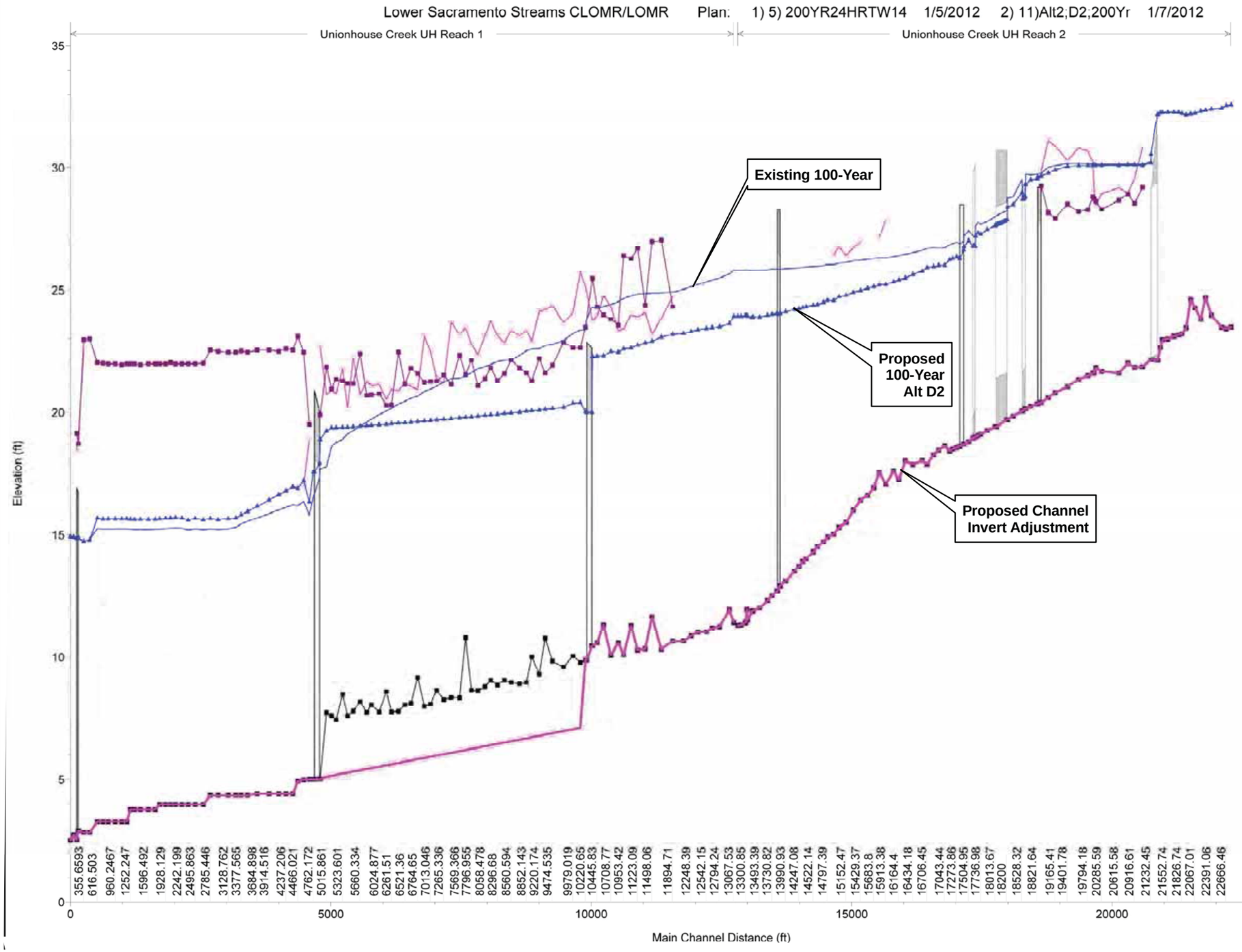
FIGURE 7A



CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING
UNIONHOUSE CREEK 200-YEAR
EXISTING CONDITIONS VS. PROPOSED ALT. D2
JANUARY 2012

NORTH

WS Max - Proposed Alt. D2
WS Max - Existing Conditions
Ground
Left Levee
Right Levee
Ground

PRELIMINARY

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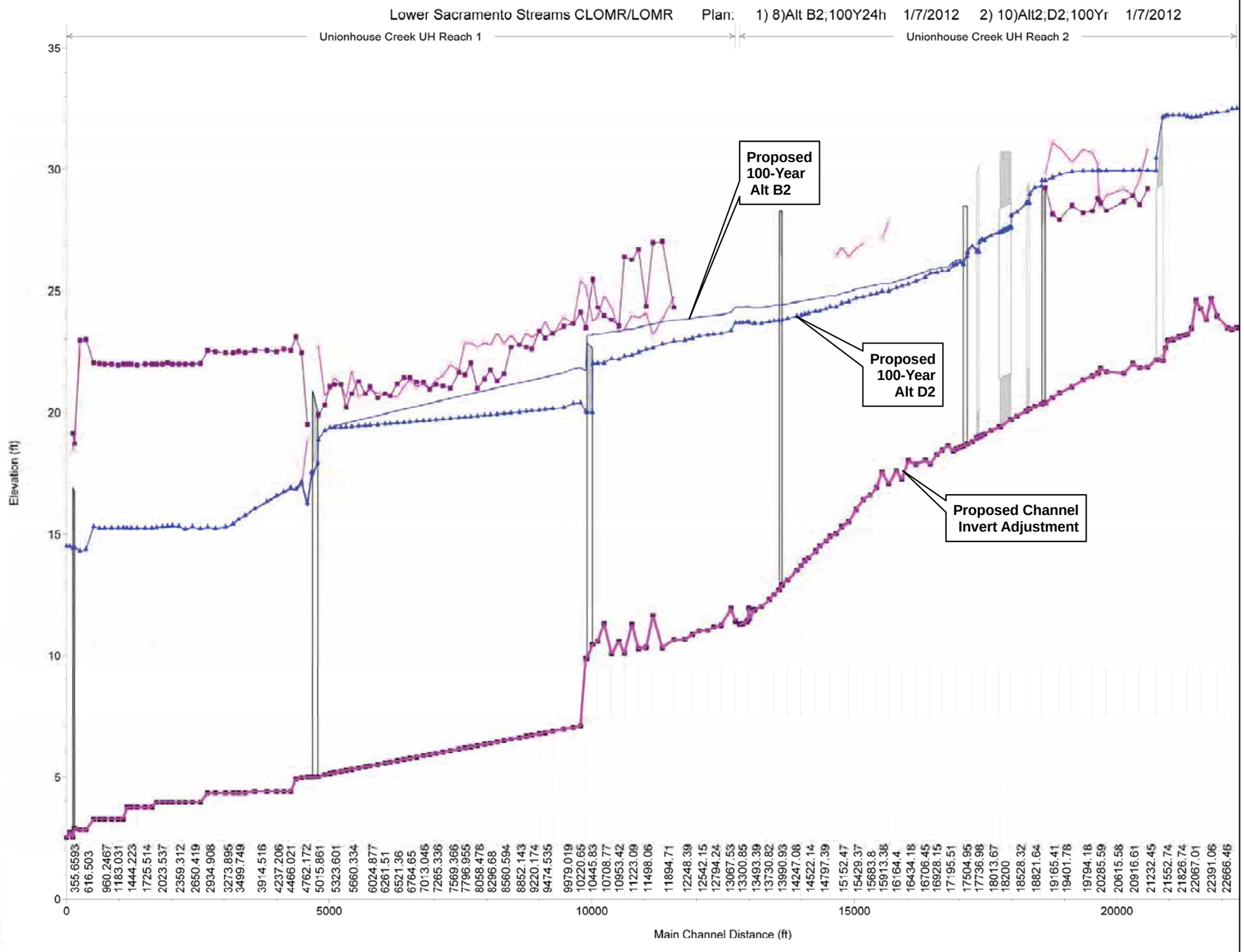
FIGURE 7B



CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING
UNIONHOUSE CREEK 100-YEAR
PROPOSED ALT. B2 VS. PROPOSED ALT. D2
JANUARY 2012

NORTH

WS Max - Proposed Alt. D2
WS Max - Proposed Alt. B2
Ground
Left Levee
Right Levee
Ground

PRELIMINARY

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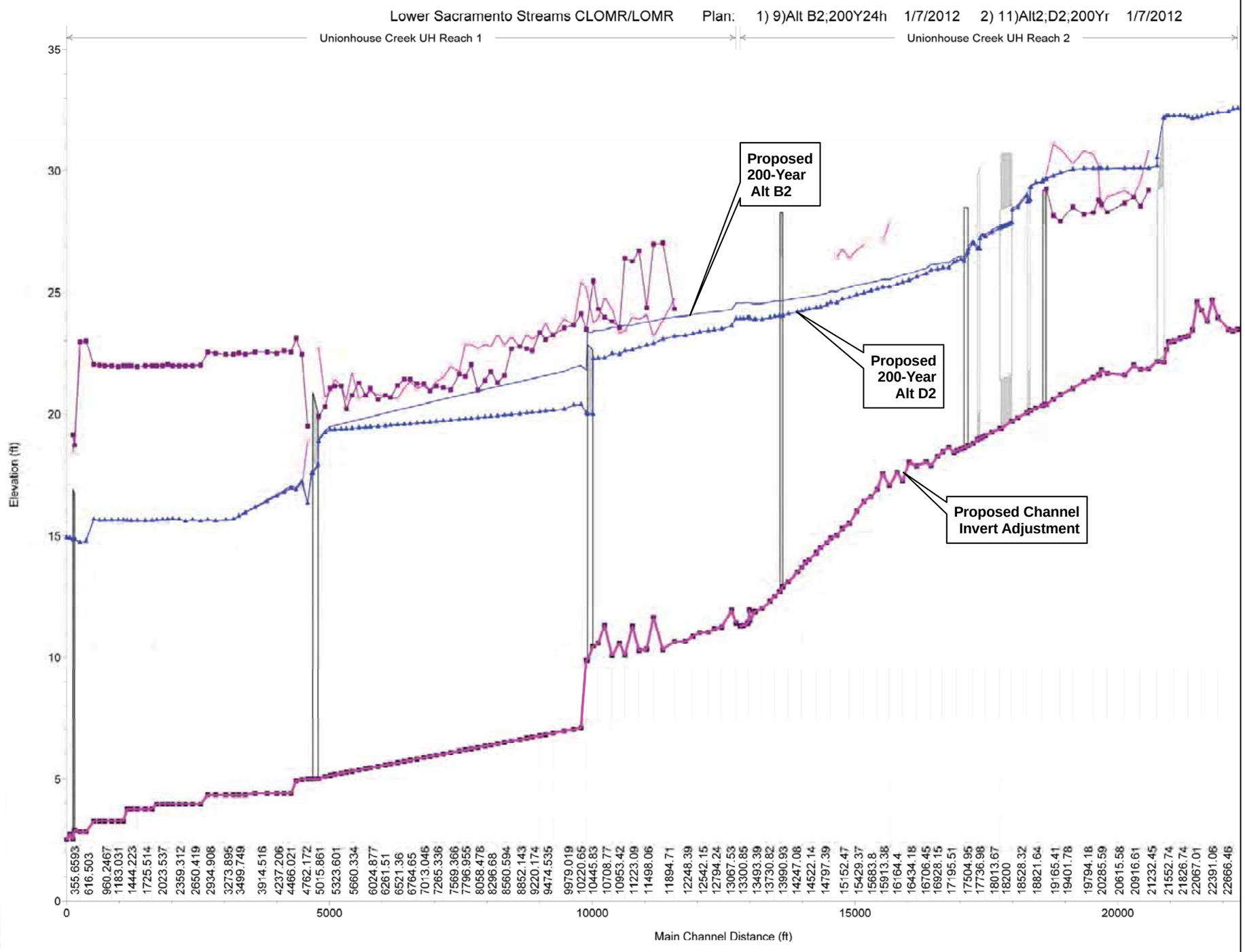
J:\Jobs\8239.007-MorrisonCreekLOMR\Morrison_Unionhouse_Creeks_CLOMR_LOMR\GIS\Tasks\ReportFigures\Fig8A_Unionhouse_100yr_altB2_vs_altD2_20120111_V1.mxd 1/12/2012 12:10:37 PM jbuchanan

FIGURE 8A



CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING
UNIONHOUSE CREEK 200-YEAR
PROPOSED ALT. B2 VS. PROPOSED ALT. D2
JANUARY 2012

NORTH

WS Max - Proposed Alt. D2
WS Max - Proposed Alt. B2
Ground
Left Levee
Right Levee
Ground

PRELIMINARY

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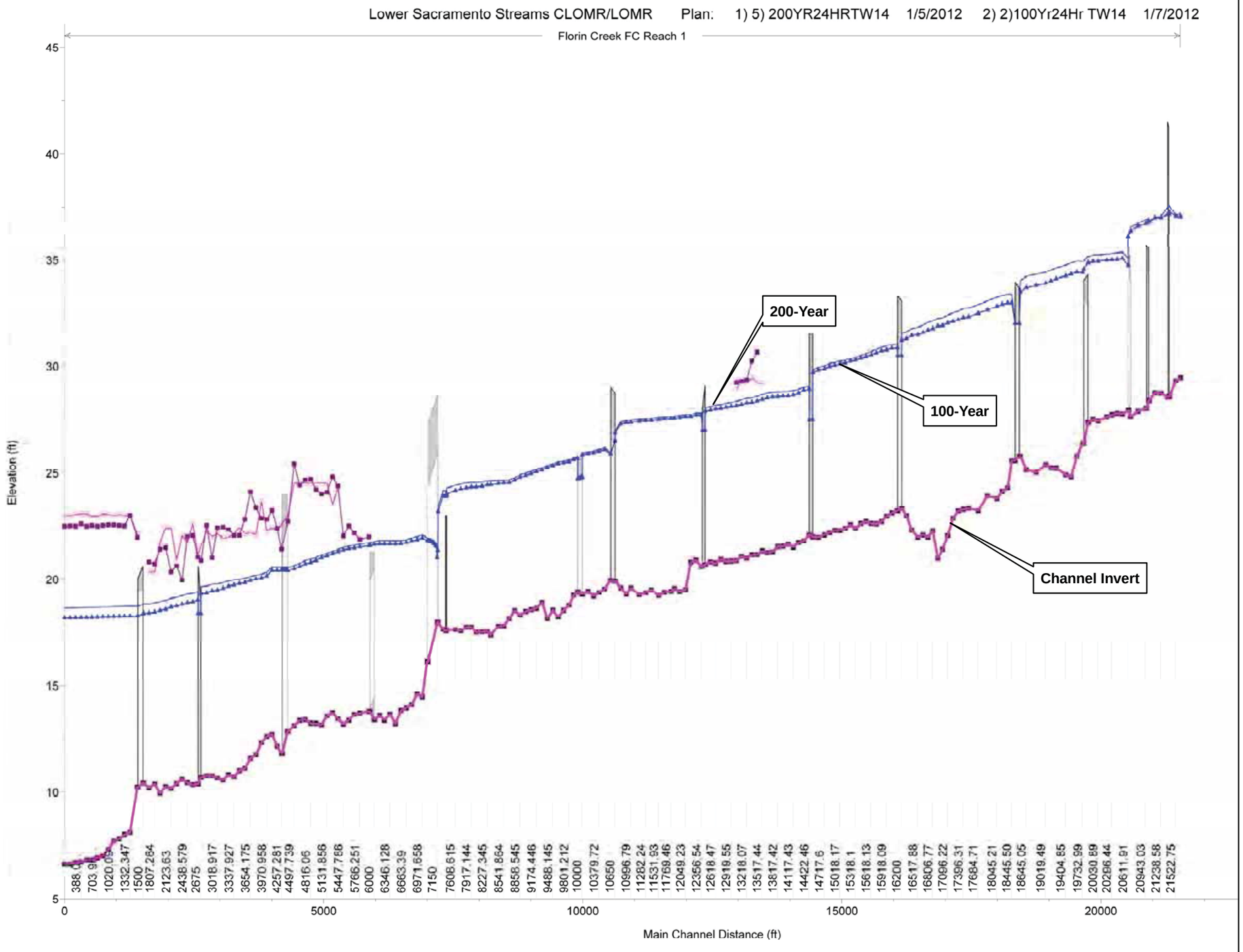
FIGURE 8B



CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING
FLORIN CREEK 200-YEAR AND 100-YEAR
EXISTING CONDITIONS
JANUARY 2012

NORTH

WS Max - 200 Year
WS Max - 100 Year
Ground
Left Levee
Right Levee
Ground

PRELIMINARY

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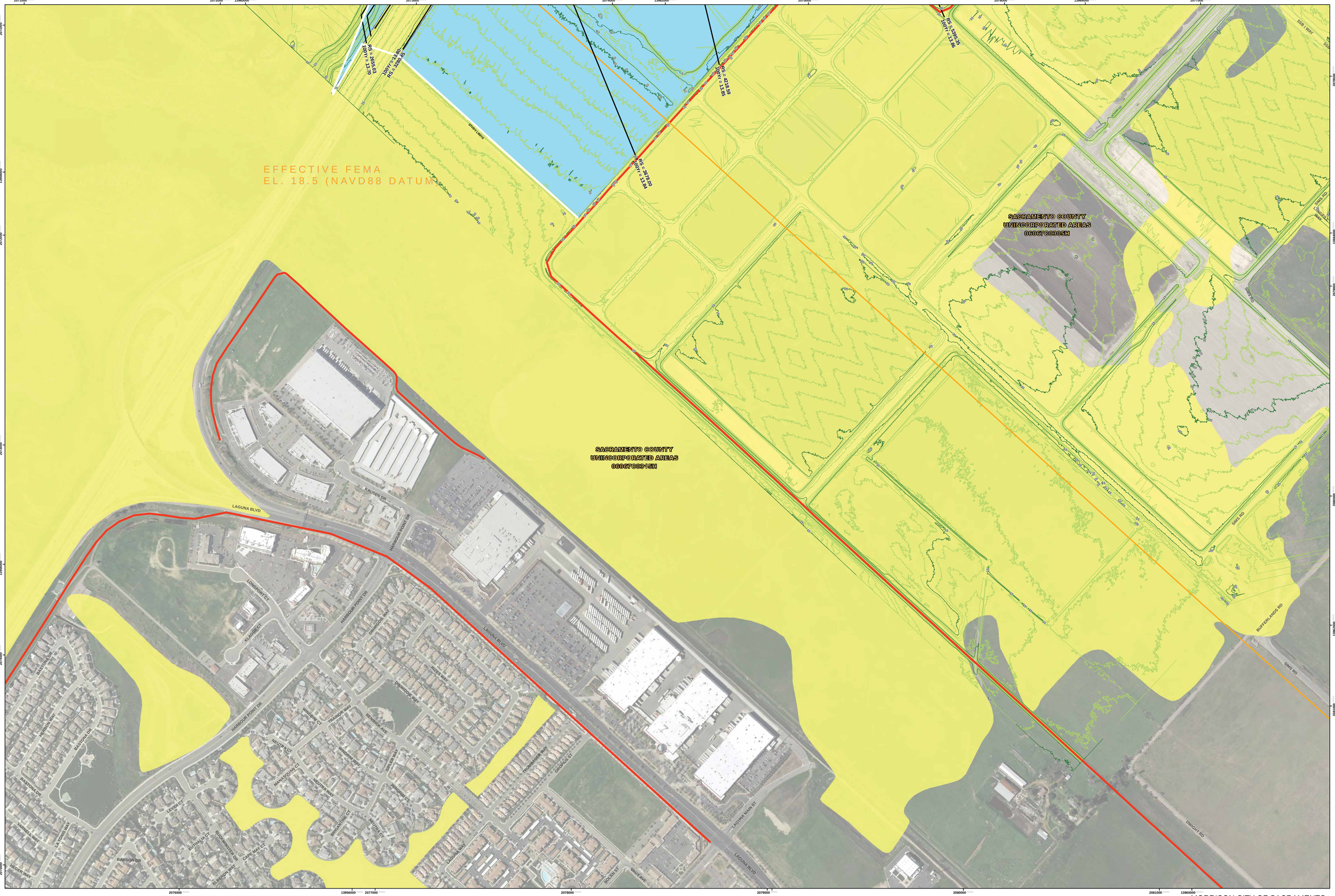
FIGURE 9

APPENDICES



LiDAR Data Source: PhotoScience, 2008.
Image Source: PhotoScience, 2008.
Horizontal Datum: UTM NAD83 Zone 10 Feet.
Vertical Datum: NAVD88.

Legend

Proposed FEMA Effective:
- 1-Percent Annual Chance Flood
- KKKKK Proposed BFE
- Stream Centerlines
- HEC-RAS Cross Section
- FEMA FIRM Panel
- 100Yr = 2297.67 HEC-RAS 100-Year Results
- RS = 1.23 HEC-RAS River Station
- A Proposed FEMA Cross Section Letter
- Pump Station

FEMA Preliminary Effective (July 30, 2010):
- 1-Percent Annual Chance Flood
- KKKKK Preliminary BFE
- Contours (1 ft)
- Contours (5 ft)
- Levee
- Embankment Overflow
- Railroad
- Structure

NORTH
0 100 200 400
Feet
SCALE AT FULL SIZE

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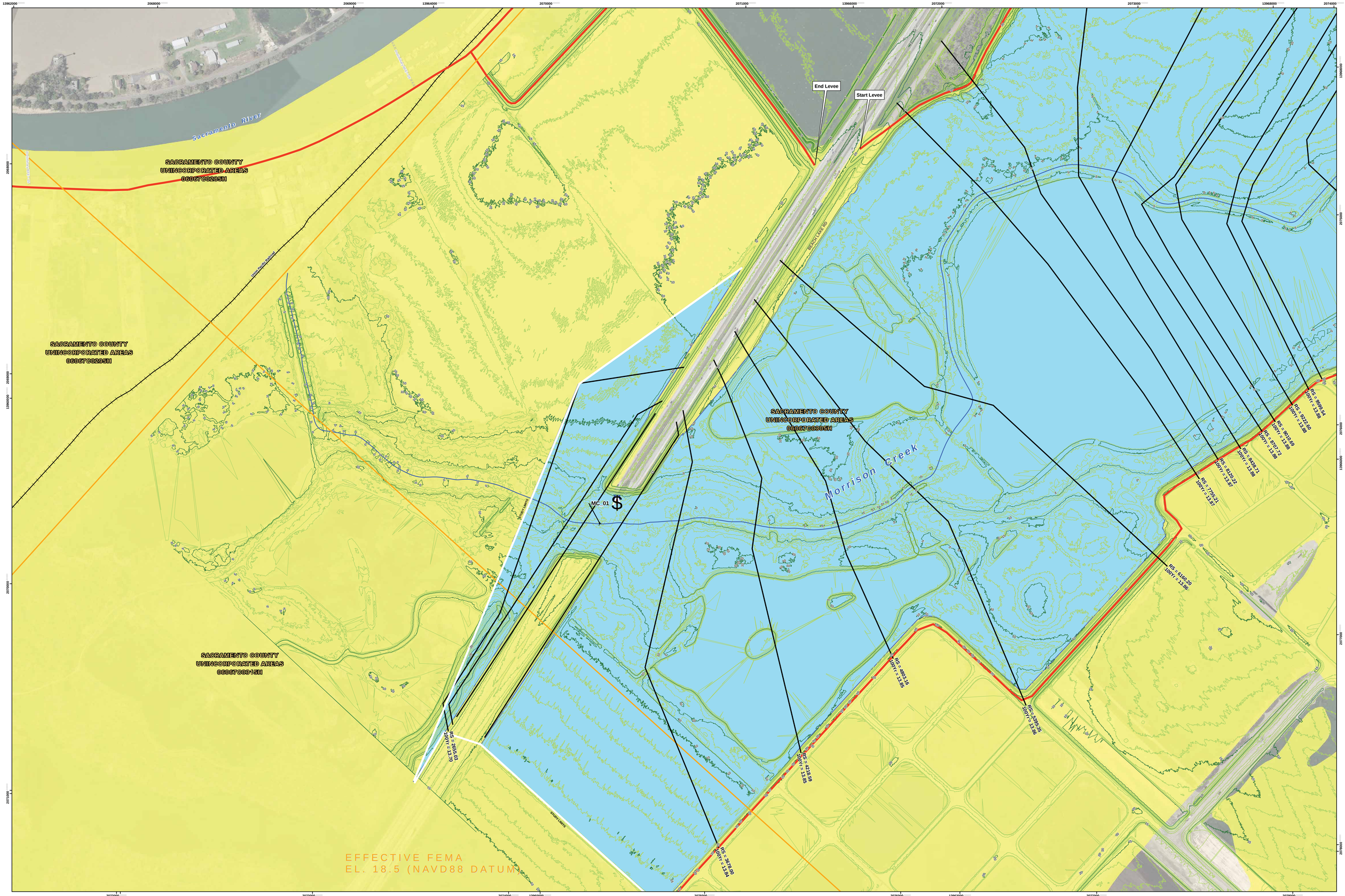
MORRISON CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING

EXISTING CONDITIONS 100-YEAR FLOODPLAIN
JANUARY 2012
WORK MAP 1 OF 13

DRAFT



LiDAR Data Source: PhotoScience, 2008.
Image Source: PhotoScience, 2008.
Horizontal Datum: UTM NAD83 Zone 10 Feet.
Vertical Datum: NAVD88.

Legend

Proposed FEMA Effective:
- 1-Percent Annual Chance Flood
- KKKKK Proposed BFE
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- FEMA FIRM Panel
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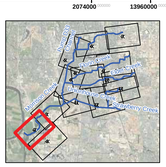
- KKKKK Preliminary BFE
- Contours (1 ft)
- Contours (5 ft)
- Levee
- Embankment Overflow
- Railroad
- Structure



NORTH

0 100 200 400
Feet
SCALE AT FULL SIZE

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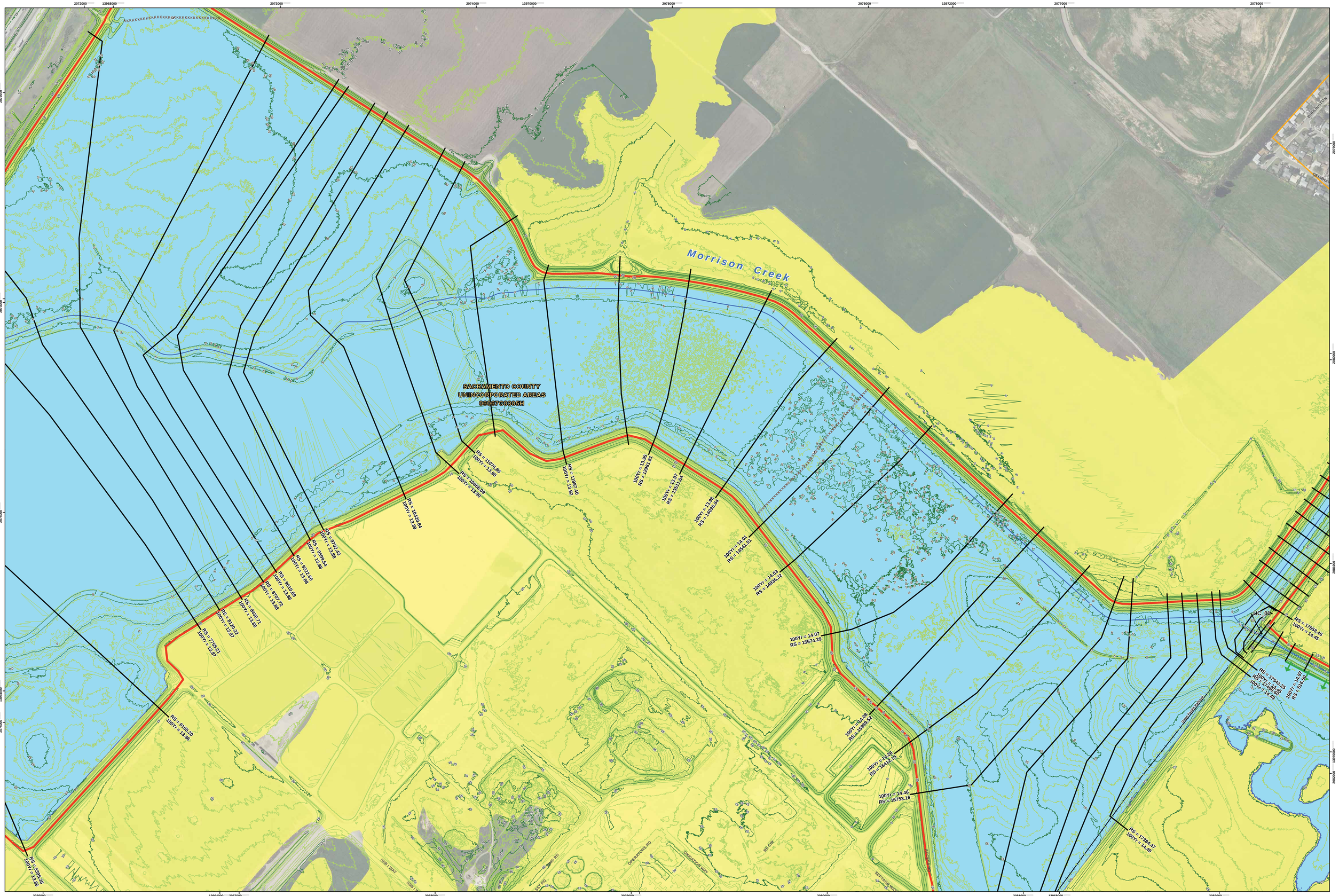
MORRISON CITY OF SACRAMENTO SOUTH SACRAMENTO STREAMS GROUP EXISTING CONDITIONS AND CHANNEL IMPROVEMENTS MODELING

EXISTING CONDITIONS 100-YEAR FLOODPLAIN
JANUARY 2012

WORK MAP 2 OF 13

DRAFT



LiDAR Data Source: PhotoScience, 2011.
Image Source: PhotoScience, 2008.
Horizontal Datum: UTM NAD83 Zone 10 Feet.
Vertical Datum: NAVD88.

Legend

Proposed FEMA Effective:
- 1-Percent Annual Chance Flood
- KKKK Proposed BFE
- Stream Centerlines
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- FEMA FIRM Panel
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- Pump Station

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- KKKK Preliminary BFE
- Contours (1 ft)
- Contours (5 ft)
- Levee
- Embankment Overflow
- Railroad
- Structure

NORTH

0 100 200 400
Feet
SCALE AT FULL SIZE

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MORRISON CITY OF SACRAMENTO SOUTH SACRAMENTO STREAMS GROUP EXISTING CONDITIONS AND CHANNEL IMPROVEMENTS MODELING

EXISTING CONDITIONS 100-YEAR FLOODPLAIN
JANUARY 2012

WORK MAP 3 OF 13

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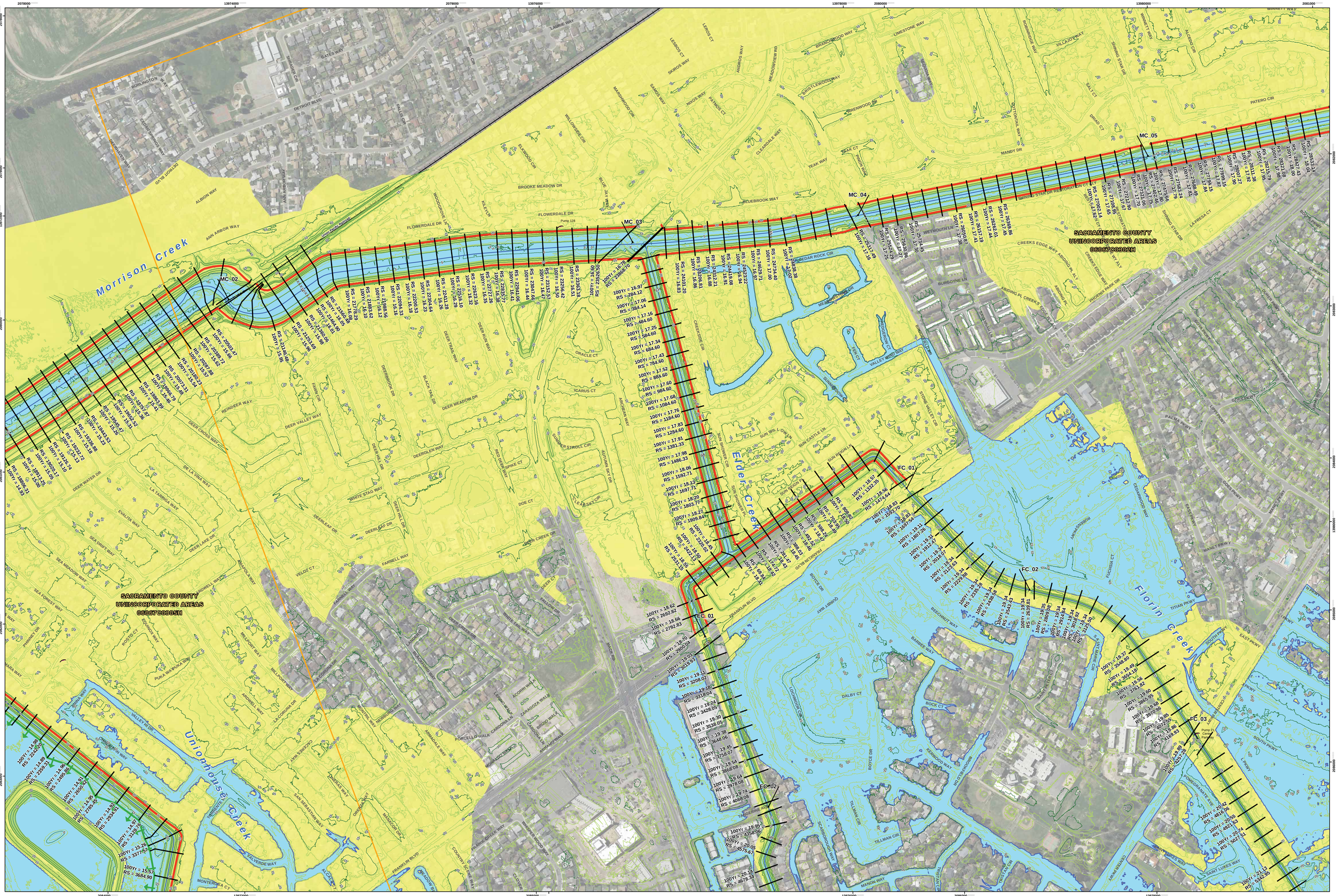

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Image Source: PhotoScience, 2008.
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Vertical Datum: NAVD88.

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Legend

Proposed FEMA Effective:
- 1-Percent Annual Chance Flood
- KKKKK Proposed BFE
- Stream Centerlines
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- Pump Station

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- Contours (1 ft)
- Contours (5 ft)
- Levee
- Embankment Overflow
- Railroad
- Structure

NORTH

0 100 200 400
Feet
SCALE AT FULL SIZE

MORRISON CITY OF SACRAMENTO
SOUTH SACRAMENTO STREAMS GROUP
EXISTING CONDITIONS AND
CHANNEL IMPROVEMENTS MODELING

EXISTING CONDITIONS 100-YEAR FLOODPLAIN
JANUARY 2012

WORK MAP 4 OF 13

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