US Army Corps of Engineers®

CHICAGO DISTRICT

LEADERS IN CUSTOMER CARE

WESTMINSTER
EAST GARDEN GROVE

STRUCTURAL APPENDIX

FEASIBILITY REPORT

JUNE 2019

STRUCTURAL APPENDIX

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APPENDIX TITLE
APPENDIX A

INTRODUCTION

1. For the Westminster feasibility level report, this Structural Appendix develops the major structural features for the new bridge to replace the existing Channel Outlet Structure and for the Warner Avenue Bridge extension and widening. The structural features are developed only to a level necessary to develop a feasibility level cost estimate.

CHANNEL OUTLET STRUCTURE

General

2. The existing channel outlet structure is being removed to create a 146 foot wide channel with vertical side walls. This structure consists of a double reinforced concrete wall system with tie rods and 11 foot apron slabs. The structure will be replaced with a bridge to maintain the access across the channel. To create the side walls of the channel and to also provide support for the bridge, two cantilever concrete abutments will be provided. These abutments will extend to and tie into the typical dual row sheet pile channel wall section. The new bridge will provide a 24'-8" clear span between rails and be capable of carrying vehicular traffic, similar to the existing bridge.

Figure 1. Existing Channel Outlet Structure

Hydraulic Requirements

3. The existing Channel Outlet Structure and gate structure is required to be removed to create a 146 foot wide channel with no hydraulic separation.

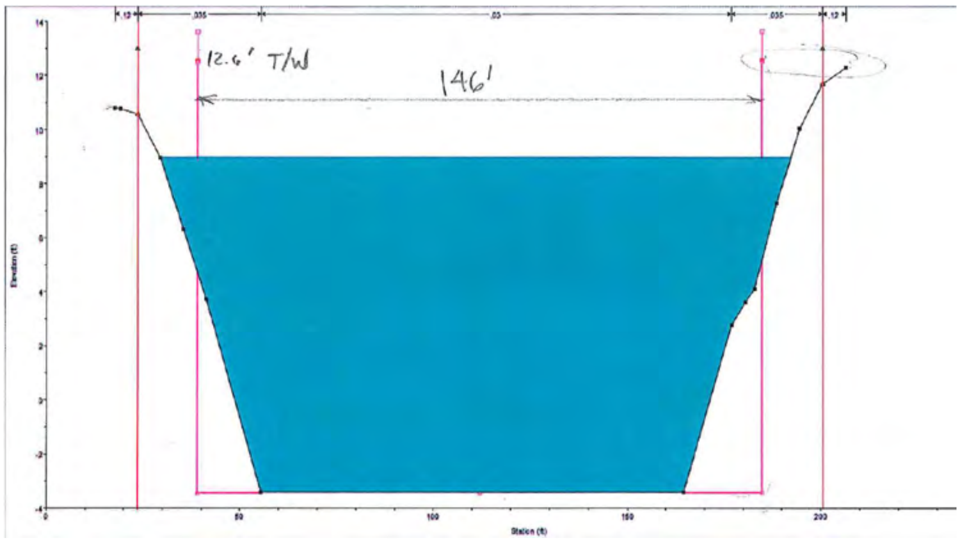

Figure 2. Hydraulic Channel Shape and Dimensions

The new bridge will have three pile bents which is less than the four pile bents on the Oil Field road bridge directly upstream and therefore, will not constrict flow. The abutments will create vertical side walls for the new channel to match the dual sheet pile channel cross section upstream of the new bridge. The required elevation of the new bridge abutment is EL. 12.6 (NAVD88) with the elevation equal to EL. 13.1 at the channel centerline. This places the lower chord of the new bridge at approximately EL. 10.6 at the abutments to EL. 11.1 at the channel centerline.

Demolition of Existing Channel Outlet Structure

4. The entire existing channel outlet structure including apron slab is required to be removed for opening of the channel and to allow installation of the new bridge pile bents and abutments.

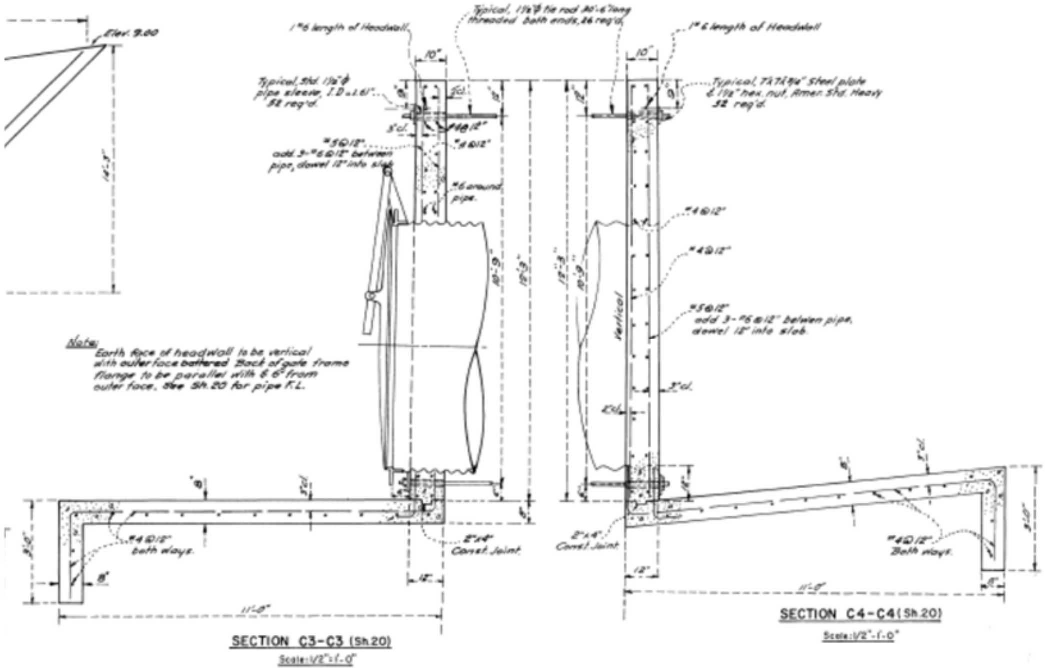

Figure 3. Cross Section of Existing Channel Outlet Structure

It is anticipated that the contractor may be able to demolish and remove the existing structure working from the far side bank on top of the structure and working back towards the nearside bank, removing a section of the existing structure at a time. This will require care not to destabilize the existing structure supporting construction equipment and personnel. Mobilization of a large marine plant may not be possible due to the limited draft available. The contractor may also choose to cofferdam and dewater a portion of the structure at a time to accomplish the demolition and perhaps utilized the cofferdam in conjunction with the new bridge abutment installation. During planning, engineering and design (PED) phase, cofferdam width restrictions will need to be provided to ensure flooding does not occur upstream on the channel side.

Abutments

5. The top elevation of the abutments is set at EL. 12.6 per hydraulic requirements. The abutments consist of cantilever retaining walls founded on piles to prevent differential settlement of the abutments with respect to the bridge pile bents. The piles are shown to terminate at the same tip elevation of the pile bents. A concrete retaining wall type abutment is required to create the vertical side wall of the channel.

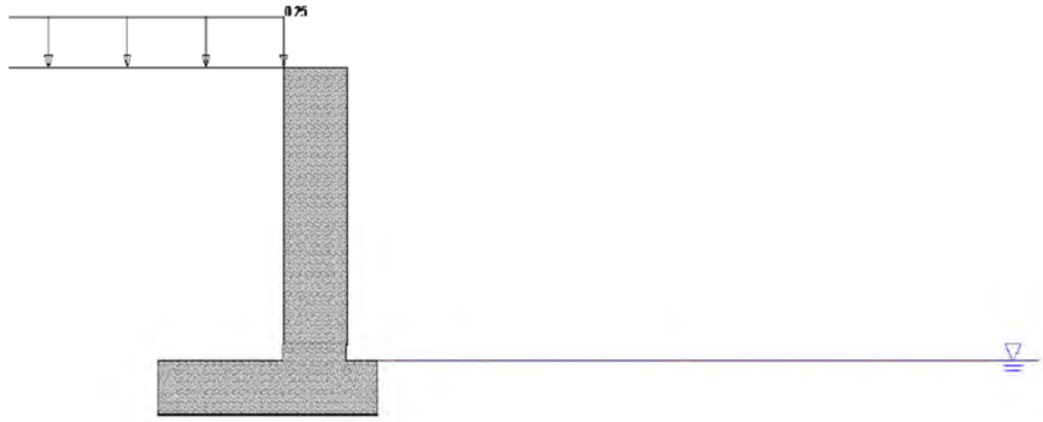

Figure 4. Abutment Shape (Piles not shown)

The concrete retaining wall abutment will tie into the typical dual sheet pile wall being used to create the channel upstream of the new bridge. During PED, it can be investigated if a concrete abutment cap can be placed on the dual sheet pile wall system to act as an abutment. This was not done at this level of design due to the uncertainties with calculating the lateral stability of the dual sheet pile wall system. The cantilever concrete retaining wall abutment lateral stability was checked using CTWALL and is contained in Attachment A-2.

Pile Bents

6. Three intermediate bridge pile bents are provided which consist of cast in place or driven precast/pre-stressed concrete piles supporting a cast-in-place bridge bent. The pile design is based on similar pile requirements at the oil field bridge just upstream of the bridge. Approximately 60 foot long piles are required for the pile bents.

Bridge Deck

The bridge deck will consists of 18 inch deep precast/pre-stressed concrete “voided slabs”. The slab units will span 36’-6” between the abutments and pile bents.

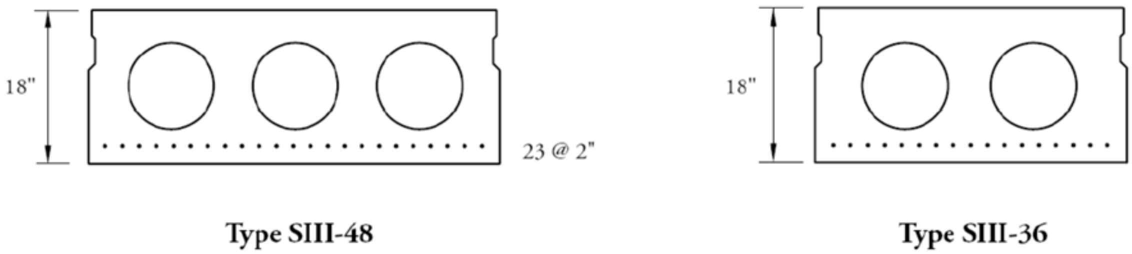

Figure 5. Precast/Pre-stressed Concrete "Voided Slab"

A preliminary design for the slab deck units is based on the PCI Bridge Design Manual (1997), preliminary design chart SB-2, indicating the SIII 18" slabs are adequate for spans up to 45 to 50 feet. A six inch cast in place topping slab will be placed over the slab units. The topping slab will incorporate a 1'-8" curb on each side of the bridge for mounting of the bridge rail.

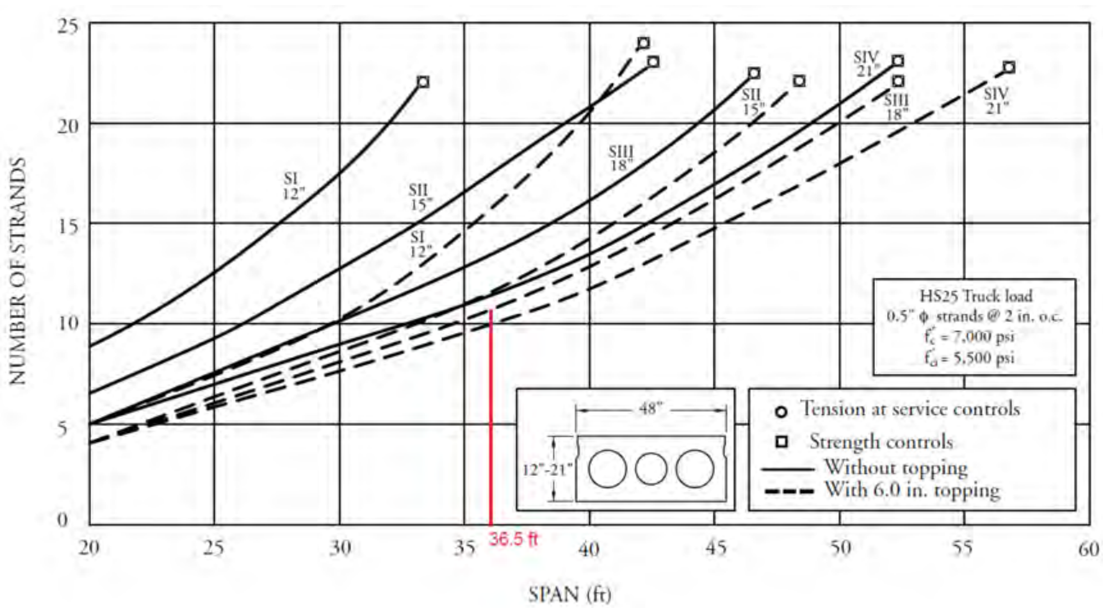

Figure 6. Voided Slab Preliminary Design - PCI Bridge Design Manual (1997)

Bridge Rail

A vehicular and pedestrian bridge rail is required for the bridge. A California ST-10 bridge rail appropriate for coastal zones is assumed for the bridge. A minimum of a 42 inch high pedestrian/bicycle rail is required for the anticipated use of the bridge.

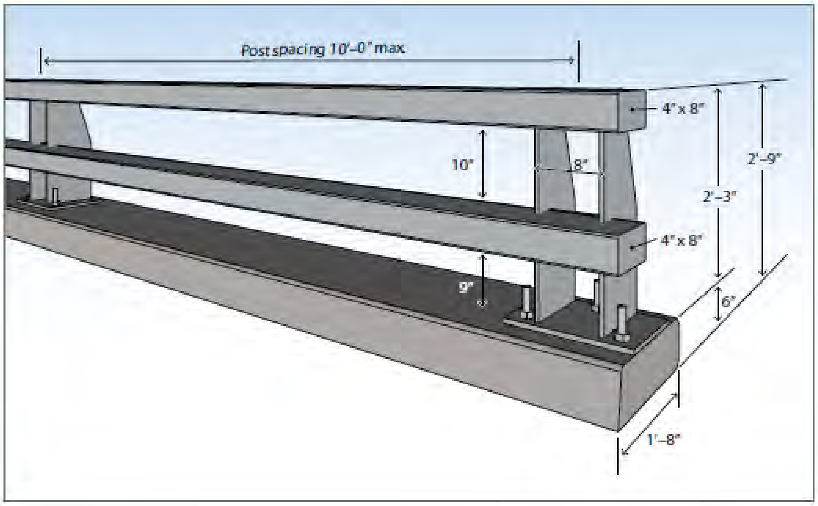

Figure 7. California ST-10 Bridge Rail – Caltrans

Figure 8. Example ST-10 Bridge Rail with addition of Pedestrian Rail

Scour Protection

Rip rap is assumed around the bridge abutments to prevent scouring. The abutments are pile supported in the event some scouring does occur.

Quantities

Estimated quantities for the channel outlet structure are provided in the figure below.

ITEM	Quantity	Unit
Demolition of Existing Channel Outlet Structure	1	LS
Piles - 16" Cast in Place Concrete (Alternate Class 200 Prestressed Concrete)	2859	lineal feet
Abutment and Bent Cast in Place Concrete	527	cuyd
Voided Slab Type SIII-48"	584	lineal feet
Voided Slab Type SIII-36"	584	lineal feet
6" Topping Slab and Curb	85	cuyd
ST-10 Caltrans Railing and Pedestrian Rail	292	lineal feet
Rip Rap Scour Protection (cross section as required along abutments)	125	lineal feet

Figure 9. Estimated Quantities - Channel Outlet Structure Bridge Replacement

WARNER AVENUE BRIDGE

General

The Warner Avenue Bridge crosses the Bolsa Chica Channel right next to the Bolsa Chica Conservancy area. It's founded on four pile bents made up of a cast-in-place concrete pile cap over 11 pre-cast concrete piles. The bridge deck is made up of 15 inch deep precast/pre-stressed concrete "voided slabs" that span the 30 foot spacing of the pile bents. The voided slabs are topped with a 3 inch wearing surface of asphalt. The north side of the bridge has a 6 foot wide reinforced concrete sidewalk and a small shoulder bike lane. The south side of the bridge also has a small shoulder bike lane and a reinforced concrete Type 732SW bridge Rail.

Figure 10. Warner Avenue Bridge Site

Proposed Modifications to the Channel and Bridge

As currently laid out the Bolsa Chica Channel is constricted under the bridge impeding high flows. Therefore the channel is going to be widened and in order to do that the bridge will have to be expanded. Another 3 pile bents will be added to increase the length of the bridge from approximately 91 feet long to 182 feet long essentially doubling the span. The plan is to leave as much of the existing bridge as possible while widening the channel and increasing the bridge span. Also a new bike lane and sidewalk will be added to the south side of the bridge. It will be separated from the road by the existing reinforced bridge rail and a new extension of that bridge rail.

Figure 11. Warner Avenue Bridge with new Channel Contours

New Bridge Construction

The new sections of the bridge will match the existing bridge construction using precast piles topped with cast-in-place pile caps. 15 inch deep precast/pre-stressed concrete "voided slabs" will be placed on top of the pile caps that span the 30 foot spacing of the pile bents. The voided slabs will be topped with a 3 inch wearing surface of asphalt. The new bike lane and sidewalk will implement the same underlying bridge construction features. This will allow for future lane expansion if the road is widened without having to do another major re-build.

The proposed channel grade elevation at the bridge is approximately shown on plates and provided by H&H. Precast piles are assumed for the bridge support including at the bridge approaches. Concrete retaining wall abutments may be necessary if there are additional channel clearance requirements for flow conveyance.

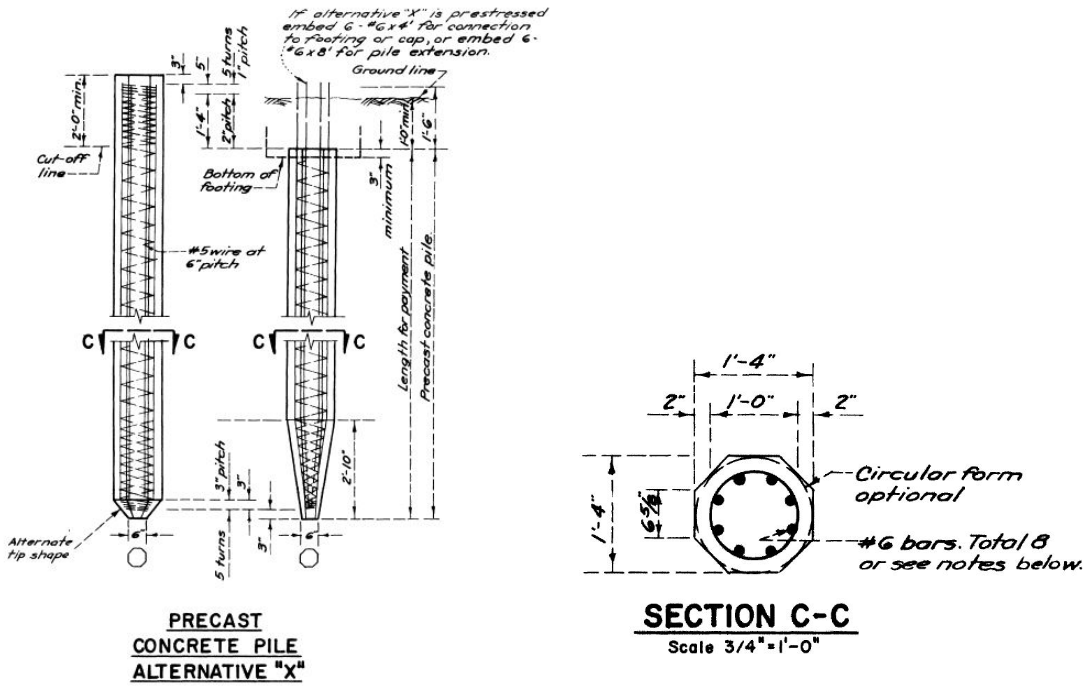

Figure 12. Pre-Cast Pile Details

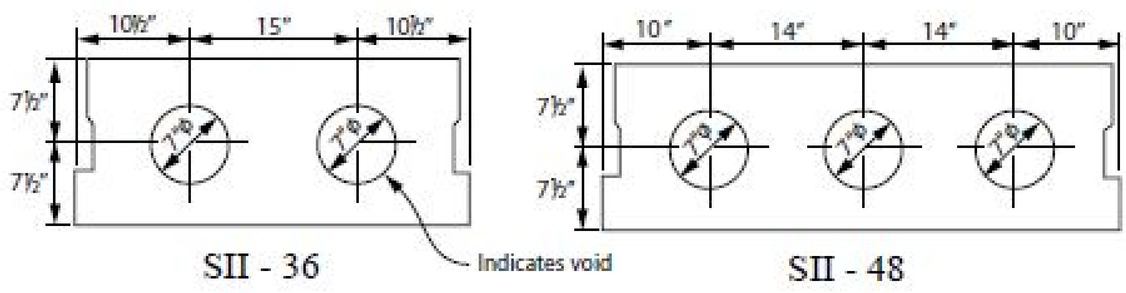

Figure 13. 15 Inch Voided Slab Details

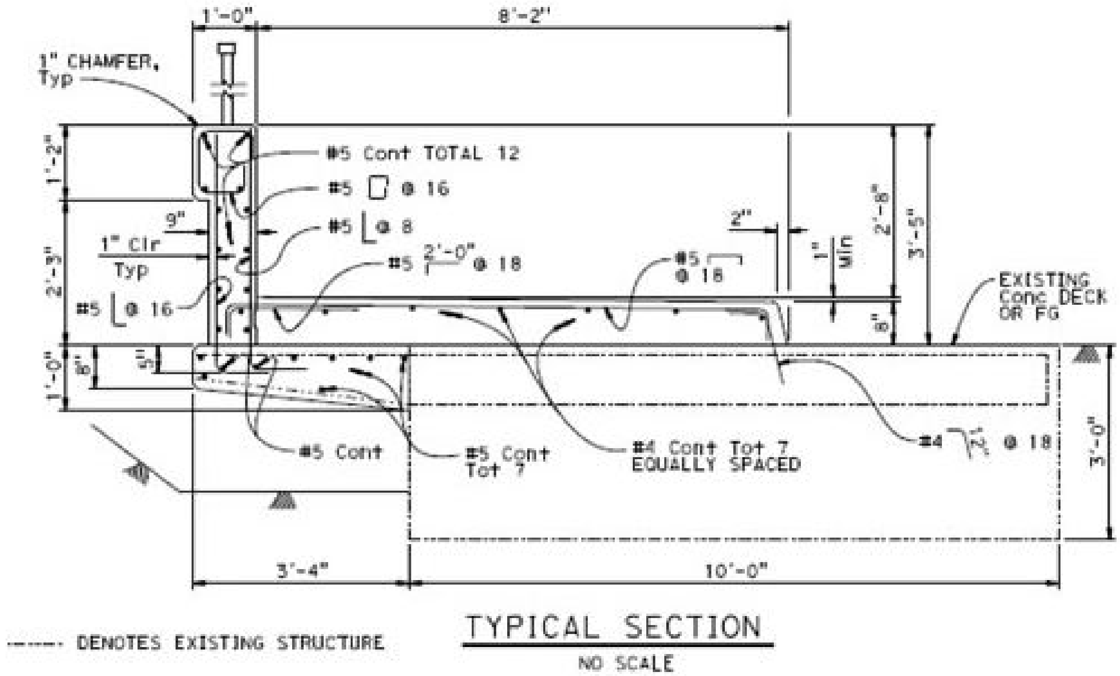

Figure 14. Typical 732SW Bridge Rail Details

Figure 15. Sample 732SW Bridge Rail Picture

Construction Staging

The new bridge construction and the modifications to the existing bridge will be done in stages. It is currently envisioned that the staged construction sequence will allow for half the bridge and approach be open at a time to allow for traffic flow across the channel. The plan is to start on the south side of the bridge which includes the new bike lane and sidewalk. First the existing west approach will be demolished and the channel bank will be graded back. Next the new bridge structure will be constructed. Finally the north side of bridge approach will be demolished and the rest of the channel grading will be done. Finally the rest of the new bridge structure will be built.

Quantities

Estimated quantities for the Warner Ave. Bridge widening are provided in the figure below:

ITEM	Quantity	Unit
Demolition of Existing Approach Structure	1	LS
16 inch Oxegonal Pre-Cast Concrete Piles	3540	Linear Feet
15" Voided Slabs Type SI - 36	270	Linear Feet
15" Voided Slabs Type SI - 48	2460	Linear Feet
South Side New Sidewalks and 732SW Bridge Rail	96	cyd
North Side New Sidewalks and 732SW Bridge Rail	36	cyd
3" Asphalt waring surface	104	cyd
Cast-In-Place Pile Bent Cap Beams	80	cyd

Figure 16. Estimated Quantities – Warner Ave. Bridge Widening

REFERENCES

Technical Publications

- AASHTO LRFD Bridge Design Specifications, Latest Edition
- American Concrete Institute, Building Code Requirements for Structural Concrete and Commentary (ACI 318-14).
- American Institute of Steel Construction (AISC), Manual of Steel Construction, Allowable Stress Design, 9th Edition.
- PCI Bridge Design Manual, 1997, Preliminary Design Charts

USACE Publications

- EM 1110-2-2000 Standard Practice for Concrete for Civil Works Structures Change 2 March 2001.
- EM 1110-2-2104 Strength Design Criteria for Reinforced Concrete Hydraulic Structures, November 2016.
- EM 1110-2-2906 Design of Pile Foundations, January 1991.
- CASE CTWALL-R, Computer Program, X0153-R, T-WALL Design

ATTACHMENT A-1

PLATES

PLAN NORTH

0 20' 40'

A1 CHANNEL OUTLET STRUCTURE DEMOLITION PLAN

SCALE: 1" = 20'

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MARK	DESCRIPTION	DATE

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CHECKED BY: FL	CONTRACT NO.: W912P6-19-C-00XX
SUBMITTED BY: FAYE LEFFLER, PE	PROJECT ID: 465002
SIZE: ANSI D	FILE NAME: CO-SD-101.dgn

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CHICAGO DISTRICT
231 S. LASALLE ST, SUITE 1500
CHICAGO, ILLINOIS 60604

WESTMINSTER
EAST GARDEN GROVE

CHANNEL OUTLET STRUCTURE
DEMOLITION PLAN

SHEET ID

SD-101

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B1 BRIDGE STRUCTURAL PLAN

SCALE: 1" = 20'

0 20' 40'

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SUBMITTED BY: FAYE LEFFLER, PE	PROJECT ID: 465002
SIZE: ANSI D	FILE NAME: CO-S-100.dgn

WESTMINSTER
EAST GARDEN GROVE

CHANNEL OUTLET STRUCTURE

SHEET ID

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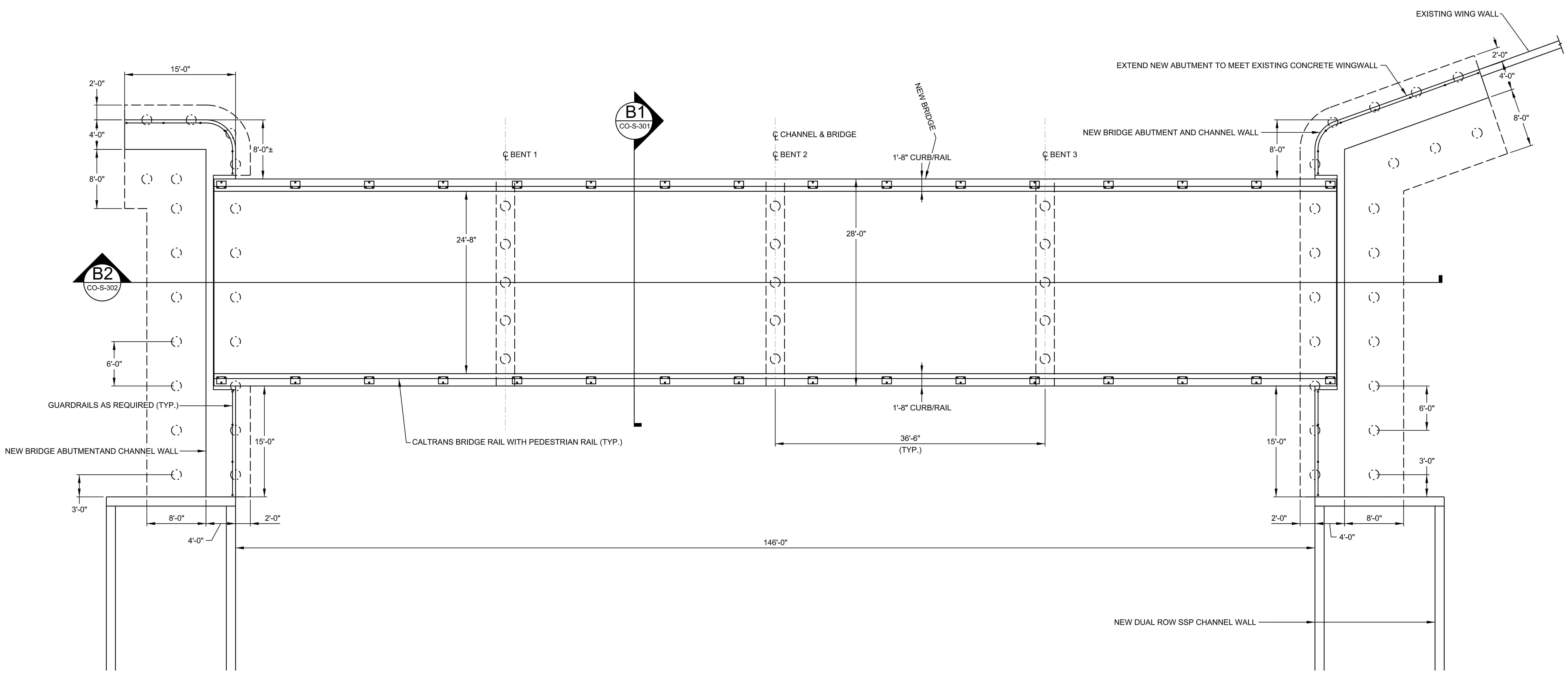

B2 BRIDGE STRUCTURAL PLAN

SCALE: 1/8" = 1'

0 4' 8' 16'

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EAST GARDEN GROVE

BRIDGE PLAN

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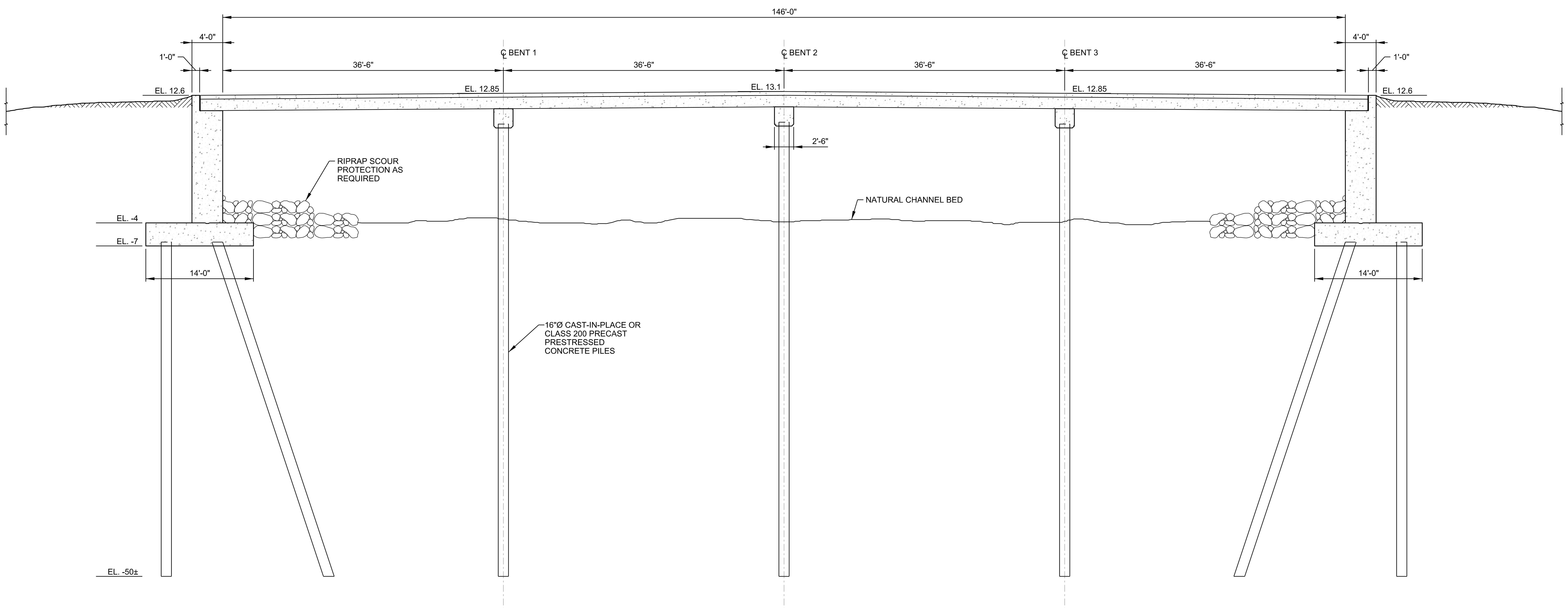

F5 CO-S-101 B1

SECTION AT BRIDGE CENTERLINE

SCALE: 1/8" = 1'

0 4' 8' 16'

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SOLICITATION NO.: W912P6-19-B-00XX
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PROJECT ID: 465002

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EAST GARDEN GROVE

SECTION AT BRIDGE CENTERLINE

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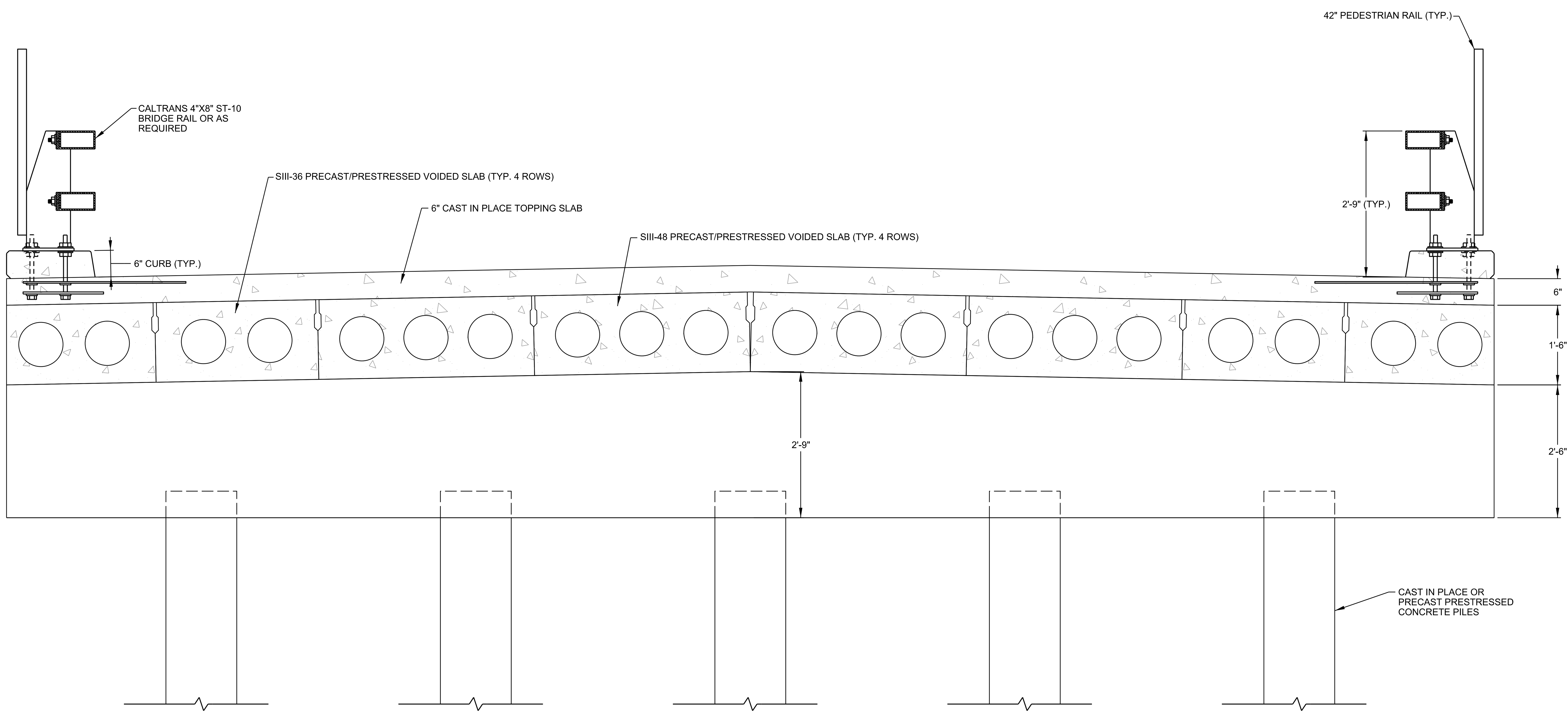

E2
CO-S-301
B2

TYPICAL TRANSVERSE SECTION AT PILE BENT

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0 1' 2' 4'

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WESTMINSTER
EAST GARDEN GROVE

TYPICAL TRANSVERSE SECTION
AT PILE BENT

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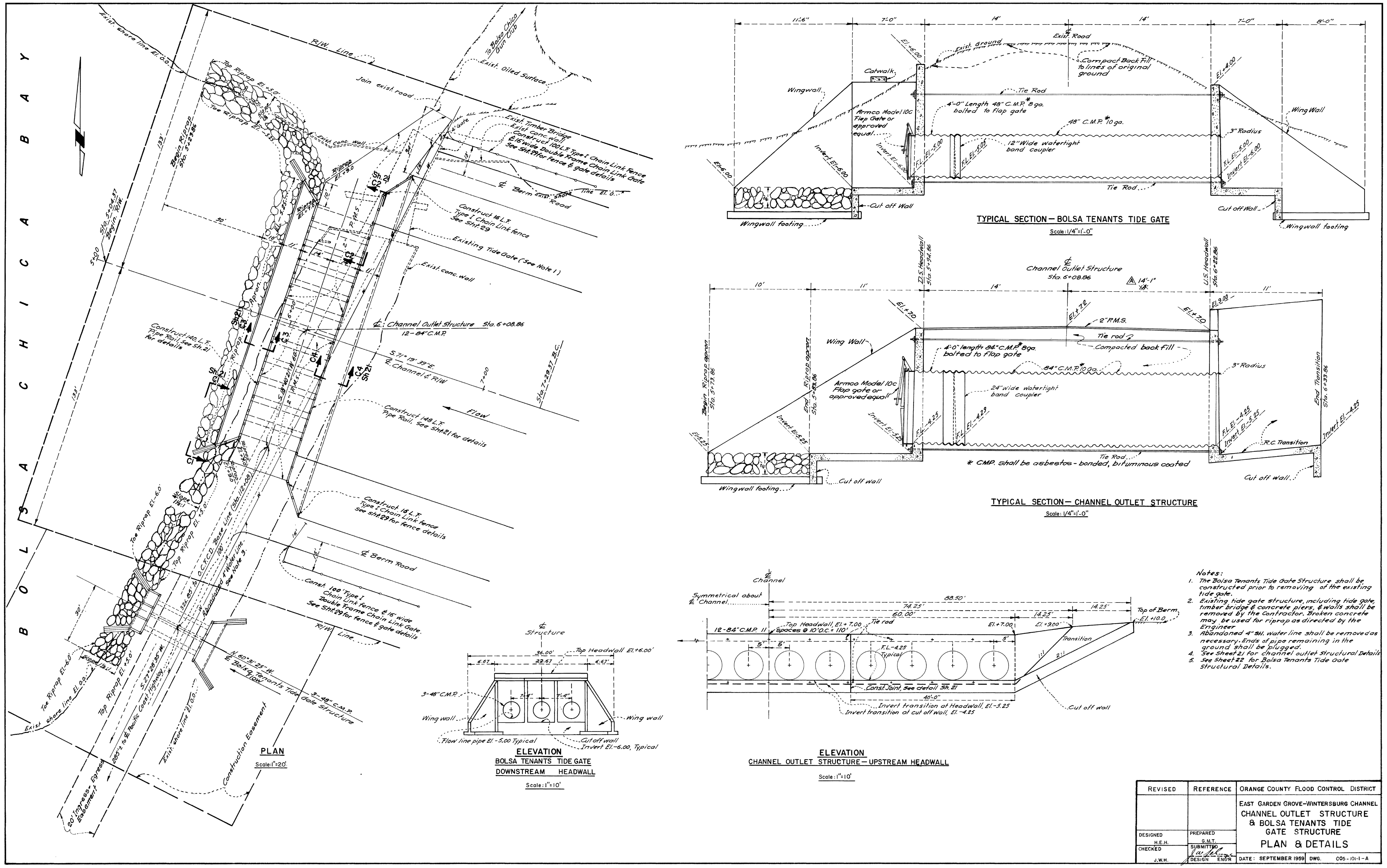

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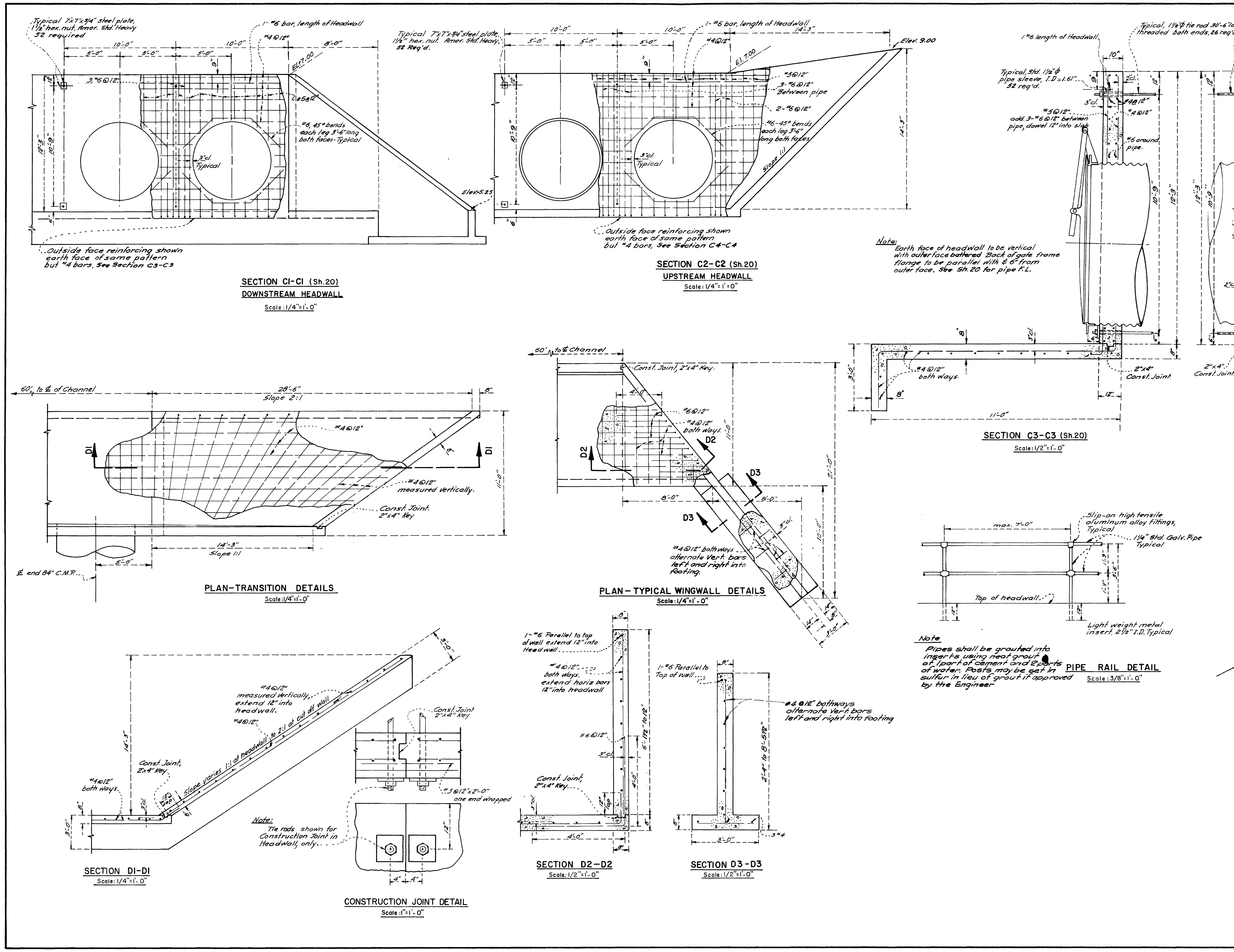

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		CHANNEL OUTLET STRUCTURE
DESIGNED H.E.H.	PREPARED G.M.T.	STRUCTURAL DETAILS
CHECKED J.W.H.	SUBMITTED DESIGN ENG'R.	DATE: SEPTEMBER 1959 DWG. C05-101-1-A

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WESTMINSTER
EAST GARDEN GROVE

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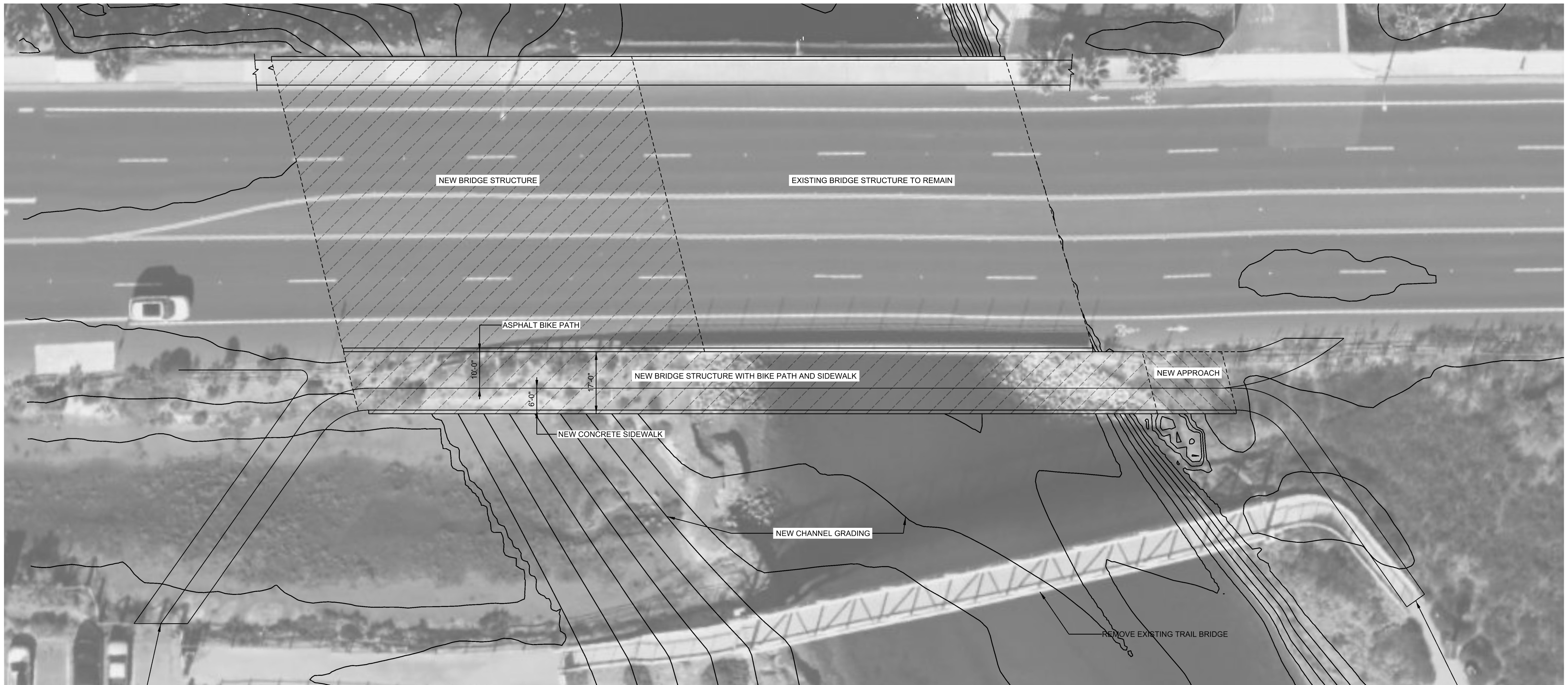

RUN THE NEW SIDEWALK AND BIKE TRAIL DOWN TO THE BOLSA CHICA CONSERVANCY VISITOR CENTER

RUN NEW SIDEWALK TO ALIGN WITH THE EXISTING TRAIL.

PLAN NORTH

C4 WARNER AVE BRIDGE SITE PLAN

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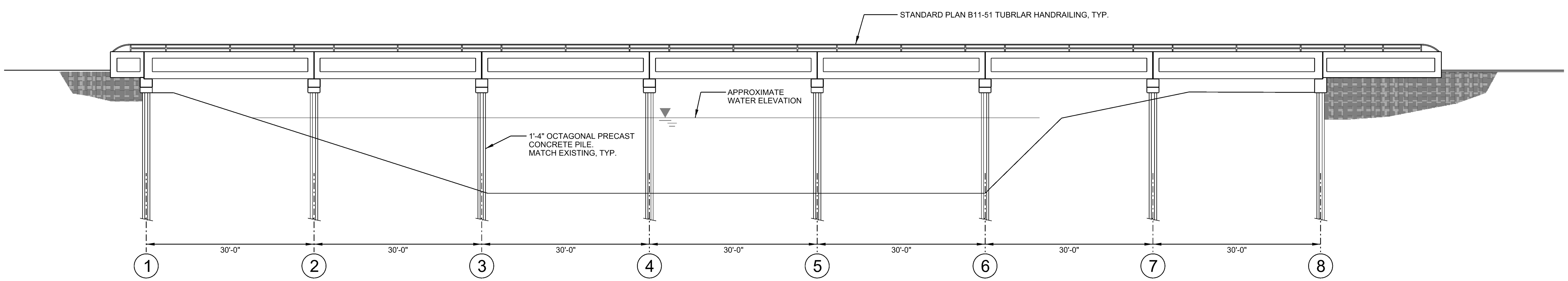

A5 SOUTH ELEVATION

SCALE: 3/32" = 1'

0 8' 16' 32'

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WESTMINSTER
EAST GARDEN GROVE

WARNER AVE BRIDGE
STRUCTURAL SITE PLAN

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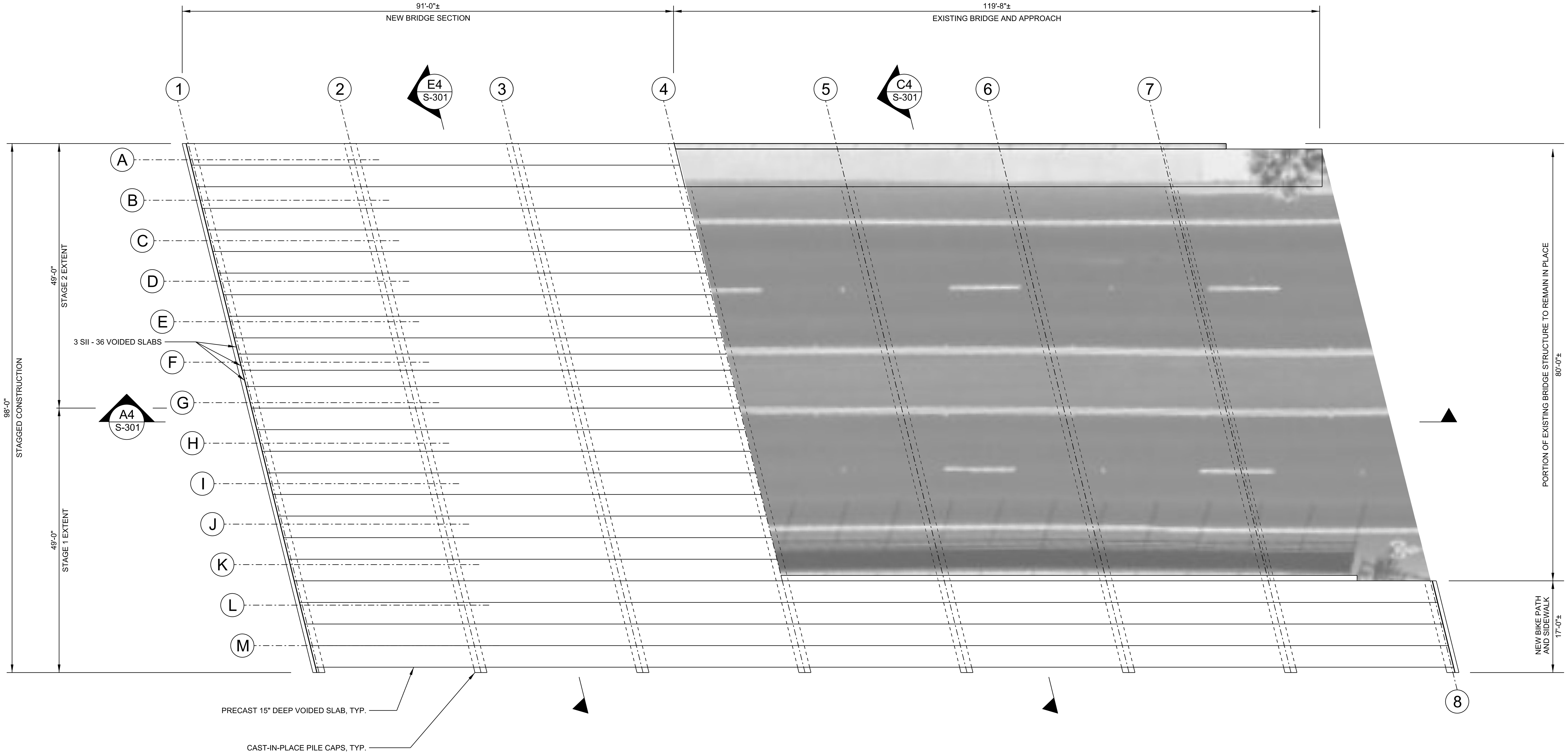

C4 STRUCTURAL PLAN

SCALE: 3/32" = 1'

0 8' 16' 32'

PLAN NORTH

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WARNER AVE BRIDGE
STRUCTURAL FRAMING PLAN

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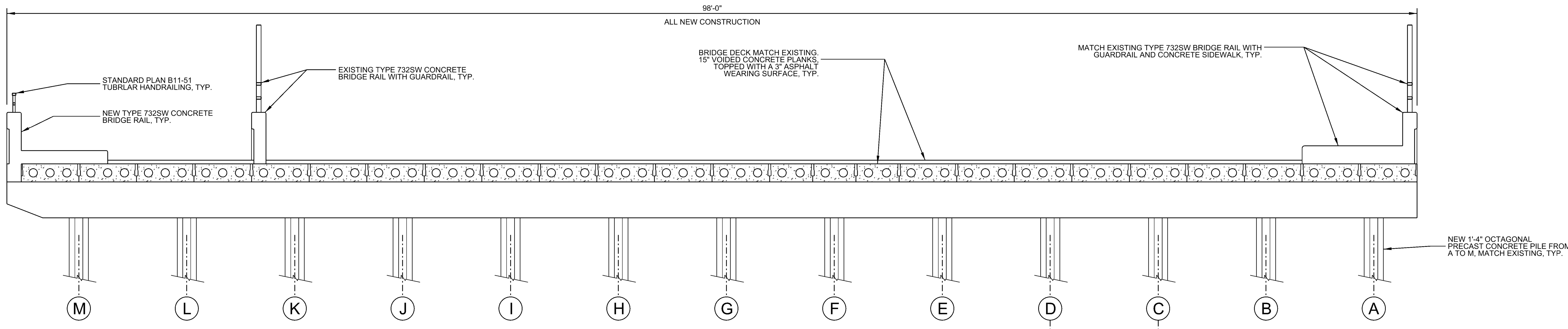

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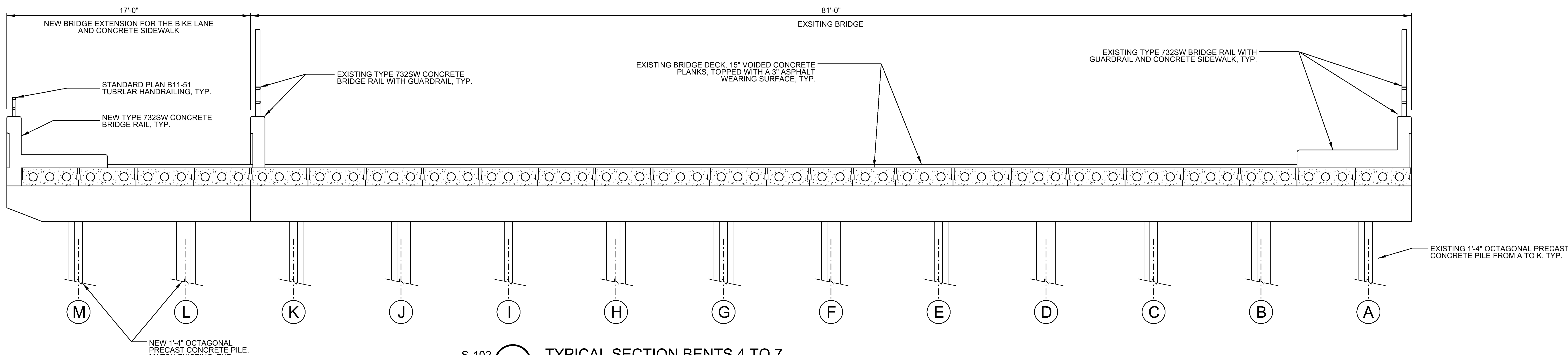

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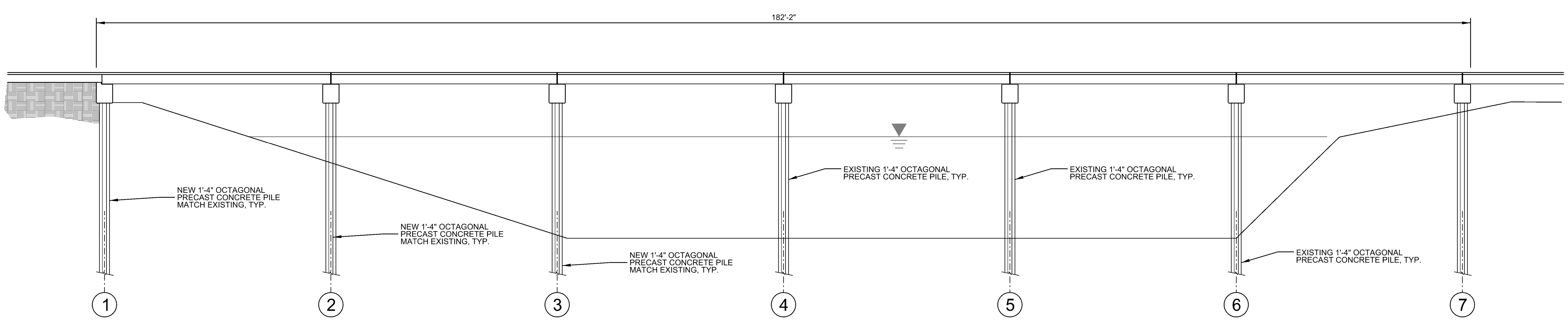

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CHICAGO, ILLINOIS 60604

WESTMINSTER
EAST GARDEN GROVE

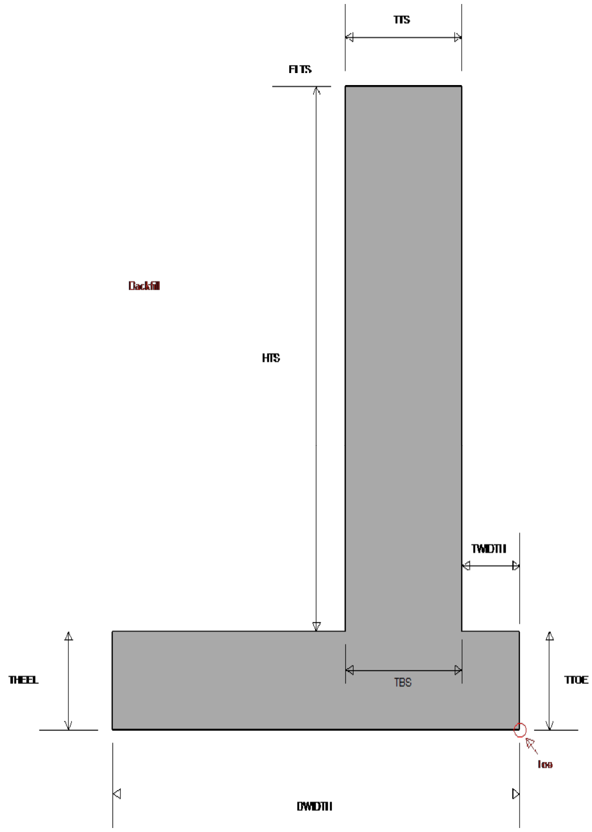
WARNER AVE BRIDGE STRUCTURAL SECTIONS

SHEET ID

S-301

ATTACHMENT A-2

CTWALL Calculations - Bridge Abutment at Outlet Control Structure.



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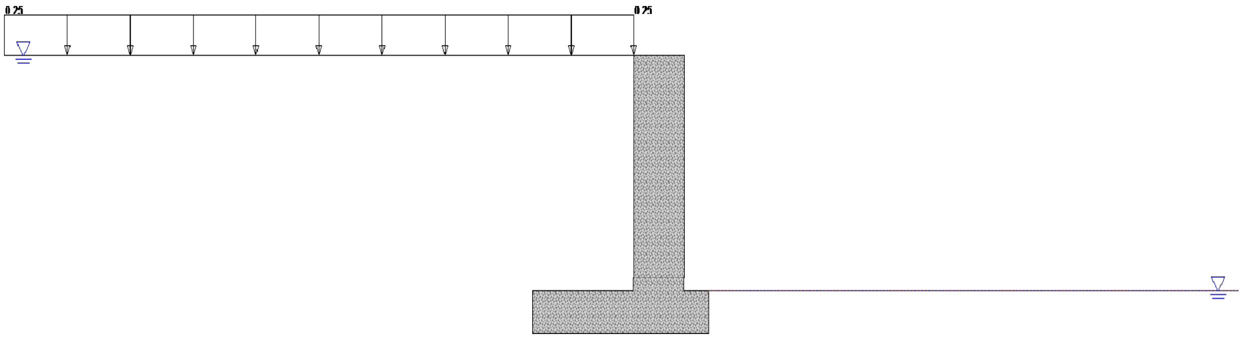
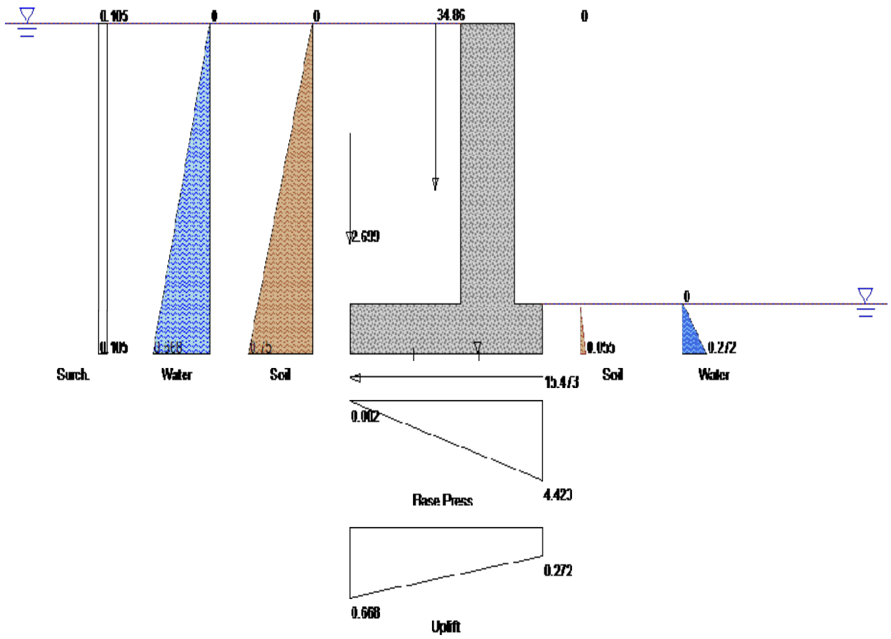
HK=	0.00
HTS=	16.60
TBS=	4.00
TBSR=	0.00
THEEL=	3.00
TK=	0.00
TTOE=	3.00
TTS=	4.00
TWIDTH=	2.00

NOTE: All units in feet

Input file= abutment1.dat



Input file= abutment1.dat



```
****************** Echoprint of Input Data ******************

Date: 2019/ 5/10                              Time: 10.27.40

Structural geometry data:
  Elevation of top of stem (ELTS)       =    12.60 ft
  Height of stem (HTS)                  =    16.60 ft
  Thickness top of stem (TTS)           =     4.00 ft
  Thickness bottom of stem (TBS)        =     4.00 ft
  Dist. of batter at bot. of stem (TBSR)=     0.00 ft
  Depth of heel (THEEL)                 =     3.00 ft
  Distance of batter for heel (BTRH)    =     0.00 ft
  Depth of toe (TTOE)                   =     3.00 ft
  Width of toe (TWIDTH)                 =     2.00 ft
  Distance of batter for toe (BTRT)     =     0.00 ft
  Width of base (BWIDTH)                =    14.00 ft
  Depth of key (HK)                     =     0.00 ft
  Width of bottom of key (TK)           =     0.00 ft
  Dist. of batter at bot. of key (BTRK) =     0.00 ft

Structure coordinates:

   x (ft)    y (ft)
  ==================
      0.00     -7.00
      0.00     -4.00
      8.00     -4.00
      8.00     12.60
     12.00     12.60
     12.00     -4.00
     14.00     -4.00
     14.00     -7.00

NOTE: X=0 is located at the left-hand side
      of the structure.  The Y values correspond
      to the actual elevation used.

Structural property data:
  Unit weight of concrete =    0.150 kcf

Driving side soil property data:

                      Moist   Saturated          Elev.
```

Phi (deg)	c (ksf)	Unit wt. (kcf)	unit wt. (kcf)	Delta (deg)	soil (ft)
28.00	0.000	0.120	0.125	16.00	12.60

Driving side soil geometry:

Soil point	Batter (in:1ft)	Distance (ft)
1	0.00	500.00
2	0.00	0.00
3	0.00	500.00

Driving side soil profile:

Soil point	x (ft)	y (ft)
1	-1492.00	12.60
2	8.00	12.60

Resisting side soil property data:

Phi (deg)	c (ksf)	Moist Unit wt. (kcf)	Saturated unit wt. (kcf)	Elev. soil (ft)	Batter (in:1ft)
28.00	0.000	0.120	0.125	-4.00	0.00

Resisting side soil profile:

Soil point	x (ft)	y (ft)
1	14.00	-4.00
2	514.00	-4.00

Foundation property data:

phi for soil-structure interface = 30.00 (deg)
c for soil-structure interface = 0.000 (ksf)
phi for soil-soil interface = 28.00 (deg)
c for soil-soil interface = 0.000 (ksf)

Water data:

Driving side elevation = 12.60 ft
Resisting side elevation = -4.00 ft
Unit weight of water = 0.0624 kcf

```
  Seepage pressures computed by Line of Creep method.

Uniform load data:
  Magnitude of load =     0.2500 k/ft

Minimum required factors of safety:
  Sliding FS   =    1.50
  Overturning  =  100.00% base in compression

Crack options:
  o  Crack depth is to be calculated
  o  Computed cracks *will* be filled with water

Strength mobilization factor =   0.6667

At-rest pressures on the resisting side *are used*
in the overturning analysis.

Forces on the resisting side *are used* in the sliding analysis.

*Do* iterate in overturning analysis.




***** Summary of Results *****

***************    *** Satisfied ***
* Overturning *    Required base in comp. = 100.00 %
***************    Actual base in comp.   = 100.00 %
                   Overturning ratio      =   1.88

Xr (measured from toe) =   4.67 ft
Resultant ratio        = 0.3335
Stem ratio             = 0.1429
Base pressure at heel =    0.0025 ksf
Base pressure at toe  =    4.4227 ksf

***********    *** Not Satisfied ***
* Sliding *    Min. Required =   1.50
***********    Actual FS     =   1.24

  To increase stability try one or a combination
  of the following:
    1.  Increase the base width
    2.  Slope the base of the structure
    3.  Lower the wall base
    4.  Add a key
```

```
***********
* Bearing *
***********

Net ultimate bearing pressure =     1.3588 (ksf)
Factor of safety =      0.410



******************** Output Results ********************


Date: 2019/ 5/10                              Time: 10.27.40


***************************
**  Overturning Results  **
***************************

Solution converged in  1 iterations.

SMF used to calculate K's =   0.6667
Alpha for the SMF          = -46.0147
Calculated earth pressure coefficients:
  Driving side at rest K    =   0.4210
  Driving side at rest Kc   =   0.6403
  Resisting side at rest K  =   0.5305
  Resisting side at rest Kc =   0.7284
  At-rest K's for resisting side calculated.

Depth of cracking =     0.00 ft

** Driving side pressures **

  Water pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
        12.60     0.0000
        -7.00     0.6683

  Earth pressures:
    Elevation   Pressure
      (ft)        (ksf)
    ======================
        12.60     0.0000
        -7.00     0.7500
```

```
  Surcharge pressures:
       Elev.   Press.
       (ft)    (ksf)
    ===================
        12.60    0.105
        -7.00    0.105

** Resisting side pressures **

  Water pressures:
    Elevation   Pressure
      (ft)       (ksf)
    ======================
        -4.00     0.0000
        -7.00     0.2721

  Earth pressures:
    Elevation   Pressure
      (ft)       (ksf)
    ======================
        -4.00     0.0000
        -7.00     0.0546

** Uplift pressures **

  Water pressures:
     x-coord.   Pressure
       (ft)      (ksf)
    ======================
         0.00     0.6683
        14.00     0.2721

** Forces and moments **

=========================================================================
              Part           |    Force (kips)     | Mom. Arm  |  Moment |
                             |  Vert.   |   Horiz.|   (ft)    |  (ft-k) |
=========================================================================
Structure:
  Structure weight...........   16.260                   -5.16    -83.94
Structure, driving side:
  Moist soil.................    0.000                    0.00      0.00
  Saturated soil.............   16.600                  -10.00   -166.00
  Water above structure......    0.000                    0.00      0.00
  Water above soil...........    0.000                    0.00      0.00
  External vertical loads....    2.000                  -10.00    -20.00
  Ext. horz. pressure loads..              0.000          0.00      0.00
```

```
  Ext. horz. line loads......              0.000       0.00      0.00
Structure, resisting side:
  Moist soil................   0.000                   0.00      0.00
  Saturated soil............   0.000                   0.00      0.00
  Water above structure.....   0.000                   0.00      0.00
  Water above soil..........   0.000                   0.00      0.00
Driving side:
  Effective earth loads......              7.350       6.53     48.02
  Shear (due to delta).......   2.699                -14.00    -37.79
  Horiz. surcharge effects...              2.063       9.80     20.22
  Water loads................              6.550       6.53     42.79
Resisting side:
  Effective earth loads......             -0.082       1.00     -0.08
  Water loads................             -0.408       1.00     -0.41
Foundation:
  Vertical force on base.....  -30.976                -4.67    144.64
  Shear on base.............            -15.473       0.00      0.00
  Uplift....................   -6.583                 -7.98     52.55
=====================================================================
** Statics Check **   SUMS =     0.000     0.000                  0.00

Angle of base        =     0.00 degrees
Normal force on base =   30.976 kips
Shear force on base  =   15.473 kips
Max. available shear force =   17.884 kips

Base pressure at heel =   0.0025 ksf
Base pressure at toe  =   4.4227 ksf

Xr (measured from toe) =     4.67 ft
Resultant ratio        =   0.3335
Stem ratio             =   0.1429
Base in compression    =   100.00 %
Overturning ratio      =     1.88

Volume of concrete =     4.01 cubic yds/ft of wall

NOTE:  The engineer shall verify that the computed
bearing pressures below the wall do not exceed the
allowable foundation bearing pressure, or, perform a
bearing capacity analysis using the program CBEAR.
Also, the engineer shall verify that the base pressures
do not result in excessive differential settlement of
the wall foundation.
```

```
**********************
**  Sliding Results  **
**********************
```

Solution converged. Summation of forces = 0.

Wedge Number	Horizontal Loads (kips)	Vertical Loads (kips)
1	0.000	4.236
2	0.000	2.000
3	0.000	0.000

Water pressures on wedges:

Wedge number	Top press. (ksf)	Bottom press. (ksf)	x-coord. (ft)	press. (ksf)
1	0.0000	0.6683		
2			0.0000	0.6683
2			14.0000	0.2721
3	0.0000	0.2721		

Points of sliding plane:
Point 1 (left), x =   0.00 ft,   y =   -7.00 ft
Point 2 (right), x =   14.00 ft,   y =   -7.00 ft

Depth of cracking =   0.00 ft

Wedge number	Failure angle (deg)	Total length (ft)	Weight of wedge (kips)	Submerged length (ft)	Uplift force (kips)
1	-49.154	25.910	20.759	25.910	8.658
2	0.000	14.000	32.860	14.000	6.583
3	33.374	5.454	0.854	5.454	0.742

Wedge number	Net force (kips)
1	-13.979
2	13.215
3	0.764
SUM =	0.000

```
+----------------------------+
| Factor of safety =    1.235 |
+----------------------------+




**********************
**  Bearing Results  **
**********************

            Base width =     14.000 (ft)
                    Xr =      4.669 (ft)
  Effective base width =      9.339 (ft)
   (measured along slope)
            Base slope =     0.0000 (deg)

                   phi =     28.000 (deg)
                     c =      0.000 (ksf)
       Effective gamma =     0.0626 (kcf)

           Normal load =     30.976 (kips)
      Load inclination =     26.542 (deg)
     Load eccentricity =      2.331 (ft)

             Surcharge =     0.1878 (ksf)
             Embedment =      3.000 (ft)
          Ground slope =     0.0000 (deg)


          Bearing Capacity Factors
=============================================
                  C        Q         G
=============================================
Bearing         25.8033   14.7199   11.1897
Embedment        1.1069    1.0535    1.0535
Inclination      0.4971    0.4971    0.0027
Base Tilt        1.0000    1.0000    1.0000
Ground Slope     1.0000    1.0000    1.0000

Net ultimate bearing pressure =     1.3588 (ksf)

+------------------------------+
| Factor of safety =      0.410 |
+------------------------------+
```