APPENDIX C
SUBSTRUCTURE DESIGN CALCULATIONS

DETERMINE SAMPLE TESTING LOCATIONS / FOUNDATION TYPE

Caution: the following charts apply to most conditions, consult DM4 for final footing elevation determination. For example excessive scour depths.

Project: JC-22 Hadden Run

Abutment	Core #	OGE	Depth to TOR, ft	TOR Elev.
1	CB-1	1357.04	9.00	1348.04
1	CB-2	1355.90	8.10	1347.80
1	CB-5	1356.65	10.40	1346.25
1	CB-6	1353.57	6.40	1347.17
1	CB-7	1354.69	8.50	1346.19
2	CB-3	1357.38	26.00	1331.38
2	CB-4	1357.11	21.00	1336.11
2	CB-8	1356.81	20.80	1336.01
2	CB-9	1361.56	24.60	1336.96
2	CB-10	1352.49	16.40	1336.09

COLOR KEY

User Input

Comp. Output

Abutment	Core #	Spread on Rock: Min. BFE (TOR-1.5')	Min. BFE (Stream - 6')	Preliminary BFE	Ground Depth, OGE-BFE, ft	Streambed to BFE, ft	Rock Exc. Depth TOR-BFE, ft	Recovery @ BFE	RQD @ BFE
1	CB-1	1346.54	1346	1344.50	12.54	7.50	3.54	100	52
1	CB-2	1346.30	1346	1344.50	11.40	7.50	3.30	100	29
1	CB-5	1344.75	1346	1344.50	12.15	7.50	1.75	100	0
1	CB-6	1345.67	1346	1344.50	9.07	7.50	2.67	100	26
1	CB-7	1344.69	1346	1344.50	10.19	7.50	1.69	88	0
2	CB-3	1329.88	1346	1334.25	23.13	17.75	-2.87	20	0
2	CB-4	1334.61	1346	1334.25	22.86	17.75	1.86	75	0
2	CB-8	1334.51	1346	1334.25	22.56	17.75	1.76	80	0
2	CB-9	1335.46	1346	1334.25	27.31	17.75	2.71	100	64
2	CB-10	1334.59	1346	1334.25	18.24	17.75	1.84	95	38

Abutment	Core #	Footing on piles: Min. BFE (frost)	Min. BFE (Stream - 4')	Preliminary BFE	Ground Depth, OGE-BFE, ft	Streambed to BFE, ft
2	CB-3	1347.92	1348	1347.50	9.88	4.50
2	CB-4	1347.92	1348	1347.50	9.61	4.50
2	CB-8	1347.92	1348	1347.50	9.31	4.50
2	CB-9	1347.92	1348	1347.50	14.06	4.50
2	CB-10	1347.92	1348	1347.50	4.99	4.50

Key	Min. Elev.	Requirement
OGE - Orginal Ground Elevation	1352.00	Stream bed elevation
TOR - Top of Rock	1349.00	3' cover above stream bed
BFE - Bottom of Footing Elevation	1347.92	49" frost heave below stream bed - governs

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ABUTMENT DESIGN LOADS

Superstructure Dead Load (total force on one abutment)

- Reference LRFD P/S beam output "loads and load modifiers"
- Define units for computer program kips := 1000lb
- Calculation Form: Load/ft/beam * Number of Beams * 1/2 Structure Length
- Define variables:

NumBeams := 4

Length := 53.406ft 55ft

$$Length_{0.5} := \frac{Length}{2}$$

Skew := 70deg

Width := 30.875ft (out to out width)

BeamWidth := 48in

BeamHeight := 21in

EndDiaphThickness := 1.25ft

DeckThickness := 8in

NormalParapetHeight := 3.5ft

OutToOutLength := 55ft

- Evaluate variables: $Length_{0.5} = 26.703$ ft
- Reference computer beam analysis "Load and Load Modifiers" for loads. Compare interior, exterior, etc. beam runs and use larger of the two. Exterior beam governs unless otherwise noted.

The following are dead loads applied as DC or DW.

1. $PSBeam := 0.585 \frac{kips}{ft} \cdot NumBeams \cdot Length_{0.5}$ <PSLRFD "girder">

   PSBeam = 62.485 kips

2. $ConcreteDeck := 0.798 \frac{kips}{ft} \cdot NumBeams \cdot Length_{0.5}$ <PSLRFD "slab and haunch">

   Interior Governs
   ConcreteDeck = 85.236 kips

3. $FormWork := 0.116 \frac{kips}{ft} \cdot NumBeams \cdot Length_{0.5}$ <PSLRFD "additional DC1"> ← additional DC1 (haunch)

   FormWork = 12.390 kips

4. AlternateParapet := 0kips NA <PSLRFD "DC2">

5. $NormalParapet := 0.259 \frac{kips}{ft} \cdot ~~2~~ \cdot Length_{0.5}$ (NumBeams) <PSLRFD "DC2">

   NormalParapet = 13.832 kips

6. $FWS := 0.210 \frac{kips}{ft} \cdot NumBeams \cdot Length_{0.5}$ <PSLRFD "future wearing surface">

   FWS = 22.431 kips <Beam calculations>

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7. Sidewalk := 0kips NA

8. $\text{InteriorDiaphragms} := \frac{0.408\text{kips}}{2} \cdot \text{NumBeams}$ <PSLRFD "interior diaphragm">

   InteriorDiaphragms = 0.816 kips

9. ExteriorDiaphragms := 0kips NA

10.

$$\text{EndDiaphragms} := (\text{Width} - \text{NumBeams} \cdot \text{BeamWidth}) \cdot \text{EndDiaphThickness} \cdot \text{BeamHeight} \cdot 150 \frac{\text{lb}}{\text{ft}^3}$$

   EndDiaphragms = 4.881 kips <Calculate dead load of end diaphragm on one abutment>

11. Utilties := 0kips NA, no attached utilities

Note: Parapet loads first 2 beams for spread box, not entire section.

LOADS ON ABUTMENTS COMMANDS - LAB (PSLRFD lists output as kips but actually kips/ft)

DC - Dead load of the bridge superstructure and any nonstructural attachments

- Reference superstructure dead load above.

$$\text{DC} := \text{PSBeam} + \text{ConcreteDeck} + \text{FormWork} + \text{AlternateParapet} + \text{NormalParapet} + \text{Sidewalk} \ldots + \text{InteriorDiaphragms} + \text{ExteriorDiaphragms} + \text{EndDiaphragms} + \text{Haunch}$$

DC = 179.640 kips

$$\text{DCLoadPerFoot} := \frac{\text{DC}}{\text{Width}}$$

$$\text{DCLoadPerFoot} = 5.818 \frac{\text{kips}}{\text{ft}}$$

DW - Dead load of wearing surfaces and utilities on the superstructure

- Reference superstructure dead load above.

DW := FWS + Utilties

DW = 22.431 kips

$$\text{DWLoadPerFoot} := \frac{\text{DW}}{\text{Width}}$$

$$\text{DWLoadPerFoot} = 0.726 \frac{\text{kips}}{\text{ft}}$$

PL - Pedestrian live load on the superstructure

- Reference P/S girder input calculations.
  Not Applicable

Vertical WS - Vertical wind load acting on the superstructure

- Reference AASHTO 3.8.2, 20lb/sf

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$$VerticalWS := 20\frac{lb}{ft^2}\cdot Width\cdot Length$$

$$VerticalWS = 32.978\,kips$$

$$VerticalWSPerAbutment := \frac{VerticalWS}{2}$$

$$VerticalWSPerAbutment = 16.489\,kips$$

$$VerticalWSPerFoot := \frac{VerticalWSPerAbutment}{Width}$$

$$VerticalWSPerFoot = 0.534\frac{kips}{ft}$$

As per LRFD abutment program manual, vertical WS is acting in a negative direction.
Therefore vertical WS = -0.534 kips/ft.

<u>Horizontal WS</u> - Horizontal wind load acting on superstructure
This load is applied in the direction that is perpendicular to the skew of the abutment. Hence, the magnitude of the load should be adjusted accordingly.

- Reference AASHTO 3.8.1.2, 50lb/sf

$$SuperstructureDepth := BeamHeight + DeckThickness + NormalParapetHeight$$

$$SuperstructureDepth = 5.917\,ft$$

$$WSPerFoot := \frac{50\frac{lb}{ft^2}\cdot SuperstructureDepth\cdot OutToOutLength}{Width}$$

$$WSPerFoot = 0.527\frac{kips}{ft}$$

$$AdustForSkewWSPerFoot := WSPerFoot\cdot \cos(Skew)$$

$$AdustForSkewWSPerFoot = 0.180\frac{kips}{ft}$$

<u>WL</u> - Horizontal wind load acting on the live load on the bridge superstructure.
This load is applied in the direction that is perpendicular to the skew of the abutment. Hence, the magnitude of the load should be adjusted accordingly.

- Reference AASHTO 3.8.1.3, 0.10kips/ft

$$WL := 0.10\frac{kips}{ft}\cdot Length$$

$$WL = 5.341\,kips$$

$$WLPerFoot := \frac{WL}{Width}$$

$$WLPerFoot = 0.173\frac{kips}{ft}$$

$$AdustForSkewWLPerFoot := WLPerFoot\cdot \cos(Skew)$$

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$\text{AdustForSkewWLPerFoot} = 0.059 \dfrac{\text{kips}}{\text{ft}}$

<u>TU</u> - Horizontal load induced at the bearing location by thermal expansion and contraction in the superstructure.
This load is applied in the direction that is perpendicular to the skew of the abutment. Hence, the magnitude of the load should be adjusted accordingly.
Reference AASHTO 3.12

$TU = G\ A\ \alpha\ L\ T_{delta}$ (Number of beams) / h_{rt}

G = shear modulus of elastomer = 113 psi Average Value (AASHTO 14.7.5.2)
(G for hardness of 50 ranges from 0.66 to 0.90 MPa, Average of 0.78 MPa, Convert to 113 psi.)

$G := 113 \dfrac{\text{lb}}{\text{in}^2}$

A = plan area of pad = 2 pads = $A := 2\cdot(10\text{in}\cdot 13\text{in})$

$A = 260.000\ \text{in}^2$

α = coefficient of expansion of concrete = 6.0×10^{-6} / F° (AASHTO 5.4.2.2)

$\alpha := 0.000006$

L = center to center bearing, $L := \text{Length}$

$L = 53.406\ \text{ft}$

T_{delta} = temperature change = 100 F°

$T_{delta} := 100$

h^{rt} = total "elastomer" thickness, $h_{rt} := 2.5\text{in}$

$$TU := \frac{G\cdot A\cdot \alpha\cdot L\cdot T_{delta}\cdot \text{NumBeams}}{h_{rt}}$$

$TU = 18.076\ \text{kips}$

$$\text{TUPerFoot} := \frac{TU}{\text{Width}}$$

$\text{TUPerFoot} = 0.585 \dfrac{\text{kips}}{\text{ft}}$

$\text{AdjustForSkewTUPerFoot} := \text{TUPerFoot}\cdot\sin(\text{Skew})$

$\text{AdjustForSkewTUPerFoot} = 0.550 \dfrac{\text{kips}}{\text{ft}}$

DESIGN LIVE LOADING COMMAND - DLL

<u>Downward LL</u> - Design live loading reaction applied in the downward direction and does not include effects due to impact.

- Reference Figure 2.5-1 PSLRFD Program

From PSLRFD, "live load effects". PL-93 LC1 governs, Tandem + Lane Governs.
Draw diagram with two 31.25kip loads 4 feet apart to get maximum reaction of abutment and sum

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moments to determine reaction at abutment. Center to center bearing distance is 53.406'

R 53.406 = 31.25(53.406) + 31.25(54.406 - 4) Solve for R, R = 60.744 kips

Result compares with PSLRFD output. Good.
Two lane bridge, therefore multiply by 2.

$$\text{Live Load per foot} = \frac{2 \cdot 60.744\text{kips}}{\text{Width}} = 3.935\frac{\text{kips}}{\text{ft}}$$

<u>Vertical Backwall LL</u> - The vertical live load on the backwall is applied along the front edge of the corbel. This vertical load includes any effect due to impact. This force is only considered in the backwall.

Not Applicable.

<u>Upward LL</u> - Design live loading reaction applied in the upward direction and does not include effects due to impact.
Not Applicable

<u>BR</u> - Design horizontal live loading braking force. This load is applied in the direction that is perpendicular to the skew of the abutment. Hence, the magnitude of the load should be adjusted accordingly.

- Reference AASHTO 3.6.4, PSLRFD Figure 2.5-1
- From PSLRFD, "live load effects". PL-93 LC1 governs.
- Since the structure is not likely to become one directional, braking force will be applied to a single lane only.

$$\text{BR} := 0.25 \cdot (31.25\text{kips} + 31.25\text{kips})$$

$$\text{BR} = 15.625\,\text{kips}$$

$$\text{BRPerFoot} := \frac{\text{BR}}{\text{Width}}$$

$$\text{BRPerFoot} = 0.506\frac{\text{kips}}{\text{ft}}$$

$$\text{AdjustForSkewBRPerFoot} := \text{BRPerFoot} \cdot \sin(\text{Skew})$$

$$\text{AdjustForSkewBRPerFoot} = 0.476\frac{\text{kips}}{\text{ft}}$$

<u>CE - Design horizontal live loading braking force.</u> This load is applied in the direction that is perpendicular to the skew of the abutment. Hence, the magnitude of the load should be adjusted accordingly.

- Reference AASHTO 3.6.3
- Since the proposed bridge is on a horizontal alignment, centrifugal force is not applicable.

CE = 0 kips/ft

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Foundation Vertical Loads for Quality Assurance

Define variables:

VPerFoot = Vertical load per foot along abutment

VTotal = Total vertical load on abutment

$DCLoadPerFoot = 5.818 \frac{kips}{ft}$

$DWLoadPerFoot = 0.726 \frac{kips}{ft}$

$VerticalWSPerFoot = 0.534 \frac{kips}{ft}$

$PLLoadPerFoot = 0.000 \frac{kips}{ft}$

$LLoadPerFoot = 3.935 \frac{kips}{ft}$

Calculate:

$VPerFoot := DCLoadPerFoot + DWLoadPerFoot + VerticalWSPerFoot + PLLoadPerFoot \ldots$
$+ LLoadPerFoot$

$VPerFoot = 11013.695 \frac{lb}{ft}$

$LengthofFooting := 32.9ft$

$VTotal := VPerFoot \cdot LengthofFooting$

$VTotal = 181.175 ton$

Foundation Horizontal Loads for Quality Assurance

Define variables:

HPerFoot = Horizontal load per foot along abutment

HTotal = Total horizontal load on abutment

$AdustForSkewWSPerFoot = 0.180 \frac{kips}{ft}$

$AdustForSkewWLPerFoot = 0.059 \frac{kips}{ft}$

$AdjustForSkewTUPerFoot = 0.550 \frac{kips}{ft}$

$AdjustForSkewBRPerFoot = 0.476 \frac{kips}{ft}$

$CE = 0.000 \frac{kips}{ft}$

Calculate:

$HPerFoot := AdustForSkewWSPerFoot + AdustForSkewWLPerFoot \ldots$
$+ AdjustForSkewTUPerFoot + AdjustForSkewBRPerFoot + CE$

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$$HPerFoot = 1.265 \frac{kips}{ft}$$

$LengthofFooting = 32.900\ ft$

$HTotal := HPerFoot \cdot LengthofFooting$

$$HTotal = 20.811\ ton$$

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ABUTMENT ELEVATIONS AND DECK ELEVATIONS

Caluculate the top of abutment elevation given the following:
Define Variables:

Minimum deck thickness = $Deck := 8in$

From beam runs, average final camber = $FinalCamber := \frac{2.30in + 2.24in}{2}$

$FinalCamber = 2.2700\,in$

Span center to center bearing = $CCBearing := 53.406ft$

Bridge Skew, PennDOT = $Skew := 70deg$

$Haunch := 0.5in$

$BeamDepth := 21in$

Bearing pad thickness = $BPad := 3.098in$ 2.5"

Top of Abutment Longitudinal Slope
Set top of abutment with roadway slope (-4.00%) and adjust for slope of beam camber.
As per DM4.14.7.5.3.5

$FinalCamber = 2.2700\,in$ $CCBearing = 53.4060\,ft$

Rotation in radians = $Rotation_{rad} := \frac{16}{5} \cdot \left(\frac{FinalCamber}{CCBearing}\right)$

$Rotation_{rad} = 0.0113$

Covert to degrees: $Rotation_{deg} := Rotation_{rad} \cdot \frac{180}{\pi}$

$Rotation_{deg} = 0.6494$

Convert to percent slope: $100\tan(0.649deg) = 1.1328$ %

- Abutment 1 - Expansion

Therefore abutment slope = 1.133% / and 4.000% \ = $4.000 - 1.133 = 2.8670$ % \

- Abutment 2 - Fixed

Therefore abutment slope = 1.133% \ and 4.00% \ = $4.000 + 1.133 = 5.1330$ % \

Beam Seat Width
Determine the minimum width of beam seat. Dependent on the construction procedures, but assume the break in grade for the beam on the abutment is perpendicular to abutment face, conservative. Therefore account for skew.
Top of abutment width is 18"

$Skew = 70.0000\,deg$

$\frac{18in}{\tan(Skew)} = 6.5515\,in$

Therefore minimum width beam seat = $48in + 2 \cdot 6.551in = 61.1020\,in$

Add say 2 inches to each side for tolorence $61in + 2 \cdot 2in = 65.0000\,in$ SAY 5'-6" OR 66in

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The following is a check of the spreadsheet for deck elevations along the centerline of the abutment.

Top of Abutment Transverse Slope, along abutment

Finished Grade Elevation at abutment bearing centerline:

Abutment 1 = $Abut1_{FGE} := 1364.5405ft$

Abutment 2 = $Abut2_{FGE} := 1362.4021ft$

- Abutment 1

Determine elevation of abutment at critical slab thicknesses, denoted as " * " on attached typical bridge section sketch.

Equation form: centerline bearing finished deck grade elevation - slope drop along deck perpendicular to centerline station - (deck thickness - beam depth - bearing pad thickness - 1/2" haunch - total camber) + or - skew adjustment(elevation difference due to 4% vertical profile grade)

$Deck = 8.0000in$ $\quad Haunch = 0.5000in$ $\quad FinalCamber = 2.2700in$

$BeamDepth = 21.0000in$ $\quad BPad = 3.0980in$

$$A1DeckElev_3 := Abut1_{FGE} - (5.9922ft)\cdot 0.02 - \frac{5.9922ft}{\tan(Skew)}\cdot 0.04$$

$$A1DeckElev_3 = 1364.3334ft$$

$$A1Elev_3 := A1DeckElev_3 - (Deck + BeamDepth + BPad + Haunch + FinalCamber)$$

$$A1Elev_3 = 1361.4278ft$$

$$A1DeckElev_2 := Abut1_{FGE} - (5.9922ft)\cdot 0.02 + \frac{(5.9922ft)}{\tan(Skew)}\cdot 0.04$$

$$A1DeckElev_2 = 1364.5079ft$$

$$A1Elev_2 := A1DeckElev_2 - (Deck + BeamDepth + BPad + Haunch + FinalCamber)$$

$$A1Elev_2 = 1361.6022ft$$

$$A1DeckElev_4 := Abut1_{FGE} - (10ft\cdot 0.02 + 3.9766ft\cdot 0.04) - \frac{13.9766ft}{\tan(Skew)}0.04$$

$$A1DeckElev_4 = 1363.9780ft$$

$$A1Elev_4 := A1DeckElev_4 - (Deck + BeamDepth + BPad + Haunch + FinalCamber)$$

$$A1Elev_4 = 1361.0723ft$$

$$A1DeckElev_1 := Abut1_{FGE} - (10ft\cdot 0.02 + 3.9766ft\cdot 0.04) + \frac{13.9766ft}{\tan(Skew)}0.04$$

$$A1DeckElev_1 = 1364.3849ft$$

$$A1Elev_1 := A1DeckElev_1 - (Deck + BeamDepth + BPad + Haunch + FinalCamber)$$

$$A1Elev_1 = 1361.4793ft$$

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Summary, Abutment 1:

$A1DeckElev_1 = 1364.3849\,ft$ ✓ $A1Elev_1 = 1361.4793\,ft$ ✓

$A1DeckElev_2 = 1364.5079\,ft$ ✓ $A1Elev_2 = 1361.6022\,ft$ ✓

$A1DeckElev_3 = 1364.3334\,ft$ ✓ $A1Elev_3 = 1361.4278\,ft$ ✓

$A1DeckElev_4 = 1363.9780\,ft$ ✓ $A1Elev_4 = 1361.0723\,ft$ ✓

- Abutment 2

Determine elevation of abutment at critical slab thicknesses, denoted as " * " on attached typical bridge section sketch.
Equation form: centerline bearing finished deck grade elevation - slope drop along deck perpendicular to centerline station - (deck thickness - beam depth - bearing pad thickness - 1/2" haunch - total camber) + or - skew adjustment(elevation difference due to 4% vertical profile grade)

$Deck = 8.0000\,in$ $Haunch = 0.5000\,in$ $FinalCamber = 2.2700\,in$

$BeamDepth = 21.0000\,in$ $BPad = 3.0980\,in$

$$A2DeckElev_3 := Abut2_{FGE} - (5.9922ft)\cdot 0.02 - \frac{5.9922ft}{\tan(Skew)}\cdot 0.04$$

$A2DeckElev_3 = 1362.1950\,ft$

$A2Elev_3 := A2DeckElev_3 - (Deck + BeamDepth + BPad + Haunch + FinalCamber)$

$A2Elev_3 = 1359.2894\,ft$

$$A2DeckElev_2 := Abut2_{FGE} - (5.9922ft)\cdot 0.02 + \frac{(5.9922ft)}{\tan(Skew)}\cdot 0.04$$

$A2DeckElev_2 = 1362.3695\,ft$

$A2Elev_2 := A2DeckElev_2 - (Deck + BeamDepth + BPad + Haunch + FinalCamber)$

$A2Elev_2 = 1359.4638\,ft$

$$A2DeckElev_4 := Abut2_{FGE} - (10ft\cdot 0.02 + 3.9766ft\cdot 0.04) - \frac{13.9766ft}{\tan(Skew)}0.04$$

$A2DeckElev_4 = 1361.8396\,ft$

$A2Elev_4 := A2DeckElev_4 - (Deck + BeamDepth + BPad + Haunch + FinalCamber)$

$A2Elev_4 = 1358.9339\,ft$

$$A2DeckElev_1 := Abut2_{FGE} - (10ft\cdot 0.02 + 3.9766ft\cdot 0.04) + \frac{13.9766ft}{\tan(Skew)}0.04$$

$A2DeckElev_1 = 1362.2465\,ft$

$A2Elev_1 := A2DeckElev_1 - (Deck + BeamDepth + BPad + Haunch + FinalCamber)$

$A2Elev_1 = 1359.3409\,ft$

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Summary, Abutment 2:

$A2DeckElev_1 = 1362.2465\,ft$ $A2Elev_1 = 1359.3409\,ft$

$A2DeckElev_2 = 1362.3695\,ft$ $A2Elev_2 = 1359.4638\,ft$

$A2DeckElev_3 = 1362.1950\,ft$ $A2Elev_3 = 1359.2894\,ft$

$A2DeckElev_4 = 1361.8396\,ft$ $A2Elev_4 = 1358.9339\,ft$

WRW ✓

Bridge Deck Elevations

Project: JC22 Hadden Run

PVT Sta.	171.72	PVT Elev.	1365.22	Grade PVT to PVC (%)	-4.00 down
PVC Sta.	261.38	PVC Elev.	1361.63		

BRIDGE ELEVATIONS

ABUT. DESIGN

Station	A	B	BB-1	BM-1 CL	C	BE-1	BB-2	BM-2 CL	BE-2	CL Road	BB-3	BM-3 CL	BE-3	BB-4	E	BM-4 CL	BE-4	F	G
171.72										1365.22									
183.07	1364.57	1364.41	1364.41	1364.49	1364.57	1364.57	1364.65	1364.69	1364.73	1364.77	1364.73	1364.69	1364.65	1364.57	1364.57	1364.49	1364.41	1364.41	1364.57
183.59	1364.55	1364.38	1364.39	1364.47	1364.54	1364.55	1364.62	1364.66	1364.70	1364.74	1364.70	1364.66	1364.62	1364.55	1364.54	1364.47	1364.39	1364.38	1364.55
183.60	1364.55	1364.38	1364.39	1364.47	1364.54	1364.54	1364.62	1364.66	1364.70	1364.74	1364.70	1364.66	1364.62	1364.54	1364.54	1364.47	1364.39	1364.38	1364.55
184.33	1364.52	1364.36	1364.36	1364.44	1364.52	1364.52	1364.60	1364.64	1364.68	1364.72	1364.68	1364.64	1364.60	1364.52	1364.52	1364.44	1364.36	1364.36	1364.52
185.05	1364.49	1364.33	1364.33	1364.41	1364.49	1364.49	1364.57	1364.61	1364.65	1364.69	1364.65	1364.61	1364.57	1364.49	1364.49	1364.41	1364.33	1364.33	1364.49
185.06	1364.49	1364.33	1364.33	1364.41	1364.49	1364.49	1364.57	1364.61	1364.65	1364.69	1364.65	1364.61	1364.57	1364.49	1364.49	1364.41	1364.33	1364.33	1364.49
186.51	1364.43	1364.27	1364.27	1364.35	1364.43	1364.43	1364.51	1364.55	1364.59	1364.63	1364.59	1364.55	1364.51	1364.43	1364.43	1364.35	1364.27	1364.27	1364.43
187.24	1364.41	1364.24	1364.24	1364.32	1364.40	1364.40	1364.48	1364.52	1364.56	1364.60	1364.56	1364.52	1364.48	1364.40	1364.40	1364.32	1364.24	1364.24	1364.41
187.96	1364.38	1364.21	1364.21	1364.29	1364.37	1364.37	1364.45	1364.49	1364.53	1364.57	1364.53	1364.49	1364.45	1364.37	1364.37	1364.29	1364.21	1364.21	1364.38
188.69	1364.35	1364.18	1364.18	1364.26	1364.34	1364.34	1364.42	1364.46	1364.50	1364.54	1364.50	1364.46	1364.42	1364.34	1364.34	1364.26	1364.18	1364.18	1364.35
189.42	1364.32	1364.15	1364.15	1364.23	1364.31	1364.31	1364.39	1364.43	1364.47	1364.51	1364.47	1364.43	1364.39	1364.31	1364.31	1364.23	1364.15	1364.15	1364.32
190.14	1364.29	1364.12	1364.12	1364.20	1364.28	1364.28	1364.36	1364.40	1364.44	1364.48	1364.44	1364.40	1364.36	1364.28	1364.28	1364.20	1364.12	1364.12	1364.29
190.87	1364.26	1364.09	1364.09	1364.17	1364.25	1364.25	1364.33	1364.37	1364.41	1364.45	1364.41	1364.37	1364.33	1364.25	1364.25	1364.17	1364.09	1364.09	1364.26
192.32	1364.20	1364.04	1364.04	1364.12	1364.20	1364.20	1364.28	1364.32	1364.36	1364.40	1364.36	1364.32	1364.28	1364.20	1364.20	1364.12	1364.04	1364.04	1364.20
192.33	1364.20	1364.03	1364.04	1364.12	1364.19	1364.20	1364.27	1364.31	1364.35	1364.39	1364.35	1364.31	1364.27	1364.20	1364.19	1364.12	1364.04	1364.03	1364.20
193.05	1364.17	1364.01	1364.01	1364.09	1364.17	1364.17	1364.25	1364.29	1364.33	1364.37	1364.33	1364.29	1364.25	1364.17	1364.17	1364.09	1364.01	1364.01	1364.17
193.78	1364.14	1363.98	1363.98	1364.06	1364.14	1364.14	1364.22	1364.26	1364.30	1364.34	1364.30	1364.26	1364.22	1364.14	1364.14	1364.06	1363.98	1363.98	1364.14
193.79	1364.14	1363.98	1363.98	1364.06	1364.14	1364.14	1364.22	1364.26	1364.30	1364.34	1364.30	1364.26	1364.22	1364.14	1364.14	1364.06	1363.98	1363.98	1364.14
194.31	1364.12	1363.96	1363.96	1364.04	1364.12	1364.12	1364.20	1364.24	1364.28	1364.32	1364.28	1364.24	1364.20	1364.12	1364.12	1364.04	1363.96	1363.96	1364.12
196.00	1364.05	1363.89	1363.89	1363.97	1364.05	1364.05	1364.13	1364.17	1364.21	1364.25	1364.21	1364.17	1364.13	1364.05	1364.05	1363.97	1363.89	1363.89	1364.05
198.00	1363.97	1363.81	1363.81	1363.89	1363.97	1363.97	1364.05	1364.09	1364.13	1364.17	1364.13	1364.09	1364.05	1363.97	1363.97	1363.89	1363.81	1363.81	1363.97
200.00	1363.89	1363.73	1363.73	1363.81	1363.89	1363.89	1363.97	1364.01	1364.05	1364.09	1364.05	1364.01	1363.97	1363.89	1363.89	1363.81	1363.73	1363.73	1363.89
202.00	1363.81	1363.65	1363.65	1363.73	1363.81	1363.81	1363.89	1363.93	1363.97	1364.01	1363.97	1363.93	1363.89	1363.81	1363.81	1363.73	1363.65	1363.65	1363.81
204.00	1363.73	1363.57	1363.57	1363.65	1363.73	1363.73	1363.81	1363.85	1363.89	1363.93	1363.89	1363.85	1363.81	1363.73	1363.73	1363.65	1363.57	1363.57	1363.73
206.00	1363.65	1363.49	1363.49	1363.57	1363.65	1363.65	1363.73	1363.77	1363.81	1363.85	1363.81	1363.77	1363.73	1363.65	1363.65	1363.57	1363.49	1363.49	1363.65
208.00	1363.57	1363.41	1363.41	1363.49	1363.57	1363.57	1363.65	1363.69	1363.73	1363.77	1363.73	1363.69	1363.65	1363.57	1363.57	1363.49	1363.41	1363.41	1363.57
210.00	1363.49	1363.33	1363.33	1363.41	1363.49	1363.49	1363.57	1363.61	1363.65	1363.69	1363.65	1363.61	1363.57	1363.49	1363.49	1363.41	1363.33	1363.33	1363.49
212.00	1363.41	1363.25	1363.25	1363.33	1363.41	1363.41	1363.49	1363.53	1363.57	1363.61	1363.57	1363.53	1363.49	1363.41	1363.41	1363.33	1363.25	1363.25	1363.41
214.00	1363.33	1363.17	1363.17	1363.25	1363.33	1363.33	1363.41	1363.45	1363.49	1363.53	1363.49	1363.45	1363.41	1363.33	1363.33	1363.25	1363.17	1363.17	1363.33
215.39	1363.28	1363.11	1363.11	1363.19	1363.27	1363.27	1363.35	1363.39	1363.43	1363.47	1363.43	1363.39	1363.35	1363.27	1363.27	1363.19	1363.11	1363.11	1363.28
216.00	1363.25	1363.09	1363.09	1363.17	1363.25	1363.25	1363.33	1363.37	1363.41	1363.45	1363.41	1363.37	1363.33	1363.25	1363.25	1363.17	1363.09	1363.09	1363.25
218.00	1363.17	1363.01	1363.01	1363.09	1363.17	1363.17	1363.25	1363.29	1363.33	1363.37	1363.33	1363.29	1363.25	1363.17	1363.17	1363.09	1363.01	1363.01	1363.17

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WRW ✓

ABUT DESIGN

220.00	1363.09	1362.93	1362.93	1363.01	1363.09	1363.09	1363.17	1363.21	1363.25	1363.29	1363.25	1363.21	1363.17	1363.09	1363.09	1363.01	1362.93	1362.93	1363.09
222.00	1363.01	1362.85	1362.85	1362.93	1363.01	1363.01	1363.09	1363.13	1363.17	1363.21	1363.17	1363.13	1363.09	1363.01	1363.01	1362.93	1362.85	1362.85	1363.01
224.00	1362.93	1362.77	1362.77	1362.85	1362.93	1362.93	1363.01	1363.05	1363.09	1363.13	1363.09	1363.05	1363.01	1362.93	1362.93	1362.85	1362.77	1362.77	1362.93
226.00	1362.85	1362.69	1362.69	1362.77	1362.85	1362.85	1362.93	1362.97	1363.01	1363.05	1363.01	1362.97	1362.93	1362.85	1362.85	1362.77	1362.69	1362.69	1362.85
228.00	1362.77	1362.61	1362.61	1362.69	1362.77	1362.77	1362.85	1362.89	1362.93	1362.97	1362.93	1362.89	1362.85	1362.77	1362.77	1362.69	1362.61	1362.61	1362.77
230.00	1362.69	1362.53	1362.53	1362.61	1362.69	1362.69	1362.77	1362.81	1362.85	1362.89	1362.85	1362.81	1362.77	1362.69	1362.69	1362.61	1362.53	1362.53	1362.69
232.00	1362.61	1362.45	1362.45	1362.53	1362.61	1362.61	1362.69	1362.73	1362.77	1362.81	1362.77	1362.73	1362.69	1362.61	1362.61	1362.53	1362.45	1362.45	1362.61
234.00	1362.53	1362.37	1362.37	1362.45	1362.53	1362.53	1362.61	1362.65	1362.69	1362.73	1362.69	1362.65	1362.61	1362.53	1362.53	1362.45	1362.37	1362.37	1362.53
236.00	1362.45	1362.29	1362.29	1362.37	1362.45	1362.45	1362.53	1362.57	1362.61	1362.65	1362.61	1362.57	1362.53	1362.45	1362.45	1362.37	1362.29	1362.29	1362.45
236.48	1362.43	1362.27	1362.27	1362.35	1362.43	1362.43	1362.51	1362.55	1362.59	1362.63	1362.59	1362.55	1362.51	1362.43	1362.43	1362.35	1362.27	1362.27	1362.43
237.00	1362.41	1362.25	1362.25	1362.33	1362.41	1362.41	1362.49	1362.53	1362.57	1362.61	1362.57	1362.53	1362.49	1362.41	1362.41	1362.33	1362.25	1362.25	1362.41
237.01	1362.41	1362.25	1362.25	1362.33	1362.41	1362.41	1362.49	1362.53	1362.57	1362.61	1362.57	1362.53	1362.49	1362.41	1362.41	1362.33	1362.25	1362.25	1362.41
237.74	1362.38	1362.22	1362.22	1362.30	1362.38	1362.38	1362.46	1362.50	1362.54	1362.58	1362.54	1362.50	1362.46	1362.38	1362.38	1362.30	1362.22	1362.22	1362.38
238.46	1362.35	1362.19	1362.19	1362.27	1362.35	1362.35	1362.43	1362.47	1362.51	1362.55	1362.51	1362.47	1362.43	1362.35	1362.35	1362.27	1362.19	1362.19	1362.35
238.47	1362.35	1362.19	1362.19	1362.27	1362.35	1362.35	1362.43	1362.47	1362.51	1362.55	1362.51	1362.47	1362.43	1362.35	1362.35	1362.27	1362.19	1362.19	1362.35
239.92	1362.30	1362.13	1362.13	1362.21	1362.29	1362.29	1362.37	1362.41	1362.45	1362.49	1362.45	1362.41	1362.37	1362.29	1362.29	1362.21	1362.13	1362.13	1362.30
240.64	1362.27	1362.10	1362.10	1362.18	1362.26	1362.26	1362.34	1362.38	1362.42	1362.46	1362.42	1362.38	1362.34	1362.26	1362.26	1362.18	1362.10	1362.10	1362.27
241.37	1362.24	1362.07	1362.07	1362.15	1362.23	1362.23	1362.31	1362.35	1362.39	1362.43	1362.39	1362.35	1362.31	1362.23	1362.23	1362.15	1362.07	1362.07	1362.24
242.10	1362.21	1362.04	1362.04	1362.12	1362.20	1362.20	1362.28	1362.32	1362.36	1362.40	1362.36	1362.32	1362.28	1362.20	1362.20	1362.12	1362.04	1362.04	1362.21
242.82	1362.18	1362.01	1362.01	1362.09	1362.17	1362.17	1362.25	1362.29	1362.33	1362.37	1362.33	1362.29	1362.25	1362.17	1362.17	1362.09	1362.01	1362.01	1362.18
243.55	1362.15	1361.98	1361.98	1362.06	1362.14	1362.14	1362.22	1362.26	1362.30	1362.34	1362.30	1362.26	1362.22	1362.14	1362.14	1362.06	1361.98	1361.98	1362.15
244.28	1362.12	1361.95	1361.96	1362.04	1362.11	1362.12	1362.19	1362.23	1362.27	1362.31	1362.27	1362.23	1362.19	1362.12	1362.11	1362.04	1361.96	1361.95	1362.12
245.73	1362.06	1361.90	1361.90	1361.98	1362.06	1362.06	1362.14	1362.18	1362.22	1362.26	1362.22	1362.18	1362.14	1362.06	1362.06	1361.98	1361.90	1361.90	1362.06
245.74	1362.06	1361.90	1361.90	1361.98	1362.06	1362.06	1362.14	1362.18	1362.22	1362.26	1362.22	1362.18	1362.14	1362.06	1362.06	1361.98	1361.90	1361.90	1362.06
246.46	1362.03	1361.87	1361.87	1361.95	1362.03	1362.03	1362.11	1362.15	1362.19	1362.23	1362.19	1362.15	1362.11	1362.03	1362.03	1361.95	1361.87	1361.87	1362.03
247.18	1362.01	1361.84	1361.84	1361.92	1362.00	1362.00	1362.08	1362.12	1362.16	1362.20	1362.16	1362.12	1362.08	1362.00	1362.00	1361.92	1361.84	1361.84	1362.01
247.19	1362.00	1361.84	1361.84	1361.92	1362.00	1362.00	1362.08	1362.12	1362.16	1362.20	1362.16	1362.12	1362.08	1362.00	1362.00	1361.92	1361.84	1361.84	1362.00
247.72	1361.98	1361.82	1361.82	1361.90	1361.98	1361.98	1362.06	1362.10	1362.14	1362.18	1362.14	1362.10	1362.06	1361.98	1361.98	1361.90	1361.82	1361.82	1361.98
261.38										1361.63									

Notes: 1) Elevation difference from A to B and F to G is 2 inches, see BD601. 2) Reference "skew stations along CL bearing" spreadsheet for stations along abutment.

WRW ✓

TOP OF ABUTMENT ELEVATIONS

	A	B	BB-1	BM-1 CL	C	BE-1	BB-2	BM-2 CL	BE-2	CL Road	BB-3	BM-3 CL	BE-3	BB-4	E	BM-4 CL	BE-4	F	G
ABUTMENT 1																			
SURFACE			1364.39 ✓	1364.44		1364.49	1364.51 ✓	1364.52	1364.53		1364.47	1364.40	1364.33 ✓	1364.20		1364.09	1363.98 ✓		
TOP ABUT			1361.48 ✓	*2.9057*			1361.60 ✓	*2.9057*				*2.9057*	1361.43 ✓			*2.9057*	1361.07 ✓		
ABUTMENT 2																			
SURFACE			1362.25 ✓	1362.30		1362.35	1362.37 ✓	1362.38	1362.39		1362.33	1362.26	1362.19 ✓	1362.06		1361.95	1361.84 ✓		
TOP ABUT			1359.34 ✓	*2.9057*			1359.46 ✓	*2.9057*				*2.9057*	1359.29 ✓			*2.9057*	1358.93 ✓		

<u>Key:</u>

BB - Beam Begin

BM - Beam Middle

BE - Beam End

<u>Distance from deck to abutment</u>

slab thickness = 8in

beam thickness = 21in

beam camber = 2.27in

bearing thickness = 3.0980in

haunch = 1/2in

Total thickness = 2.9057 ft

WRW ✓

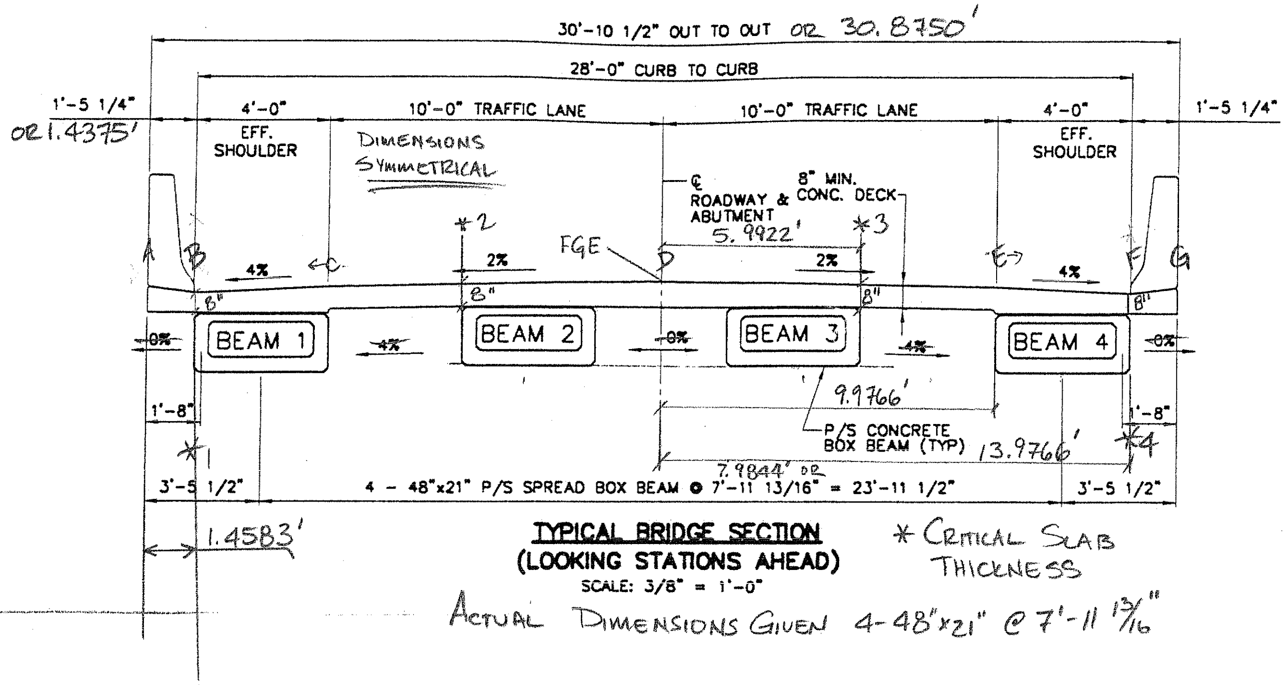
Stations along abutment skew

Project: JC22 Hadden Run

		A	B	BB-1	BM-1 CL	C	BE-1	BB-2	BM-2 CL	BE-2	**CL Road**	BB-3	BM-3 CL	BE-3	BB-4	E	BM-4 CL	BE-4	F	G
Distance from CL		15.44	14.00	13.98	11.98	10.00	9.98	5.99	3.99	1.99	0.00	1.99	3.99	5.99	9.98	10.00	11.98	13.98	14.00	15.44
CL Begin Station	188.69	183.07	183.59	183.60	184.33	185.05	185.06	186.51	187.24	187.96	188.69	189.42	190.14	190.87	192.32	192.33	193.05	193.78	193.79	194.31
CL End Station	242.10	236.48	237.00	237.01	237.74	238.46	238.47	239.92	240.64	241.37	242.10	242.82	243.55	244.28	245.73	245.74	246.46	247.18	247.19	247.72
Skew	70.00																			

<u>Spread sheet notes:</u>
Check +/- in equation depending on skew angle direction.
Verify cells used in equation.

For "Stations Along Abutment Skew" Chart

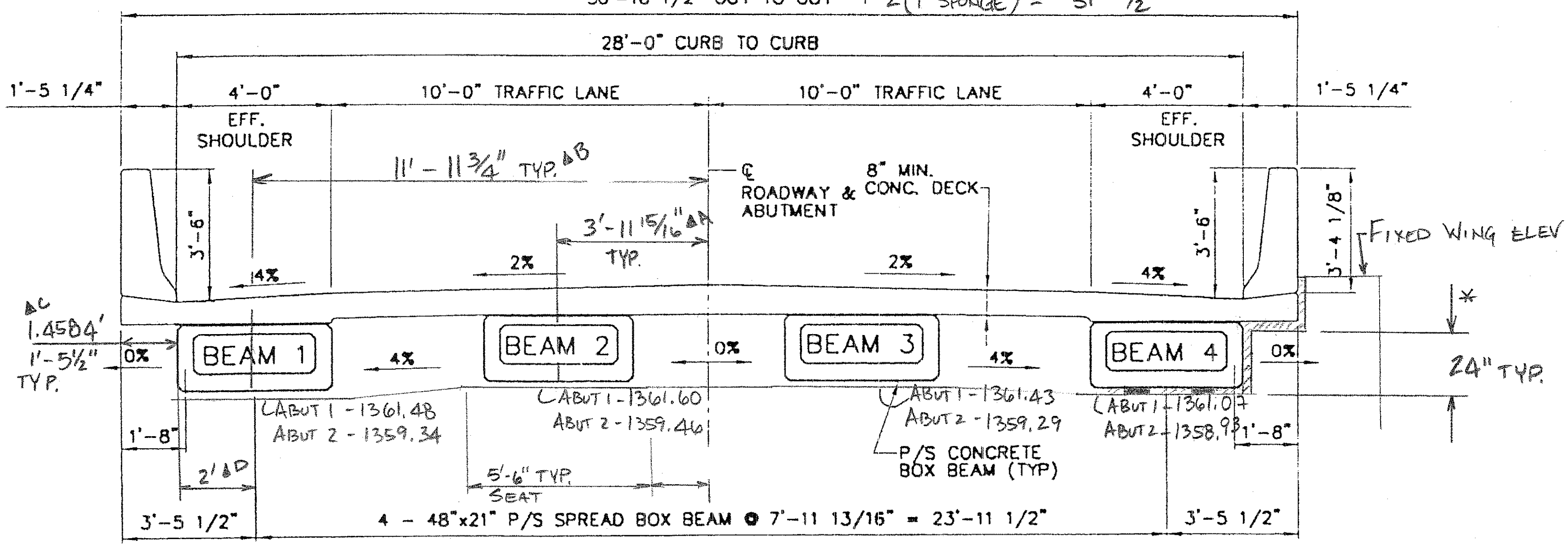


TYPICAL BRIDGE SECTION
(LOOKING STATIONS AHEAD)
SCALE: 3/8" = 1'-0"

* Critical Slab Thickness

Actual Dimensions Given 4-48"x21" @ 7'-11 13/16"

Beam Layout and Abutment and Cheekwall Elevations (Abut. 1 + 2)

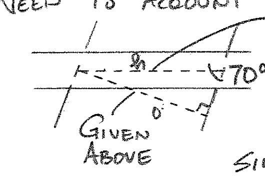


TYPICAL BRIDGE SECTION
(LOOKING STATIONS AHEAD)
SCALE: 3/8" = 1'-0"

* Bearing Pad Thickness + Haunch + Beam − Sponge

3" + ½" + 21" − ½" = 24"

▲ Need To Account For Skew (Mathcad) on Contract Drawings



$\sin\alpha = \frac{o}{h}$

▲A = 4'-3"
▲B = 12'-9"
▲C = 1'-6⅝"
▲D = 2'-2⅝" (1" sponge included)
▲E = 33'-7/16"

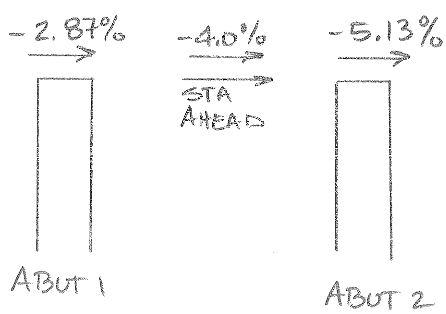
Beam Elevations Along Abutment at Four Corners of Beam Seat.
Requested by District 10-0

ABUTMENT 1				
	Beam 1	Beam 2	Beam 3	Beam 4
Centerline Elevation, ft	1361.48	1361.6	1361.43	1361.07
Slope A, %	-2.87	-2.87	-2.87	-2.87
AbutSkewWidth0.5, ft	0.7981	0.7981	0.7981	0.7981
Front Face Elevation, ft	1361.457	1361.577	1361.407	1361.047
Rear Face Elevation, ft	1361.503	1361.623	1361.453	1361.093

ABUTMENT 2				
	Beam 1	Beam 2	Beam 3	Beam 4
Centerline Elevation, ft	1359.34	1359.46	1359.29	1358.93
Slope A, %	-5.13	-5.13	-5.13	-5.13
AbutSkewWidth0.5, ft	0.7981	0.7981	0.7981	0.7981
Front Face Elevation, ft	1359.381	1359.501	1359.331	1358.971
Rear Face Elevation, ft	1359.299	1359.419	1359.249	1358.889

Verify sign in equation for FF and RF Elevations.

NA b/c dapped the beams.



JAMES A. McGEE ENGINEERING
202 Virginia Avenue
Punxsutawney, PA 15767
(814) 938-7210

Project : JC-22 Clark Road
Calculated By : WRWieserman ✓ 3-4-04
Checked By : AMS 3-4-04

H-PILE DESIGN Point-Bearing Pile

Reference Material: AASHTO LRFD 2nd Edition, PennDOT DM4 (section 10.7), BC-757

Notes:
-Minimum pile penetration = 10ft DM4.10.7.1.2.
-Minimum footing thickness for driven piles = 2.5 feet DM4.10.7.1.5.
-Driving method - Method A, method for bearing piles to absolute refusal. DM4.1.7.5P.
-Pile spacing, clearances and embedment - minimum spacing = 3ft or 2 time diagonal dimension for H pile, maximum spacing = 15ft, minimum clearance from footing edge = 9 in and from centerline of pile = 1. ft, pile embedment into footing = 1ft. Additional information such as reinforcement bar location in DM4.10.7.1.5.
-Recommended batter slope 1:4, DM4.10.7.1.6. Due to the slope of bedrock at JC22 consider this for setting batter piles. (In February 2004, additional core boring were complete to obtain more information on TOR elevations. Locations of the core boring were placed at anticapted pile tip contact points. See core boring logs.)
-Protection against deterioration - because of low resistivity and pH is very close to 5.5 it was determined to deduct 1/16" from exposed surface of the pile to be conservative against corrosion. DM4.10.7.1.8.
-Test piles - provide 2 test piles for each abutment, DM4.10.7.1.13.
-Method to determine pile resistance bearing on rock, see DM4.10.7.3.5. For pile driven to absolute refusal see DM4.10.7.4 for structural design.
-To avoid approval from the Chief Bridge Engineer start with at least a HP12x53, DM4.6.15.1P.
-Resistance factor for axial resistance in compression is 0.35 since core boring 3 encountered a intermediate layer of rock before encountering competent rock, DM4.6.5.4.2. This intermediate layer may make it difficult to drive, therefore use larger amount of smaller piles verses fewer amount of large piles.
-If vertical and battered pile are to be used the combined axial and flexural resistance factors will not apply, DM4.6.15.2.P.
-Battered piles shall resist the entire horizontal load through the horizontal component of their axial capacity, DM4.10.7.3.8.1P.

Define Unique Computer Variables: $ksi := 1000\frac{lb}{in^2}$ $kip := 1000lb$

MODIFIED H-PILE SECTION PROPERTIES
Due to corrosive environment, 1/16" will be deducted from the section for corrosion protection.

- Define section properties of a HP12x74:

$Area := 21.8in^2$

$Depth := 12.13in$

$WebThickness := 0.605in$

$FlangeWidth := 12.215in$

$FlangeThickness := 0.610in$

$T := 9.5in$ is the distance of web from inside edge of flange to inside edge of flange

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- Determine modified section properties, redefine variables

$AreaSectionLoss := \frac{1}{16} in \cdot [\, 2 \cdot FlangeWidth + 2 \cdot Depth + 2 \cdot (FlangeWidth - WebThickness) \,]$

$AreaSectionLoss = 4.494\, in^2$

$Area := Area - AreaSectionLoss$

$Area = 17.306\, in^2$

$Depth := Depth - 2 \frac{1}{16} in$

$Depth = 12.005\, in$

$WebThickness := WebThickness - 2 \cdot \frac{1}{16} in$

$WebThickness = 0.480\, in$

$FlangeWidth := FlangeWidth - 2 \cdot \frac{1}{16} in$

$FlangeWidth = 12.090\, in$

$FlangeThickness := FlangeThickness - 2 \cdot \frac{1}{16} in$

$FlangeThickness = 0.485\, in$

$$I_x := 2 \cdot \left[\frac{1}{12} \cdot FlangeWidth \cdot FlangeThickness^3 \ldots + FlangeWidth \cdot FlangeThickness \cdot \left(\frac{Depth - FlangeThickness}{2} \right)^2 \right] \ldots + \frac{1}{12} \cdot WebThickness \cdot (Depth - FlangeThickness)^3$$

$I_x = 450.467\, in^4$

$$I_y := 2 \cdot \frac{1}{12} FlangeThickness \cdot FlangeWidth^3 + \frac{1}{12} \cdot (Depth - 2 \cdot FlangeThickness) \cdot WebThickness^3$$

$I_y = 142.948\, in^4$

$r_x := \sqrt{\frac{I_x}{Area}}$

$r_x = 5.102\, in$

$r_y := \sqrt{\frac{I_y}{Area}}$

$r_y = 2.874\, in$

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Estimate Pile Length

Proposed bottom of footing elevation = BFE := 1347.50ft

Top of rock elevations at abutment 2 are within 1 foot of each other except CB-3.

Anticipated maximum pile tip elevation = PTE := 1332ft

Estimated pile length = BFE − PTE = 15.500 ft Say 20 feet

Limiting Slenderness Ratio

Compression members shall satisfy the slenderness requirements, A6.9.3:

$$\frac{K \cdot l}{r} \le 120 \qquad \text{(For main members)}$$

Define variables: K := 1.9 (per Figure C4.6.2.5-1 for value of Ga=1 and Gb=10)

$l := \frac{20ft}{2}$ $r := r_y$ (minimum radius of gyration) $r = 2.874\,in$

$$\frac{K \cdot l}{r} = 79.330 \quad \text{OK}$$

Local Buckling - limiting width/thickness rations for axial compression, A6.9.4.2.
The slenderness of plates shall satisfy:

$$\frac{b}{t} \le k \cdot \sqrt{\frac{E}{F_y}}$$

- Check Flange Local Buckling

For a HP section $k := 0.56$ and $b := \frac{FlangeWidth}{2}$

Define variables: $E := 29000ksi$ $F_y := 36ksi$ $t := FlangeThickness$

$\frac{b}{t} = 12.464$ $k\sqrt{\frac{E}{F_y}} = 15.894$

OK, flange local buckling does not control ϕPn.

- Check Web Local Buckling

For a HP section $k := 1.49$ and $b := T$

Define variables: $E = 29000.000\,ksi$ $F_y = 36.000\,ksi$ $t := WebThickness$

$\frac{b}{t} = 19.792$ $k\sqrt{\frac{E}{F_y}} = 42.290$

OK, web local buckling does not control ϕPn.

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Nominal Compressive Resistance

For steel piles under axial load, Pn shall not exceed the following:

$P_n < F_y \cdot A_s$

Define Variables: $F_y = 36.000\,\text{ksi}$ $A_s :=$ Area

$A_s = 17.306\,\text{in}^2$

$P_n := F_y \cdot A_s$ (No reduction in nominal compressive resistance for steel piles axially loaded, see DM4-6.9.4.1 vs. AASHTO 6.9.4.1)

$P_n = 623.002\,\text{kip}$

The factored resistance of components in compression Pn shall be taken as, A6.9.2:

Define variables: $\phi_c := 0.25$ (DM4-6.5.4.2, "Axial resistance of piles bearing on soluble bedrock", see also ABLRFD 6.12.4)

$P_r := \phi_c \cdot P_n$

$P_r = 155.751\,\text{kip}$ or ϕPn

$\phi P_n := P_r$

Battered Piles - ABLRFD calculates this also if batter component are inputted

Battered pile at 1H:4V or $\theta := \text{atan}\left(\frac{1}{4}\right)$

$\theta = 14.036\,\text{deg}$

-X Component $\phi P_n \cdot \sin(\theta) = 37.775\,\text{kip}$ $P_n \cdot \sin(\theta) = 151.100\,\text{kip}$

-Y Component $\phi P_n \cdot \cos(\theta) = 151.100\,\text{kip}$ $P_n \cdot \cos(\theta) = 604.401\,\text{kip}$

Use all vertical piles for first trial, if no success then battered piles for second trial.

Out of range
ABLRFD upper limit = 100 Kip
Therefore under estimate pile strength
and use 100 kip.

loads. This curve, shown as a solid line, shall be used for both sand and clay. At higher loads the curves for clay are shown with a broken line.

An independent analysis with the COM624G program shall be performed when actual soil conditions are worse than those covered by the soil profiles. If soil conditions are better than those covered by the soil profiles, an independent analysis may be performed if a substantial cost savings can be realized by a further increase in the lateral load resistance. In many cases, where soil conditions are good, the lateral load resistance will be controlled by the available moment determined by the interactive equations rather than deflections. The effect of improved soil conditions is generally less for the load vs. maximum moment curves than it is for the load vs. deflection curves.

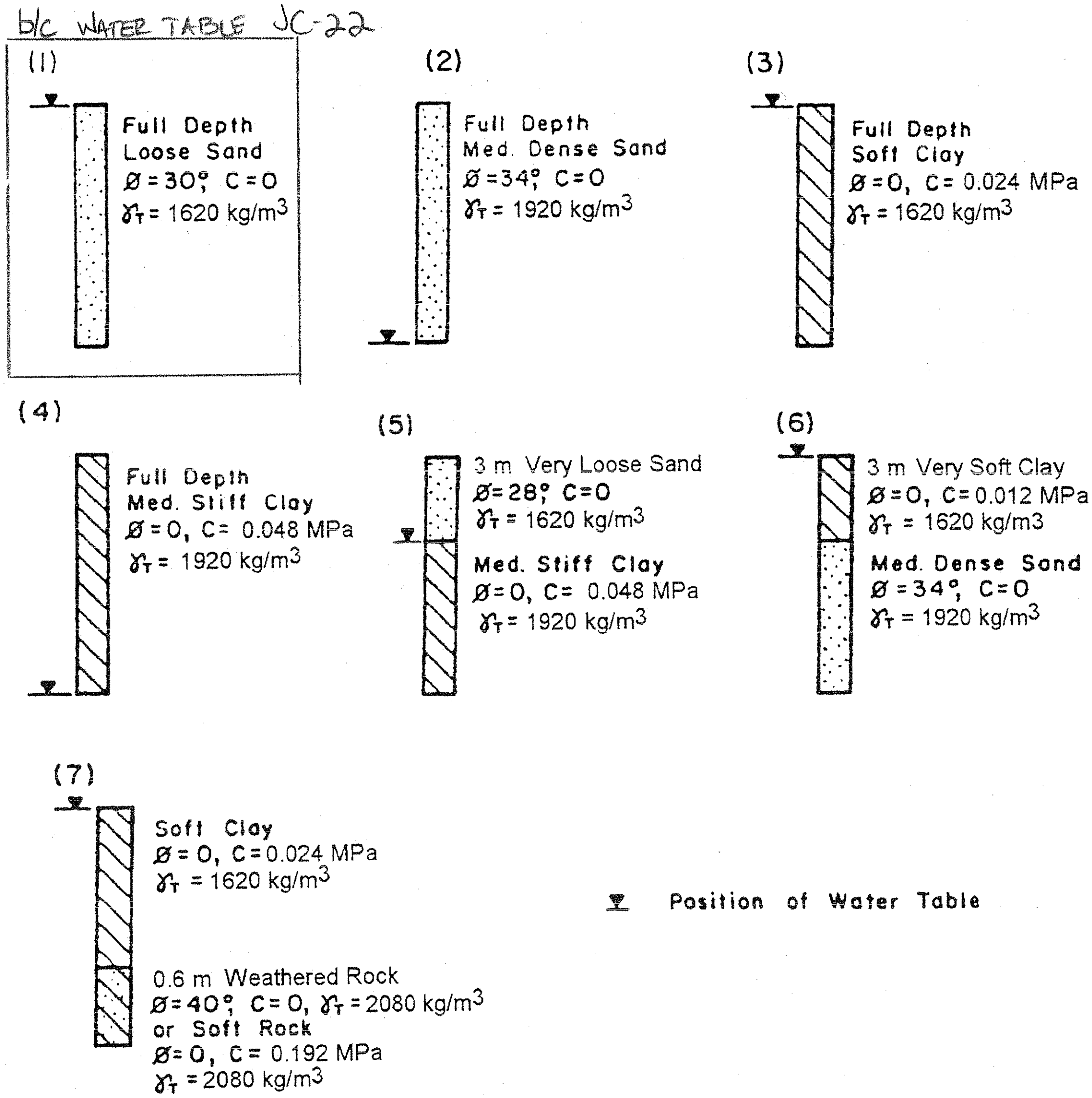
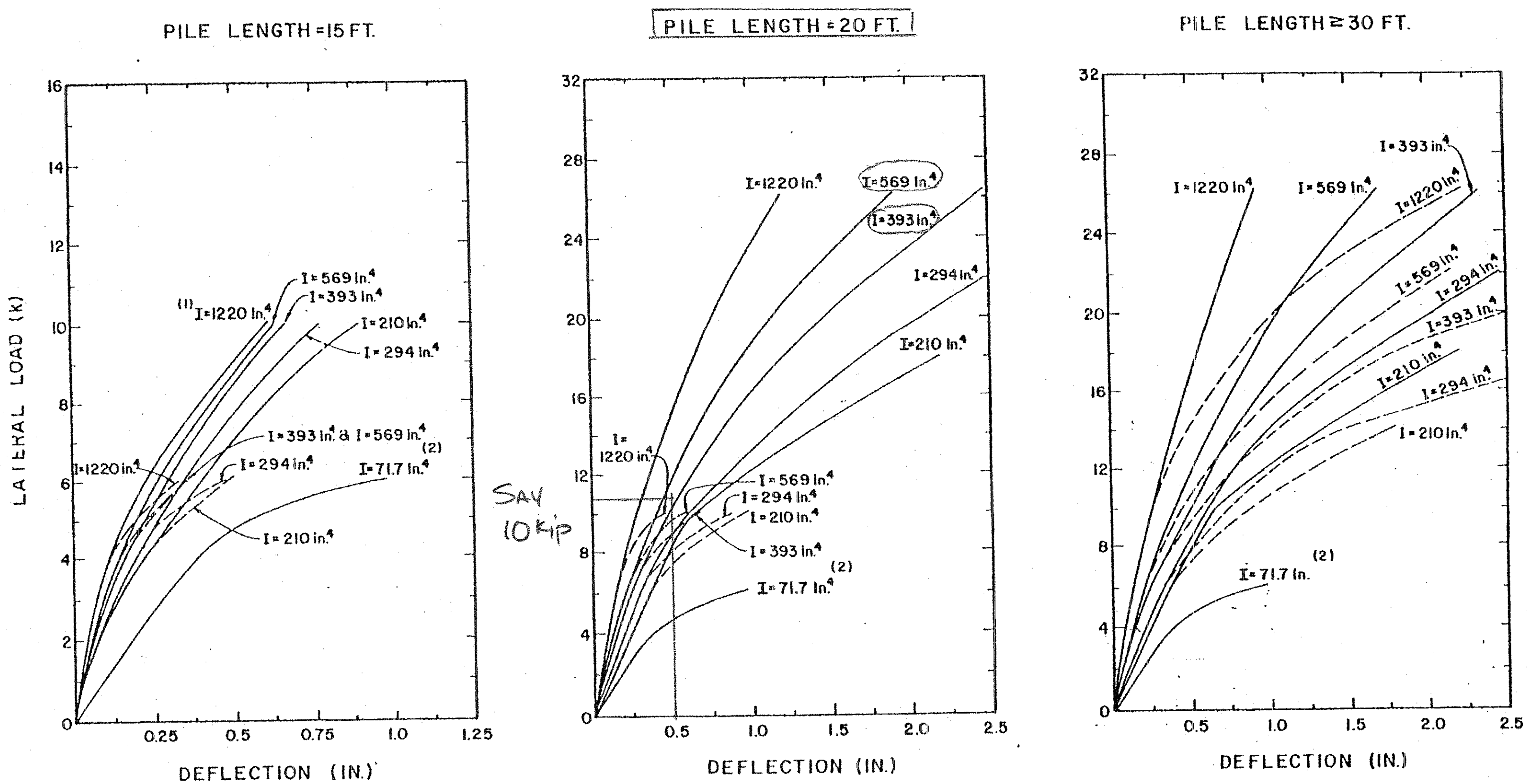


Figure 1.1.6-1 - Lateral Pile Loading Soil Profiles



$I_x = 450\ in^4$ MODIFIED

LEGEND: Sand ————
Clay — — — —

$\frac{569+393}{2} = 481\ in^4$

SOIL CONDIT

AXIAL LOAD: 12 ksi

Figure 1.1.8-1 - Load vs. Deflection for Steel H-Piles, Soil Profiles 1 & 3

LATERAL CAPACITY, STRENGTH = 10 kip

LATERAL CAPACITY, SERVICE = 10 kip (0.85) = 8.5 kip

$\phi_f = 0.85$ (Flexural Resistance)

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Checked By : WRW
MRR

Hydraulics - Vertical Clearance

- Once abutment heights are determined, an accurate vertical clearance can be determined.
- Due to the roadway grade and bridge skew, beam 4 at abutment 2 will be the lowest.
- The beam seat elevation at the abutment centerline is BeamSeat := 1358.93ft Reference "Beam elevation along abutment at four corners of beam seat" chart in Foundation Report Appendix C, page 15b.

Define variables:

BeamSeat = 1358.9300ft (defined above)

BearingpadThk:= 3.098in

StreamElev:= 1352ft

~~BridgeGrade:= $-0.04\frac{ft}{ft}$~~

BotBeamAtAbutCL := BeamSeat + BearingpadThk

*** BotBeamAtAbutCL = 1359.1882ft

Must project this elevation along vertical profile till reaches streambed.

AbutToStrmLength:= 10.2ft (Horizontal distance from centerline of abutment to streambed elevation)

BeamElevAtStream := BotBeamAtAbutCL − BridgeGrade·AbutToStrmLength

*** BeamElevAtStream = 1359.5962ft

VertClearance := BeamElevAtStream − StreamElev

*** VertClearance = 7.5962ft

-Determine vertical clearance from vertical profile and bridge geometry

Define variables:

CLBearingElev:= 1362.40ft (elevation at center line of roadway)

BridgeGrade:= $-0.04\frac{ft}{ft}$

LaneWidth:= 10ft

LaneGrade:= $0.02\frac{ft}{ft}$

ShoulderWidth:= 4ft

ShoulderGrade:= $0.04\frac{ft}{ft}$

DiffShldBeam:= 0.0208ft (difference between beam edge and edge of shoulder)

Skew = 70.0000deg

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$$StationDiff := \frac{LaneWidth + ShoulderWidth - DiffShldBeam}{\tan(Skew)}$$

StationDiff = 5.0880ft Checked with deck spreadsheet = 5.080

$DeckElevAtEdgeBeam := CLBearingElev - LaneWidth \cdot LaneGrade \ldots$
$+ -ShoulderWidth \cdot ShoulderGrade - StationDiff \cdot ShoulderGrade$

DeckElevAtEdgeBeam = 1361.8365ft Checked with deck spreadsheet = 1361.84

-Subtract superstructure depth from deck elevation to get elevation of abutment seat at centerline of bearing.

SuperstructureDepth := 8in + 21in + 2.27in + 3.098in + 0.5in (slab, beam, camber, bearing pad, and haunch)

SuperstructureDepth = 2.9057ft

AbutSeatElev := DeckElevAtEdgeBeam − SuperstructureDepth

AbutSeatElev = 1358.9308ft

-Add bearing pad thickness to get elevation of beam bottom.

*** AbutSeatElev + 3.098in = 1359.1890ft

Compare from other method. BotBeamAtAbutCL = 1359.1882ft

SAME ELEVATION.

FREEBOARD REQUIREMENTS

10-year WS elevation at RS20, $ElevQ_{10} := 1355.48ft$

$ElevFreeboardQ_{10} := ElevQ_{10} + 1ft$

$ElevFreeboardQ_{10} = 1356.4800ft$

100-year WS elevation at RS20, $ElevQ_{100} := 1356.71ft$

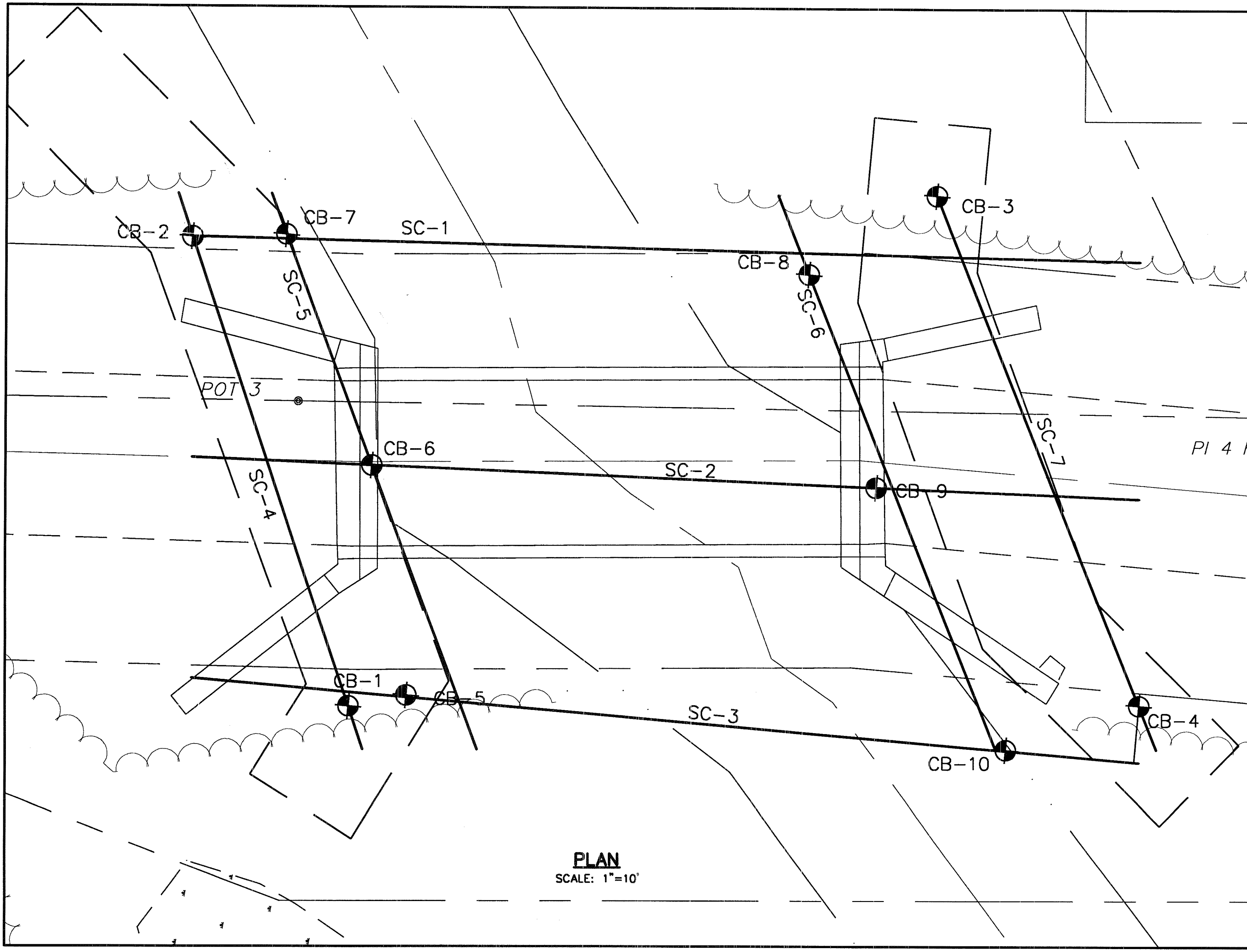
$ElevFreeboardQ_{100} := ElevQ_{100} + 2ft$

*** $ElevFreeboardQ_{100} = 1358.7100ft$ GOVERNS OR VERT. CLEARANCE 6.71'

Compare proposed beam elevation

BeamElevAtStream = 1359.5962ft GOOD

Difference $BeamElevAtStream - ElevFreeboardQ_{100} = 0.8862ft$ OR VERT PROVIDED 7.60'



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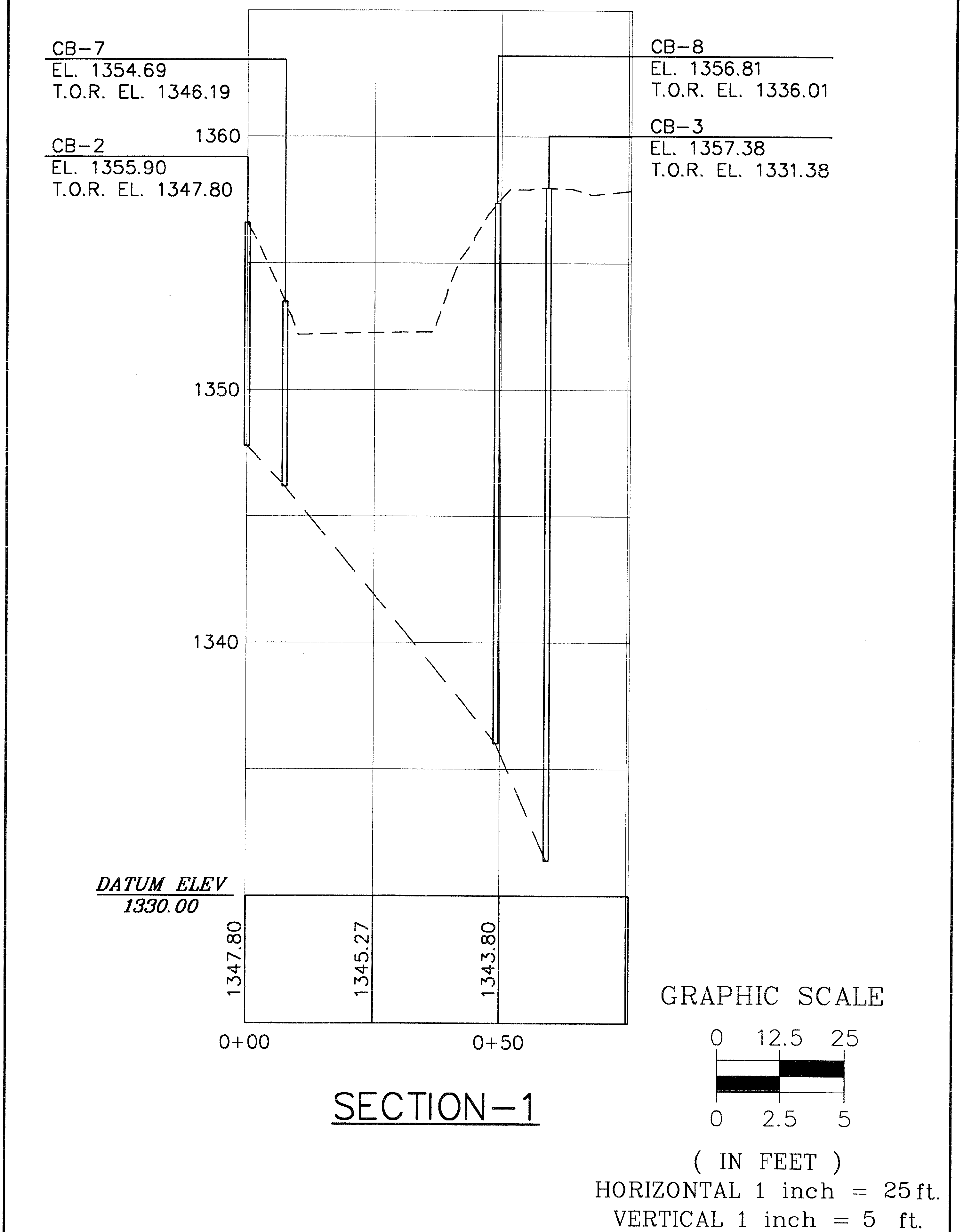
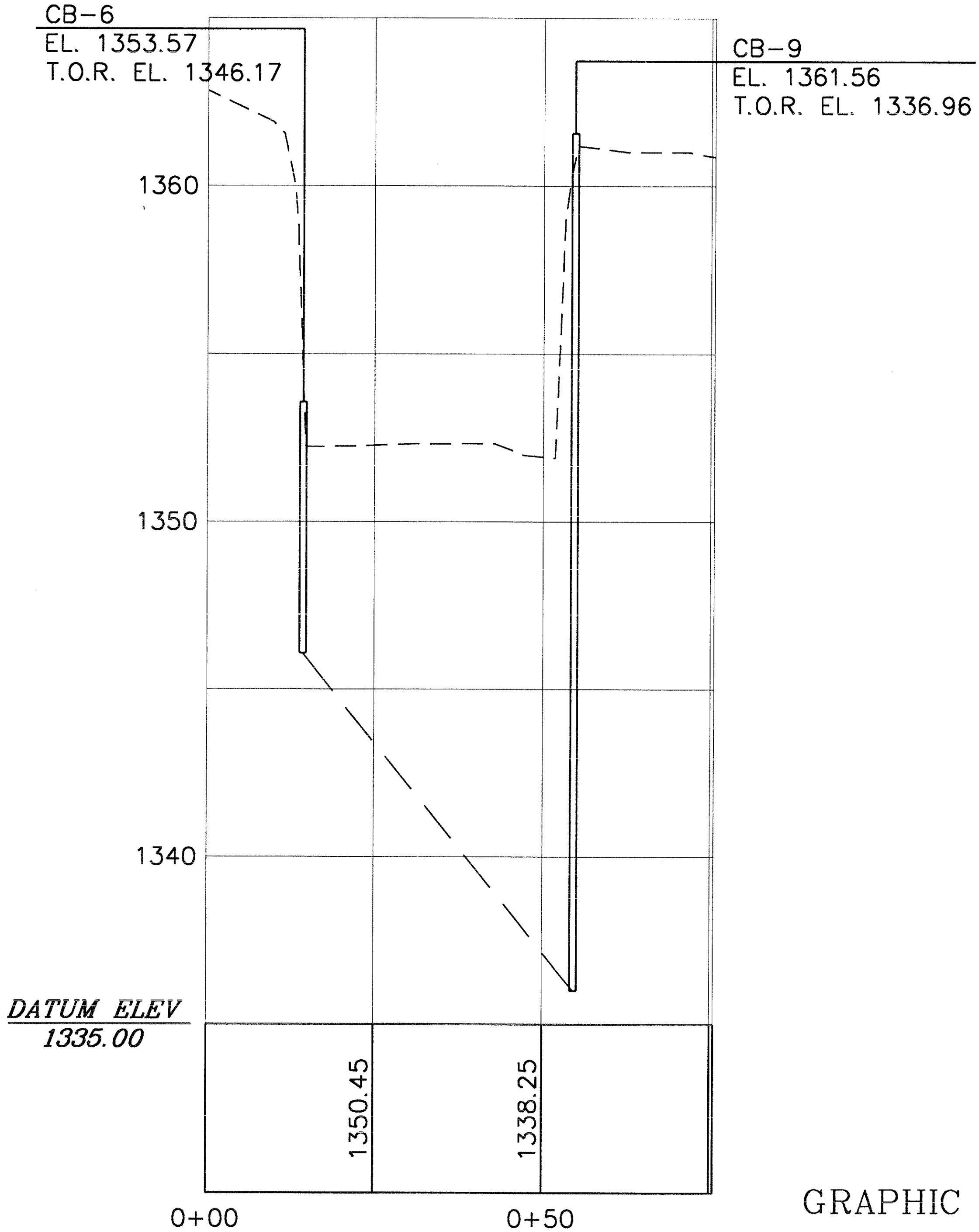
29


CB-7
EL. 1354.69
T.O.R. EL. 1346.19
CB-2
EL. 1355.90
T.O.R. EL. 1347.80
CB-8
EL. 1356.81
T.O.R. EL. 1336.01
CB-3
EL. 1357.38
T.O.R. EL. 1331.38
1360
1350
1340
DATUM ELEV
1330.00
1347.80
1345.27
1343.80
0+00
0+50
GRAPHIC SCALE
0 12.5 25
0 2.5 5
(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.

SECTION-1



SECTION-2

GRAPHIC SCALE

0 12.5 25

0 2.5 5

(IN FEET)

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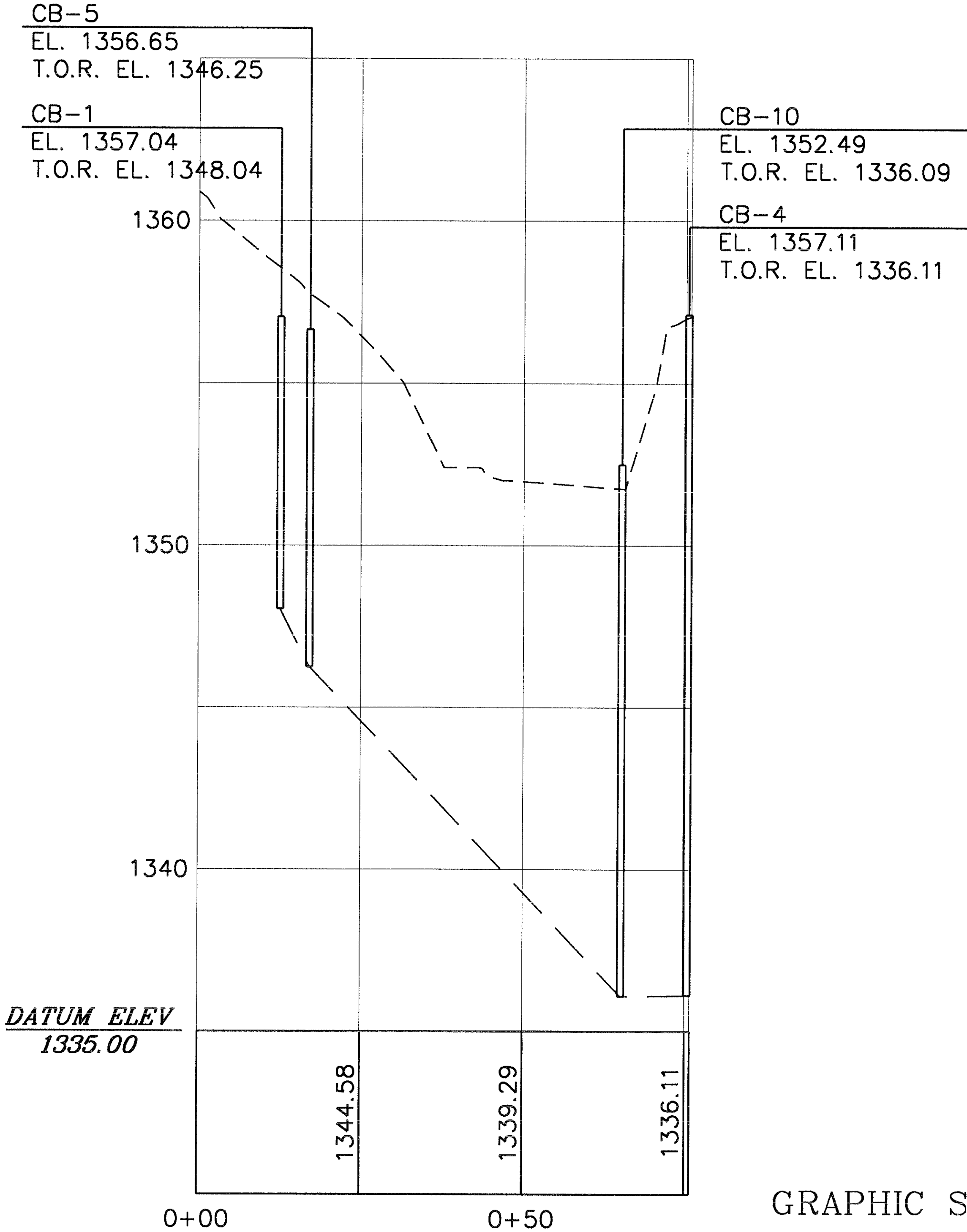
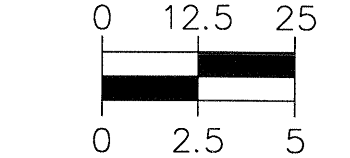
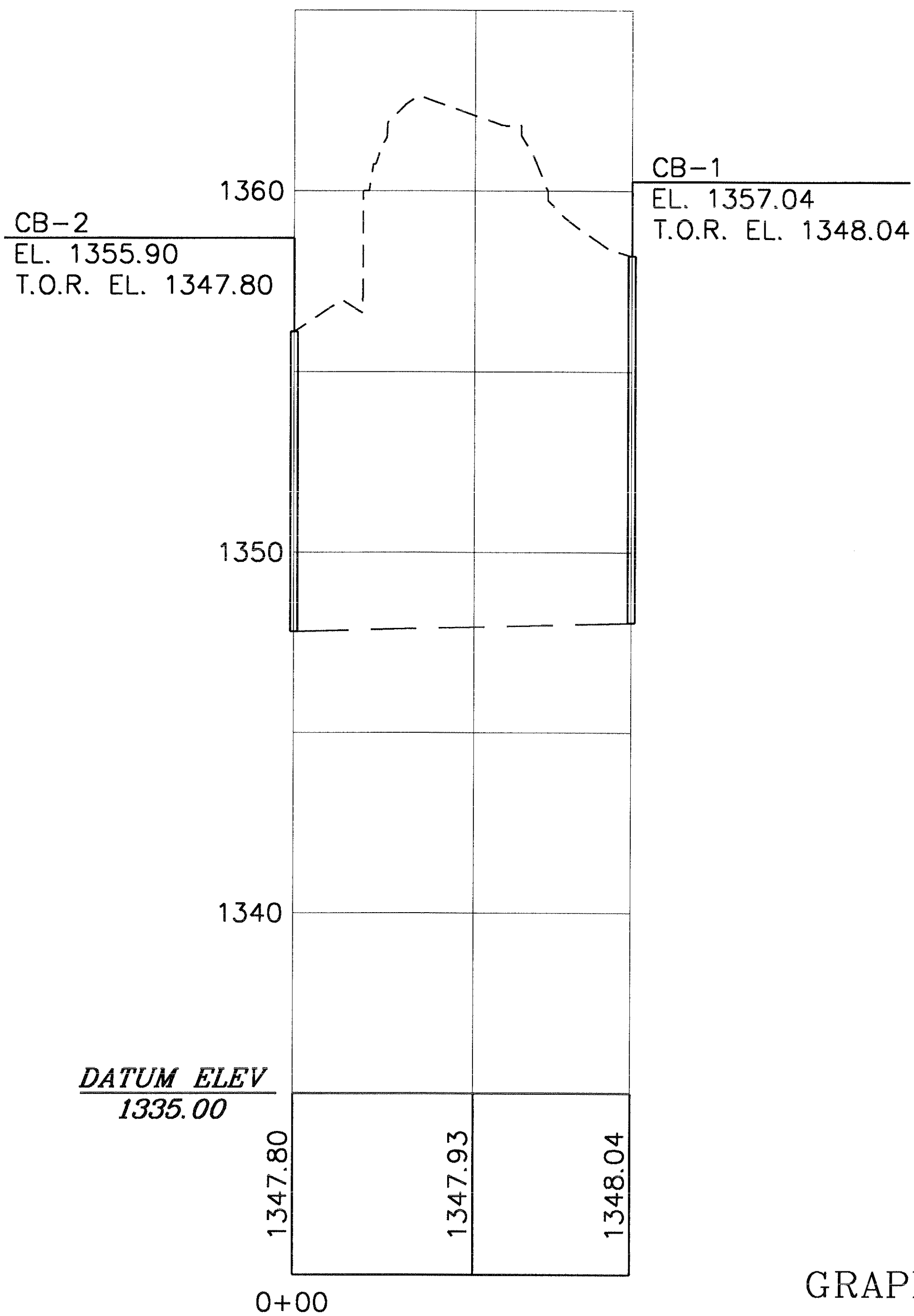
VERTICAL 1 inch = 5 ft.



SECTION-3



(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.


CB-2
EL. 1355.90
T.O.R. EL. 1347.80
CB-1
EL. 1357.04
T.O.R. EL. 1348.04
1360
1350
1340
DATUM ELEV
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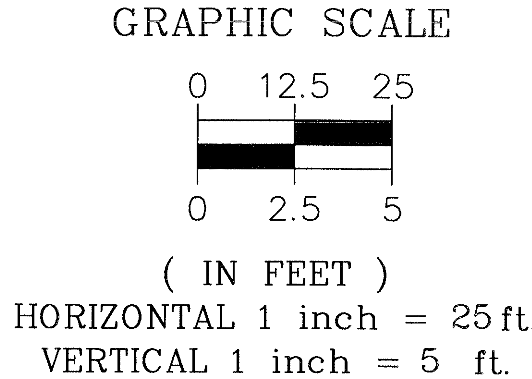
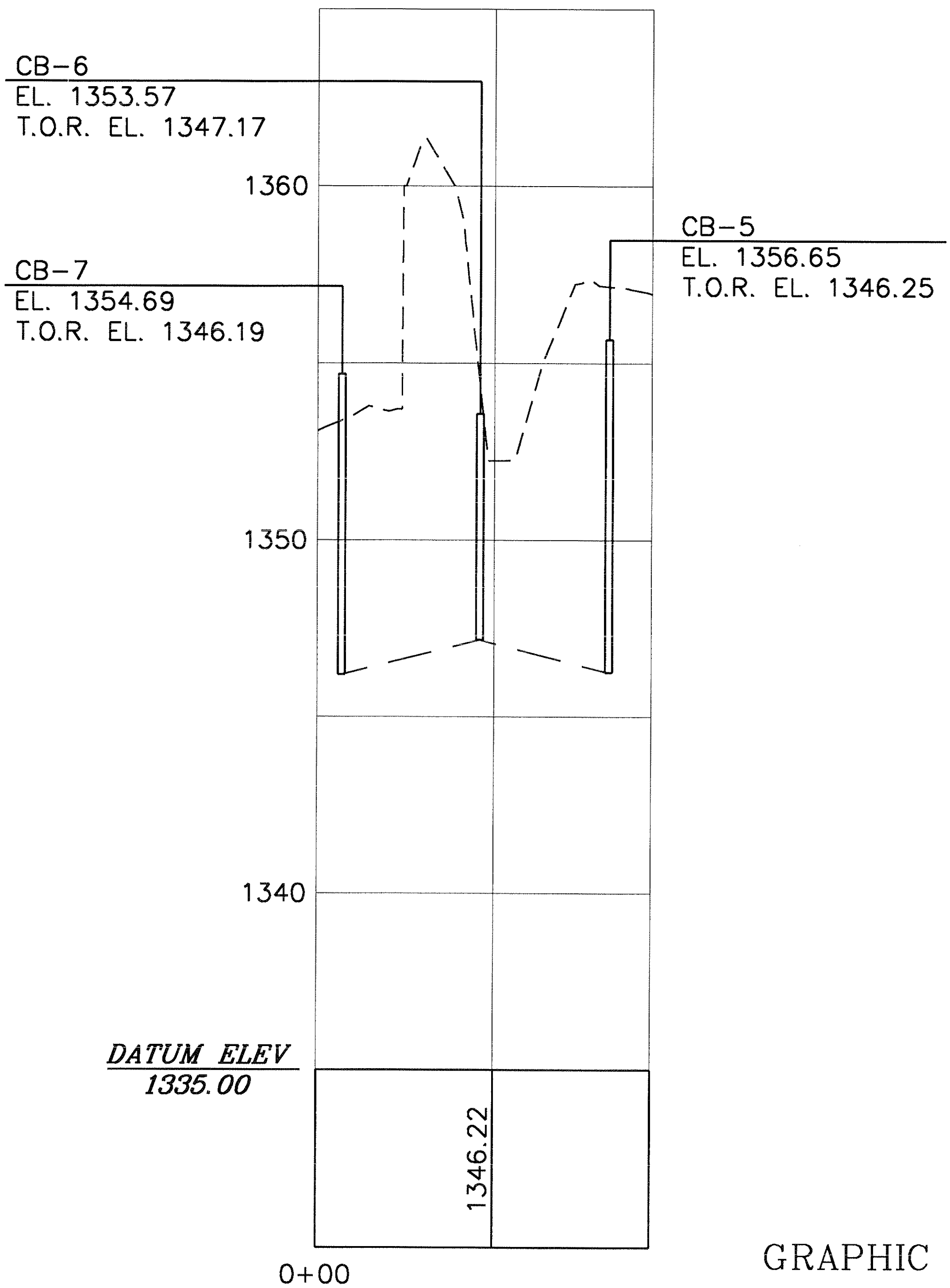
1347.80
1347.93
1348.04
0+00

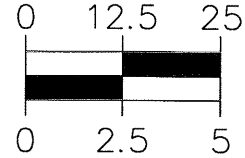
SECTION-4


GRAPHIC SCALE
0
12.5
25
0
2.5
5
(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.

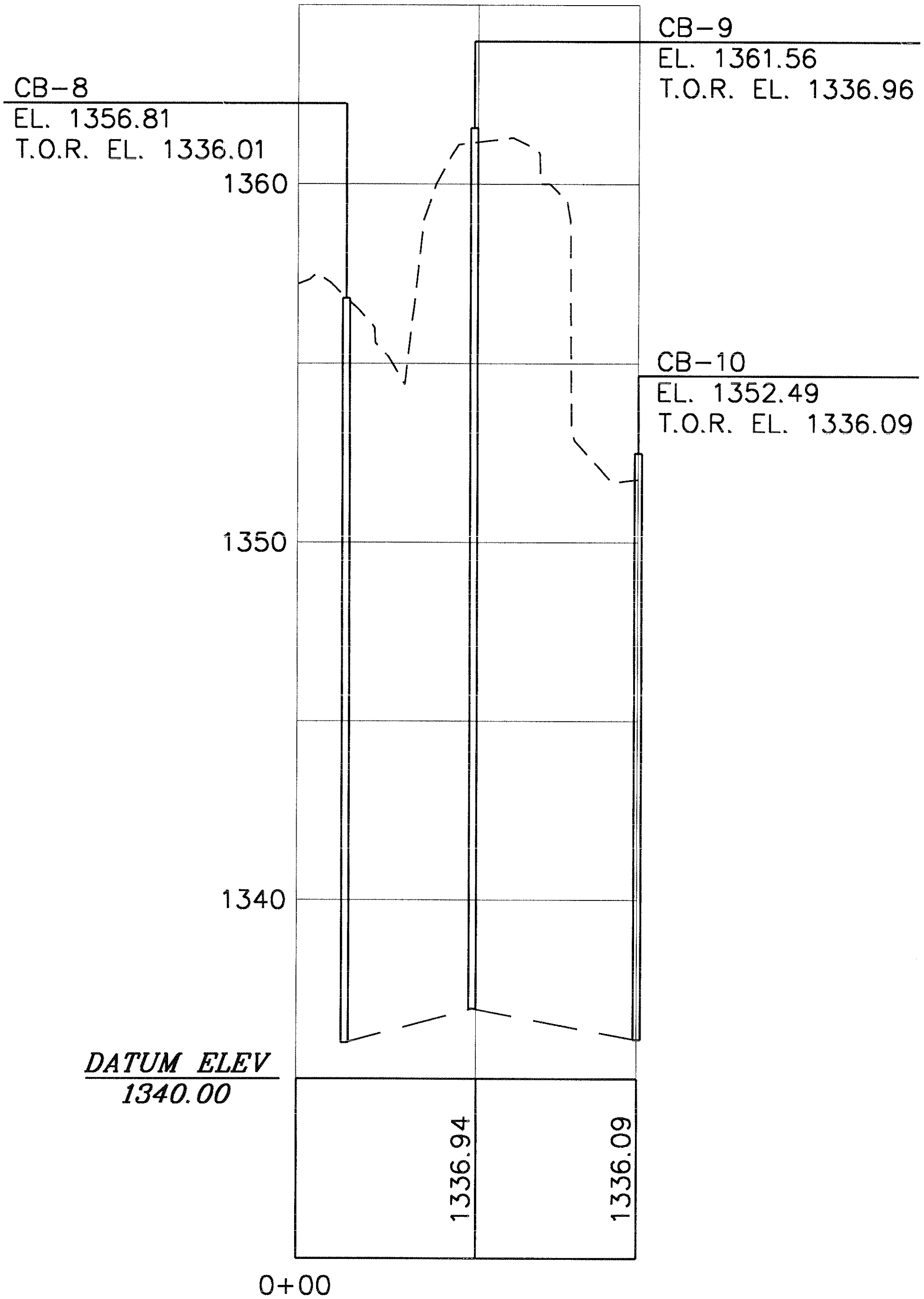


SECTION-5

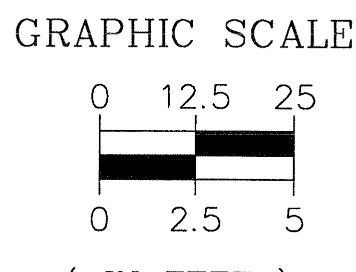
GRAPHIC SCALE



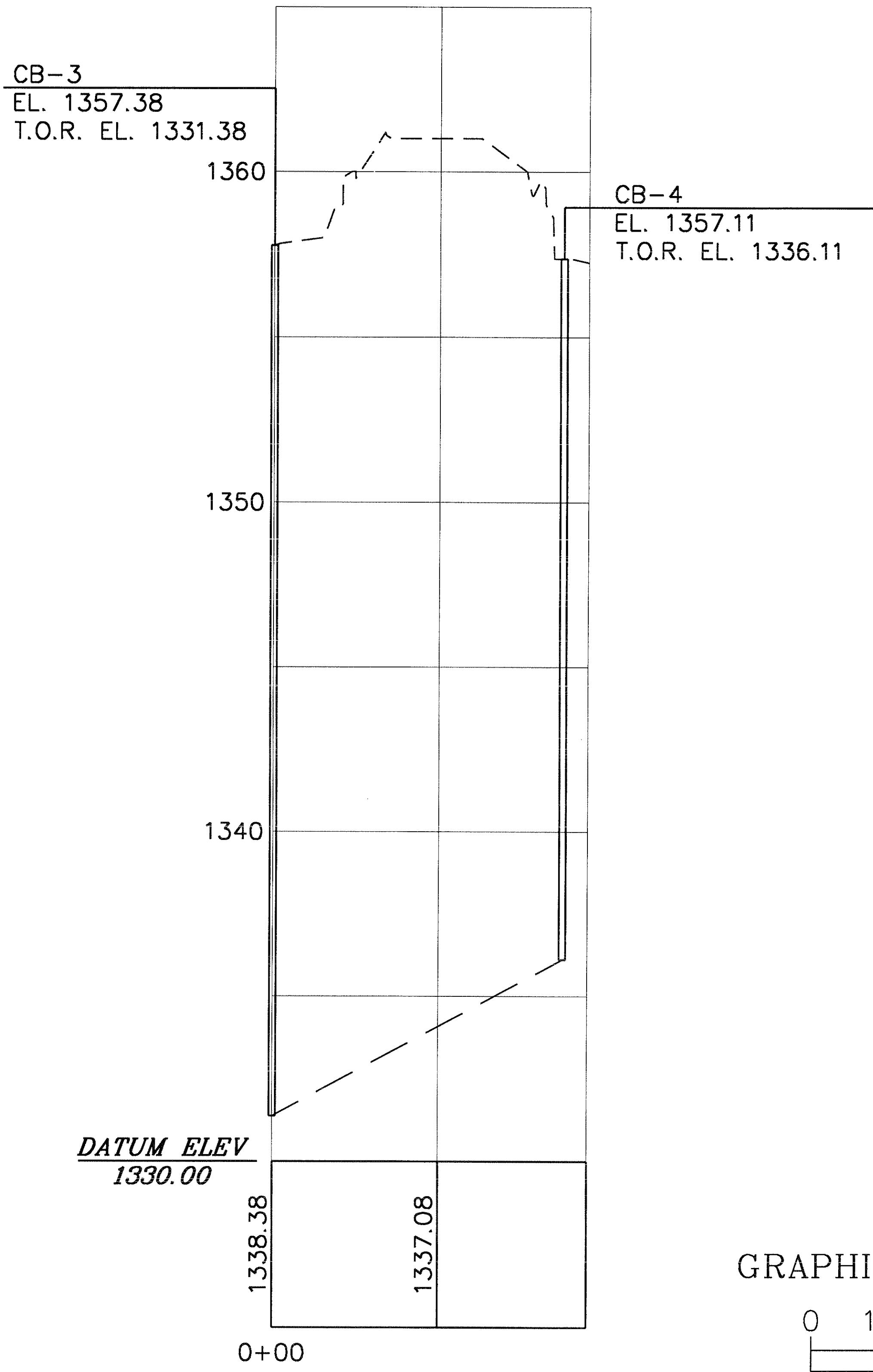
(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.



SECTION-6



HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.



SECTION-7

GRAPHIC SCALE

0 12.5 25

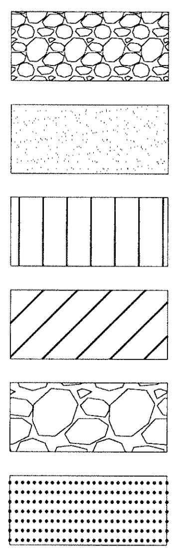
0 2.5 5

(IN FEET)

HORIZONTAL 1 inch = 25 ft.

VERTICAL 1 inch = 5 ft.

SOIL TYPES LEGEND



GRAVEL

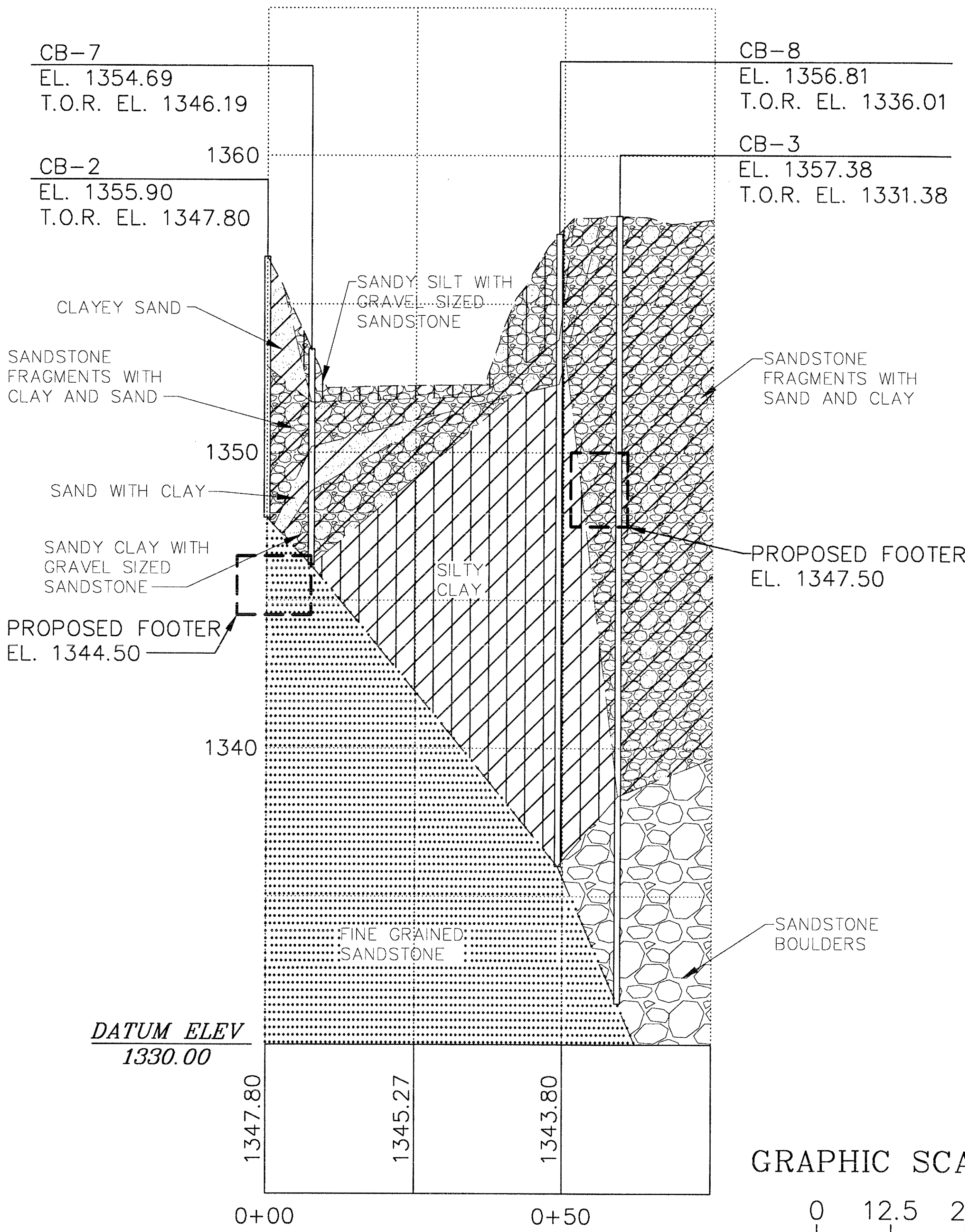
SAND

SILT

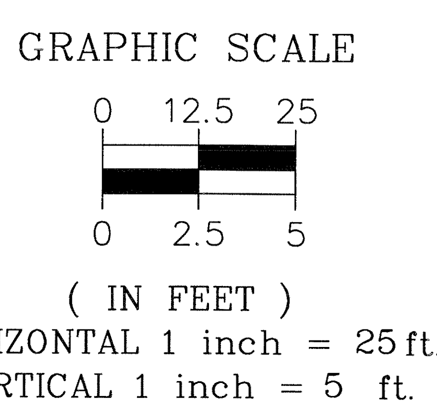
CLAY

COBBLES, BOULDERS

SANDSTONE


CB-7
EL. 1354.69
T.O.R. EL. 1346.19
CB-8
EL. 1356.81
T.O.R. EL. 1336.01
CB-3
EL. 1357.38
T.O.R. EL. 1331.38
CB-2
EL. 1355.90
T.O.R. EL. 1347.80
1360
1350
1340
CLAYEY SAND
SANDY SILT WITH GRAVEL SIZED SANDSTONE
SANDSTONE FRAGMENTS WITH CLAY AND SAND
SANDSTONE FRAGMENTS WITH SAND AND CLAY
SAND WITH CLAY
SANDY CLAY WITH GRAVEL SIZED SANDSTONE
SILTY CLAY
PROPOSED FOOTER EL. 1347.50
PROPOSED FOOTER EL. 1344.50
FINE GRAINED SANDSTONE
SANDSTONE BOULDERS
DATUM ELEV 1330.00
1347.80
1345.27
1343.80
0+00
0+50

SECTION–1


GRAPHIC SCALE
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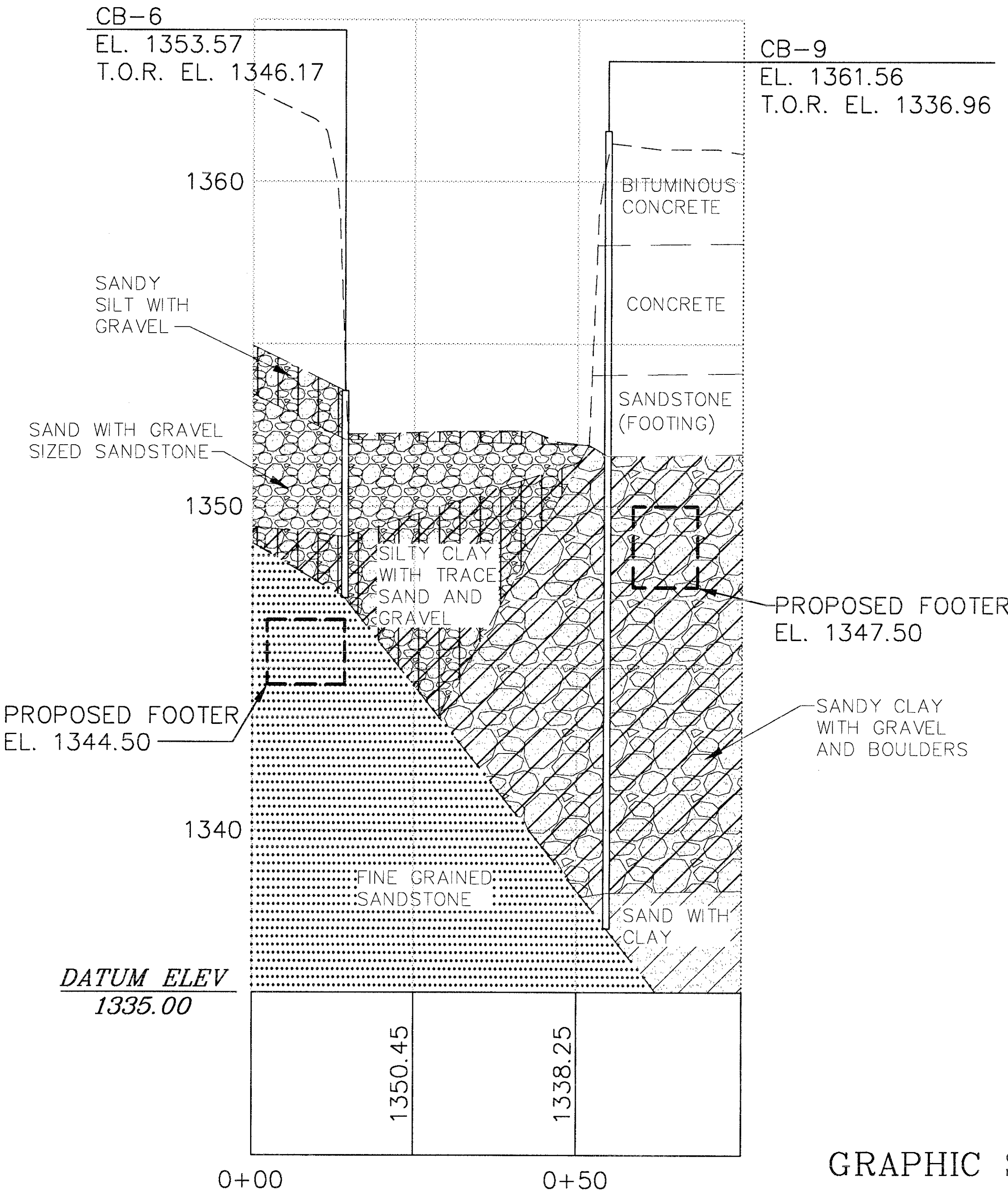
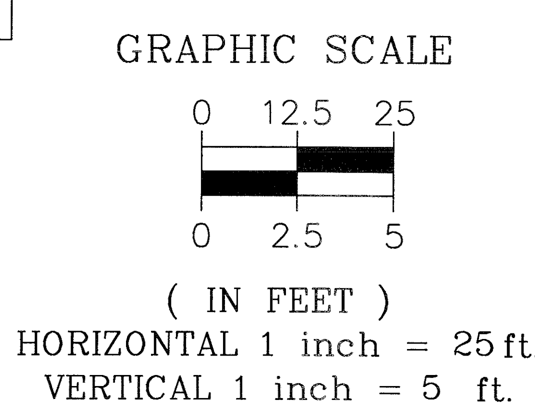
12.5
25
0
2.5
5
(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.



CB–6
EL. 1353.57
T.O.R. EL. 1346.17
CB–9
EL. 1361.56
T.O.R. EL. 1336.96
1360
1350
1340
BITUMINOUS CONCRETE
CONCRETE
SANDSTONE (FOOTING)
SANDY SILT WITH GRAVEL
SAND WITH GRAVEL SIZED SANDSTONE
SILTY CLAY WITH TRACE SAND AND GRAVEL
PROPOSED FOOTER EL. 1347.50
PROPOSED FOOTER EL. 1344.50
SANDY CLAY WITH GRAVEL AND BOULDERS
FINE GRAINED SANDSTONE
SAND WITH CLAY
DATUM ELEV 1335.00
1350.45
1338.25
0+00
0+50

SECTION–2



GRAPHIC SCALE
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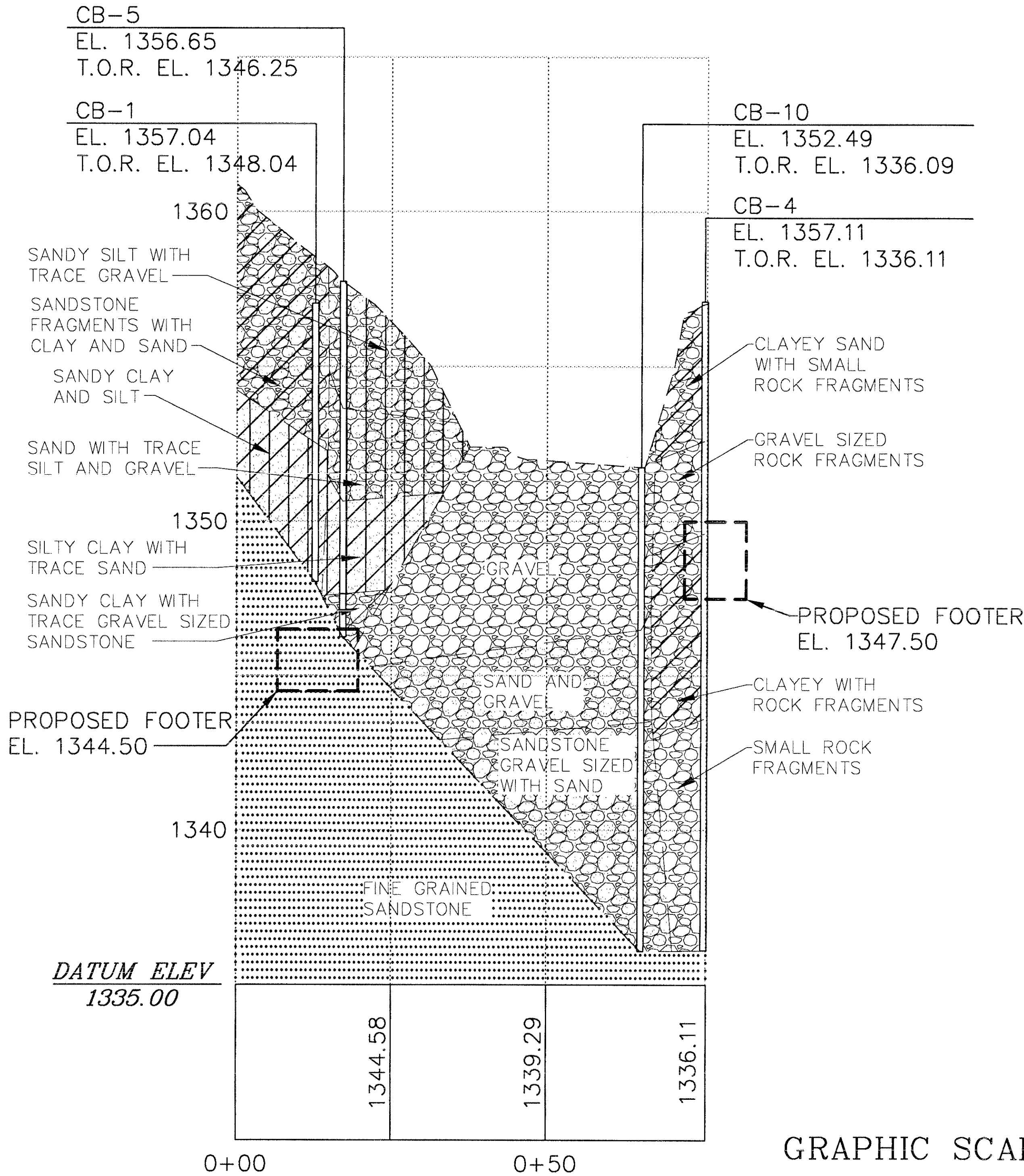
0 2.5 5
(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.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EL. 1356.65
T.O.R. EL. 1346.25
CB-1
EL. 1357.04
T.O.R. EL. 1348.04
CB-10
EL. 1352.49
T.O.R. EL. 1336.09
CB-4
EL. 1357.11
T.O.R. EL. 1336.11
1360
1350
1340
SANDY SILT WITH TRACE GRAVEL
SANDSTONE FRAGMENTS WITH CLAY AND SAND
SANDY CLAY AND SILT
SAND WITH TRACE SILT AND GRAVEL
SILTY CLAY WITH TRACE SAND
SANDY CLAY WITH TRACE GRAVEL SIZED SANDSTONE
PROPOSED FOOTER EL. 1344.50
CLAYEY SAND WITH SMALL ROCK FRAGMENTS
GRAVEL SIZED ROCK FRAGMENTS
PROPOSED FOOTER EL. 1347.50
CLAYEY WITH ROCK FRAGMENTS
SMALL ROCK FRAGMENTS
GRAVEL
SAND AND GRAVEL
SANDSTONE GRAVEL SIZED WITH SAND
FINE GRAINED SANDSTONE
DATUM ELEV
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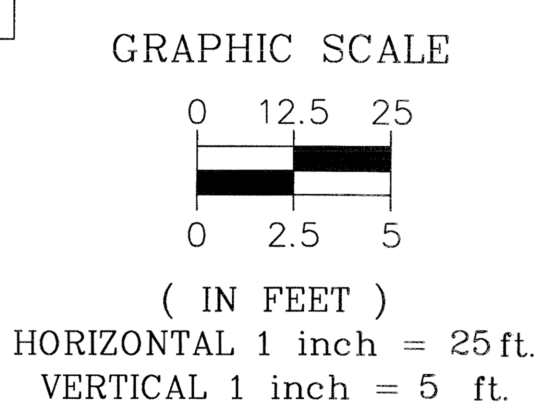
1344.58
1339.29
1336.11
0+00
0+50

SECTION-3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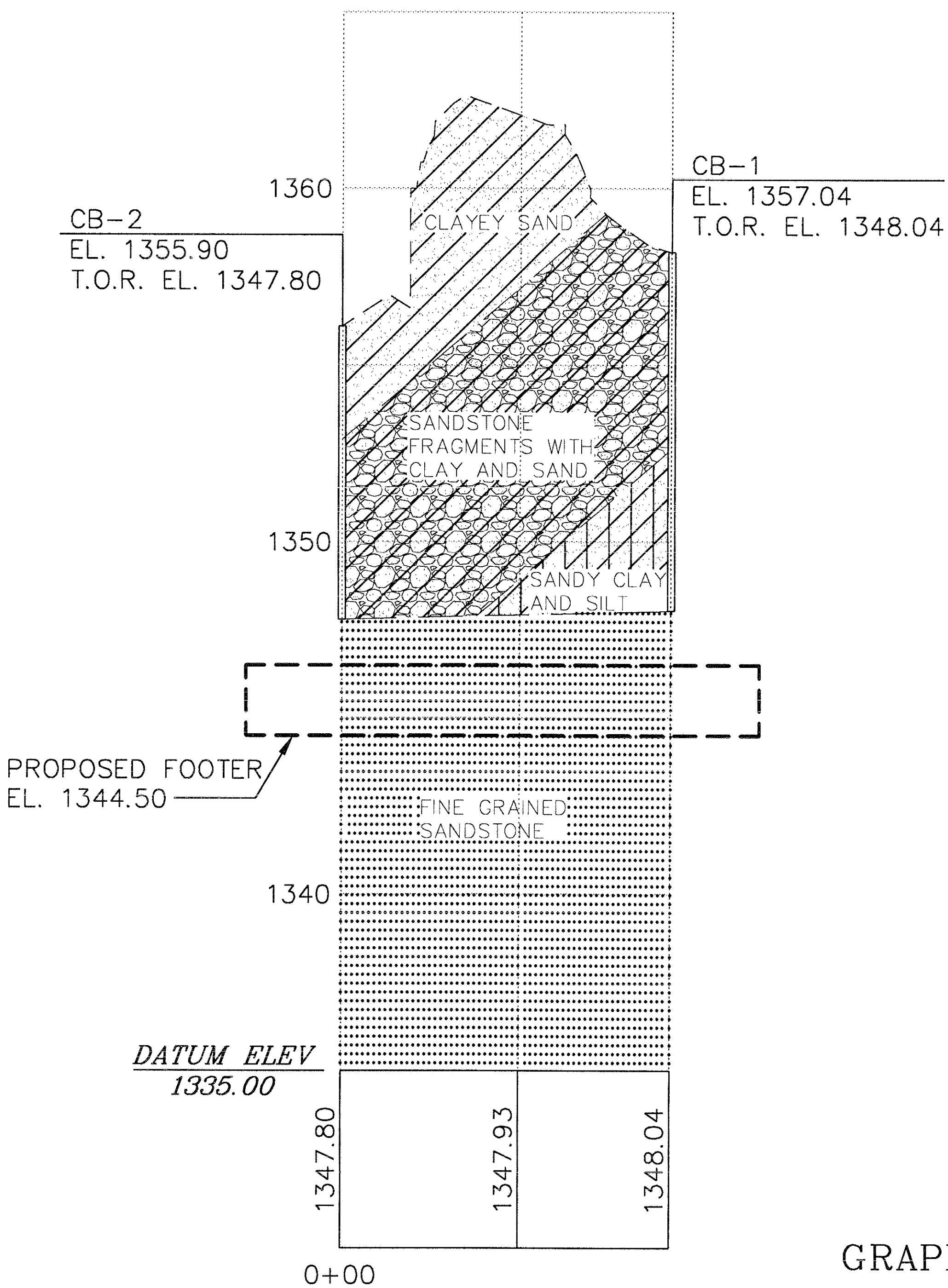
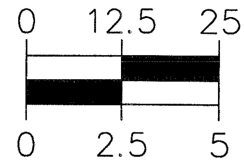
25
0
2.5
5
(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.

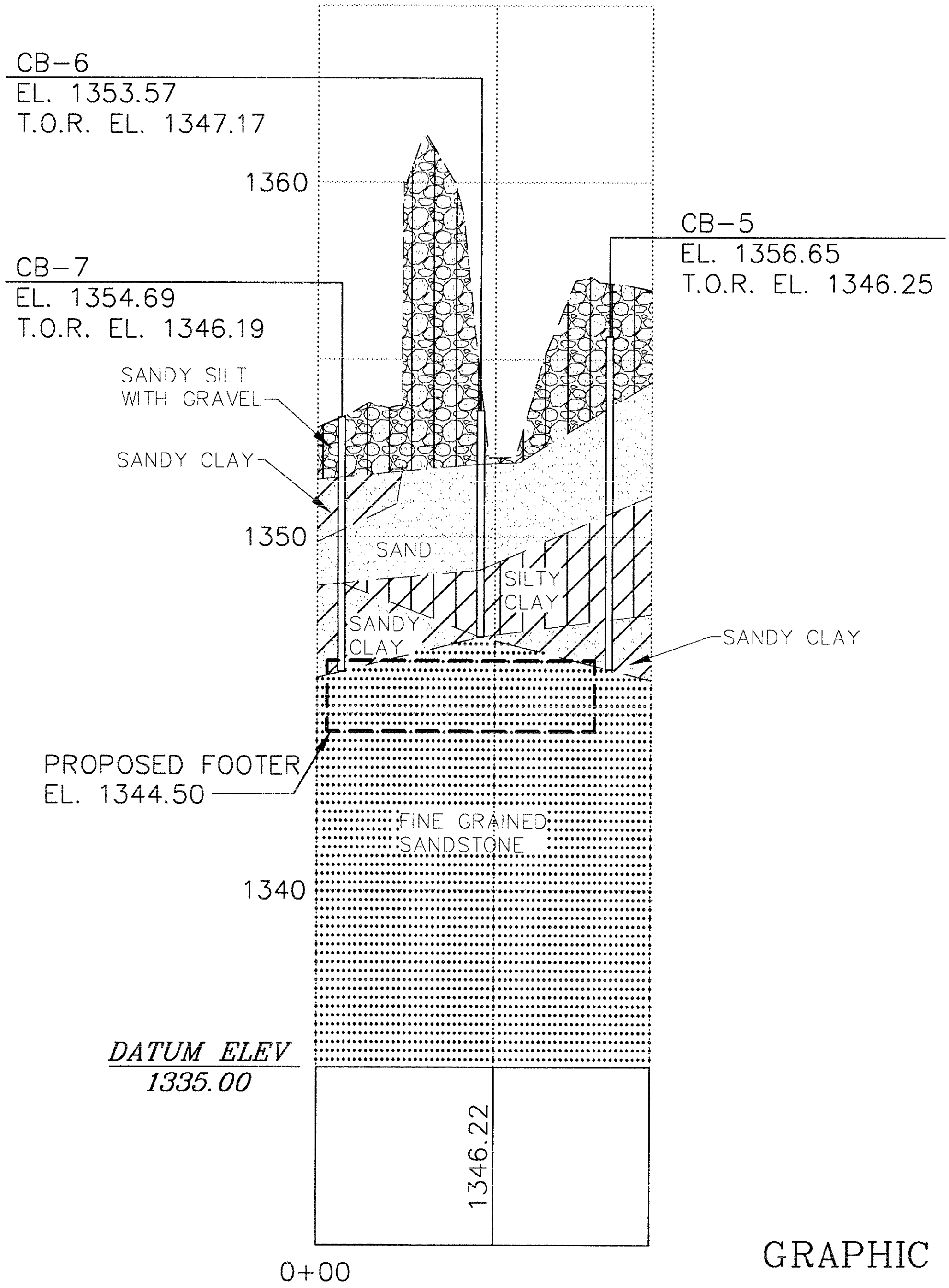


SECTION-4

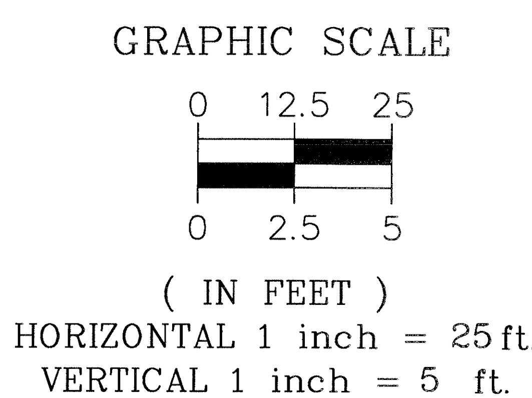
GRAPHIC SCALE

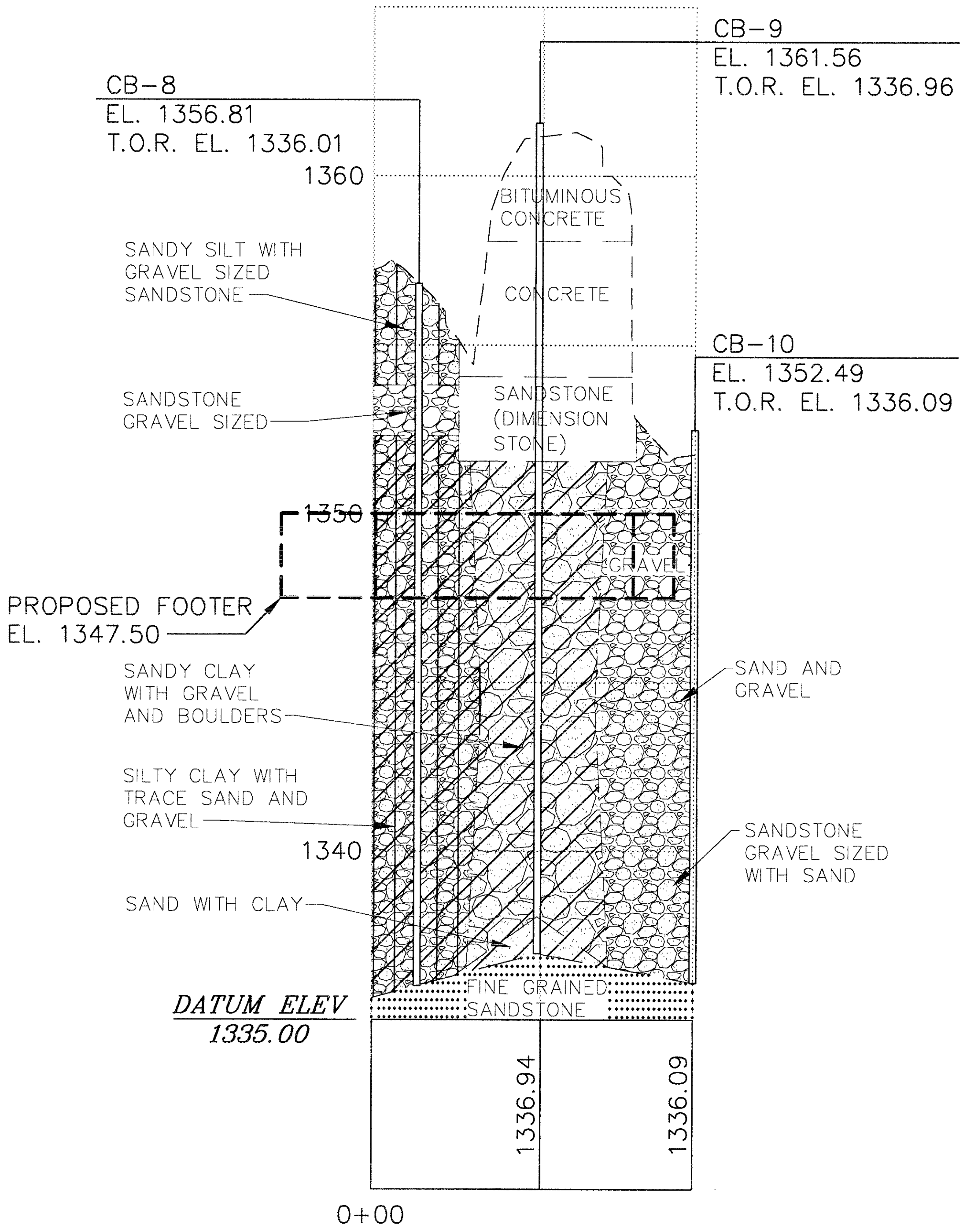


(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.


CB-6
EL. 1353.57
T.O.R. EL. 1347.17
1360
CB-5
EL. 1356.65
T.O.R. EL. 1346.25
CB-7
EL. 1354.69
T.O.R. EL. 1346.19
SANDY SILT WITH GRAVEL
SANDY CLAY
1350
SAND
SILTY CLAY
SANDY CLAY
SANDY CLAY
PROPOSED FOOTER
EL. 1344.50
FINE GRAINED SANDSTONE
1340
DATUM ELEV
1335.00
1346.22
0+00

SECTION-5


GRAPHIC SCALE
0
12.5
25
0
2.5
5
(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.



SECTION–6

GRAPHIC SCALE

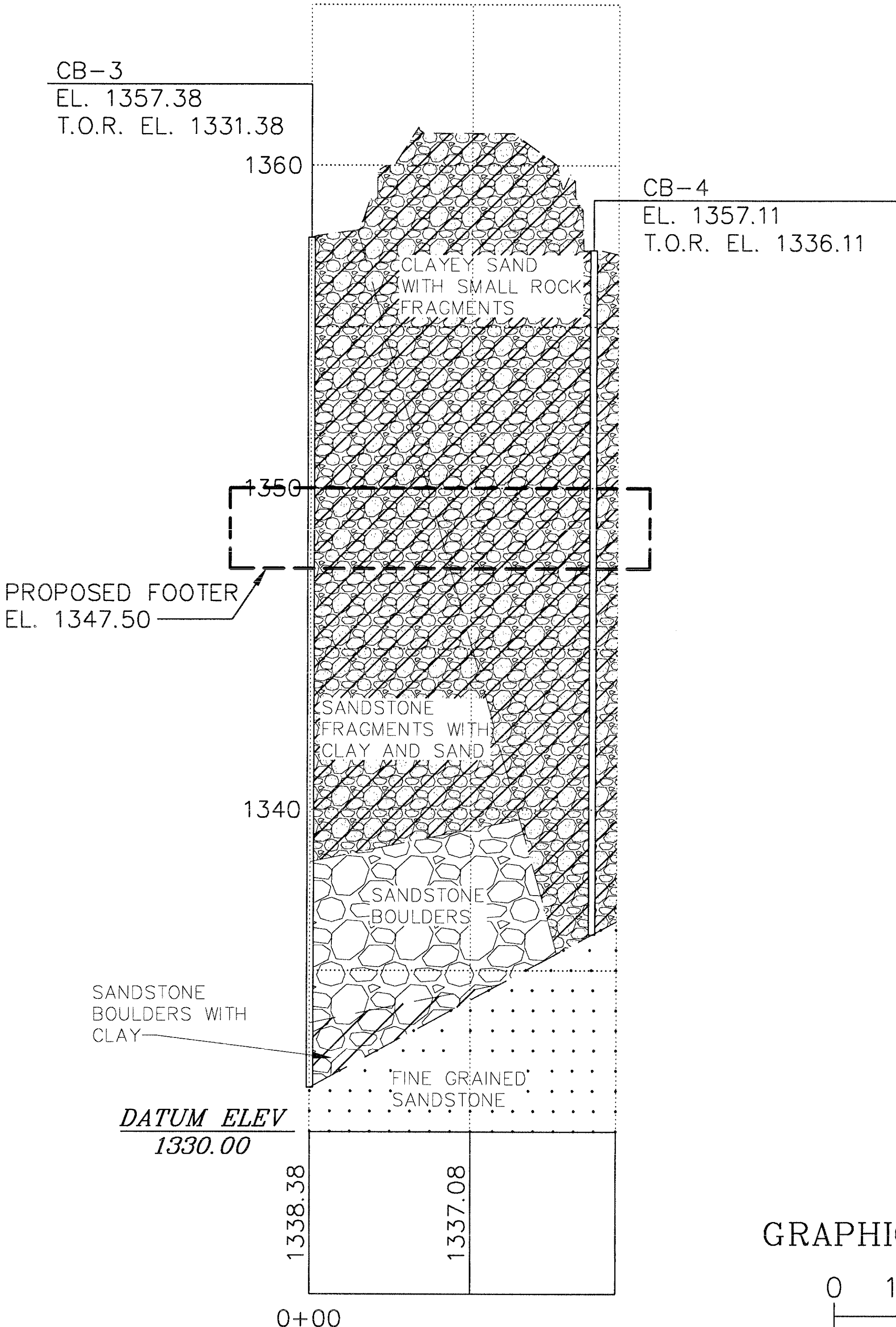
0 12.5 25

0 2.5 5

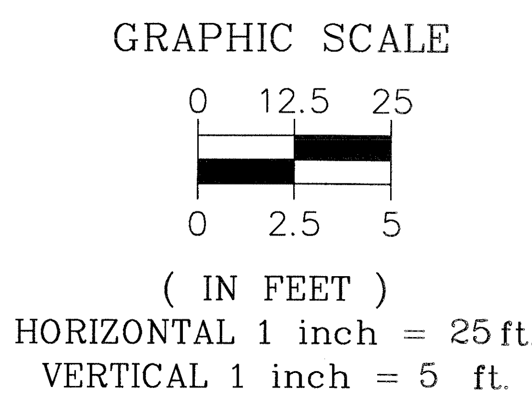
(IN FEET)

HORIZONTAL 1 inch = 25 ft.

VERTICAL 1 inch = 5 ft.


CB-3
EL. 1357.38
T.O.R. EL. 1331.38
1360
CB-4
EL. 1357.11
T.O.R. EL. 1336.11
CLAYEY SAND WITH SMALL ROCK FRAGMENTS
1350
PROPOSED FOOTER
EL. 1347.50
SANDSTONE FRAGMENTS WITH CLAY AND SAND
1340
SANDSTONE BOULDERS
SANDSTONE BOULDERS WITH CLAY
FINE GRAINED SANDSTONE
DATUM ELEV
1330.00
1338.38
1337.08
0+00

SECTION-7


GRAPHIC SCALE
0
12.5
25
0
2.5
5
(IN FEET)
HORIZONTAL 1 inch = 25 ft.
VERTICAL 1 inch = 5 ft.

Abutment 2 ON PILES

46

5.8 AWB - ABUTMENT WITHOUT BACKWALL COMMAND (Cont.)

File: jc22a2

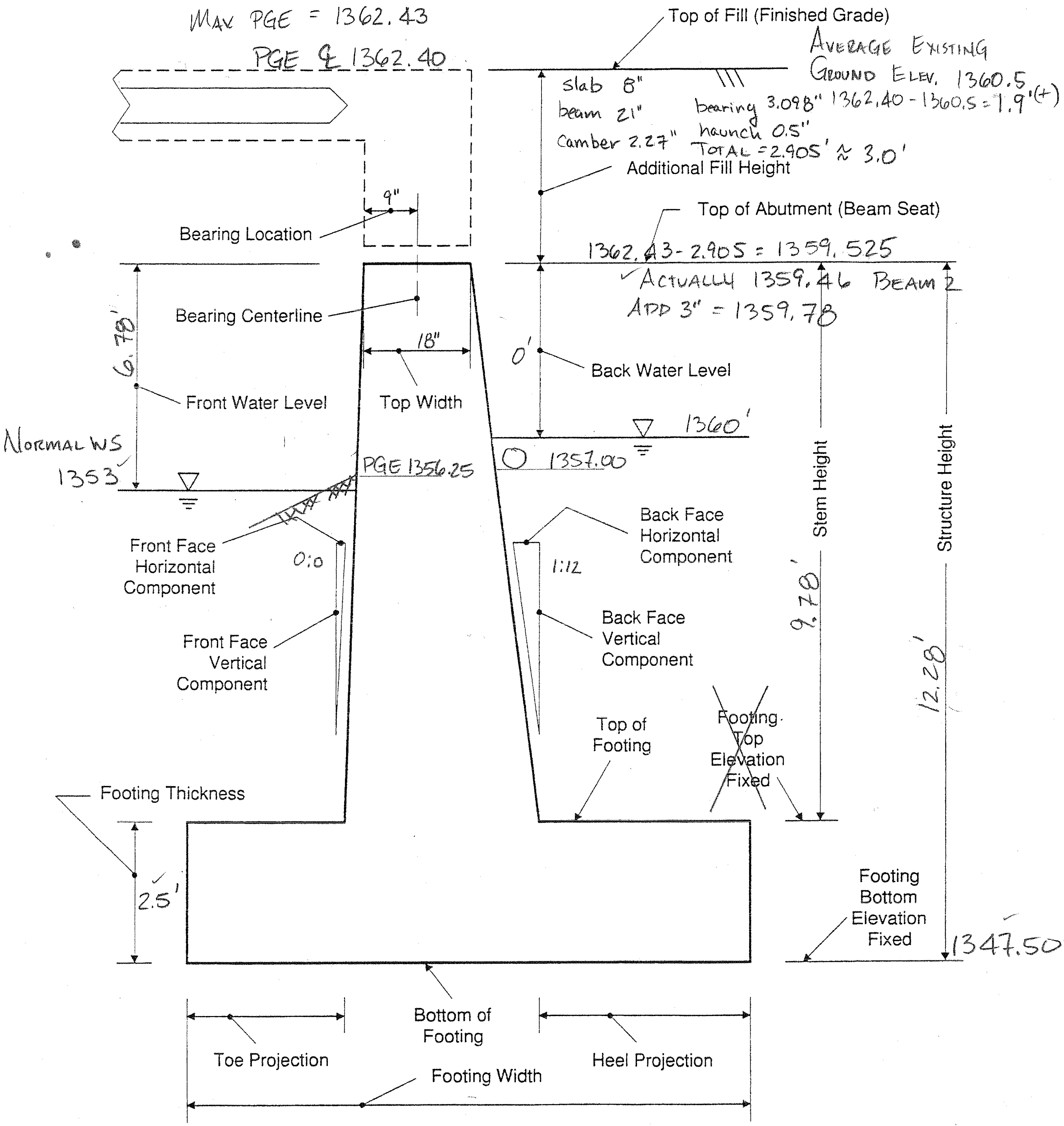
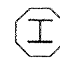


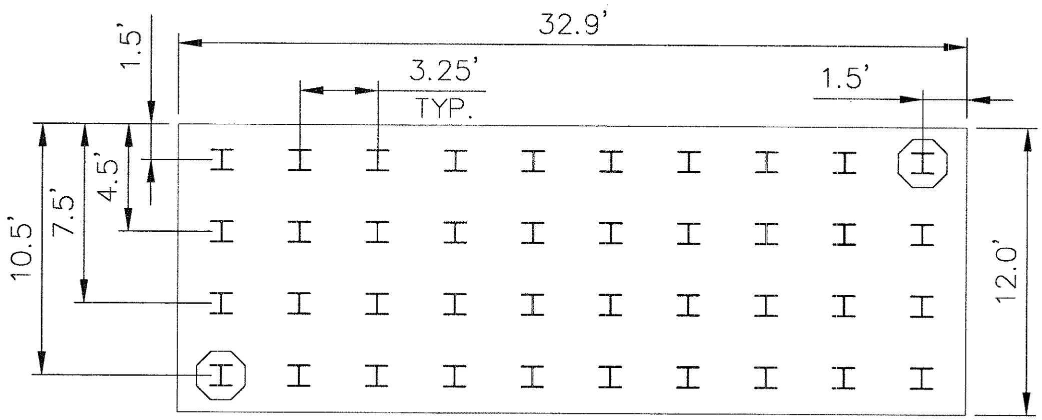
Figure 5.8-1 Abutment Without Backwall

LEGEND

VERTICAL PILE – HP 12x74



TEST PILE

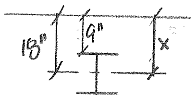


ABUTMENT 2 HP 12x74
VERTICAL PILES

SCALE: 1/8" = 1'–0"

LYD CARD

1.

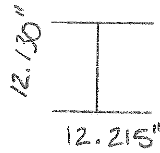


Depth = 12.13"

$X = 9 + \frac{12.13}{2} = 15.065'' < 18''$ ∴ 18"

2. Same as 1.

3. 3ft or 2(diagonal dimension)



$(12.215^2 + 12.130^2)^{1/2} = 17.215'' < 3ft$

∴ 3ft

4. 15ft

5. T

B&9 1H : 4V