Drainage

• Back to Basics 101

Prepared by: Christopher Zukowski – District IV Construction
Drainage 101

• Preconstruction
• Construction
• Finals and Follow up
Preconstruction

1) Getting started
   • Review Plans & Specifications
     a) “A” Items
     b) New items that are unfamiliar
     c) Miscellaneous Details sheets for Catchbasins
   • Look for Utility conflicts
   • Set Up Drainage books(Volume#3)
   • Field inspect all CB’s, MH’s & Pipes for damage
   • Review PC-1 for 7 day cure time
   • Review Contractors Schedule of Work
Preconstruction

• Equipment needed for drainage installations
  – OSHA approved trench box
  – Certified chains for rigging
  – Certified straps / slings
  – Ladder for trench box entry / exit
  – Jumping Jack compactor
  – Level and Rod
  – 4 foot level
Preconstruction

• Familiarize yourself with structure details
  – “Trained eye” for what you should expect to see in the field during installation
  – Review miscellaneous details for drainage structures
• Note changes which may be project specific
  – New details include Butyl Rubber Joint detail between sump and riser section
Structure details

- Full Mortar Bed
- Mortar Joint Detail
- Butyl Rubber Joint Detail
- Butyl Rubber Each Face
- Ship Lap Joint Detail
  (for use with round structures only)
Plans, Profiles & Cross Sections
Plans, Profiles & Cross Sections
Plans, Profiles & Cross Sections
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Utility Conflicts
CONSTRUCTION
Construction

• Review Contractor’s schedule
  – Typical start drainage run at lowest point or outlet
  – All drainage structures shall be staked prior installation
  – Utilize District Survey to check staking if confidence is not high
Construction

- Other methods can be utilized to check contractors accuracy
  - Field inspection of area
    - Scale distances to fixed objects
    - Utilize lock level to check grades
    - Compute change in elevation over 4 feet and check with a 4 foot level and tape measure
    - Ask contractor questions
Construction

• Ask the contractor
  – What is the invert at this structure?
  – Where is the next structure located?
  – Did you site the correct entrance into the structure?
  – What is the percent slope of the pipe?

  Is he confident in his responses?

  Changes are easier to correct at this point!
Typical start of Drainage at low end
Staking and placement of catchbasin
Construction Staking

Catch Basin offsets must be staked

* minimum of 2 offsets required per catch basin

The catch basin offsets will provide all the information necessary to set the structure

* Catch basin number and corresponding station number
* Top of frame elevation
* Distance (offset) to Edge of Road
* The 2 stakes (or other reference point i.e. PK nails) provide proper alignment
* Cut or fill distance required to Top of Frame elevation
Proper Catch Basin Staking

Pull a string line &/or tape from stake to stake extending the offset distance to determine exact catch basin location.
Catch Basin Details

- Sump
- Riser
- Corbel
- RCP – trimmed flush
- Offset to EOR
- Type ‘C’ Top
- Grate

RCP – trimmed flush
Catch Basin Details

Type ‘C’ Tops

Note – precast drop at inlet

2” typical
Catch Basin Details

All Type C Catch Basins are not created equal. Front of catch basin varies with each manufacturer. Check your basins to ensure proper installation.
Catch Basin Details

Top and bottom are parallel

Bottom is level, top slopes slightly

Bottom is level, top slopes consistently from front edge to curb
Catch basin tops set properly will match the cross slope of the roadway.

* Sump, riser, and corbel shall be set plumb
* Adjustment (shim) shall be performed under CB top.
Catch Basin Details

- Centerline of road
- Crown
- Cross slope
- Level line
- Edge of Road offset
- Top of Frame Elevation
- Typically approx 2"
- Actual grate
- Shim if needed
Catch Basin Details

Paving Details

* Screed should not have to be raised to clear a catch basin
* Rake men should remove excess Bituminous Concrete at catch basin
* Excess Bituminous Concrete can be left on shoulder to be removed later
* Rake men shall grade to drain as shown below.
Catch Basin Details

Catch basin tops set properly will match the cross slope of the roadway.
* Sump, riser, and corbel shall be set plumb
* Adjustment (shim) shall be performed under CB top.
Catch Basin Details

Paving Details
* Screed should not have to be raised to clear a catch basin
* Rake men should remove excess Bituminous Concrete at catch basin
* Excess Bituminous Concrete can be left on shoulder to be removed later
* Rake men shall grade to drain as shown below.
Structures

• Common details
  – Pervious material shall be used for backfilling
    • In no case to a depth greater than 3 feet (1 meter) below the bottom of the subbase.
    • Drainage openings may be formed in the four walls of the structure at or immediately above the bottom of the pervious backfill to convey subsurface drainage.
      – The openings shall be covered with geotextile.
Limits of Pervious

Bottom of subbase to max 3 feet

* maximum corbelling allowed (3")
Is this structure per SPEC?

Note excessive corbelling
Is this structure per SPEC?
Is this structure per SPEC?

Pipe not flush cut
Type ‘CL’ CB typical

When maximum depth exceeds 10 feet, the basin will paid as **CB over 10’ DEEP**

Discuss plan notes:
- limits of pervious backfill
- maximum corbelling allowed (3
Type ‘C’ or ‘CL’ CB (alternative)

For use where RCP would enter the structure on a corner (not permissible with a typical structure)
Manhole

Poured inverts
Concrete or Brick and mortar
Laying Pipe

• Site the next structure for proper alignment
  – RCP pipe not allowed to enter a corner of a structure – use round precast if needed
• Set up the laser
• Check the invert at first structure
• Flush cut RCP inside structures
What is wrong with this?
Laying Pipe

• Proper brick/block and mortar where pipe enters structure – 8” thick minimum
• Concrete block or brick only – NO RED BRICK
• Allow cure time prior to backfilling – if possible
• Ensure pipes are fully connected
  – Gasket installed
  – Asphalt joint
Backfilling before proper cure time
Laying Pipe

- Bedding Material
  - 4” minimum
  - 12” in rock
  - Sand or stone in wet conditions

Reinforced concrete pipe is forgiving, however Corrugated metal and ADS are not. Care must be taken to evenly backfill the pipe for proper installation.
Corrugated Metal Pipe
Corrugated Metal Pipe
Corrugated Metal Pipe
Bedding

Properly prepared bedding evenly distributes loads.
Improperly prepared bedding may result in stress concentrations.

Improperly prepared bedding.

*Figure 4-16 Transverse or circumferential cracks*
Bedding

Figure 4-17 Correlation of bedding and supporting strength for rigid pipe
Pipe Installations with Gravel Fill

Figure 2-4.4

Pipe Installations with Gravel Fill
Pipe Installations

Figure 2-4.5
Pipe Installations without Gravel Fill

- Payment Limits for Trench Excavation and Bedding Material
- LOWER VERTICAL PAYMENT LIMIT FOR TRENCH EXCAVATION AND BEDDING MATERIAL
- 4 in. IN EARTH, 12 in. MINIMUM IN ROCK
- BEDDING MATERIAL
- D = DIA. CIRCULAR PIPE & PIPE ARCH OF EQUIVALENT HORIZONTAL SPAN
- BACKFILL WITH BEDDING MATERIAL
- BACKFILL WITH BEDDING MATERIAL TO 0.1 H PRIOR TO INSTALLING PIPE
- TYPE I
- TYPE II
Setting Pipe

A transit may be used to site next structure for proper alignment

Pipe laser should be set level
Dial in percent grade

Target used to read laser

Temporary catch basin block to support pipe laser
Alternative Method to set pipe

Utilize an adjustable laser level
Dial in percent grade and the rotating beam
Projects at the correct percent slope.
Use rod and Target to check top of pipe grade at end of each length of pipe
Setting Pipe

• Without specialty tools
  – Contractor may choose to calculate the invert required at each 8 foot pipe section and check with a level and rod
  – Contractor may utilize a 4 foot level
    • More common for small runs
Finals and Follow up
Volume 3 Documentation

• All drainage must be in documented in its own Volume 3 book. (i.e. Volume 3 Book 2)
• The Volume 3 Drainage book must include a summary sheet for all items paid within the book.
• The item totals must match the SiteManager contract line item totals for each item.
### Sample of drainage summary sheet

#### PROJECT #023-116

**VOLUME III**

**BOOK II**

**DRAINAGE ITEM PAYMENT INDEX**

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**PROJECT TOTAL**

| 0.00 | 92.00 | 220.00 | 557.00 | 6.00 | 0.00 | 0.00 | 3.00 | 2.00 | 0.00 | 2.00 | 1.00 | 0.00 |

Volume III, Book II, Payment Index - Sheet 2
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(paid on DWR dated                )

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Legend

- Type "C" or "C-L" Catch Basin
- Special Type "C-L" Catch Basin
- Abandon Catch Basin
- Reset Type "C" Catch Basin
- Rein.Conc.Culvert End (Various)

Direction of Flow

Legend

- Manhole
- Convert C.B. to Manhole
- Reset Manhole
- Reset Manhole (Water)
- Reset Manhole (Sanitary)
- Rein.Conc.Pipe (Various)

Sta. ____________, ______

Trench Ex. Length = _________ ft.

Bedding Length = _________ ft.

Pipe Length = _________ ft.

Legend

- Type "C" or "C-L" Catch Basin
- Special Type "C-L" Catch Basin
- Abandon Catch Basin
- Reset Type "C" Catch Basin
- Rein.Conc.Culvert End (Various)

Legend

- Manhole
- Convert C.B. to Manhole
- Reset Manhole
- Reset Manhole (Water)
- Reset Manhole (Sanitary)
- Rein.Conc.Pipe (Various)

Legend

- Type "C" or "C-L" Catch Basin
- Special Type "C-L" Catch Basin
- Abandon Catch Basin
- Reset Type "C" Catch Basin
- Rein.Conc.Culvert End (Various)

Legend

- Manhole
- Convert C.B. to Manhole
- Reset Manhole
- Reset Manhole (Water)
- Reset Manhole (Sanitary)
- Rein.Conc.Pipe (Various)

Legend

- Type "C" or "C-L" Catch Basin
- Special Type "C-L" Catch Basin
- Abandon Catch Basin
- Reset Type "C" Catch Basin
- Rein.Conc.Culvert End (Various)

Legend

- Manhole
- Convert C.B. to Manhole
- Reset Manhole
- Reset Manhole (Water)
- Reset Manhole (Sanitary)
- Rein.Conc.Pipe (Various)
Sample

Sta. __________, ______  
_____________________

Trench Ex. L1 = _______ ft.  
Trench Ex. L2 = _______ ft.  
Trench Ex. L3 = _______ ft.

Flowline

_____ ft.  
_____ ft.  
_____ ft.

Sta. __________, ______  
_____________________

Bedding Length = _______ ft.

Pipe Length = _______ ft.

* Quantity included in Trench Excavation of Structure.
Drainage Notes and Factors

General Notes (for Trenching)

Top of trench (within cut) = existing grade
Top of trench (within fill) = 1.00 ft. above top of culvert
Bottom of trench = elevation as shown on plans
Length\_R,C.P. = Field measured length of installed R.C.P.
Length\_bedding\_mat. = Length\_R,C.P. - thickness of walls of C.B./M.H.
Length\_trench\_exc. = 2.00 ft. - Length\_bedding\_mat. - 2.00 ft.

where 2.00 ft. = width of excavation included in the computations for the C.B./M.H.
Depth of trench = top of trench - bottom of trench + 1.00 ft. (in rock)
Depth of trench = top of trench - bottom of trench (in earth)

Trench Excavation (for C.B., M.H.)

For Type "C" or "C-L" Catch Basin
\[
\text{Length C.B. Ex.} = 2.00 \text{ ft.} + 5.333 \text{ ft.}^* + 2.00 \text{ ft.} = 9.333 \text{ ft.}
\]
\[
\text{Width C.B. Ex.} = 2.00 \text{ ft.} + 4.333 \text{ ft.}^* + 2.00 \text{ ft.} = 8.333 \text{ ft.}
\]

\[
\text{Area} \text{ C.B. Ex.} = \text{Length C.B. Ex.} \times \text{Width C.B. Ex.} = 9.333 \text{ ft.} \times 8.333 \text{ ft.} = 77.57 \text{ ft}^2
\]

For Type "C-L" Catch Basin Double Grate - Type II
\[
\text{Length C.B. (Dbl.Grate) Ex.} = 2.00 \text{ ft.} + 7.875 \text{ ft.}^* + 2.00 \text{ ft.} = 11.875 \text{ ft.}
\]
\[
\text{Width 1 C.B. (Dbl.Grate) Ex.} = 1.00 \text{ ft.} + 1.25 \text{ ft.} + 1.00 \text{ ft.} = 3.25 \text{ ft.}
\]
\[
\text{Area} \text{ C.B. (Dbl.Grate) Ex.} = \text{Length C.B. (Dbl.Grate) Ex.} \times \text{Width 1 C.B. (Dbl.Grate) Ex.} = 11.875 \text{ ft.} \times 3.25 \text{ ft.} = 39.52 \text{ ft}^2
\]

For Special Type "C-L" Catch Basin
\[
\text{Length C.B. Ex.} = \text{Calculated Individually.}
\]
\[
\text{Width C.B. Ex.} = \text{Calculated Individually.}
\]

For Manhole
\[
\text{Area M.H. Ex.} = \pi \text{D}^2/4:
\]
where \( D = (2.00 \text{ ft.} + \text{M.H. Footprint Dia.})^* + 2.00 \text{ ft.} \)
\[
\pi (10.00 \text{ ft.})^2/4 = 78.54 \text{ ft}^2
\]

For Manhole (5.0' dia.)
\[
\text{Area M.H. Ex.} = \pi \text{D}^2/4:
\]
where \( D = (2.00 \text{ ft.} + \text{M.H. Footprint Dia.})^* + 2.00 \text{ ft.} \)
\[
\pi (11.00 \text{ ft.})^2/4 = 95.03 \text{ ft}^2
\]

Trench Excavation (for R.C.C.E.)

For 12" Reinforced Concrete Culvert End
\[
\text{Length} \text{ R.C.C.E. Ex.} = 1.00 \text{ ft.} + 6.031 \text{ ft.} + 1.00 \text{ ft.} = 8.031 \text{ ft.}
\]
\[
\text{Width} \text{ R.C.C.E. Ex.} = 1.00 \text{ ft.} + 1.25 \text{ ft.} + 1.00 \text{ ft.} = 3.25 \text{ ft.}
\]
\[
\text{Length} \text{ R.C.C.E. Ex.} = 1.00 \text{ ft.} + 2.00 \text{ ft.} + 1.00 \text{ ft.} = 4.00 \text{ ft.}
\]
\[
\text{Area} \text{ R.C.C.E. Ex.} = 8.031 \text{ ft.} \times 1/2 \times (3.00 \text{ ft.} + 4.00 \text{ ft.}) = 8.031 \text{ ft.} \times 3.50 \text{ ft.} = 28.11 \text{ ft}^2
\]

For 15" Reinforced Concrete Culvert End
\[
\text{Length} \text{ R.C.C.E. Ex.} = 1.00 \text{ ft.} + 6.057 \text{ ft.} + 1.00 \text{ ft.} = 8.057 \text{ ft.}
\]
\[
\text{Width 1 R.C.C.E. Ex.} = 1.00 \text{ ft.} + 1.25 \text{ ft.} + 1.00 \text{ ft.} = 3.25 \text{ ft.}
\]
\[
\text{Width 2 R.C.C.E. Ex.} = 1.00 \text{ ft.} + 2.50 \text{ ft.} + 1.00 \text{ ft.} = 4.50 \text{ ft.}
\]
\[
\text{Area} \text{ R.C.C.E. Ex.} = 8.057 \text{ ft.} \times 1/2 \times (3.25 \text{ ft.} + 4.50 \text{ ft.}) = 8.057 \text{ ft.} \times 3.88 \text{ ft.} = 31.36 \text{ ft}^2
\]

For 18" Reinforced Concrete Culvert End
\[
\text{Length} \text{ R.C.C.E. Ex.} = 1.00 \text{ ft.} + 6.083 \text{ ft.} + 1.00 \text{ ft.} = 8.083 \text{ ft.}
\]
\[
\text{Width 1 R.C.C.E. Ex.} = 1.00 \text{ ft.} + 1.50 \text{ ft.} + 1.00 \text{ ft.} = 3.50 \text{ ft.}
\]
\[
\text{Width 2 R.C.C.E. Ex.} = 1.00 \text{ ft.} + 3.00 \text{ ft.} + 1.00 \text{ ft.} = 5.00 \text{ ft.}
\]
\[
\text{Area} \text{ R.C.C.E. Ex.} = \pi \text{D}^2/4:
\]
where \( D = (2.00 \text{ ft.} + \text{M.H. Footprint Dia.})^* + 2.00 \text{ ft.} \)
\[
\pi (10.00 \text{ ft.})^2/4 = 78.54 \text{ ft}^2
\]

For 24" Reinforced Concrete Culvert End
\[
\text{Length} \text{ R.C.C.E. Ex.} = 1.00 \text{ ft.} + 6.125 \text{ ft.} + 1.00 \text{ ft.} = 8.125 \text{ ft.}
\]
\[
\text{Width 1 R.C.C.E. Ex.} = 1.00 \text{ ft.} + 2.00 \text{ ft.} + 1.00 \text{ ft.} = 4.00 \text{ ft.}
\]
\[
\text{Width 2 R.C.C.E. Ex.} = 1.00 \text{ ft.} + 4.00 \text{ ft.} + 1.00 \text{ ft.} = 6.00 \text{ ft.}
\]
\[
\text{Area} \text{ R.C.C.E. Ex.} = \pi \text{D}^2/4:
\]
where \( D = (2.00 \text{ ft.} + 7.00 \text{ ft.}^* + 2.00 \text{ ft.}) \)
\[
\pi (11.00 \text{ ft.})^2/4 = 95.03 \text{ ft}^2
\]

For 30" Reinforced Concrete Culvert End
\[
\text{Length} \text{ R.C.C.E. Ex.} = 1.00 \text{ ft.} + 6.146 \text{ ft.} + 1.00 \text{ ft.} = 8.146 \text{ ft.}
\]
\[
\text{Width 1 R.C.C.E. Ex.} = 1.00 \text{ ft.} + 2.50 \text{ ft.} + 1.00 \text{ ft.} = 4.50 \text{ ft.}
\]
\[
\text{Width 2 R.C.C.E. Ex.} = 1.00 \text{ ft.} + 5.00 \text{ ft.} + 1.00 \text{ ft.} = 7.00 \text{ ft.}
\]
\[
\text{Area} \text{ R.C.C.E. Ex.} = \pi \text{D}^2/4:
\]
where \( D = (2.00 \text{ ft.} + 7.00 \text{ ft.}^* + 2.00 \text{ ft.}) \)
\[
\pi (11.00 \text{ ft.})^2/4 = 95.03 \text{ ft}^2
\]
Drainage Notes and Factors

General Notes (for Trenching)

- Top of trench (within cut) = existing grade
- Top of trench (within fill) = 1.00 ft. above top of curb
- Bottom of trench = elevation as shown on plans
- Length LCF = Field measured length of installed R.C.P.
- Length LCM = - Length LCF - thickness of walls of C.B./M.H.
- Length Lthank = 2.00 ft. - Length Lthank = 2.00 ft.

where 2.00 ft. = width of excavation included in the computations for the C.B./M.H.

Depth of trench = top of trench - bottom of trench + 1.00 ft. (in rock)
                = top of trench - bottom of trench (in earth)

Trench Excavation (for R.C.P.)

Volume = Length Lthank X Depth LCM X Width

- for 12.00 in. R.C.P., width = 1.00 ft. + 2.00 ft. = 3.00 ft.
- for 15.00 in. R.C.P., width = 1.25 ft. + 2.00 ft. = 3.25 ft.
- for 18.00 in. R.C.P., width = 1.50 ft. + 2.00 ft. = 3.50 ft.
- for 24.00 in. R.C.P., width = 2.00 ft. + 2.00 ft. = 4.00 ft.
- for 30.00 in. R.C.P., width = 2.50 ft. + 3.00 ft. = 5.50 ft.

Bedding Material

Volume = Length Lthank X Bedding Factor (note: values are C.Y. per L.F.)

- for 12" R.C.P.,
  in earth (4" below R.C.P.): factor = 0.0640
  in rock (12" below R.C.P.): factor = 0.1390
- for 15" R.C.P.,
  in earth (4" below R.C.P.): factor = 0.0770
  in rock (12" below R.C.P.): factor = 0.1521
- for 18" R.C.P.,
  in earth (4" below R.C.P.): factor = 0.0844
  in rock (12" below R.C.P.): factor = 0.1708
- for 24" R.C.P.,
  in earth (4" below R.C.P.): factor = 0.1065
  in rock (12" below R.C.P.): factor = 0.2052
- for 30" R.C.P.,
  in earth (4" below R.C.P.): factor = 0.1180
  in rock (12" below R.C.P.): factor = 0.2207
Excel Forms

• Drainage forms can be found on the share drive, use the following link:
  – \Sdcdb60\Groups\DOTSHARE\ConstManual\Approved_Foms
Common mistakes to avoid

• Make payments for complete drainage runs only.
• Pay complete catch basins.
• Make sure all compss are reviewed, checked and signed.
Common mistakes to avoid

• If an item, such as rip rap, geotextile, or compacted granular fill is paid in other books, as well as the drainage book, make sure the represented item quantity is properly referenced in the drainage book summary sheet so all item totals match.
## Project #051-254
### Volume III
#### Book II
##### Section 2

### Drainage Item Payment Index

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<th>250mm Conc. Pipe</th>
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**Original Quantities**

| 255.68 | 111.58 | 6.00 | 0.00 | 1.00 | 0.00 | 1.00 | 12.00 | 1.00 | 0.00 | 33.31 | 4.00 | 8.00 | 26.80 | 109.00 |

**Project Total**

Volumes III, Book II, Section 2, Payment Index - Page 1

Clearly reference payments made elsewhere so item totals match SiteManager
Testing

• Ensure all precast concrete products have PC-1’s.
• Field verify cast dates
• Field inspect all precast for damage, reject if necessary look for the following:
  – Cracked or broken bells or spigots
  – Transverse of Longitudinal cracks
  – Exposed rebar
• Individual units may be rejected for any of the following conditions:
  – Units do not bear proper identification
  – Structures show evidence of honeycomb or patching in excess of 30 sq. in.
Individual units may be rejected for any of the following conditions:

• Structures have the following defects:
  – Fractures or cracks passing through the wall
  – Defects that indicate imperfect concrete mix
  – Surface defects which indicate honeycombing
  – Damaged or cracked ends which prevent making satisfactory joints
  – Damage caused by mishandling by the contractor
Samples of RCP which should be rejected.
Samples of RCP which should be rejected.
Samples of RCP which should be rejected.

Notice patching of damaged Pipe.
Project Completion

- Are all structures clean?
  - Has construction debris been removed from sumps
    - Removal of concrete block for laser installation
    - Removal of excess mortar from parging operation
Are all structures clean?
Are all structures clean?
Project Completion

• Has final pointing & parging been completed?
Pointing and Parging

08/03/2006
Parging Required
Form 816 - Supplemental

• Drainage method payment to change
  – Trench excavation, bedding, and pipe to be included in the pay item for the pipe.
  – Catch basins / manholes will include the excavation per vertical foot