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CITY OF ELK GROVE

Standards Update Transmittal

Reference Number: 2024-14
Standards: Standard Construction Specifications, Section 38
Improvement Standards, Section 9-11, 9-12, 9-24, 9-25
Standard Drawings, ST-10 & SD-23

Update:

1. Modification to Standard Construction Specifications:
   a. Section 38-9.03, was a reserved section. This section will now be titled "Plastic Pipe Deflection Testing."
2. Modifications to Improvement Standards:
   a. Section 9-11, HYDRAULICS, 9-12, CLOSED CONDUITS, 9-24, DRAINAGE IN RURAL AREAS and 9-25, STORM DRAIN SYSTEMS IN PRIVATE STREETS.
3. Modifications to Standard Drawings:
   a. Standard Drawing ST-10, TRENCH SECTIONS IN IMPROVED AREAS HORTICULTURE, LAWN, OR CULTIVATED AREAS and SD-23, PIPE CONNECTIONS
4. Deletion of Standard Drawings:
   a. Standard Drawings SD-20, DRAINAGE INLET TYPE H, SD-21.1, CORRUGATED METAL PIPE DRAINAGE INLET TYPE I (PG 1 OF 2), SD-21.2, CORRUGATED METAL PIPE DRAINAGE INLET TYPE I (PG 2 OF 2) and SD-22, CORRUGATED PIPE FITTINGS

Effect of Update:

1. Modifications are as follows:
   a. Standard Construction Specifications Section 50 added a new section, "Plastic Pipe." Section 38, "Plastic Pipe Deflection Testing" is being added to the Standard Construction Specifications to ensure the final product does not exceed the deflection limitations.
2. Modifications are as follows:
   a. Sections 9-11, 9-12, 9-24 and 9-25 are being modified due to:
      i. Metal Pipe is no longer being allowed in the City limits. Metal pipe references and specifications are deleted.
      ii. Polypropylene Dual Wall Pipe is being allowed within City limits for drainage only. Specifications were updated to allow this type of pipe.
3. Modifications are as follows:

a. Standard Drawing ST-10 was edited to show bedding under the pipe and clarify the excavation backfill areas.
b. Standard Drawing SD-23 deletes details that included metal pipe.

4. Modifications are as follows:
   a. Standard Drawings SD-20, SD-21.1, SD-21.2 and SD-22 are being deleted because metal pipe is no longer allowed within the City limits.

Request for Update Initiated By: Standard Review Committee 09/30/2023

Update Reviewed for Conformity and Consistency to Standards:

Shoaib Ahrary 4/25/2024 | 1:29 PM PDT
Shoaib Ahrary, PE, ESD Manager Date

Update to Standards Approved:

Jeffrey R. Werner 4/29/2024 | 5:53 AM PDT
Jeffrey R. Werner, PE, City Engineer Date

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9-11. HYDRAULICS

A. Hydraulic Grade Line

1. Hydraulic grade line calculations for pipe storm drain systems shall begin at the worst case existing ultimate 10-year channel or basin water surface elevation. For the design storm, the hydraulic grade line shall be a minimum one-half foot (0.5') below the elevation of all inlet grates, or curb opening flow lines and a minimum one foot (1') below the elevation of manhole cover. The hydraulic grade line must be checked for the 100-year channel or basin water surface elevation, in order to determine the extent of flooding and the 100-yr water surface elevation throughout the area served by the basin.

2. The hydraulic grade line shall be shown on the plans.

3. For open channel systems, the hydraulic grade line shall be shown for the 10-year and 100-year storm events. In adjacent unimproved areas with no current development plans, the future gutter flow line is assumed one and one-half feet (1.5') lower than the natural ground elevation, for purposes of pipe hydraulics calculations. This also applies to in-fill development, where the elevation of the hydraulic grade line is not known.

4. In order to analyze the drainage system to determine if design flows can be accommodated without causing flooding at some locations or causing flows to exit the system at locations where this is unacceptable, the Engineer of Record shall analyze the hydraulic gradient. A water surface profile calculation must be performed by the Engineer of Record for the entire system. The starting elevation for all hydraulic grade line calculations must be clearly noted on all plans and calculations. The source of this elevation must also be indicated (Master Plan, FEMA, etc.). If it is not readily available it must be calculated. If it is assumed, the basis of the assumption must be noted.

B. Friction Losses

Friction losses can be calculated two ways. These methods cannot be interchanged for design of the pipe system. One method shall be used throughout the analysis. The first method uses a conservative Manning's "n" value to account for minor losses.

1. Method 1

A water surface profile calculation must be performed by the Engineer of Record for all open channels, closed conduits and culverts.

The minimum 'n' values to be used in the Manning's formula shall conform to the following:

Precast Concrete Pipe	0.015
Corrugated Polyethylene Pipe	0.015
Polypropylene Dual Wall Pipe	0.015
Polyvinylchloride Pipe	0.015
Concrete Box Culvert (within a closed conduit system)	0.016

Concrete Cast-In-Place Pipe	0.015
Pavement Surfaces	0.016
Open Channel Fully Lined	0.018
Open Channel with Lined Bottom, Clean Sides	0.035
Earth Channel with Clean and Uniform Sides	0.060
Earth Channel with natural bottom and sides	0.080

Using Method 1 does not require the analysis of other minor losses. Pipes and culverts that are designed with inlet control shall account for losses associated with inlet control.

2. Method 2 – Minor Losses

Calculation of minor losses more accurately models the system. Energy losses from pipe friction shall be determined by the following:

$S_f = [Qn/1.486\ AR^{2/3}]^2$

Where: S_f = friction slope, ft/ft
Q= flow rate, ft^3/s
n= Manning's coefficient
A= area, ft^2
R= hydraulic radius

The head loss due to friction is determined by the formula:

Hf = SfL

Where: Hf = friction head loss, ft
L = length of outflow pipe, ft

The minimum "n" value used in Manning's formula shall conform to the following:

Precast Concrete Pipe	0.012
Corrugated Polyethylene Pipe	0.012
Polypropylene Dual Wall Pipe	0.012
Polyvinylchloride Pipe	0.012
Concrete Box Culvert (within a closed conduit system)	0.013
Concrete Cast-In-Place Pipe	0.014
Pavement Surfaces	0.016
Open Channel Fully Lined	0.018
Open Channel with Lined Bottom, Clean Sides	0.035
Earth Channel (Clean, Uniform Sides) or Natural Channel	0.060
Earth Channel with natural bottom and sides	0.080

D. Velocity Head Losses

Analysis methods must account for all minor losses.

Minor head loss is usually written as:

$H_L = K_c\ (V^2/2g)$

Where: HL is the minor head loss
Kc is the sum of minor loss coefficients

V2/2g is the velocity head

The loss coefficient and the form of the equation are different depending on the type of loss, whether flow is open channel or pressure flow, and at times, whether flow is sub-critical or supercritical. Full discussion and values of coefficients are given in several references (Chow *Open Channel Hydraulics*; Brater and King *Handbook of Hydraulics*; Rouse *Fluid Mechanics for Hydraulic Engineers*; Hendrickson *Hydraulics of Culverts*). The following are minor head loss formulas for hydraulic structures commonly found in storm drain systems and open channels.

E. Entrance Losses

Entrance losses to box culverts and pipes of various materials can be estimated by using the entrance loss coefficients listed in Table 9-3 in conjunction with the minor head loss equation, once outlet control has been established.

F. Manhole and Junction Losses

Junctions are locations where two or more pipes join together to form another pipe or channel.

Multiple pipes or channels coming together at a junction shall flow together smoothly to avoid high head losses. Items that promote turbulent flow and high losses include a large angle between the two (>60°), a large vertical difference between the two (greater than 6 inches (6") between the two inverts), and absence of a semicircular channel or benching at the bottom of the junction box in the case of pipes. Special problems arise when smaller pipes join a larger one at a junction.

1. Straight Through Manhole

   In a straight through manhole where there is no change in pipe size, the minor loss shall be calculated by:

   $$H_m = 0.05\ (V^2/2g)$$

2. Incoming Opposing Flows

   Design of opposing flows or 90 degree angles must be avoided. The head loss at a junction, H_{j1}, for two almost equal and opposing flows meeting head-on with the outlet direction perpendicular to both incoming directions is considered as the total velocity head of outgoing flow.

   $$H_{j1} = V^2/2g$$

3. Changes in Direction of Flow

   When main storm drainpipes or lateral lines meet in a junction, velocity is reduced within the chamber and specific head increases to develop the velocity needed in the outlet pipe. As a bend becomes sharper (approaching 90°), the more severe the energy loss becomes. When the outlet conduit is sized, determine the velocity and compute head loss in the chamber by the minor head loss formula in conjunction with the following:

K	Degree of Turn (In Junction)

0.19	15
0.35	30
0.47	45
0.56	60
0.64	75
0.70	90 and greater

Any degree of turn greater than 90 degrees requires the approval of the Director.

For a graphic solution to other degree of turns, refer to drawing SD-5. For culverts the Engineer of Record must determine if the culvert works with inlet or outlet control for the peak flow of the given design frequency.

Table 9-3
Entrance Loss Coefficients for Culverts (HDS 5 – latest edition) Outlet Control, Full or Partly Full Entrance Head Loss.

$H_e = k_e (V^2/2g)$

Type of *Structure and Design of Entrance*	***Coefficient k_e***
Pipe Concrete	
Projecting from fill, socket end (groove-end)	0.2
Projecting from fill, sq. cut end	0.5
Headwall or headwall and wing walls	
• Socket end of pipe (groove-end)	0.2
• Square Edge	0.5
• Rounded (radius = 1/12D)	0.2
• Mitered to conform to fill slope	0.7
• *End-section conforming to fill slope	0.5
• Beveled edges, 33.78 or 458	0.2
Bevels--Side- or slope-tapered inlet	0.2
Pipe or Pipe-Arch	0.9
Projecting from fill (no headwall)	0.5
Headwall or headwall and wing walls square-edge	0.7
Mitered to conform to fill slope, paved or unpaved slope	0.5
*End-section conforming to fill slope	0.2
Beveled edges, 33.78 or 458 bevels	0.2
Bevels--Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
Headwall parallel to embankment (no wing walls)	
• Square-edged on 3 edges	0.5
• Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
Wing walls at 308 to 758 to barrel	
• Square-edged at crown	0.4
• Crown edge rounded to radius of ½ barrel dimension, or beveled top edge.	0.2
Wing walls at 108 to 258 to barrel	
• Square-edged at crown	0.5

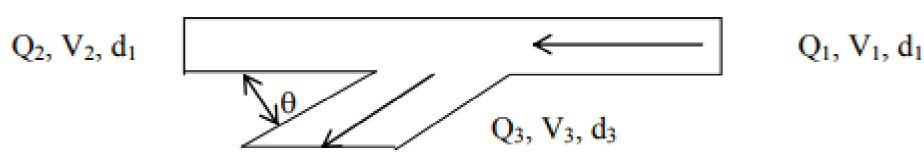
Type of *Structure and Design of Entrance*	*Coefficient k_e*
Wing walls parallel (extension of sides)	
• Square-edged at crown	0.7
• Side - or slope-tapered inlet	0.2

*Note: "End-section conforming to fill slope," made of either, concrete, Corrugated Polyethylene pipe or Polypropylene dual wall pipe are the sections commonly available from manufacturers. From limited hydraulic tests they are equivalent in operation to a headwall in both *inlet* and *outlet* control. Some end sections, incorporating a *closed* taper in their design, have a superior hydraulic performance.

HDS -5 (U.S. DOT "Hydraulic Design of Highway Culverts Series No. 5, Latest edition

The following equation may be used to determine the loss in head in cases where it may be necessary to split or branch the flow into another drain.

Figure 9-1



$$H_{br} = cV_1^2/2g$$

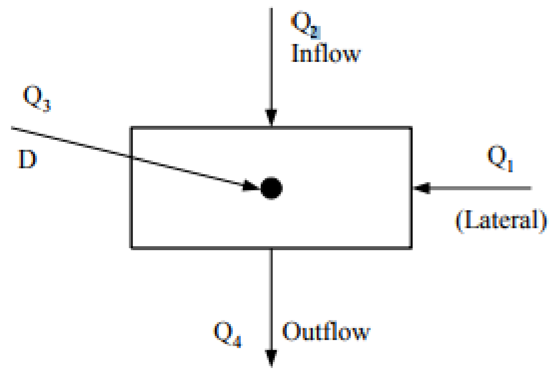
Divergence Angle - θ	$Q_3/Q_1 = 0.3$	$Q_3/Q_1 = 0.5$	$Q_3/Q_1 = 0.7$
90°	c = 0.76	0.74	0.80
60°	c = 0.59	0.54	0.52
45°	c = 0.35	0.32	0.30

4. Several Entering Flows

The computation of losses in a junction with several entering flows utilizes the principle of conservation of energy, involving both position energy (elevation of water surface) and momentum energy (mass times velocity head). Thus, for a junction with several entering flows, the energy content of the inflows is equal to the energy content of the outflows plus additional energy required by the collision and turbulence of flows passing through the junction. In addition, when two nearly equal flows enter the junction from opposing directions, head loss is considered as the total velocity head of the outgoing flow.

For example, the total junction losses at the sketched intersection are as follows (Figure 9-2):

Figure 9-2



$$Hj_2 = [(Q_4V_4^2) - (Q_1V_1^2) - (Q_2V_2^2) + (KQ_1V_1^2)] / (2gQ_4)$$

Where: Hj2 = junction losses, ft
Q = discharges, cfs
V = horizontal velocities ft/s
V3 = is assumed to be zero
K = bend loss factor

Subscript nomenclature for the equation is as follows:

Q1 = 90 ° lateral, cfs
Q2 = straight through inflow, cfs
Q3 = vertical dropped-in flow, from an inlet, cfs
Q4 = main outfall = total computed discharge, cfs
V1, V2, V3, V4 are the horizontal velocities of foregoing flows, respectively in feet per second

Also assume:

Hb = K (V12)/2g for change in direction.

No velocity head of an incoming line is greater than the velocity head of the outgoing line.

Water surface of inflow and outflow pipes in junction to be level.

When losses are computed for any junction condition for the same or a lesser number of inflows, the above equation shall be used with zero quantities for those conditions not present. If more directions or quantities are at the junction, additional terms shall be inserted with consideration given to the relative magnitudes of flow and the coefficient of velocity head for directions other than straight through.

G. Bend Loss

Bend losses shall be calculated from the following equations:

Hb = Kb (V2/2g)

In which: Kb = 0.20 (Δ/90°)0.5

Where: Δ = Central angle of bend in degrees.

Bend losses shall be included for all closed conduits, those flowing partially full as well as those flowing full.

H. Trash-Rack Head Loss

The head loss through a stationary trash-rack is commonly determined from the following equation:

HTR = KTR (V2n/2g)

KTR = 1.45 – 0.45 An/Ag – (An/Ag)2

Where: KTR = Trash-rack coefficient

An	= Net area through bars, in ft2
Ag	= Gross area of trash-rack and supports (water area without trash-rack in place), in ft2
Vn	= Average velocity through the rack openings (Q/An), in ft/sec

For design, assume that the rack is clogged, thereby reducing the value of A_n by 50%.

9-12. CLOSED CONDUITS

The specific type of pipe or alternate pipe to be used in the development shall be shown on the profile sheets. The minimum inside diameter for pipes used in the public right of way shall be no less than twelve inches (12”). No storm drain conduit shall have a diameter less than that of the conduit immediately upstream of it.

A. Material

Publicly maintained drainage systems shall be constructed of the following materials and installed consistent with the latest edition of City of Elk Grove’s Standard Construction Specifications:

1. Reinforced Concrete Pipe

   Class of pipe shall be based upon depth as detailed in the Standard Drawings. Pipe shall conform to ASTM C76, latest revision. The consultant shall specify on the plans that the assembly of joints shall be in accordance with the pipe manufacturer’s recommendations and the requirements of ASTM C443.

2. Concrete Cast-In-Place-Pipe

   a.) Where Concrete Cast-In-Place-Pipe is to be used, a soil report is required for the project that addresses placement of Concrete Cast-In-Place-Pipe.

   b.) The Engineer of Record shall provide details on the plans for connection of the concrete cast-in-place-pipe to the different piping materials being used.

3. Polyvinyl Chloride Pipe

Polyvinyl Chloride (PVC) Pipe may be used conforming to the Standard Construction Specifications. Use of polyvinyl chloride downstream of the last manhole or junction structure to outfalls to channels or detention basins is not allowed.

4. Corrugated Polyethylene Pipe

   a) Corrugated Polyethylene Pipe used for drainage shall conform to the Standard Construction Specifications.

   b) Corrugated Polyethylene Pipe shall not be used in existing or future roadways or for driveway culverts. It may only be used outside of roadways.

   c) Use of Corrugated Polyethylene Pipe downstream of the last manhole or junction structure to open channels, detention facilities or to a daylight condition is not allowed.

5. Polypropylene Dual Wall Pipe used for drainage shall conform to the Standard Construction Specifications. Use of polypropylene dual wall pipe downstream of the last manhole or junction structure to outfalls to channels or detention basins are not allowed.

B. Cover Requirements

1. The minimum cover requirement shall be per Standard Drawings SD-6.0, SD-6.1 and SD-6.2

2. The maximum height of cover shall be per Table 9-4.

C. Temporary Construction Vehicle Loading

1. A note shall be made on the plans stating the minimum cover requirements during construction for temporary heavy construction vehicle loading, such as scraper or truck haul routes.

2. For flexible pipes, place at least four feet (4') of cover over the top of the pipe.

3. For rigid pipes, place at least three feet (3') of cover over the top of the pipe.

D. Trench Requirements

1. Trenches shall be excavated with full depth and with vertical sides whenever possible.

2. The minimum trench width shall be per the Standard Construction Specifications Section 19 "Trench Excavation, Bedding and Backfill. Where conditions require side sloping of trenches, the minimum vertical trench shall be from the bottom of the trench to one foot (1') over the top of the pipe.

3. In fill areas, or in areas with poor soil conditions where it is anticipated that a good, firm, vertical-walled trench cannot be constructed, the Engineer of Record shall design the pipe structural requirements in accordance with good

engineering practice. A note shall be placed on the plans directing the contractor to place the proper strength pipe if trench conditions encountered differ from those stated in the design trench plans.

E. Spacing Requirements

When multiple adjacent pipe lines are used, they shall be spaced so that the sides of the pipes shall be no closer than two feet (2'). For parallel pipes larger than forty-eight inch (48") the spacing shall be no closer than one half (1/2) the nominal diameter. This is to permit adequate compaction of backfill material. Special bedding and backfill considerations shall be taken when depths of parallel pipes vary.

F. Alignment Requirements

1. The preferred location of storm drainage pipes in new streets shall be typically six feet (6') north or west of and parallel to the centerline of the street. In special situations, and if necessary to meet State required water separation standards, pipelines may be placed in alternative locations, including under curb and gutter, as approved by the Director.

2. All new storm drain mains shall be placed a minimum of one hundred feet (100') from existing and proposed water wells. Encroachments less than one hundred feet (100') require approval of Director and the water purveyor prior to plan approval.

3. Avoid unnecessary meandering and angular changes of pipelines. Angular changes, when necessary, shall not exceed 90 degrees unless approved by the Director. No angular changes in direction are allowed for concrete cast-in-place-pipe other than on a radius.

4. Pipeline Radius Criteria: All pipe placed on curves shall meet manufacturer's recommendations for curved alignment. All curves, radii, length of pipe joints, and types of pipe shall be shown on the plans. The minimum radius of curvature for concrete cast-in-place-pipe shall be determined by the formula $R = 30D$ where R = radius of curvature, and D = nominal internal pipe diameter, with R and D expressed in the same units.

5. Pipelines shall be laid straight in both horizontal and vertical planes between manholes unless otherwise approved by the Director.

6. Where storm drain pipelines of different diameter join, the invert elevations shall be adjusted to maintain a uniform energy gradient.

G. Velocity

1. The minimum full flow velocity shall be no less than two (2) feet per second. The maximum velocity, at maximum pipe system capacity, shall be less than the critical velocity.

2. For velocities larger than ten (10) ft/second, special provisions shall be taken to prevent pipe displacement, and/or manhole lid surcharge.

H. Pipe Inlets and Outlets

1. Headwalls, flared end section and other structures at inlets shall be designed to increase hydraulic efficiency, prevent erosion adjacent to the conduit and provide a counterweight to prevent flotation. Headwalls or flared end sections shall be used at both intake and discharge ends of culverts and pipes.

2. Standard headwalls shall be installed at pipe outlets per standard drawings of the latest edition of the Standard Construction Specifications.

3. The vertical face of the headwall shall be set back a sufficient distance from the channel side slope to accommodate flap-gates (when needed) in a fully opened position without encroachment of the flap past the channel side slope face.

4. All pipe and culvert entrance and outlet locations must be provided a concrete apron with a minimum length of five (5) pipe diameters for erosion control and maintenance purposes.

5. Pipe inlets greater than 24 inches shall have a trash rack installed. Pipe Outlets greater than 36 inches, not in an area enclosed with a fence, shall have a trash rack installed for access control.

6. Energy dissipators must be utilized at outlets at the end of the concrete apron. All energy dissipation shall be designed considering outlet velocities and hydraulic jumps. Rip-rap shall not be placed on the outlet apron. See Standard Drawings SD-26 and SD-27

I. Water and Soil Tight System

1. All storm drain pipe, manholes, and fitting connections, including drain inlet laterals shall be water and soil tight and tested in conformance with the City's Standard Construction Specifications.

2. A note shall be placed on the improvement plans stating these requirements and that the contractor is responsible for providing equipment and labor for performing tests and making measurements when directed to do so by the City's inspector.

J. Bored and Jacked Pipe

All casing pipes shall be sealed at both ends in such a manner as to provide water resistant seal.

K. Backfill Seepage

A concrete filled cutoff barrier shall be utilized at inlets and outlets where water may periodically penetrate pipe backfill material.

END OF SECTION 12

Note _ there were no edits to section 12 thru 23.

MOVE TO SECTION 24

9-24. DRAINAGE IN RURAL AREAS

Closed conduit pipelines, not open drainage ditches, shall be utilized for runoff collection and conveyance along public right-of-ways, except in rural residential areas zoned for agricultural/residential lots at least 2 acres in size. Non-roadside ditches shall use the criteria for open channels and may require private easements to be recorded for cross lot drainage.

When appropriate, open roadside ditches shall use the criteria for design of Class "C" streets and the following requirements:

A. Roadside ditches shall be sized to convey design runoff. Analysis of 100-year flows shall be considered per Section 9-1. Analysis shall include culverts. The 10-year and 100-year hydraulic grade lines shall be shown on the profile. A minimum grade of 0.3% or a minimum velocity of 1 ft/second shall be secured.

B. Roadside ditches shall use 4:1 or flatter side slopes. Roadside ditches, including slopes, shall be completely contained within the right-of way. See also Section 4 of these standards.

C. Driveway culverts shall be designed to pass the greater of the 10-year design runoff, the roadside ditch capacity, or a twelve inches (12") minimum diameter. Culverts shall be constructed out of RCP pipe. Driveway side slopes shall be 3:1 or flatter. Culverts shall be installed with either a six inch (6") thick concrete collar and headwall; or shall extend at least 1 foot beyond the driveway side slope and include a flared end section at the upstream and downstream ends.

9.25 STORM DRAIN SYSTEMS IN PRIVATE STREETS

A. Private storm drain systems that connect to City maintained drainage facilities shall have a manhole immediately upstream of the connection within the public easement or right-of-way.

B. It shall be made clear on the plans which facilities are privately owned and appropriate signage shall be erected to inform the public.

C. Private storm drain pipes serving more than two parcels shall be built per these Improvement Standards.

Table 9-4 Maximum Pipe Cover Requirements - Concrete and Plastic Pipe

Measured to bottom of trench in feet

<table>
<tr><th rowspan="3">DIA.</th><th colspan="5">RCP</th><th rowspan="3">Cast in Place</th><th rowspan="3">PVC</th><th rowspan="3">Corrugated Polyethene</th><th rowspan="3">Polypropylene Dual Wall</th></tr>
<tr><th colspan="5">Class</th></tr>
<tr><th>I</th><th>II</th><th>III</th><th>IV</th><th>V</th></tr>
<tr><td>12</td><td rowspan="12">Not Permitted</td><td>8</td><td>12</td><td>30</td><td rowspan="8">No Limit</td><td rowspan="9">No Limit</td><td>14</td><td>15</td><td>25</td></tr>
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<tr><td>72</td><td>15</td><td>18</td><td>23</td><td>33</td><td>56</td><td>21</td></tr>
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Note: Backfill based on Class 1 uniform compacted backfill.