



HIGH DENSITY POLYETHYLENE PIPE FILL HEIGHT TABLE IN ARIZONA

Final Report 621

Prepared by:

Ahmad Ardani, Jagannath Mallela, Tim Wyatt
Applied Research Associates, Inc.
505 W. University Avenue
Champaign, IL 61820

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Submitted to:

Arizona Department of Transportation
206 S. 17th Avenue
Mail Drop 075R
Phoenix, AZ 85007

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16. Abstract This report documents a review of nationwide practices with regard to recommendations for fill heights over high density polyethylene (HDPE) pipes. Another item of interest to the investigation was typical use of HDPE pipes by various agencies. The bulk of the report's information, which is related to HDPE pipe diameter, minimum and maximum fill heights, backfill materials, and other pertinent items, was gathered via telephone interviews with the concerned staff from various state highway agencies. Limited information was also obtained by contacting the industry representatives, pipe manufacturers, and reviewing documents from American Association of State Highway and Transportation Officials (AASHTO) and American Society for Testing and Materials (ASTM). All 50 state agencies were contacted for information, of which 47 responded. In addition, a survey questionnaire was developed and sent to selected personnel in five state agencies to gather more in-depth information. Based on this information, recommendations for maximum fill heights and recommended use of HDPE pipes in roadways were developed for consideration by the Arizona Department of Transportation.					
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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
<u>LENGTH</u>					<u>LENGTH</u>				
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
<u>AREA</u>					<u>AREA</u>				
in ²	square inches	645.2	square millimeters	mm ²	mm ²	Square millimeters	0.0016	square inches	in ²
ft ²	square feet	0.093	square meters	m ²	m ²	Square meters	10.764	square feet	ft ²
yd ²	square yards	0.836	square meters	m ²	m ²	Square meters	1.195	square yards	yd ²
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi ²	square miles	2.59	square kilometers	km ²	km ²	Square kilometers	0.386	square miles	mi ²
<u>VOLUME</u>					<u>VOLUME</u>				
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft ³	cubic feet	0.028	cubic meters	m ³	m ³	Cubic meters	35.315	cubic feet	ft ³
yd ³	cubic yards	0.765	cubic meters	m ³	m ³	Cubic meters	1.308	cubic yards	yd ³
NOTE: Volumes greater than 1000L shall be shown in m ³ .									
<u>MASS</u>					<u>MASS</u>				
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000lb)	0.907	megagrams (or "metric ton")	mg (or "t")	mg (or "metric ton")	megagrams (or "metric ton")	1.102	short tons (2000lb)	T
<u>TEMPERATURE (exact)</u>					<u>TEMPERATURE (exact)</u>				
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
<u>ILLUMINATION</u>					<u>ILLUMINATION</u>				
fc	foot candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m ²	cd/m ²	cd/m ²	candela/m ²	0.2919	foot-Lamberts	fl
<u>FORCE AND PRESSURE OR STRESS</u>					<u>FORCE AND PRESSURE OR STRESS</u>				
lbf	poundforce	4.45	newtons	N	N	newtons	0.225	poundforce	lbf
lbf/in ²	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	lbf/in ²

SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380

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GLOSSARY OF ACRONYMS

AASHTO	American Association of State Highway and Transportation Officials
ADOT	Arizona Department of Transportation
ADS	Advanced Drainage Systems
ADT	Average daily traffic
ALDOT	Alabama Department of Transportation
ASTM	American Society for Testing and Materials
CMP	Corrugated metal pipes
DOT	Department of Transportation
Ft	Foot or feet
HDPE	High density polyethylene
In	Inch or inches
NHS	National Highway System
PPI	Plastic Pipe Institute

EXECUTIVE SUMMARY

This report documents an investigation into the uses of high-density polyethylene (HDPE) pipes nationwide for the Arizona Department of Transportation (ADOT). Most of the report's information, which is related to HDPE pipe diameters, minimum and maximum fill heights, backfill materials, and other pertinent items, was gathered via telephone interviews with the professionals from state departments of transportation. These professionals included: roadway design, hydraulic, standards, geotechnical, and materials engineers. Limited information was also obtained by contacting the industry representatives, pipe manufacturers, and by reviewing documents from the American Association of State Highway and Transportation Officials (AASHTO) and the American Society for Testing and Materials (ASTM.).

All 50 states were surveyed, of which 47 responded. In addition, a questionnaire was sent to selected personnel in five states for more in-depth information on the use of HDPE pipes in their states. A review of the data quickly revealed that although similarities existed, every state's practice, with respect to the use of HDPE pipes, was somewhat different. The following depicts a general overview of the acquired information from the states:

- Most state highway agencies tended to use HDPE pipes as side drains and cross drains. The most prevalent diameter sizes of pipes used by transportation agencies ranged anywhere from 12 to 48 inches (in). Only a few states currently use pipes with diameters of 54-60 in. Other states are considering using pipes of these sizes due to AASHTO's recent approval of their use.
- Some agencies limit the use of HDPE pipes to side drains, approaches to entrances, storm sewers, and to outlets.
- Several agencies don't allow the use of HDPE pipes under the roadway, and some limit their use to unpaved or low volume roads with average daily traffic (ADT) of 200 to 4000 vehicles.
- Minimum heights of fill are generally in range of 1 to 3 feet (ft), with 2 ft being the most prevalent. The Advanced Drainage Systems (ADS) / Hancor, Inc. Drainage Handbook ⁽¹⁾ sets the minimum heights of fill cover for pipes 4 to 48 in to 1 ft and for pipes 54 and 60 in to 2 ft.
- Some agencies specify higher minimum fill heights for HDPE pipes during construction (1 to 2 ft more) especially for larger diameter pipes.
- Maximum fill heights are somewhat varied, ranging from a few feet to over 50 ft. The most widely used fill heights were 20 ft and 10 ft. In general, the larger diameter pipes have smaller maximum fill heights. The maximum depth of cover is highly influenced by the types of backfill materials used and their compactive effort ⁽²⁾.
- Some agencies such as the Hawaii Department of Transportation, have established comprehensive criteria for the fill heights based on the type of backfill materials and compactive effort (see chapter 2 for details). Similar criteria have been established both by ADS/Hancor Inc. (in its handbook), and the Plastic Pipe Institute (PPI).

- The backfill materials used are, for the most part, based on individual agency standards or on AASHTO specifications. They include flowfill (a mixture of fine aggregate, cement, and fly ash), cement-treated aggregate, gravel, and existing local materials.
- In all, 5 states (of the 47 states interviewed) use mandrel testing to detect deflection in the horizontal and vertical direction for smaller size pipes (pipes sizes 36 in or smaller). Generally, maximum deflections are specified at 5 percent. Pipe failure is defined as deflection in excess of 5 to 7.5 percent. Those same 5 states use video cameras and visual inspections for larger diameter pipes. The remaining states did not report a consistent policy.
- Nationally established criteria for design, backfill materials, inspection, and installation of HDPE pipes include the following standard specifications:
 - AASHTO M 294 and ASTM F 2306 for materials specifications ⁽³⁾
 - ASTM D 2321 for installation ⁽⁴⁾
 - ASHHTO Section 30 and LRFD Section 12 for design criteria ⁽⁵⁾

CHAPTER 1. INTRODUCTION

1.0 BACKGROUND

Many state departments of transportation (DOTs), including ADOT, use HDPE pipes for variety of purposes including side and cross drains under the highways, outlet pipes, storm sewers, etc. However, practices for quality control, selection of pipe sizes, installation, selection of backfill materials, and overall criteria for minimum and maximum heights of fill are somewhat varied from one state to another. Several states only allow the use of HDPE pipes as side drains or they limit their use to unpaved and low volume roads.

All pipes (both flexible and rigid) rely on the properly selected backfill materials for transfer of load into the bedding. Choice backfill materials such as flowfill (a mixture of fine aggregate, cement, and fly ash), cement-treated aggregate, or granular backfill material have been used in place of the native soil by DOTs to improve the load carrying capacity of the HDPE pipes, to reduce the likelihood of buckling, and to achieve tolerable deflections. Properly designed and installed HDPE pipes could provide an attractive alternative to the commonly used reinforced concrete or metal pipes. The positive aspects of using HDPE pipes include ease of installation and hauling, safety, and cost. Potential drawbacks include buckling and high pipe deflection if improperly used.

ADOT currently limits the fill heights of HDPE pipes to 10 ft. For locations that require fill heights in excess of 10 ft, more expensive pipes such as reinforced concrete pipes or corrugated metal pipes (CMP) are used. ADOT could benefit from the reduced cost of HDPE pipes, if the required fill heights can be increased to over 10 ft. The ultimate goal of this project is to develop recommendations for specifications related to allowable HDPE pipe diameters, backfill materials, and fill heights based on surveying existing transportation agency practices and pipe manufacturer recommendations.

1.1 PROJECT OBJECTIVES

The primary objectives of this project are two-fold:

- Acquire information on the use of HDPE pipes from the state transportation agencies and industry with respect to the pipe diameter sizes, backfill materials, minimum and maximum heights of fill, and overall usage in roadway.
- Develop recommendations on the maximum fill heights and typical usage of HDPE pipes.

CHAPTER 2. DATA COLLECTION

2.0 DATA GATHERING AND COMPILATION

Most of the data on HDPE pipes was acquired by conducting phone interviews with roadway design, standard, hydraulic, geotechnical, and materials engineers from state transportation agencies. In all, 47 of the 50 states contacted for information responded and provided information on their practices for HDPE pipes. The results of the individual phone interviews with states are summarized below.

2.1 SUMMARY OF THE COLLECTED DATA

Presented in the following paragraphs is a summary of the data gathered from interviews with concerned highway agency staff and industry representatives. For states contact information refer to Appendix B.

Alabama:

- HDPE pipes 12 to 48 in are used as storm sewer and side drains
- HDPE pipes are not allowed as cross drains under the highways.
- ALDOT currently does not have fill height limits for HDPE pipe.
- Fill materials confirm to AASHTO M 294.

Alaska:

- HDPE pipes 12 to 48 in are allowed.
- For pipes 12 to 36 in (minimum fill height =2 ft, maximum fill height =30 ft).
- For pipes 40 to 48 in (minimum fill height =2 ft, maximum fill height= 20 ft).
- Note: During construction minimum fill height is specified at 4 ft.

Arkansas:

- No standard criteria for HDPE pipes.
- Not allowed under the highways.
- One pilot project is underway to use HDPE pipe as lateral storm sewer along the highway.
- Minimum fill height is set at 2 ft before traffic is allowed and maximum fill height is 55 ft.

California:

- For pipes up to 36 in diameter (minimum fill height = 2 ft, maximum fill height = 30 ft).
- For pipes 48 to 60 in diameter (minimum fill height = 2 ft, maximum fill height = 20 ft).
- Note: For pipe sizes up to 48, standard backfill materials are used; for pipes larger than 48 in, slurry cement backfill materials are used.

Colorado:

- Only 12 to 48 in diameter HDPE pipes are allowed; looking into adding the 60 in pipes in the future.
- Minimum fill height = 1-2 ft; during construction minimum fill height = 3-4 ft; maximum fill height = 30 ft for corrugated pipes and maximum fill height = 20 ft for ribbed pipes.
- Both standard backfill and flowfill are used.

Connecticut:

- The DOT is in the process of modifying its requirement for HDPE pipes.
- Pipes sizes 12 to 48 in are allowed.
- Minimum fill = 1 ft; maximum fill 8 ft.
- At the present, HDPE pipes are not allowed under the highways.

Delaware:

- HDPE pipes 8 to 48 in are allowed.
- Minimum fill height = 1 ft for a local or a sub-division road; for higher-class roads minimum fill height = 2 ft
- Maximum fill height = not specified.
- Backfill materials are based on standard specifications and AASHTO M 294.

District of Columbia:

- HDPE pipes are not used in DC.

Florida:

- HDPE pipes 15 to 48 in are allowed.
- Minimum fill height for concrete pavements = 9 in.
- Minimum fill height for asphalt = 15 in.
- Minimum fill height for commercial unpaved road = 21 in; for non-commercial road = 15 in.
- Maximum fill height for all roads = 17 ft.

Georgia:

- HDPE pipes are not allowed as cross drains under highways; they are only allowed as side pipes.
- Pipes 12 - 36 in. are allowed
- Minimum fill height = 2 ft for side pipes and 1 ft for slopes.
- Maximum fill height = 20 ft for all pipes.

Hawaii:

- Table 1 shows the HDPE fill heights specified by the Hawaii DOT.

Table 1: Maximum & minimum heights of cover for HDPE pipes (Hawaii)

Diameter (inches)	Min Depth Live Load (feet)	Min Depth No Load (feet)	Max Depth Cl-95 (feet)	Max Depth Si-90 (feet)	Max Depth Si-95 (feet)	Max Depth Sn-90 (feet)	Max Depth Sn-95 (feet)
18	3	2	8	9	16	16	22
24	3	2	8	9	15	15	22
30	3	2	8	8	13	13	19
36	3	2	8	8	14	14	21
42	3	2	7	9	14	13	20
48	3	2	7	8	13	13	20
54	4	2	7	8	12	12	18
60	4	2	7	7	11	11	17

Notes:

1. Cl-95 denotes clay soil with 95% compaction.
2. Si-90 denotes silt soil with 90% compaction.
3. Si-95 denotes silt soil with 95% compaction.
4. Sn-90 denotes gravel soil with 90% compaction.
5. Sn-95 denotes gravel soil with 95% compaction.
6. Min = Minimum
7. Max = Maximum

Idaho:

- HDPE pipes 12 to 48 in are allowed under primary and secondary highways, but not allowed for interstate highways.
- Minimum fill height = 2 ft; maximum fill height = 15 ft.
- Standard specification for fill materials is used

Illinois:

- HDPE pipes up to 36 in are allowed.
- Minimum fill height = 1 ft; maximum fill height = 15 ft.
- Their uses are limited to culvert entrance and highways less than 3000 ADT.

Indiana:

- Tables 2 and 3 show the HDPE cover limits specified by the Indiana DOT.

Table 2: Corrugated HDPE pipes height of cover limits (Indiana)

Diameter (millimeters)	Minimum (meters)	Maximum (meters)
300	0.61	3.4
375	0.61	3.4
450	0.61	3.4
525	0.61	3.4
600	0.61	3.4
750	0.61	3.4
900	0.61	3.4

Table 3: Ribbed HDPE pipes height of cover limits (Indiana)

Diameter (millimeters)	Minimum (meters)	Maximum (meters)
450	0.61	5.5
525	0.61	6.7
600	0.61	6.4
675	0.61	7.3
750	0.61	6.7
825	0.61	7.0
900	0.61	7.6

Iowa:

- HDPE pipes 24 to 48 in are used as side drains and cross drains for highways with less than 3000 ADT.
- Minimum fill height = 1 ft; maximum fill height = 15 ft.
- Backfill materials are specified as granular.
- Mandrel testing is required for pipes up to 30 in.
- Manual inspection is required for pipes greater than 48 in.

Kansas:

- No specific criteria have been established.
- Used for entrances with low traffic volumes utilizing the manufacturer's recommendations.

Kentucky:

- HDPE pipes are not allowed for National Highway System (NHS).
- Minimum fill height = 2 ft for pipes diameter 12 to 36 in; maximum fill height = 30 ft (the first 20 ft of fill is standard materials and the top 10 ft is flowfill).
- Minimum fill height = 2 ft for pipes 42 to 48 in; maximum fill height = 10 ft.
- HDPE pipes greater than 48 in are not allowed.

Louisiana:

- HDPE pipes are used as side drain and under the highways with less than 3000 ADT.
- Pipes sizes are 12 to 48 in; minimum diameter for side drain = 18 in, for cross drain = 24 in.
- Minimum fill height = 1 ft; maximum fill height = 5 ft.
- Standard specification for fill materials is used.

Maine

- HDPE pipes 12 to 48 in are allowed; on one recent job, a 60 in pipe was used.
- Pipes are used primarily as side and outlet; however, their uses under the highways are allowed on a case-by-case basis.
- Minimum fill height = 2 ft; maximum fill height = not specified; use AASHTO specification.
- AASHTO 57 stone is specified up to 9 in over the pipe and the rest is covered by standard materials.

Massachusetts:

- HDPE pipes are allowed along the highway only, not under it.
- Pipes 6 to 36 in. are allowed.
- Minimum fill height = 4 ft.; maximum fill height is not specified.
- A mandrel is used to test for deflection; 1.5% deflection is allowed with no more than 0.5 in.

Michigan:

- HDPE pipe diameters 12 to 36 in are allowed under and along highways.
- For pipes 12 to 24 in; minimum fill height = 3 ft; maximum fill height = 16 ft.
- For pipes greater than 24 in, minimum fill height = 3 ft; maximum fill height = 10 ft.
- Fill materials conform to AASHTO A1 (well-graded gravel, includes sand and very little fines) and A3 (fine sands) backfill materials.

Minnesota:

- The use of 12 to 36 in HDPE pipes are allowed as an option to concrete reinforced pipes.
- Minimum fill height for HDPE pipes = 2 ft for local road and 3 ft for trunk highways.
- Maximum fill height for pipes 12 to 15 in = 20 ft; for pipes 18 to 36 in = 20 ft.
- Deflection testing is required using a nine-point mandrel.

Mississippi:

- The use of 12 to 36 in HDPE pipes as side drains are allowed for county and low-volume roads with less than 200 ADT.
- Minimum fill height = 1 ft; maximum fill height = 50 ft.
- Testing of 54 to 60 in diameter pipes under the highways is anticipated .
- No specification for fill materials; use whatever is available.

Missouri:

- HDPE pipes 12 to 60 in are used as side drains and cross drains for roads less than 3500 ADT.
- Fill materials conform to AASHTO M 294.
- Table 4 shows the HDPE fill heights specified by the Missouri DOT.

Table 4: Maximum & minimum heights of cover for HDPE pipes (Missouri)

Diameter (inches)	Minimum fill Heights (feet)	Maximum Fill Heights (feet)
12	1	38
15	1	39
18	1	40
24	1	40
30	1	40
36	1	38
42	2	10
48	2	9
54	2	8
60	2	8

Montana:

- HDPE pipes 18 in diameter are only allowed as an option for unpaved road approaches.
- Minimum fill height = 2 ft; maximum fill height = 10 ft.
- Presently, HDPE pipes are not allowed under the highways.
- The DOT will experiment with 36 in, 42 in, and 48 in HDPE pipes under the mainline this summer.

Nebraska:

- HDPE pipes 12-36 in are allowed along and under highways.
- Minimum fill height = 1 ft; maximum fill height = 40 ft for all pipes.
- Backfill materials are granular as specified in the specification or use AASHTO M 294.

Nevada:

- Although there are no written policies with respect to pipes diameter, or minimum and maximum height of fill, HDPE pipes are used.
- Deflection testing is performed only if they are required in special provisions.

New Jersey:

- The DOT currently is in the process of establishing criteria for the use of HDPE pipes
- HDPE pipes have been used as side drains but not under the highways

New Mexico:

- Corrugated and ribbed HDPE pipes are allowed under and along the highways.
- For corrugated pipes (12 to 60 in): minimum fill height for all pipes = 1 ft; maximum fill height = 10 ft.
- For ribbed pipes (18 to 48 in): minimum fill height = 1 ft; maximum fill height = 26 ft.

New York: Table 5 shows the minimum and maximum fill heights for smooth corrugated pipes for New York DOT.

Table 5: Structural criteria for smooth interior corrugated polyethylene pipes (New York)

Diameter (millimeters)	Minimum. Fill Height to Subgrade Surface (meters)	Maximum Allowable Height of Cover (meters)
300	0.3	4.5
375		
450		
600		
750		
900		
1050		
1200		

North Carolina:

- The DOT started using HDPE pipes 12 to 48 in as a pilot project for storm runoff.
- Minimum fill height = 1.5 ft; no specification for maximum fill height.
- HDPE pipes are not allowed under the highways.
- Planning on experimenting with HDPE within the next 2 years.

Ohio:

- HDPE pipes 12 to 60 in are used as side and cross drains.
- Minimum fill height = 2 ft; maximum fill height= 20 ft.
- Backfill materials confirms to AASHTO M 294.

Oklahoma:

- HDPE pipes are rarely used in Oklahoma due to very stringent requirements, nevertheless they allow 18 to 60 in diameter pipes for side and cross drains as long as flowfill is used as backfill material.
- Table 6 shows the HDPE fill heights specified by the Oklahoma DOT.

Table 6: Maximum & minimum heights of cover for HDPE pipes (Oklahoma)

Diameter (inches)	Minimum Fill Heights (inches)	Maximum Fill Heights (feet)
18	15	10
24	20	
30	25	
36	30	
42	35	
48	40	
54	45	
60	50	

Oregon:

- HDPE pipes 12 to 60 in are used as side and cross drains.
- Minimum fill height = 1 ft; maximum fill = 15 ft.
- The DOT is in the process of re-evaluating fill heights.
- Fill materials conform to standard specifications.

Rhode Island:

- HDPE pipes 12 to 24 in are used as side and cross drains.
- Larger diameter pipes up to 48 in are used for other applications with no live load.
- Minimum fill height = 3 ft; maximum fill height is not specified.
- Gravel is used for backfill material as specified by standard specification.
- Mandrel testing is used for deflection.

South Carolina: Table 7 shows the HDPE fill heights specified by the South Carolina DOT.

Table 7: Cover heights for corrugated HDPE pipes (South Carolina)

Diameter (inches)	Maximum Allowable Cover (feet)	Minimum Allowable Cover (feet)	Minimum Allowable During Construction (feet)
12	20	1	3
15	20	1	3
18	20	1	3
24	20	1	3
30	20	1	3
36	20	1	3
42	20	1	4
48	18	1	4
54	18	2	4
60	18	2	4

Notes:

1. Recommend minimum Class III Backfill (ASTM D2321), compacted to 95 % standard proctor density.
2. Maximum cover heights can be increased based on engineer's review and approval.
3. Backfill materials for interstate highways are AASHTO A1 and A3 materials and for other highways are AASHTO A2-4 and A2-5 materials (sand and gravel with low to moderate-plasticity silt).

South Dakota:

- HDPE pipes are not allowed under the highways.
- HDPE pipes are used as an option for approaches in gravel, county, and low-volume roads.
- Pipe diameter must be 18 in or greater.
- Minimum fill height = 1 ft; maximum fill height is not specified.

Tennessee:

- HDPE pipes 12 to 48 in are allowed as side drains and cross drains for roads less than 1000 ADT.
- Minimum fill height = 1 ft; maximum fill height = 10 ft; however, based on a study conducted, the DOT will increase the maximum fill height to 18 ft.
- Backfill materials conform to AASHTO A1 & A3 materials.

Texas:

- HDPE pipes 18 to 48 in are allowed as side drains and cross drains for roads less than 4000 ADT.
- Minimum fill = 2 ft; maximum fill = 12 ft.
- Backfill materials include type I (flowfill), type II (Cement stabilized backfill), and type III (granular backfill).

Utah:

- Pipe sizes 18 to 60 in are allowed along and under highways as Table 8 shows below:

Table 8: Maximum & minimum heights of cover for HDPE pipes (Utah)

Pipes Diameter (inches)	Minimum Fill Height (feet)	Maximum Fill Height (feet)
18	2	17
24		15
30		14
36		12
42		12
48		11
60		11

Vermont:

- HDPE pipes 12 to 48 in are allowed as side and cross drains.
- Minimum fill height = 3 ft; however, will allow minimum fill height less than 3 ft based on manufacturer's recommendation.
- The DOT would like to keep the pipe under the frost-line as much as possible.
- Maximum fill height = not specified and use manufacturer's recommendation (ADS).
- Fill material is based on standard specification.

Virginia:

- HDPE pipes 12 to 48 in are allowed as side and cross drains.
- Use AASHTO M 294 for backfill materials.
- Table 9 shows the HDPE fill heights specified by the Virginia DOT.

Table 9: Maximum & minimum heights of cover for HDPE pipes (Virginia)

Pipes Diameter (inches)	Minimum Fill Height (feet)	Maximum Fill Height (feet)
12	2	21
15		21
18		20
24		20
30		19
36		18
42		18
48		17

Washington:

- HDPE pipes are allowed both for storm and culvert applications under highways.
- Pipes sizes used are 12 to 60 in.
- Minimum fill height = 2 ft; and maximum fill height = 15 ft.
- Standard fill materials are used; occasionally cement slurry is used.

West Virginia:

- HDPE pipes 12 to 48 in are used as side drains and under unpaved roads.
- Minimum fill height = 2 ft; maximum fill height is not specified.
- Based on a recent study conducted by West Virginia University, the DOT will revise their use of HDPE pipes requirement for minimum and maximum fill heights and backfill materials.

Wisconsin:

- HDPE pipes up to 36 in diameter are allowed .
- Minimum fill height = 1 ft, and maximum fill height = 15 ft.

Wyoming:

- The use of HDPE pipes has not yet been adopted as standard..
- Minimum fill height = 2 ft, and maximum fill height = 30 ft.
- The DOT is in the process of evaluating HDPE pipes for highway application.
- HDPE pipes have been used in irrigation applications without noteworthy performance .

Hancor, Inc. Drainage Handbook:

- Pipes with diameters of 4 to 48 in installed in trafficked areas (AASHTO H-25 or H-25 loads) must have at least 1 ft of cover over the pipe’s crown, while 54 to 60 in pipes must have at least 24 in of cover ⁽¹⁾.
- Tables 10 and 11 show the HDPE fill heights specified by the Hancor Drainage Handbook.

Table 10: Minimum cover height requirements (Hancor, Inc.)

Inside diameter (inches)	Minimum cover (feet)
3	1
4	1
6	1
8	1
10	1
12	1
15	1
18	1
24	1
30	1
36	1
42	1
48	1
54	2
60	2

Table 11: Maximum cover heights, feet (Hancor, Inc)

Diameter (inches)	Class I Compacted	Class I Uncompacted	Class II 95%	Class II 90%	Class II 85%	Class III 95%	Class III 90%	Class III 85%
4	55	17	36	25	17	25	18	16
6	54	16	35	24	16	24	17	15
8	53	16	34	23	16	24	17	15
10	54	16	35	23	16	24	17	15
12	56	18	37	25	18	26	19	17
15	55	17	36	24	17	25	18	16
18	54	17	35	24	17	24	18	16
24	53	15	34	23	15	23	16	14
30	50	14	32	21	14	22	15	13
36	48	13	31	20	13	21	14	12
42	46	12	29	19	12	20	13	11
48	47	12	30	19	12	20	13	11
54	43	11	28	18	11	19	12	10
60	44	11	28	18	11	19	12	10

Notes:

1. Calculations assume no hydrostatic pressure and a density of 120 pounds per cubic foot?? (pcf) (1926 kilograms /meter) for overburden material.
2. Backfill materials and compaction levels not shown in the table may also be acceptable. Contact Hancor for further detail.
3. For projects where cover exceeds the maximum values listed above, contact Hancor for specific considerations.

PPI: Tables 12 and 13 show the HDPE fill heights specified by the PPI

Table 12: Minimum cover height requirements for corrugated polyethylene pipe (PPI)

Inside Diameter (inches)	Minimum Cover (feet)
3	1
4	1
6	1
8	1
10	1
12	1
15	1
18	1
24	1
30	1
36	1
42	1
48	1
54	1.5
60	1.5

Table 13: Maximum cover heights, feet (PPI)

Diameter (inches)	Class I Uncompacted	Class I Compacted	Class II 85%	Class II 90%	Class II 95%	Class II 100	Class III 85%	Class III 90%	Class III 95%
4	17	59	17	24	37	59	15	18	24
6	16	57	16	24	36	57	15	17	24
8	14	51	14	21	32	51	13	15	22
10	13	50	13	20	31	50	12	14	21
12	13	49	13	20	31	49	12	14	21
15	13	49	13	20	31	49	12	14	21
18	13	49	13	20	31	49	12	14	21
24	13	51	13	21	32	51	12	14	21
30	13	51	13	21	32	51	12	14	21
36	13	50	13	20	31	50	12	14	21
42	11	47	11	19	29	47	10	13	19
48	11	46	11	18	29	46	10	12	19
54	11	44	11	18	28	44	10	12	18
60	11	45	11	18	28	45	10	12	18

Notes:

1. Alternate backfill materials and compaction levels not shown in the table may also be acceptable. This is a general guideline based on Table 5. Contact manufacturer for further detail.
2. Class I: Manufactured aggregate, open graded, clean, non-plastic.
3. Class II: Coarse-grained soils, clean, non-plastic.
4. Class III: Coarse-grained soils with fines, very low plasticity.

A glance at the acquired data quickly revealed that although similarities existed in agency practices, every state's practice with respect to the use of HDPE pipes was somewhat different.

2.2 DETAILED QUESTIONNAIRE

A detailed questionnaire was developed and distributed to select agencies to further understand how their policies on HDPE pipe usage and fill heights, materials and specifications, construction specifications, and any documented performance information were developed. The agencies surveyed included: Colorado, Hawaii, Minnesota, Rhode Island, and South Carolina. Appendix A presents the questionnaire developed for this purpose.

2.3 DATA ANALYSIS

Data analysis consisted of reviewing the compiled information that was obtained via telephone interviews, literature review, and a detailed questionnaire. The acquired data was synthesized with respect to HDPE pipe diameter sizes, minimum heights of fill, maximum heights of fill, backfill materials, and construction quality control practices. An analysis of the acquired data on each individual item is presented in the following sections:

2.3.1 HDPE Pipes Diameter Sizes

The most prevalent diameter sizes of pipes used by transportation agencies ranged anywhere from 12 to 48 in. The minimum diameter sizes ranged from 8 to 24 in. Pipes with diameters 54 to 60 in are used by few states, and are currently being considered by some states since AASHTO has recently approved their use.

2.3.2 Minimum Heights of Fill

Minimum heights of fill are generally in the range of 1 to 3 ft, with 2 ft being the most prevalent. Generally, larger diameter sizes have higher minimum covers. The Hancor, Inc. Drainage Handbook ⁽¹⁾ sets the minimum heights of fill cover for pipes 4 to 48 in to 1 ft and for pipes 54 and 60 in diameter to 2 ft. PPI sets the minimum heights of fill to 1 ft for pipes that have 4 to 48 in diameters and 1.5 ft for pipes sizes 54 and 60 in. Some states specify higher minimum fill heights for HDPE pipes during construction (1 to 2 ft more) especially for larger diameter pipes.

2.3.3 Maximum Heights of Fill

States' practices with respect to maximum fill heights are somewhat varied, ranging from a few feet to over 50 ft, with 20 ft and 10 ft being the most widely used fill heights respectively. The maximum depth of cover is highly influenced by the types of backfill materials used and their compactive effort. Hawaii DOT has established comprehensive criteria for the fill heights based on the type of backfill materials and compactive effort. Similar criteria have been established by ADS/Hancor, Inc. and PPI.

Table 14 and Figure 1 represent the ranges of allowable maximum fill heights by the states that were interviewed. Over 20 percent of the 47 states (11 states) interviewed have no specified maximum fill heights.

Table 14: Established maximum fill heights, feet

	Less than 10	10	Greater than 10, and less than 15	Greater than 15, and less than 20	20	30	Greater than 30
Number of States (1)	2	6	6	3	8	2	4

(1) 47 states surveyed

In most cases, the maximum fill heights listed above are shown as average for all pipe sizes. It should be noted that some states have stringent criteria for the maximum heights of fill that takes into account the pipe’s diameter, type of backfill materials used, and compactive effort. Hancor, Inc., and the Plastic Pipe Institute have developed comprehensive tables for HDPE pipes’ maximum heights of fill, which closely follows the AASHTO specifications.

Excluding the 11 states with no specifications, nearly 74 percent (23) of the states interviewed allow maximum heights over 10 ft, 54 percent (17) over 15 ft, 45 percent (14) at or above 20 ft, and 19 percent (6) at or above 30 ft. For more details on state and industry practices on maximum fill heights, refer to Chapter 2, Section 2.1.

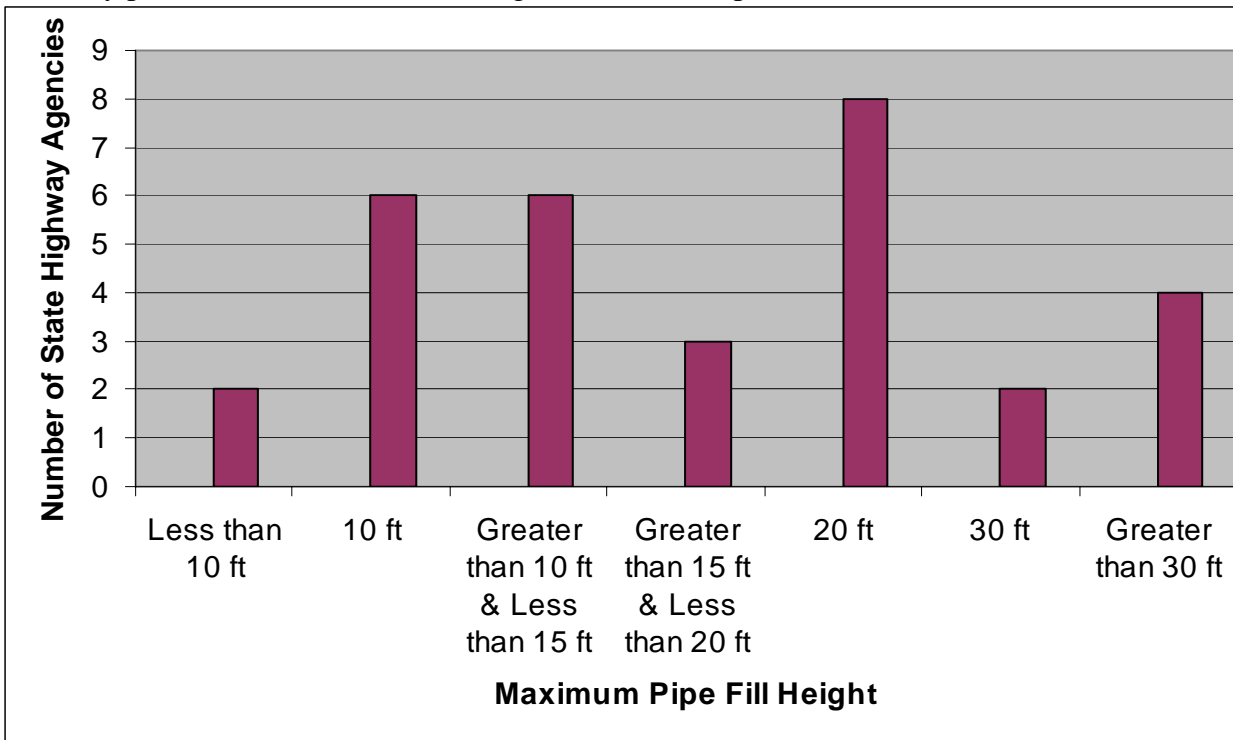


Figure1. Nationwide state-of-the-practice with regard to maximum pipe fill heights

2.3.4 Backfill Materials

Backfill materials used are for the most part based on states’ standards or AASHTO specifications and include flowfill, cement-treated aggregate, gravel, and existing local

materials. Nationally established criteria for design, backfill materials, inspection, and installation of HDPE pipes include the following documents:

- AASHTO M 294 and ASTM F 2306 for materials specifications.
- AASHTO Section 30 and ASTM D 2321 for installation.
- ASHHTO LRFD Section 12 (Bridge Design Specifications) for design criteria.

2.3.5 Quality Control Practices

Many states have established quality control criteria as standard specification for allowable deflections of their HDPE pipes; however, most do not enforce these criteria. Mandrel testing is used by 5 of the 47 states interviewed to detect deflection in the horizontal and vertical direction for smaller size pipes (36 in or smaller). Maximum allowable deflections are specified at 5 percent. Pipe failure is defined as deflection in excess of 5 - 7.5 percent. Video cameras and visual inspections are conducted for larger diameter pipes.

2.3.6 Survey Questionnaire Results

A questionnaire was developed and sent to five states that were previously interviewed via telephone. These states included Colorado, Hawaii, Minnesota, Rhode Island, and South Carolina. The goal was to acquire more in-depth information on the use of HDPE pipes in their respective states, and confirm the already provided information.

These states have been using HDPE pipes of various diameters from the early 1990s to the early 2000s. Backfill materials used including the criteria for maximum and minimum fill heights are primarily based on nationally available documents such as AASHTO specifications and ASTM standards and can be accessed using the Web. Both visual and mandrel testing is used to inspect the integrity of the pipes during and after construction. The anecdotal reports on the overall performance of these pipes ranged from marginal to very satisfactory. Newer pipes seem to have better quality.

CHAPTER 3. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

3.1 SUMMARY

This report documents an investigation into the uses of HDPE pipes nationwide for ADOT. Most of the report's information, which is related to HDPE pipe diameters, minimum and maximum fill heights, backfill materials, and other pertinent items, was gathered via telephone interviews with the professionals from state departments of transportations. These professionals included: roadway design, hydraulic, standard, geotechnical and materials engineers. Limited information was also obtained by contacting the industry representatives and pipe manufacturers, and by reviewing documents from AASHTO and the ASTM.

All 50 states were contacted for information, and of which 47 of them responded. In addition, a questionnaire was developed and sent to selected personnel in five states for more in-depth information on the use of HDPE pipes in their states. The ultimate goal of the study was to develop recommendations with respect to the maximum fill heights and overall use of HDPE pipes in roadways for ADOT.

3.2 CONCLUSIONS

Conclusions presented below are based on the data collected from state transportation agencies via telephone and a survey questionnaire:

- In general, most states use HDPE pipes as side drains and cross drains. The most prevalent sizes of pipes used by transportation agencies ranged anywhere from 12 to 48 in. Pipes with diameters 54 to 60 in have only recently been approved by AASHTO. Consequently, they are used by few states but are being considered by more states.
- Some states limit the use of HDPE pipes to side drains, approaches to entrances, storm sewer, and outlets.
- Several states don't allow the use of HDPE pipes under the roadway, and some limit their use to unpaved or low volume road with an ADT of 200 - 4000 vehicles.
- Minimum heights of fill are generally in the 1 to 3 ft range, with 2 ft being the most prevalent. The ADS / Hancor, Inc. Drainage Handbook ⁽¹⁾ sets the minimum heights of fill cover for pipes 4 to 48 in to 1 ft and for pipes 54 to 60 in to 2 ft.
- Some states specify higher minimum fill heights for HDPE pipes during construction (1 to 2 ft or more) especially for larger diameter pipes.
- Maximum fill heights are somewhat varied, ranging from a few feet to over 50 ft, with 20 ft and 10 ft being the most widely used. In general, the larger diameter pipes have shorter maximum fill heights. The maximum depth of cover is highly influenced by the types of backfill materials used and their compactive effort.
- Some states, such as Hawaii, have established comprehensive criteria for the fill heights based on the type of backfill materials and compactive effort (see Chapter 2 for details). Similar criteria have been established by ADS/Hancor, Inc. and PPI.

- Backfill materials used are for the most part based on states' standard or AASHTO specifications and include flowfill, cement treated aggregate, gravel, and existing local materials.
- Few states use mandrel testing to detect deflection in the horizontal and vertical direction for smaller size pipes (pipes sizes 36 in or smaller). Generally, maximum deflections are specified at 5 percent. Pipe failure is defined as deflection in excess of 5 to 7.5 percent. Video cameras and visual inspections are conducted for larger diameters pipes.

3.3 RECOMMENDATIONS

Recommendations listed below are strictly based on the information furnished to the research team by personnel from state transportation agencies and, to a limited extent, by the industry. Recommendations are based on the most prevalent practices as quantified by the responding state transportation agencies on HDPE pipes, which the authors view as reasonable. Recommendations are solely based on telephone surveys of individuals considered knowledgeable in the field of HDPE pipes and, therefore, are not based on engineering analysis. These recommendations include:

- State agencies' practices with regard to the use of HDPE pipes as indicated in the preceding paragraphs are varied. Most agencies allow their use in parallel systems (approaches to entrances, storm sewer, etc.) but some agencies limit their use under the highways to low volume roads. After review of the prevalent practices by agencies and review of several research studies and, based on the survey results and manufacturers data, the research team recommends the use of HDPE pipes under the highways as long as proper backfill materials are used with adequate compactive effort.
- For backfill use granular materials (Class I) for maximum stability and pipe support. Class II and Class III materials may be used. Compaction must be in accordance with ADOT specifications.
- Determine how other DOTs developed their fill height tables and whether these evaluations are applicable to ADOT.
- Perform an actual engineering analysis of pipe materials and soil materials fill heights.
- For more information related to overall of HDPE pipes including design, materials, installation, and inspection, refer to AASHTO M 294, ASTM F 2306, AASHTO Section 30, AASHTO Section 12, and ASTM D 2321.

REFERENCES

1. Advance Drainage System (ADS) / Hancor, Inc. Drainage Handbook, Chapter 2 Structures, March, 2006.
2. Plastics Pipe Institute (PPI), The Complete Corrugated Polyethylene Pipe Design Manual and Installation Guide (Chapter 5: Design Methodology), Web Document—http://drainage.plasticpipe.org/Resources.Design_Manual.asp.
3. ASTM, Standard F 2306/F 2306M – 05, Standard Specification for 12 to 60 in. [300 to 1500 mm] Pipe Fittings for Gravity-Flow Storm Sewer and Subsurface Drainage Applications, 2005.
4. Plastics Pipe Institute (PPI), The Complete Corrugated Polyethylene Pipe Design Manual and Installation Guide (Chapter 6: Installation and Construction), Web Document—http://drainage.plasticpipe.org/Resources.Design_Manual.asp.
5. ASTM, Standard D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-flow Applications, 2005.

APPENDIX A: DETAILED SURVEY QUESTIONNAIRE

**ARIZONA DOT
RECOMMENDATIONS FOR FILL HEIGHTS OVER HIGH DENSITY
POLYETHYLENE PIPES**

Policy on Using HDPE Pipes

1. Does your agency allow the use of HDPE pipes?
 - Yes (Since when and typical diameters of pipes used?)
 - No (Reasons:)
 - Do not know (are there others in the agency who would have knowledge in this area?)
 - Other _____

2. At the project level, what criteria are used to determine if HDPE pipes are an option?
 - Importance of roadway (Explain:)
 - Construction considerations (Explain:)
 - Materials considerations (Explain:)
 - Structural design considerations (Explain:)
 - Cost considerations (Explain:)
 - Dictated by policy not a project level decision
 - Other _____

Materials Design

3. Are there any restrictions on the maximum fill heights for HDPE pipes?
 - Yes (Explain)
 - No
 - Do not know (are there others in the agency who would have knowledge in this area)
 - Other _____

How do these compare with other pipe types, e.g., concrete pipes?

4. How were the maximum fill heights established (e.g., research, engineering judgment, etc.)? Do they vary by the size of the pipe or by its usage?

Links to relevant documentation: _____

Material Specifications

5. Can you point us to an electronic database, website, or hardcopy with specifications or special provisions for HDPE pipes? Can we have a copy of these specifications?
- Yes
 - No
 - Do not know (are there others in the agency who would have knowledge?)

Construction, Construction Specification, and Constructability Issues

6. What are the typical backfill materials used?
7. What test methods and/or aggregate properties are used to accept and control HDPE pipe and backfill placement?
8. Are there constructability issues related to the use of HDPE pipes compared to traditional concrete pipes and corrugated metal pipes?
- No
 - Yes (Explain (confinement, construction equipment, etc.))
 - Do not know (are there others in the agency who would have knowledge in this area)

Performance Observations

9. What is your agency's overall experience with HDPE pipe usage?
- 1. Excellent
 - 2. Very Satisfactory
 - 3. Satisfactory
 - 4. Marginal
 - 5. Poor
 - 6. Not applicable/Do not know (are there others in the agency who would have knowledge in this area)
10. Does your agency have performance data/reports/anecdotal evidence on roadway sections constructed with HDPE pipes?
- No
 - Yes (Is this information publicly available? Where?)
 - Do not know (are there others in the agency who would have knowledge in this area).

**APPENDIX B: CONTACT INFORMATION, AND RESULT OF
TELEPHONE INTERVIEWS**

Alabama: David Ramsey, ramseyd@dot.state.al.us ,

Tel: 334-242-6310

1409 Coliseum Blvd.

Montgomery, AL 36130-0001

- Alabama DOT (ALDOT) uses HDPE pipes 12 to 48 in as storm sewer and side drains.
- HDPE pipes are not allowed as cross drain under the highways.
- ALDOT currently does not have fill height limits for HDPE pipe.
- Fill materials confirms to AASHTO M 294.

Alaska: Gary Hogan

Tel: 907-465-6958

3132 Channel Drive

Juneau, AK 99801-7898

- Allow HDPE Pipes 12 to 48 in.
- Pipes 12 to 36 in (minimum fill height = 2 ft, maximum fill height = 30 ft).
- Pipes 40 to 48 in (minimum fill height = 2 ft, maximum fill height = 20 ft).
- Note: During construction minimum fill height is specified at 4 ft.

Arkansas: John Mathis

Tel: 501-569-2211

10324 Interstate 30

Little Rock, AR 72209

- No standard criteria for HDPE pipes.
- Do not allow their use under the highways.
- One pilot project is under way to use HDPE pipe as lateral storm sewer along the highway.
- Minimum fill height is set at 2 ft before traffic is allowed and maximum fill height is 55 ft.

California: Glenn Decou, glenn_s_decou@dot.ca.gov

Tel: 916-653-1302

1120 N Street, MS-49

Sacramento, CA 95814

- For pipes up to 36 in diameter (minimum fill height = 2 ft, maximum fill height = 30 ft).
- For pipes 48 to 60 in diameter (minimum fill height = 2 ft, maximum fill height = 20 ft).
- Note: for pipe sizes up to 48 in use standard backfill materials and for greater than 48 in use slurry cement backfill materials.

Colorado: Steve Johnson, steve.r.johnson@dot.state.co.us; Amanullah Mommandi, amanullah.mommandi@dot.state.co.us ,

Tel: 303-757-9364; 303-757-9083

4201 E. Arkansas Ave

Denver, CO 80222-3406

- Only allow 12 to 48 in diameter HDPE pipes; looking into adding the 60 in pipes in the future.
- Minimum fill height = 1-2 ft; during construction minimum fill height = 3-4 ft; maximum fill height = 30 ft for corrugated pipes and maximum fill height = 20 ft for ribbed pipes.
- Both standard backfill and flowfill are used.

Connecticut: Jon Hagert, jon.hagert@po.state.ct.us

Tel: 860-594-3417

2800 Berlin Turnpike

P.O. Box 317546

Newington, CT 06111

- The DOT is in the process of modifying their requirement for HDPE pipes.
- Allow pipes sizes 12 to 48 in.
- Minimum fill = 1 ft; maximum fill 8 ft.
- At the present HDPE pipes are not allowed under the highways.

Delaware: George Nagase, George.Nagase@state.de.us

Tel: 302-760-2252

800 Bay Road, Route 113

Dover, DE 19903

- Allow HDPE pipes 8 to 48 in.
- Minimum fill height = 1 ft for local road, sub-division road; for higher class road minimum fill height = 2 ft.
- Maximum fill height = not specified.
- Backfill materials are based on standard specifications and AASHTO M 294.

District of Columbia: Paul Stevenson

Tel: 202-673-6812

2000 14th Street, NW., 6th Floor

Washington, D.C. 20009-4473

- HDPE pipes are not used in DC.

Florida: Linda Seigle
 Tel: 850-414-4315
 605 Suwannee Street
 Tallahassee, FL 32399-0450

- HDPE Pipes 15 to 48 in are allowed.
- Minimum fill height for concrete pavements = 9 in.
- Minimum fill height for Asphalt = 15 in.
- Minimum fill height for commercial unpaved road = 21 in; for non-commercial road = 15 in.
- Maximum fill height for all roads = 17 ft.

Georgia: Gary Owens
 Tel: 404-656-5396
 2 Capital Square
 Atlanta, GA 30334-9003

- Do not allow HDPE pipes as cross drains under highways; only allow as side pipes.
- Allow pipe sizes 12 - 36 in diameters.
- Minimum fill height = 2 ft for side pipes and 1 ft for slopes.
- Maximum fill height =20 ft for all pipes.

Hawaii: Gary Choy, gary.choy@hawaii.gov
 Tel: 808-692-7560
 869 Punchbowl Street
 Honolulu, HI 96813-5097

Table 1: Maximum & minimum heights of cover for HDPE pipes (Hawaii)

Diameter (inches)	Min Depth Live Load (feet)	Min Depth No Load (feet)	Max Depth CI-95 (feet)	Max Depth Si-90 (feet)	Max Depth Si-95 (feet)	Max Depth Sn-90 (feet)	Max Depth Sn-95 (feet)
18	3	2	8	9	16	16	22
24	3	2	8	9	15	15	22
30	3	2	8	8	13	13	19
36	3	2	8	8	14	14	21
42	3	2	7	9	14	13	20
48	3	2	7	8	13	13	20
54	4	2	7	8	12	12	18
60	4	2	7	7	11	11	17

Notes: CI-95 denotes clay soil with 95% compaction.
 Si-90 denotes silt soil with 90% compaction.
 Si-95 denotes silt soil with 95% compaction.
 Sn-90 denotes gravel soil with 90% compaction.
 Sn-95 denotes gravel soil with 95% compaction.
 Min = Minimum
 Max = Maximum

Idaho: Lotwick Reese, lreese@itd.state.id.us

Tel: 208-334-8491

3311 West State Street

P.O. Box 7129

Boise, ID 83707

- Allow HDPE Pipes 12 to 48 in under primary and secondary highways, and do not allow for interstate highways.
- Minimum fill height = 2 ft; maximum fill = 15 ft.
- Use standard specification for fill materials.

Illinois: Mike Brand, brandmd@dot.il.gov

Tel: 217-782-3568

2300 South Dirksen Parkway

Springfield, IL 62764-0001

- Allow up to 36 in diameter HDPE pipes.
- Minimum fill height = 1 ft maximum fill height = 15 ft.
- Their uses are limited to culvert entrance and highways less than 3000 ADT.

Indiana: Dale R. Sedler, DSEDLER@indot.IN.gov

Tel: 317-232-6439

100 North Senate Ave, Room N758

Indianapolis, IN 46204-2249

Table 2: Corrugated HDPE pipes height of cover limits (Indiana)

Diameter (millimeters)	Minimum (meters)	Maximum (meters)
300	0.61	3.4
375	0.61	3.4
450	0.61	3.4
525	0.61	3.4
600	0.61	3.4
750	0.61	3.4
900	0.61	3.4

Table 3: Ribbed HDPE pipes height of cover limits (Indiana)

Diameter (millimeters)	Minimum (meters)	Maximum (meters)
450	0.61	5.5
525	0.61	6.7
600	0.61	6.4
675	0.61	7.3
750	0.61	6.7
825	0.61	7.0
900	0.61	7.6

Iowa: Dave Claman, david.claman@dot.state.ia.us

Tel: 515-239-1487

800 Lincoln Way

Ames, IA 50010-6915

- HDPE pipes 24 to 48 in are used as side drain and cross drain for highways less than 3000 ADT.
- Minimum fill height = 1 ft; maximum fill height = 15 ft.
- Backfill materials are specified as granular.
- Mandrel testing is required for pipes up to 30 in.
- Manual inspection is required for pipes greater than 48 in.

Kansas: Richard Adams / Jim Kowach, radams@ksdot.org

Tel: 785-296-3285

915 Harrison

Topeka, KS 66612-1568

- Don't have any criteria and don't use it all that much.
- Use it for entrances with low traffic and use manufacturer's recommendations.

Kentucky: Richard Thomas

Tel: 502-564-3730

501 High Street

Frankfort, KY 40622

- HDPE pipes are not allowed for National Highway System (NHS).
- Minimum fill height = 2 ft for pipes diameter 12 to 36 in; maximum fill height = 30 ft (the first 20 ft of fill is standard materials and the top 10 ft is flowfill).
- Minimum fill height = 2 ft for pipes 42 to 48 in; maximum fill height = 10 ft.
- HDPE pipes greater than 48 in are not allowed.

Louisiana: Joan Kurts

Tel: 225-379-1342

1201 Capitol Access Road

Baton Rouge, LA 70804-9245

- HDPE pipes are used as side drain and under the highways with less than 3000 ADT.
- Pipes sizes are 12 to 48 in ; Min diameter for side drain = 18", for cross drain = 24".
- Minimum fill height = 1 ft; maximum fill height = 5 ft.
- Use standard specification for fill materials.

Maine: Bob Watson, robert.watson@maine.gov

Tel: 207-624-3535

State House Section 16

Augusta, ME 04333-0016

- HDPE pipes 12 to 48 in are allowed; on one recent job 60 in pipe was used.
- Pipes are used primarily as side and outlet; however, their uses under the highways are allowed on a case-by-case basis.
- Minimum fill height = 2 ft; maximum fill height = not specified; use AASHTO specification.
- AASHTO 57 stone is specified up to 9 in over the pipe and the rest is covered by standard materials.

Massachusetts: Mike McGrath, michael.mcgrath-dpw@state.ma.us

Tel: 617-973-7521

10 Park Plaza, Room 3170

Boston, MA 02116-3973

- Only allow HDPE pipes along the highway and not under it.
- Pipe sizes used are 6 to 36 in.
- Minimum fill height = 4 ft.; maximum fill height is not specified.
- Use Mandrel to test for deflection; allow 1.5 percent deflection and no more than ½ in.

Michigan: Peter Funkhouser /Gary Croski

Tel: 517-335-2171

425 West Ottawa, P.O. Box 30050

Lansing, MI 48913

- Allow HDPE pipes diameters 12 to 36 in under and along highways.
- For pipes 12 to 24 in minimum fill height = 3 ft; maximum fill height = 16 ft.
- For pipes greater than 24 in minimum fill height = 3 ft; maximum fill height = 10 ft.
- Fill materials conforms to AASHTO A1 and A3 backfill materials.

Minnesota: Khalid Obeidat, Khalid.Obeidat@dot.state.mn.us

Tel: 651-747-2149

3485 Hadley Avenue North

Oakdale, MN 55128

- Allow the use of 12 to 36 in HDPE pipes as an option to concrete reinforced pipes.
- Minimum fill height for HDPE pipes = 2 ft for local road and 3 ft for trunk highways.
- Maximum fill height for HDPE pipes 12 to 15 in = 20 ft; for HDPE pipes 18 to 36 = 20 ft.
- Deflection testing is required using nine point mandrel.

Mississippi: Steve Reeves, sreeves@mdot.state.ms.us

Tel: 601-359-7281

401 N. West Street, Room 157

Jackson, MS 39205

- Allow the use of 12 to 36 in HDPE pipes as side drain for county road and low volume roads less than 200 ADT.
- Minimum fill height = 1 ft; maximum fill height = 50 ft.
- Planning on testing 54 to 60 in diameter pipes under the highways in the future.
- No specification for fill materials; use what ever is available.

Missouri: Dennis Heckman, Dennis.Heckman@modot.mo.gov

Tel: 573-526-3672

P.O. Box 270

105 West Capitol Ave

Jefferson City, MO 65102-0270

- HDPE pipes 12 to 60 in are used as side drain & cross drain for roads less than 3500 ADT.
- Fill materials confirms to AASHTO M 294.

Table 4: Maximum & minimum heights of cover for HDPE pipes (Missouri)

Diameter (inches)	Minimum fill Heights (feet)	Maximum Fill Heights (feet)
12	1	38
15	1	39
18	1	40
24	1	40
30	1	40
36	1	38
42	2	10
48	2	9
54	2	8
60	2	8

Montana: Mark Goodman, mgoodman@state.mt.us

Tel: 406-444-6246

2701 Prospect Ave

Helena, MT 59620-9726

- Only allow the use of 18 in HDPE pipes as an option for unpaved road approaches.
- Minimum fill height = 2 ft; maximum fill height = 10 ft.
- Presently HDPE pipes are not allowed under the highways.
- The DOT will experiment with 36 in, 42 in, and 48 in HDPE pipes under the mainline this summer.

Nebraska: Kevin Donahoo, kdonahoo@dor.state.ne.us

Tel: 402-479- 4725

1500 Nebraska Highway 2

Lincoln, NE 68509

- Allow 12 to 36 in HDPE pipes along and under highways.
- Minimum fill height = 1 ft; maximum fill height = 40 ft for all pipes.
- Backfill materials are granular as specified in the specification or use AASHTO M 294.

Nevada: Amir Soltani, asoltani@dot.state.nv.us

Tel: 775-888-7619

1263 South Stewart Street

Carson City, NV 89712-0001

- Use HDPE pipes; however there are no written policy with respect to pipes diameter, minimum and maximum height of fill.
- Deflection testing is performed only if they are required in special provisions.

New Jersey: Emerson Misner

Tel: 609-530-5514

1035 Parkway Ave, P.O. Box 600

Trenton, NJ 08625-0601

- The DOT currently is in the process of establishing criteria for the use of HDPE pipes.
- HDPE pipes have been used as side drain and not under the highways.

New Mexico: Robert J Salazar, Robert.J.Salazar@state.nm.us

Tel: 505-827-5310

PO Box 1149

1120 Cerrillos Road

Santa Fe, NM 87504

- Allow corrugated and ribbed HDPE pipes under and along the highways.
- For corrugated pipes (12 to 60 in): minimum fill height for all pipes = 1 ft; maximum fill height = 10 ft.
- For ribbed pipes (18 to 48 in): minimum fill height = 1 ft; maximum fill height = 26 ft.

New York: George Long, glong@gw.dot.state.ny.us

Tel: 518-457-9730

50 Wolf Road

Albany, NY 12232

Table 5: Structural criteria for smooth interior corrugated polyethylene pipes (New York)

Diameter (millimeters)	Minimum. Fill Height to Subgrade Surface (meters)	Maximum Allowable Height of Cover (meters)
300	0.3	4.5
375		
450		
600		
750		
900		
1050		
1200		

North Carolina: Dave Henderson, Dhenderson@dot.state.nc.us

Tel: 919-250-4100

One South Wilmington Street

Raleigh, NC 27611

- The DOT started using HDPE pipes 12 to 48 in as pilot project for storm runoff.
- Minimum fill height = 1.5 ft; no specification for maximum fill height.
- HDPE pipes are not allowed under the highways.
- Planning on experimenting with HDPE within the next 2 years.

Ohio: David Riley, david.riley@dot.state.oh.us

Tel: 614-466-2599

1980 W. Broad St.

Columbus, OH 43223

- HDPE pipes 12 to 60 in are used as side and cross drains.
- Minimum fill height = 2 ft; maximum fill height= 20 ft.
- Backfill materials confirms to AASHTO M 294.

Oklahoma: Larry Curts, lcurts@odot.org

Tel: 405-521-6759

200 N.E. 21st Street

Oklahoma City, OK 73105-3204

- HDPE pipes are rarely used in Oklahoma due to very stringent requirement, nevertheless they allow 18 to 60 in diameter pipes for side and cross drains as long as flow fill is used as backfill materials.

Table 6: Maximum & minimum heights of cover for HDPE pipes (Oklahoma)

Diameter (inches)	Minimum Fill Heights (inches)	Maximum Fill Heights (feet)
18	15	10
24	20	
30	25	
36	30	
42	35	
48	40	
54	45	
60	50	

Oregon: Dave Pooley,

Tel: 503-986-3738

355 Capitol Street, NE.

Salem, OR 97310-3871

- HDPE pipes 12 to 60 in are used as side and cross drains.
- Minimum fill height= 1 ft; maximum fill = 15 ft.
- The DOT is in the process of reevaluating fill heights.
- Fill materials confirms to standard specification.

Rhode Island: Mike Penn, mpenn@dot.ri.gov

Tel: 401-222-2023

2 Capitol Hill, Room 210

Providence, RI 02903

- HDPE pipes 12 to 24 in are used as side and cross drains.
- larger diameter pipes up to 48” are use for other application with no live load.
- Minimum fill height = 3 ft; maximum fill height is not specified.
- Gravel is used for backfill materials as specified by standard specification.
- Use mandrel testing for deflection.

South Carolina: Ed Eargle, EargleES@dot.state.sc.us

Tel: 803-737-1377

955 Park Street

Columbia, SC 29202

Table 7: Cover heights for corrugated HDPE pipes (South Carolina)

Diameter (inches)	Maximum Allowable Cover (feet)	Minimum Allowable Cover (feet)	Minimum Allowable During Construction (feet)
12	20	1	3
15	20	1	3
18	20	1	3
24	20	1	3
30	20	1	3
36	20	1	3
42	20	1	4
48	18	1	4
54	18	2	4
60	18	2	4

Notes:

1. Recommend minimum Class III Backfill (ASTM D2321), compacted to 95 % standard proctor density.
2. Maximum cover heights can be increased based on engineer's review and approval.
3. Backfill materials for interstate highways are AASHTO A1 and A3 materials and for other highways are AASHTO A2-4 and A2-5 materials (sand and gravel with low to moderate-plasticity silt).

South Dakota: Dean VanDeWeile

Tel: 605-773-3287

700 E. Broadway Ave

Pierre, SD 57501-2586

- Don't allow HDPE pipes under the highways.
- Use as option for approaches in gravel county, and low-volume roads.
- Use diameter pipes 18 in or greater.
- Minimum fill height = 1 ft; maximum fill height is not specified.

Tennessee: Ali Hangul, Ali.Hangul@state.tn.us

Tel: (615) 741-0840

700 James K. Polk Building

Fifth & Deaderick St.

Nashville, TN 37243-0349

- Allow HDPE pipes 12 to 48 in as side drain and cross drain for roads less than 1000 ADT.
- Minimum fill height = 1 ft; maximum fill height = 10 ft; however based on a study conducted, the DOT will increase the maximum fill height to 18 ft.
- Backfill materials confirm to AASHTO A1 & A3 materials.

Texas: John Delphia, JDELPHI@dot.state.tx.us

Tel: 512-416-2359

125 E. 11th St.

Austin, TX 78701-2483

- Allow HDPE pipes 18 to 48 in as side drain and cross drain for roads less than 4000 ADT.
- Minimum fill = 2 ft; maximum fill = 12 ft.
- Backfill materials include type I (flowfill), type II (Cement stabilized backfill), and type III (granular backfill).

Utah: Richard Miller, rmiller@utah.gov

Tel: 801-965-4289

4501 S. 2700 West

Salt Lake City, UT 84114-1245

- Allow pipe sizes 18 through 60 in along and under highways as follows:

Table 8: Maximum & minimum heights of cover for HDPE pipes (Utah)

Pipes Diameter (inches)	Minimum Fill Height (feet)	Maximum Fill Height (feet)
18	2	17
24		15
30		14
36		12
42		12
48		11
60		11

Vermont: Mike Tuttle, mike.tuttle@state.vt.us

Tel: 802-828-5763

Drawer 33

Montpelier, VT 056335001

- Allow HDPE pipes 12 to 48 in as side and cross drain.
- Minimum fill height = 3 ft; however, will allow minimum fill height less than 3 ft based on manufacturer's recommendation.
- The DOT would like to keep the pipe under the frost-line as much as possible.
- Maximum fill height = not specified and use manufacturer's recommendation (ADS).
- Fill material is based on standard specification.

Virginia: Roy Mills, roy.mills@viriniadot.org

Tel: 804 786-2534

1401 E. Broad St.

Richmond, VA 23219

- Allow HDPE pipes 12 to 48 in as side and cross drain.
- Use AASHTO M 294 for backfill materials.

Table 9: Maximum & minimum heights of cover for HDPE pipes (Virginia)

Pipes Diameter (inches)	Minimum Fill Height (feet)	Maximum Fill Height (feet)
12	2	21
15		21
18		20
24		20
30		19
36		18
42		18
48		17

Washington: Jay Christianson, ChristJ@wsdot.wa.gov

Tel: 360-705-7230

P.O. Box 47316, Maple Park Drive

Olympia, WA 98504-7316

- HDPE pipes are allowed for storm and as culvert application under highways.
- Pipes sizes used are 12 to 60 in.
- Minimum fill height = 2 ft; and maximum fill height = 15 ft.
- Use standard fill materials; occasionally use cement slurry.

West Virginia: Lovell Facemire

Tel: 304-558-0681

1900 Kanawha Blvd., East

Capitol Complex, Building 5, room 109

Charleston, WV 25305

- Allow HDPE pipes 12 to 48 in as side drain and under unpaved road.
- Minimum fill height = 2 ft; maximum fill height is not specified.
- Based on a recent study conducted by West Virginia University, the DOT will revised their use of HDPE pipes requirement for minimum, and maximum fill heights and backfill materials.

Wisconsin: Peter Kemp, peter.kemp@dot.state.wi.us

Tel: 608-246-7953

4802 Sheboygan Ave

Madison, WI 53702

- Allow up to 36 in diameter pipes.
- Minimum fill height = 1 ft, and maximum fill height = 15 ft.

Wyoming: Bill Wilson, bill.wilson@dot.state.wy.us

Tel: 307-777-4375

5300 Bishop Blvd.

Cheyenne, WY 82009-3340

- The use of HDPE pipes are not adopted as standard yet.
- Minimum fill height = 2 ft, and maximum fill height = 30 ft.

- The DOT is in the process of evaluating HDPE Pipes for highway application.
- Have used as irrigation pipes and the performance has not been all that good.

Hancor, Inc. Drainage Handbook:

- Pipes with diameters of 4 to 48 in installed in trafficked areas (AASHTO H-25 or H-25 loads) must have at least one ft of cover over the pipe’s crown, while 54 to 60 in pipes must have at least 24 in of cover ⁽¹⁾.

Table 10: Minimum cover height requirements (Hancor, Inc.)

Inside diameter (inches)	Minimum cover (feet)
3	1
4	1
6	1
8	1
10	1
12	1
15	1
18	1
24	1
30	1
36	1
42	1
48	1
54	2
60	2

Table 11: Maximum cover heights, feet (Hancor, Inc.)

Diameter (inches)	Class I Compacted	Class I Uncompacted	Class II 95%	Class II 90%	Class II 85%	Class III 95%	Class III 90%	Class III 85%
4	55	17	36	25	17	25	18	16
6	54	16	35	24	16	24	17	15
8	53	16	34	23	16	24	17	15
10	54	16	35	23	16	24	17	15
12	56	18	37	25	18	26	19	17
15	55	17	36	24	17	25	18	16
18	54	17	35	24	17	24	18	16
24	53	15	34	23	15	23	16	14
30	50	14	32	21	14	22	15	13
36	48	13	31	20	13	21	14	12
42	46	12	29	19	12	20	13	11
48	47	12	30	19	12	20	13	11
54	43	11	28	18	11	19	12	10
60	44	11	28	18	11	19	12	10

Notes:

1. Calculations assume no hydrostatic pressure and a density of 120 pounds per cubic foot?? (pcf) (1926 kilograms /meter) for overburden material.
2. Backfill materials and compaction levels not shown in the table may also be acceptable. Contact Hancor for further detail.
3. For projects where cover exceeds the maximum values listed above, contact Hancor for specific considerations.

PPI:

Table 12: Minimum cover height requirements for corrugated polyethylene pipe (PPI)

Inside Diameter (inches)	Minimum Cover (feet)
3	1
4	1
6	1
8	1
10	1
12	1
15	1
18	1
24	1
30	1
36	1
42	1
48	1
54	1.5
60	1.5

Table 13: Maximum cover heights, feet (PPI)

Diameter (inches)	Class I Uncompacted	Class I Compacted	Class II 85%	Class II 90%	Class II 95%	Class II 100	Class III 85%	Class III 90%	Class III 95%
4	17	59	17	24	37	59	15	18	24
6	16	57	16	24	36	57	15	17	24
8	14	51	14	21	32	51	13	15	22
10	13	50	13	20	31	50	12	14	21
12	13	49	13	20	31	49	12	14	21
15	13	49	13	20	31	49	12	14	21
18	13	49	13	20	31	49	12	14	21
24	13	51	13	21	32	51	12	14	21
30	13	51	13	21	32	51	12	14	21
36	13	50	13	20	31	50	12	14	21
42	11	47	11	19	29	47	10	13	19
48	11	46	11	18	29	46	10	12	19
54	11	44	11	18	28	44	10	12	18
60	11	45	11	18	28	45	10	12	18

Notes:

1. Alternate backfill materials and compaction levels not shown in the table may also be acceptable. This is a general guideline based on Table 5. Contact manufacturer for further detail.
2. Class I: Manufactured aggregate, open graded, clean, non-plastic.
3. Class II: Coarse-grained soils, clean, non-plastic.
4. Class III: Coarse-grained soils with fines, very low plasticity