

REFERENCE TABLES FOR COLLAPSE AND SOIL SUBSIDENCE OF ABANDONED PIPELINES

General Assumptions

- Loading condition modeled on Brent 1082 grain cart loaded with wheat¹
 - 72,000 lb (32659 kg) (320385 N) per axle
 - 4 wheels assumed per axle as indicated in specifications (load distributed evenly between four wheels on axle)
 - Each side of axle (2 adjacent wheels with negligible gap between wheels) used as live load with weight of 36,000 lb (16328 kgs) (160177 N)
 - Individual wheel width of 20.5 inches (520 mm) dual wheel width of 41 inches (1.04 m)
 - Length of contact area assumed as 55 inches (1.4 m) to create load pressure of 16 psi
- Specified pipe and soil conditions are as follows
 - Pipe Yield assumed to be 52ksi
 - “Fair” Soil Type (Internal Drainage) chosen to represent average conditions
 - Soil Compaction 90%
- Load model based on pressure load model. Not using point load model presented in Equation 10 of "Understanding the Mechanisms of Corrosion and Their Effects on Abandoned Pipelines".
- Impact Factor conservatively assumed to be 1.5 in all cases.
- Load centered between two wheels on one side of axle.
- Subsidence model based on method outlined in "Understanding the Mechanisms of Corrosion and Their Effects on Abandoned Pipelines" Section 7.0

Soil Type Assumptions

Soil Properties	Fine-grained soil (<25% sand)	Coarse-grained soil with fine particles	Coarse-grained soil with little or no fine particles
Soil dry density ² kg/m ³	1200	1280	1520
Soil modulus MPa ^{3 4} DOC < 1.5 m, (DOC > 1.5 m)	4.8 (6.9)	6.9 (9.7)	6.9 (10.4)
Bedding Factor	0.1	0.1	0.1
Deflection Lag	1.5	1.5	1.5
Soil Internal Drainage (Mass loss curve fit coefficient mm/Vyr)	Fair (k _{mi} = 0.1)	Fair (k _{mi} = 0.1)	Fair (k _{mi} = 0.1)

¹ <http://www.brentequip.com/graincarts/cornerauger/> (consulted on 9/10/2014)

² <http://web.ead.anl.gov/resrad/datacoll/soildens.htm> (consulted on 9/10/2014)

³ DOC - Depth of Cover

⁴ Hartley and Duncan, CEPA - Development of a Pipeline Surface Loading Screening Process & Assessment of Surface Load Dispersing Methods, Table 2-3

Time to Collapse (years) for three soil types (Imperial Units)

Time to Collapse (years) for Grain Cart (72,000 lb/axle) on Fine-grained soil (i.e., predominately clay)																		
	Pipe Diameter (inches)																	
	20			24			30			36			42			48		
	Wall Thickness (inches)																	
Depth of Cover	0.2500	0.3125	0.3750	0.3125	0.3750	0.4375	0.3750	0.4688	0.5625	0.4375	0.5313	0.6250	0.5000	0.6250	0.7500	0.5625	0.6875	0.8125
24 inches	1040	2310	4090	1740	3310	5390	2300	5150	9130	2940	6090	10400	3660	8510	15400	4460	9710	17000
36 inches	1460	2920	4890	2390	4190	6500	3240	6520	10900	4230	7890	12700	5330	11000	18600	6570	12700	20900
48 inches	2020	3690	5880	3230	5290	7850	4000	7580	12300	5270	9300	14500	6710	12900	21100	8310	15100	23900
63 inches	2440	4260	6590	3890	6120	8860	5440	9520	14700	6710	11200	16800	8590	15500	24400	10700	18300	27900

Time to Collapse for Grain Cart (72,000 lb/axle) on Coarse-grained soil with fine particles (i.e., silty – some fine particles)																		
	Pipe Diameter (inches)																	
	20			24			30			36			42			48		
	Wall Thickness (inches)																	
Depth of Cover	0.2500	0.3125	0.3750	0.3125	0.3750	0.4375	0.3750	0.4688	0.5625	0.4375	0.5313	0.6250	0.5000	0.6250	0.7500	0.5625	0.6875	0.8125
24 inches	1270	2660	4550	2100	3810	6030	2840	5940	10200	3680	7130	11700	4610	9930	17300	5670	11500	19300
36 inches	1680	3230	5290	2720	4630	7040	3740	7220	11800	4900	8810	13800	6230	12200	20300	7720	14300	22900
48 inches	2200	3940	6190	3510	5650	8290	4440	8190	13100	5890	10100	15500	7520	14000	22600	9350	16500	25700
63 inches	2580	4450	6810	4090	6380	9160	5740	9920	15200	7160	11800	17500	9200	16300	25400	11500	19300	29200

Time to Collapse for Grain Cart (72,000 lb/axle) on Coarse-grained soil with little or no fine particles (i.e., predominately sandy)																		
	Pipe Diameter (inches)																	
	20			24			30			36			42			48		
	Wall Thickness (inches)																	
Depth of Cover	0.2500	0.3125	0.3750	0.3125	0.3750	0.4375	0.3750	0.4688	0.5625	0.4375	0.5313	0.6250	0.5000	0.6250	0.7500	0.5625	0.6875	0.8125
24 inches	1260	2640	4520	2080	3780	5980	2790	5880	10100	3630	7060	11600	4560	9850	17200	5590	11300	19100
36 inches	1650	3190	5230	2680	4580	6980	3670	7120	11700	4820	8700	13700	6120	12100	20100	7560	14100	22600
48 inches	2150	3880	6110	3440	5560	8180	4340	8040	12900	5730	9910	15200	7330	13800	22200	9100	16200	25200
63 inches	2550	4410	6770	4050	6330	9110	5690	9860	15100	7080	11700	17400	9080	16100	25200	11400	19100	28900

Time to Collapse (years) for three soil types (Metric Units)

Time to Collapse (years) for Grain Cart (32,700 kg/axle) on Fine-grained soil (i.e., predominately clay)																		
	Pipe Diameter (mm)																	
	508			610			762			914			1067			1219		
	Wall Thickness (mm)																	
Depth of Cover	6.350	7.938	9.525	7.938	9.525	11.11	9.525	11.91	14.29	11.11	13.50	15.88	12.70	15.88	19.05	14.29	17.46	20.64
0.610 m	1040	2310	4090	1740	3310	5390	2300	5150	9130	2940	6090	10400	3660	8510	15400	4460	9710	17000
0.914 m	1460	2920	4890	2390	4190	6500	3240	6520	10900	4230	7890	12700	5330	11000	18600	6570	12700	20900
1.22 m	2020	3690	5880	3230	5290	7850	4000	7580	12300	5270	9300	14500	6710	12900	21100	8310	15100	23900
1.60 m	2440	4260	6590	3890	6120	8860	5440	9520	14700	6710	11200	16800	8590	15500	24400	10700	18300	27900

Time to Collapse for Grain Cart (32,700 kg/axle) on Coarse-grained soil with fine particles (i.e., silty – some fine particles)																		
	Pipe Diameter (mm)																	
	508			610			762			914			1067			1219		
	Wall Thickness (mm)																	
Depth of Cover	6.350	7.938	9.525	7.938	9.525	11.11	9.525	11.91	14.29	11.11	13.50	15.88	12.70	15.88	19.05	14.29	17.46	20.64
0.610 m	1270	2660	4550	2100	3810	6030	2840	5940	10200	3680	7130	11700	4610	9930	17300	5670	11500	19300
0.914 m	1680	3230	5290	2720	4630	7040	3740	7220	11800	4900	8810	13800	6230	12200	20300	7720	14300	22900
1.22 m	2200	3940	6190	3510	5650	8290	4440	8190	13100	5890	10100	15500	7520	14000	22600	9350	16500	25700
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Time to Collapse for Grain Cart (32,700 kg/axle) on Coarse-grained soil with little or no fine particles (i.e., predominately sandy)																		
	Pipe Diameter (mm)																	
	508			610			762			914			1067			1219		
	Wall Thickness (mm)																	
Depth of Cover	6.350	7.938	9.525	7.938	9.525	11.11	9.525	11.91	14.29	11.11	13.50	15.88	12.70	15.88	19.05	14.29	17.46	20.64
0.610 m	1260	2640	4520	2080	3780	5980	2790	5880	10100	3630	7060	11600	4560	9850	17200	5590	11300	19100
0.914 m	1650	3190	5230	2680	4580	6980	3670	7120	11700	4820	8700	13700	6120	12100	20100	7560	14100	22600
1.22 m	2150	3880	6110	3440	5560	8180	4340	8040	12900	5730	9910	15200	7330	13800	22200	9100	16200	25200
1.60 m	2550	4410	6770	4050	6330	9110	5690	9860	15100	7080	11700	17400	9080	16100	25200	11400	19100	28900

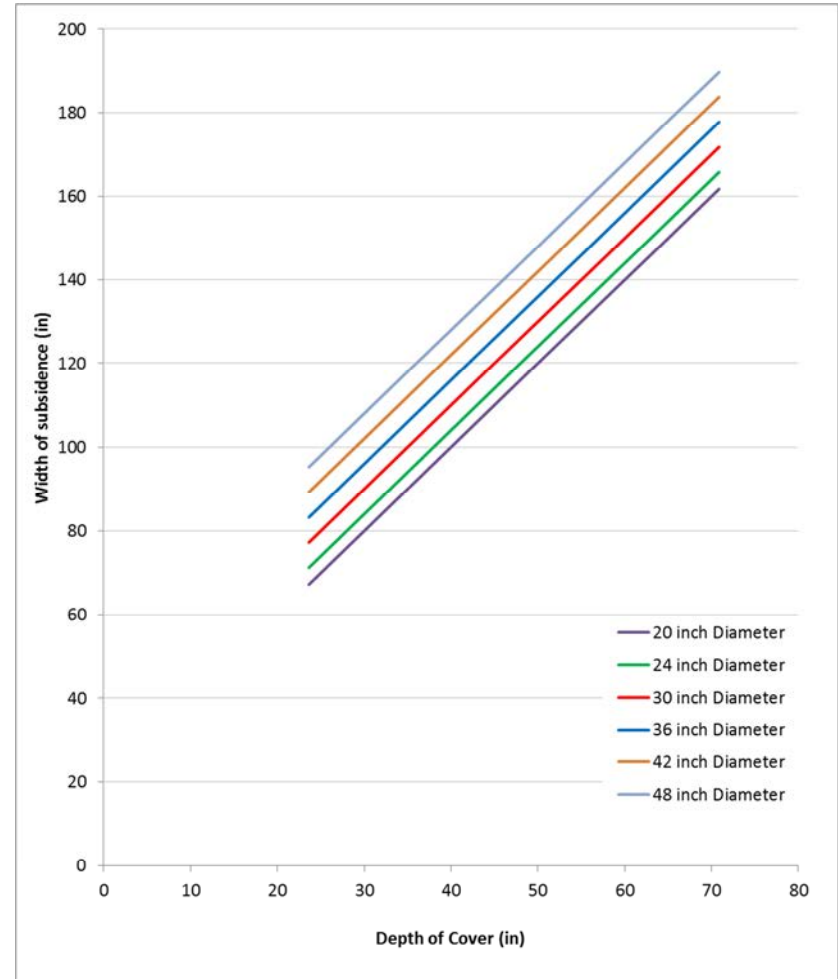
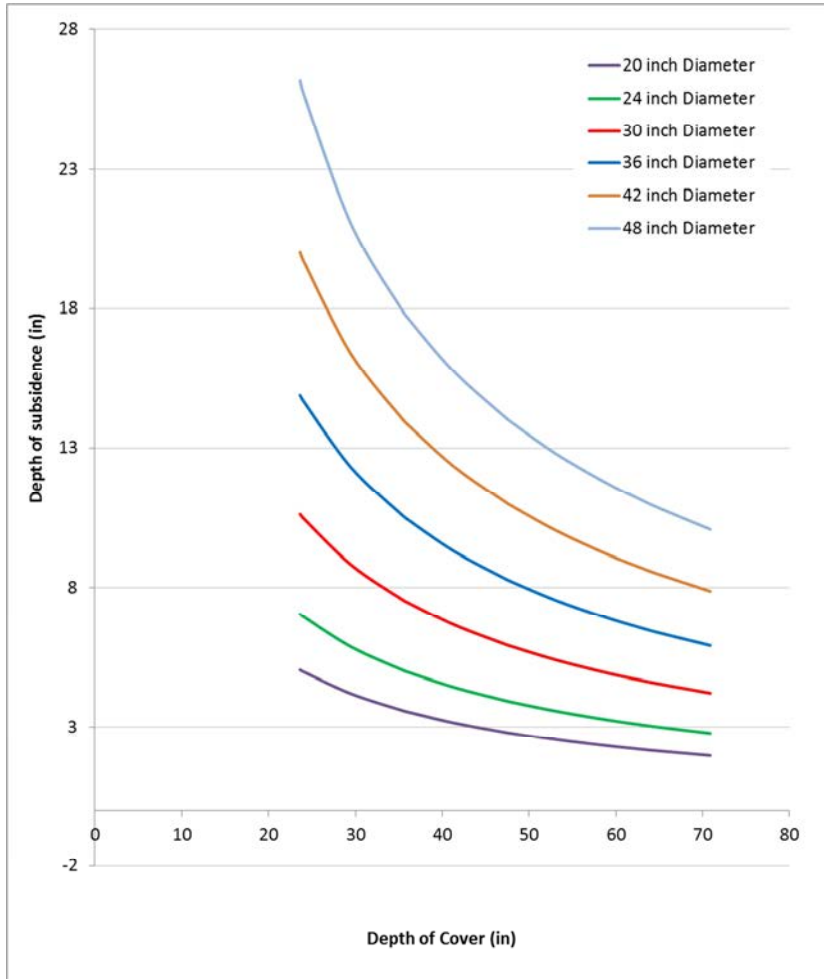
Subsidence in the Event of Failure (Depth & Width) (Imperial Units)

Subsidence (inches)						
Depth						
Width						
Depth of Cover	Nominal Pipe Diameter					
	20 inches	24 inches	30 inches	36 inches	42 inches	48 inches
24 inches	4.99	6.96	10.5	14.7	19.7	25.8
	68.0	72.0	78.0	84.0	90.0	96.0
36 inches	3.55	4.97	7.48	10.4	13.8	17.7
	92.0	96.0	102	108	114	120
48 inches	2.77	3.90	5.88	8.22	10.9	13.9
	116	120	126	132	138	144
63 inches	2.18	3.08	4.67	6.55	8.70	11.1
	146	150	156	162	168	174

Subsidence in the Event of Failure (Depth & Width) (Metric Units)

Subsidence (cm)						
Depth						
Width						
Depth of Cover	Pipe Diameter					
	508 mm	610 mm	762 mm	914 mm	1067 mm	1219 mm
0.610 m	12.7	17.7	26.6	37.2	50.1	65.4
	173	183	198	213	229	244
0.914 m	9.03	12.6	19.0	26.5	35.2	44.9
	234	244	259	274	290	305
1.22 m	7.04	9.90	14.9	20.9	27.7	35.3
	295	305	320	335	351	366
1.60 m	5.55	7.83	11.9	16.6	22.1	28.2
	371	381	396	411	427	442

Subsidence (Depth & Width) (Imperial Units)



Subsidence (Depth & Width) (Metric Units)

