Table 6-1. Relative Risk Assessment Tool Probability Index Failure Categories and Variables

Third Party Damage Depth of Cover (cover zone, casings) Activity Level (One-call reports, other utilities) Patrol Frequency and Effectiveness One-Call Effectiveness Public Education Activities Aboveground Exposures Right-of-Way Condition
Corrosion Atmospheric Corrosion Internal Corrosion Buried Pipe Corrosion Cathodic Protection Buried Coating Interferences Mechanical Corrosion Internal Line Inspection
Design Pipe Strength System Safety Factor Fatigue Potential Surge Potential Integrity Tests Earth Movements
Incorrect Operations Construction/Design Training Procedures Maps and Records Overpressure Potential Safety Systems Maintenance Communications Mechanical Error Preventors Risk Assessment

Table 6-2. One-Call Data on the Longhorn Pipeline from August 1, 1998 to April 1, 1999

County	Beginning Station (ft)	End Station (ft)	Feet of Pipeline in County	Total Calls	Cleared Calls	Dispatched Calls	Percent Calls Dispatched	Calls per 10 Feet of Pipeline	Code (2)
Austin	337659	489702	161023	77	31	46	60	0.0048	Medium
Bastrop	632229	810379	180150	255	53	202	79	0.0142	High
Bell	0	0	0	1	1	0	0	(1)	None
Blanco	1010656	1148496	131740	4	0	4	100	0.0003	Low
Brazoria	0	0	0	1	0	1	100	(1)	None
Brazos	0	0	0	5	1	4	80	(1)	None
Crane	2395852	2542522	113980	54	4	50	93	0.0047	Medium
Crockett	1934341	2071221	136880	0	0	0	0	0.0000	Low
Culberson	2952749	3225275	272529	0	0	0	0	0.0000	Low
Ector	0	0	0	2	0	2	100	(1)	None
El Paso	3578518	3666496	88603	0	0	0	0	0.0000	Low
Fayette	489702	632229	123127	18	5	13	72	0.0015	Medium
Galveston	0	0	0	3	3	0	0	(1)	None
Gillespie	1148496	1272896	124400	13	2	11	85	0.0010	Medium
Harris	0	265235	265039	10690	3853	6837	64	0.4033	High
Hays	957388	1010656	59368	46	8	38	83	0.0077	Medium
Hockley	0	0	0	1	0	1	100	(1)	None
Houston	0	0	0	1	0	1	100	(1)	None
Howard	0	0	0	1	1	0	0	(1)	None
Hudspeth	3225275	3578518	352615	0	0	0	0	0.0000	Low
Hunt	0	0	0	1	1	0	0	(1)	None
Kimble	1448456	1631959	183503	8	0	8	100	0.0004	Low
Lee	0	0	10400	4	0	4	100	0.0038	Medium
Llano	0	0	3339	0	0	0	0	0.0000	Low
Mason	1272896	1448456	172221	2	0	2	100	0.0001	Low
Menard	1631959	1651727	19768	0	0	0	0	0.0000	Low
Nueces	0	0	0	1	1	0	0	(1)	None
Orange	0	0	0	1	1	0	0	(1)	None
Reagan	2071221	2219167	137946	0	0	0	0	0.0000	Low
Reeves	2774200	2952749	178831	0	0	0	0	0.0000	Low
Schleicher	1651727	1934341	282614	2	0	2	100	0.0001	Low
Travis	810379	957388	147009	3739	1286	2453	66	0.2543	High
Upton	2219167	2395852	176685	19	1	18	95	0.0011	Medium
Waller	265235	337659	72445	30	11	19	63	0.0041	Medium
Ward	2542522	2774200	264068	0	0	0	0	0.0000	Low
Total			3658282	14979	5263	9716	65		

(1): Calls were received for counties where Longhorn Pipeline does not run.

(2): Code levels:

High – Calls per 10 feet of pipeline is greater than 0.01

Medium – Calls per 10 feet of pipeline is greater than 0.001

Low – Calls per 10 feet of pipeline is less than 0.001

None – Calls received in counties where there is no pipeline

Table 6-3. Longhorn Partners Pipeline – WES Risk Ranking Assessment

Beginning Station	Ending Station	Beginning Milepost	Ending Milepost	Population	Environmental Areas
196+39	218+04	3.7	4.1	High	Creek
350+34	364+43	6.6	6.9	High	Greens Bayou
517+40	531+35	9.8	10.1	High	Greens Bayou
901+48	915+18	17.1	17.3	High	Halls Bayou
1233+96	1247+66	23.4	23.6	High	Creek
1557+74	1571+44	29.5	29.8	High	H.C.F.C.D. Channel
1629+75	1644+95	30.9	31.2	High	Little White Oak Bayou
1801+38	1805+04	34.1	34.2	High	
1805+04	1988+71	34.2	37.7	High	
3362+42	3386+82	63.7	64.1	Low	Brazos River
6595+02	6726+91	124.9	127.4	High	Buescher State Park
6726+91	6805+44	127.4	128.9	Low	
6805+44	7089+91	128.9	134.3	Low	
7089+91	7111+88	134.3	134.7	Low	Colorado River
8407+37	8625+93	159.2	163.4	High	McKinney Falls State Park
8625+93	8665+27	163.4	164.1	High	Creek
8802+30	9152+68	166.7	173.3	High	Edwards Aquifer
9546+10	9559+30	180.8	181.0	Medium	Creek
10209+88	10485+21	193.4	198.6	High	Pedernales State Park

Table 6-4. Comparison of Attributes of Three Relative Risk Assessments

Comparison	EPC	WES	Current (EA)*	Notes
Number of geographic sections for analysis	7	138	10,100+	
Avg segment length	65.7 miles	5.0 miles	400 ft	1
Number of risk variables	~54	~54	~82	
Approx. pieces of information used to assess risks	~700	~13,800	~1,200,000	
Basis of model	Muhlbauer, 1996	Muhlbauer, 1996	Muhlbauer, 1996 (modified)	
Highest risk segments	Eckert to Bastrop	125-127 (Buescher State Park) 167-173 (Edwards Aquifer)	Miles 11-17 Miles 22-35 Miles 166-174	
Highest failure-probability segments	Kemper to Ft McKavet Crane to Kemper	34-37 64-67 (Brazos River)	Miles 11-22 Miles 172-176 Miles 357-453	
Highest consequence segments	Eckert to Bastrop	4-31 (various) 163 180	Miles 11 to 17 Miles 22 to 36 Miles 166 to 174	
Risk--range of scores, highest segment risk to lowest	16 to 58	30 to 125	2 to 300+	2
Probability-- range of scores (worst to best)	203 to 245	222 to 311	159 to 267	2
Consequence-- range of scores (best to worst)	3.6 to 13.2	2.3 to 8.3	0.2 to 60+	3, 4

1. EPC model covers only Kemper to Baytown section
2. Higher numbers indicate more safety--reduced risk--for the risk and probability scores. Range is function of choice of scaling factors.
3. Higher numbers indicate increased risk for the consequence score.
4. These consequence numbers are heavily dependent upon product characteristics, nearby receptors, and choice of scales used for spill score.

*Important: The scores for the EA Model in this table are *not* comparable to the results listed elsewhere in this study. The scores shown in this table were generated in a way that they can be compared to the other risk assessments. Specifically, population density is included since the other models' scores depend heavily on that variable.

Table 6-5. Comparison of EPC, WES, and EA Risk Model Features

EPC	WES	Current (EA) Model
No “surge potential” noted	No “surge potential” noted	Higher weighting for surge; potential seen as “high” in some places
No fatigue issues	Differences, but unknown criteria	Higher weighting, potential seen
Unknown	ROW = “good”	Some very poor ROW sections
Standard pipe pressure/wall thickness calculations	Standard pipe pressure/wall thickness calculations	Penalty for pre-1970 ERW and for older girth welds
No differences in “earth movements” potential	No differences in “earth movements” potential	More variations seen; seismic;. landslide; soils databases; model for scour
Qualitative CP system scoring	Qualitative CP system scoring	Actual test lead and CIS readings used
Qualitative coating condition scoring	Qualitative coating condition scoring	Qualitative coating condition scoring plus databases of repairs and visual inspections
Uncertain use of data	Uncertain use of data	Use of previous ILI indications as direct evidence
Uncertain use of data	Uncertain use of data	Use of previous leaks
Uncertain use of data	Uncertain use of data	Use of previous repairs
Uncertain use of data	Uncertain use of data	More detailed overland and subsurface spread model

Table 6-6. Frequency and Probability Data for Pipe Spills

Leak Database Spill Size (bbls)	Historical EPC Number	Normalized EPC Frequency spills/mile/yr	Adjustment Factor	Normalized Estimated LH Frequency (worst case estimate) spills/mile/yr	Estimated Probability 1 Year	Estimated Probability 50 Year
≥ 5000	2	1.53E-04	9.01E-01	1.38E-04	9.50E-02	9.93E-01
≥ 1500 - < 5000	3	2.30E-04	9.01E-01	2.07E-04	1.39E-01	9.99E-01
≥ 500 - < 1500	4	3.07E-04	9.01E-01	2.76E-04	1.81E-01	<1.00E+00
≥ 50 - < 500	3	2.30E-04	9.01E-01	2.07E-04	1.39E-01	9.99E-01
< 50	17	1.30E-03	9.01E-01	1.17E-03	5.72E-01	1<.00E+00

Table 6-7. Frequency and Probability of Pump Station Spills

Leak Database Spill Size (bbls)	Historical Number	Normalized EPC Frequency spills/station/yr	Adjustment Factor	Normalized Estimated LH Frequency (worst case estimate) spills/station/yr	Estimated Probability 1 Year	Estimated Probability 50 Year
≥ 5000	3	1.29E-02	4.31E-01	5.57E-03	5.56E-03	2.43E-01
≥ 1500 - < 5000	4	1.72E-02	4.31E-01	7.43E-03	7.40E-03	3.10E-01
≥ 500 - < 1500	7	3.02E-02	4.31E-01	1.30E-02	1.29E-02	4.78E-01
≥ 50 - < 500	34	1.47E-01	4.31E-01	6.32E-02	6.12E-02	9.58E-01
< 50	100	4.31E-01	4.31E-01	1.86E-01	1.70E-01	<1.00E+00

Table 6-8. Ignition Probabilities Assigned to Various Spill Sizes

Spill Size (bbl)	Probability of Ignition
∃5,000	5.0E-01
1,500 – 4,999	2.5E-01
500 – 1,499	1.25E-01
50 – 499	6.25E-02
<50	6.25E-02

Table 6-9. Locations of Selected Sensitive Areas

Sensitive Area	Station Begin (ft)	Station End (ft)
Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	75600	77000
Buescher State Park	673338	679884
Colorado River	709983	710083
Hillcrest Elementary School	861050	861485
Brown Schools	887990	888941
Karst Preserve	901500	901930
Shiloh Subdivision	889152	893376
Cedar Valley Pump Station	958848	959218
Edwards Aquifer - General	875615	914682
Cenozoic Pecos Aquifer A	2358249	2685651

Table 6-10. PSA/ESA Probability Values – 50 Year

Total Line Average Spill Frequency 1.45E+00 spills/yr (all sizes)
Pump Station Spill Frequency 2.75E-01 spills/station
Spill size: > 5,000 bbl

	Sensitive Area	Span Distance (mi)	PS	PA	PL	PF	PE	PSPILL	PFIRE	PEXPL
Probability Basis: 1 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	9.52E-02	5.00E-01	3.67E-04	5.00E-01	5.00E-02	3.49E-05	8.73E-06	8.73E-07
2	Buescher State Park	1.24	9.52E-02	5.00E-01	1.71E-03	5.00E-01	5.00E-02	1.63E-04	4.08E-05	4.08E-06
3	Colorado River	0.02	9.52E-02	5.00E-01	2.62E-05	5.00E-01	5.00E-02	2.49E-06	6.24E-07	6.24E-08
4	Hillcrest Elementary School	0.08	9.52E-02	5.00E-01	1.14E-04	5.00E-01	5.00E-02	1.08E-05	2.71E-06	2.71E-07
5	Brown Schools	0.18	9.52E-02	5.00E-01	2.49E-04	5.00E-01	5.00E-02	2.37E-05	5.93E-06	5.93E-07
6	Karst Preserve	0.08	9.52E-02	5.00E-01	1.13E-04	5.00E-01	5.00E-02	1.07E-05	2.68E-06	2.68E-07
7	Shiloh Subdivision	0.80	9.52E-02	5.00E-01	1.11E-03	5.00E-01	5.00E-02	1.05E-04	2.63E-05	2.63E-06
8	Cedar Valley Pump Station	0.07	5.57E-03	5.00E-01	5.56E-02	5.00E-01	5.00E-02	3.09E-04	7.73E-05	7.73E-06
9	Edwards Aquifer - General	7.40	9.52E-02	5.00E-01	1.02E-02	5.00E-01	5.00E-02	9.74E-04	2.44E-04	2.44E-05
10	Cenozoic Pecos Aquifer A	62.01	9.52E-02	5.00E-01	8.58E-02	5.00E-01	5.00E-02	8.17E-03	2.04E-03	2.04E-04
11	For Any Mile	1.00	9.52E-02	5.00E-01	1.38E-03	5.00E-01	5.00E-02	1.32E-04	3.29E-05	3.29E-06
Probability Basis: 50 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	9.93E-01	5.00E-01	3.67E-04	5.00E-01	5.00E-02	3.64E-04	9.11E-05	9.11E-06
2	Buescher State Park	1.24	9.93E-01	5.00E-01	1.71E-03	5.00E-01	5.00E-02	1.70E-03	4.26E-04	4.26E-05
3	Colorado River	0.02	9.93E-01	5.00E-01	2.62E-05	5.00E-01	5.00E-02	2.60E-05	6.50E-06	6.50E-07
4	Hillcrest Elementary School	0.08	9.93E-01	5.00E-01	1.14E-04	5.00E-01	5.00E-02	1.13E-04	2.83E-05	2.83E-06
5	Brown Schools	0.18	9.93E-01	5.00E-01	2.49E-04	5.00E-01	5.00E-02	2.47E-04	6.19E-05	6.19E-06
6	Karst Preserve	0.08	9.93E-01	5.00E-01	1.13E-04	5.00E-01	5.00E-02	1.12E-04	2.80E-05	2.80E-06
7	Shiloh Subdivision	0.80	9.93E-01	5.00E-01	1.11E-03	5.00E-01	5.00E-02	1.10E-03	2.75E-04	2.75E-05
8	Cedar Valley Pump Station	0.07	2.44E-01	5.00E-01	5.56E-02	5.00E-01	5.00E-02	1.35E-02	3.38E-03	3.38E-04
9	Edwards Aquifer - General	7.40	9.93E-01	5.00E-01	1.02E-02	5.00E-01	5.00E-02	1.02E-02	2.54E-03	2.54E-04
10	Cenozoic Pecos Aquifer A	62.01	9.93E-01	5.00E-01	8.58E-02	5.00E-01	5.00E-02	8.52E-02	2.13E-02	2.13E-03
11	For Any Mile	1.00	9.93E-01	5.00E-01	1.38E-03	5.00E-01	5.00E-02	1.37E-03	3.43E-04	3.43E-05

PS = probability that a leak or spill of designated size range might occur somewhere on the pipeline or at a pump station
PA = probability that the total quantity of the leak or spill might reach the surface
PL = probability that the leak or spill might occur at the specified location if one occurs on the pipeline
PF = probability that the leak or spill might ignite resulting in a fire
PE = probability that the leak or spill might ignite and result in an explosion
PSPILL = probability that a leak or spill might occur at the specified location
PFIRE = probability that a spill and fire might occur at the specified location
PEXPL = probability that a spill and explosion might occur at the specified location

Table 6-11. PSA/ESA Probability Values – 50 Year

Total Line Average Spill Frequency 1.45E+00 spills/yr (all sizes)
Pump Station Spill Frequency 2.75E-01 spills/station
Spill size: ≥ 1,500 bbl to < 5,000

	Sensitive Area	Span Distance (mi)	PS	PA	PL	PF	PE	PSPILL	PFIRE	PEXPL
Probability Basis: 1 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	1.39E-01	5.00E-01	3.67E-04	2.50E-01	5.00E-02	5.11E-05	6.38E-06	1.28E-06
2	Buescher State Park	1.24	1.39E-01	5.00E-01	1.71E-03	2.50E-01	5.00E-02	2.39E-04	2.98E-05	5.97E-06
3	Colorado River	0.02	1.39E-01	5.00E-01	2.62E-05	2.50E-01	5.00E-02	3.65E-06	4.56E-07	9.12E-08
4	Hillcrest Elementary School	0.08	1.39E-01	5.00E-01	1.14E-04	2.50E-01	5.00E-02	1.59E-05	1.98E-06	3.97E-07
5	Brown Schools	0.18	1.39E-01	5.00E-01	2.49E-04	2.50E-01	5.00E-02	3.47E-05	4.34E-06	8.67E-07
6	Karst Preserve	0.08	1.39E-01	5.00E-01	1.13E-04	2.50E-01	5.00E-02	1.57E-05	1.96E-06	3.92E-07
7	Shiloh Subdivision	0.80	1.39E-01	5.00E-01	1.11E-03	2.50E-01	5.00E-02	1.54E-04	1.93E-05	3.85E-06
8	Cedar Valley Pump Station	0.07	2.80E-02	5.00E-01	9.69E-05	2.50E-01	5.00E-02	2.72E-06	3.40E-07	6.79E-08
9	Edwards Aquifer - General	7.40	1.39E-01	5.00E-01	5.56E-02	2.50E-01	5.00E-02	7.74E-03	9.67E-04	1.93E-04
10	Cenozoic Pecos Aquifer A	62.01	1.39E-01	5.00E-01	8.58E-02	2.50E-01	5.00E-02	1.19E-02	1.49E-03	2.99E-04
11	For Any Mile	1.00	1.39E-01	5.00E-01	1.38E-03	2.50E-01	5.00E-02	1.93E-04	2.41E-05	4.81E-06
Probability Basis: 50 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	9.99E-01	5.00E-01	3.67E-04	2.50E-01	5.00E-02	3.67E-04	4.58E-05	9.16E-06
2	Buescher State Park	1.24	9.99E-01	5.00E-01	1.71E-03	2.50E-01	5.00E-02	1.71E-03	2.14E-04	4.28E-05
3	Colorado River	0.02	9.99E-01	5.00E-01	2.62E-05	2.50E-01	5.00E-02	2.62E-05	3.27E-06	6.55E-07
4	Hillcrest Elementary School	0.08	9.99E-01	5.00E-01	1.14E-04	2.50E-01	5.00E-02	1.14E-04	1.42E-05	2.85E-06
5	Brown Schools	0.18	9.99E-01	5.00E-01	2.49E-04	2.50E-01	5.00E-02	2.49E-04	3.11E-05	6.22E-06
6	Karst Preserve	0.08	9.99E-01	5.00E-01	1.13E-04	2.50E-01	5.00E-02	1.13E-04	1.41E-05	2.81E-06
7	Shiloh Subdivision	0.80	9.99E-01	5.00E-01	1.11E-03	2.50E-01	5.00E-02	1.11E-03	1.38E-04	2.76E-05
8	Cedar Valley Pump Station	0.07	7.59E-01	5.00E-01	9.69E-05	2.50E-01	5.00E-02	7.35E-05	9.19E-06	1.84E-06
9	Edwards Aquifer - General	7.40	3.10E-01	5.00E-01	5.56E-02	2.50E-01	5.00E-02	1.72E-02	2.15E-03	4.31E-04
10	Cenozoic Pecos Aquifer A	62.01	9.99E-01	5.00E-01	8.58E-02	2.50E-01	5.00E-02	8.57E-02	1.07E-02	2.14E-03
11	For Any Mile	1.00	9.99E-01	5.00E-01	1.38E-03	2.50E-01	5.00E-02	1.38E-03	1.73E-04	3.46E-05

PS = probability that a leak or spill of designated size range might occur somewhere on the pipeline or at a pump station
PA = probability that the total quantity of the leak or spill might reach the surface
PL = probability that the leak or spill might occur at the specified location if one occurs on the pipeline
PF = probability that the leak or spill might ignite resulting in a fire
PE = probability that the leak or spill might ignite and result in an explosion
PSPILL = probability that a leak or spill might occur at the specified location
PFIRE = probability that a spill and fire might occur at the specified location
PEXPL = probability that a spill and explosion might occur at the specified location

Table 6-12. PSA/ESA Probability Values – 50 Year

Total Line Average Spill Frequency 1.45E+00spills/yr
Pump Station Spill Frequency 2.75E-01spills/station
Spill size: ≥ 500 to < 1,500 bbl

	Sensitive Area	Span Distance (mi)	PS	PA	PL	PF	PE	PSPILL	PFIRE	PEXPL
Probability Basis: 1 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	1.81E-01	5.00E-01	3.67E-04	1.25E-01	5.00E-02	6.65E-05	4.15E-06	1.66E-06
2	Buescher State Park	1.24	1.81E-01	5.00E-01	1.71E-03	1.25E-01	5.00E-02	3.11E-04	1.94E-05	7.77E-06
3	Colorado River	0.02	1.81E-01	5.00E-01	2.62E-05	1.25E-01	5.00E-02	4.75E-06	2.97E-07	1.19E-07
4	Hillcrest Elementary School	0.08	1.81E-01	5.00E-01	1.14E-04	1.25E-01	5.00E-02	2.07E-05	1.29E-06	5.16E-07
5	Brown Schools	0.18	1.81E-01	5.00E-01	2.49E-04	1.25E-01	5.00E-02	4.51E-05	2.82E-06	1.13E-06
6	Karst Preserve	0.08	1.81E-01	5.00E-01	1.13E-04	1.25E-01	5.00E-02	2.04E-05	1.28E-06	5.10E-07
7	Shiloh Subdivision	0.80	1.81E-01	5.00E-01	1.11E-03	1.25E-01	5.00E-02	2.01E-04	1.25E-05	5.01E-06
8	Cedar Valley Pump Station	0.07	1.29E-02	5.00E-01	5.56E-02	1.25E-01	5.00E-02	7.18E-04	4.49E-05	1.79E-05
9	Edwards Aquifer - General	7.40	1.81E-01	5.00E-01	1.02E-02	1.25E-01	5.00E-02	1.85E-03	1.16E-04	4.64E-05
10	Cenozoic Pecos Aquifer A	62.01	1.81E-01	5.00E-01	8.58E-02	1.25E-01	5.00E-02	1.55E-02	9.71E-04	3.89E-04
11	For Any Mile	1.00	1.81E-01	5.00E-01	1.38E-03	1.25E-01	5.00E-02	2.51E-04	1.57E-05	6.27E-06
Probability Basis: 50 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	<1.00E+00	5.00E-01	3.67E-04	1.25E-01	5.00E-02	3.67E-04	2.29E-05	9.17E-06
2	Buescher State Park	1.24	<1.00E+00	5.00E-01	1.71E-03	1.25E-01	5.00E-02	1.71E-03	1.07E-04	4.29E-05
3	Colorado River	0.02	<1.00E+00	5.00E-01	2.62E-05	1.25E-01	5.00E-02	2.62E-05	1.64E-06	6.55E-07
4	Hillcrest Elementary School	0.08	<1.00E+00	5.00E-01	1.14E-04	1.25E-01	5.00E-02	1.14E-04	7.12E-06	2.85E-06
5	Brown Schools	0.18	<1.00E+00	5.00E-01	2.49E-04	1.25E-01	5.00E-02	2.49E-04	1.56E-05	6.23E-06
6	Karst Preserve	0.08	<1.00E+00	5.00E-01	1.13E-04	1.25E-01	5.00E-02	1.13E-04	7.04E-06	2.82E-06
7	Shiloh Subdivision	0.80	<1.00E+00	5.00E-01	1.11E-03	1.25E-01	5.00E-02	1.11E-03	6.92E-05	2.77E-05
8	Cedar Valley Pump Station	0.07	4.78E-01	5.00E-01	5.56E-02	1.25E-01	5.00E-02	2.66E-02	1.66E-03	6.64E-04
9	Edwards Aquifer - General	7.40	<1.00E+00	5.00E-01	1.02E-02	1.25E-01	5.00E-02	1.02E-02	6.40E-04	2.56E-04
10	Cenozoic Pecos Aquifer A	62.01	<1.00E+00	5.00E-01	8.58E-02	1.25E-01	5.00E-02	8.58E-02	5.36E-03	2.14E-03
11	For Any Mile	1.00	<1.00E+00	5.00E-01	1.38E-03	1.25E-01	5.00E-02	1.38E-03	8.64E-05	3.46E-05

PS = probability that a leak or spill of designated size range might occur somewhere on the pipeline or at a pump station
PA = probability that the total quantity of the leak or spill might reach the surface
PL = probability that the leak or spill might occur at the specified location if one occurs on the pipeline
PF = probability that the leak or spill might ignite resulting in a fire
PE = probability that the leak or spill might ignite and result in an explosion
PSPILL = probability that a leak or spill might occur at the specified location
PFIRE = probability that a spill and fire might occur at the specified location
PEXPL = probability that a spill and explosion might occur at the specified location

Table 6-13. PSA/ESA Probability Values – 50 Year

Total Line Average Spill Frequency 1.45E+00spills/yr
Pump Station Spill Frequency 2.75E-01spills/station
Spill size: ≥ 50 to < 500 bbl

	Sensitive Area	Span Distance (mi)	PS	PA	PL	PF	PE	PSPILL	PFIRE	PEXPL
Probability Basis: 1 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	1.39E-01	5.00E-01	3.67E-04	6.25E-02	5.00E-02	5.11E-05	1.60E-06	1.28E-06
2	Buescher State Park	1.24	1.39E-01	5.00E-01	1.71E-03	6.25E-02	5.00E-02	2.39E-04	7.46E-06	5.97E-06
3	Colorado River	0.02	1.39E-01	5.00E-01	2.62E-05	6.25E-02	5.00E-02	3.65E-06	1.14E-07	9.12E-08
4	Hillcrest Elementary School	0.08	1.39E-01	5.00E-01	1.14E-04	6.25E-02	5.00E-02	1.59E-05	4.96E-07	3.97E-07
5	Brown Schools	0.18	1.39E-01	5.00E-01	2.49E-04	6.25E-02	5.00E-02	3.47E-05	1.08E-06	8.67E-07
6	Karst Preserve	0.08	1.39E-01	5.00E-01	1.13E-04	6.25E-02	5.00E-02	1.57E-05	4.90E-07	3.92E-07
7	Shiloh Subdivision	0.80	1.39E-01	5.00E-01	1.11E-03	6.25E-02	5.00E-02	1.54E-04	4.81E-06	3.85E-06
8	Cedar Valley Pump Station	0.07	6.12E-02	5.00E-01	5.56E-02	6.25E-02	5.00E-02	3.40E-03	1.06E-04	8.50E-05
9	Edwards Aquifer - General	7.40	1.39E-01	5.00E-01	1.02E-02	6.25E-02	5.00E-02	1.42E-03	4.45E-05	3.56E-05
10	Cenozoic Pecos Aquifer A	62.01	1.39E-01	5.00E-01	8.58E-02	6.25E-02	5.00E-02	1.19E-02	3.73E-04	2.99E-04
11	For Any Mile	1.00	1.39E-01	5.00E-01	1.38E-03	6.25E-02	5.00E-02	1.93E-04	6.02E-06	4.81E-06
Probability Basis: 50 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	9.99E-01	5.00E-01	3.67E-04	6.25E-02	5.00E-02	3.67E-04	1.15E-05	9.16E-06
2	Buescher State Park	1.24	9.99E-01	5.00E-01	1.71E-03	6.25E-02	5.00E-02	1.71E-03	5.36E-05	4.28E-05
3	Colorado River	0.02	9.99E-01	5.00E-01	2.62E-05	6.25E-02	5.00E-02	2.62E-05	8.18E-07	6.55E-07
4	Hillcrest Elementary School	0.08	9.99E-01	5.00E-01	1.14E-04	6.25E-02	5.00E-02	1.14E-04	3.56E-06	2.85E-06
5	Brown Schools	0.18	9.99E-01	5.00E-01	2.49E-04	6.25E-02	5.00E-02	2.49E-04	7.78E-06	6.22E-06
6	Karst Preserve	0.08	9.99E-01	5.00E-01	1.13E-04	6.25E-02	5.00E-02	1.13E-04	3.52E-06	2.81E-06
7	Shiloh Subdivision	0.80	9.99E-01	5.00E-01	1.11E-03	6.25E-02	5.00E-02	1.11E-03	3.46E-05	2.76E-05
8	Cedar Valley Pump Station	0.07	9.58E-01	5.00E-01	5.56E-02	6.25E-02	5.00E-02	5.32E-02	1.66E-03	1.33E-03
9	Edwards Aquifer - General	7.40	9.99E-01	5.00E-01	1.02E-02	6.25E-02	5.00E-02	1.02E-02	3.20E-04	2.56E-04
10	Cenozoic Pecos Aquifer A	62.01	9.99E-01	5.00E-01	8.58E-02	6.25E-02	5.00E-02	8.57E-02	2.68E-03	2.14E-03
11	For Any Mile	1.00	9.99E-01	5.00E-01	1.38E-03	6.25E-02	5.00E-02	1.38E-03	4.32E-05	3.46E-05

PS = probability that a leak or spill of designated size range might occur somewhere on the pipeline or at a pump station
PA = probability that the total quantity of the leak or spill might reach the surface
PL = probability that the leak or spill might occur at the specified location if one occurs on the pipeline
PF = probability that the leak or spill might ignite resulting in a fire
PE = probability that the leak or spill might ignite and result in an explosion
PSPILL = probability that a leak or spill might occur at the specified location
PFIRE = probability that a spill and fire might occur at the specified location
PEXPL = probability that a spill and explosion might occur at the specified location

Table 6-14. PSA/ESA Probability Values – 50 Year

Total Line Average Spill Frequency 1.45E+00spills/yr
Pump Station Spill Frequency 2.75E-01spills/station
Spill size: < 50 bbl

	Sensitive Area	Span Distance (mi)	PS	PA	PL	PF	PE	PSPILL	PFIRE	PEXPL
Probability Basis: 1 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	5.73E-01	5.00E-01	3.67E-04	6.25E-02	5.00E-02	2.10E-04	6.56E-06	5.25E-06
2	Buescher State Park	1.24	5.73E-01	5.00E-01	1.71E-03	6.25E-02	5.00E-02	9.82E-04	3.07E-05	2.45E-05
3	Colorado River	0.02	5.73E-01	5.00E-01	2.62E-05	6.25E-02	5.00E-02	1.50E-05	4.69E-07	3.75E-07
4	Hillcrest Elementary School	0.08	5.73E-01	5.00E-01	1.14E-04	6.25E-02	5.00E-02	6.52E-05	2.04E-06	1.63E-06
5	Brown Schools	0.18	5.73E-01	5.00E-01	2.49E-04	6.25E-02	5.00E-02	1.43E-04	4.46E-06	3.57E-06
6	Karst Preserve	0.08	5.73E-01	5.00E-01	1.13E-04	6.25E-02	5.00E-02	6.45E-05	2.02E-06	1.61E-06
7	Shiloh Subdivision	0.80	5.73E-01	5.00E-01	1.11E-03	6.25E-02	5.00E-02	6.34E-04	1.98E-05	1.58E-05
8	Cedar Valley Pump Station	0.07	1.70E-01	5.00E-01	5.56E-02	6.25E-02	5.00E-02	9.42E-03	2.94E-04	2.36E-04
9	Edwards Aquifer - General	7.40	5.73E-01	5.00E-01	1.02E-02	6.25E-02	5.00E-02	5.86E-03	1.83E-04	1.46E-04
10	Cenozoic Pecos Aquifer A	62.01	5.73E-01	5.00E-01	8.58E-02	6.25E-02	5.00E-02	4.91E-02	1.53E-03	1.23E-03
11	For Any Mile	1.00	5.73E-01	5.00E-01	1.38E-03	6.25E-02	5.00E-02	7.92E-04	2.47E-05	1.98E-05
Probability Basis: 50 year										
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	0.27	<1.00E+00	5.00E-01	3.67E-04	6.25E-02	5.00E-02	3.67E-04	1.15E-05	9.17E-06
2	Buescher State Park	1.24	<1.00E+00	5.00E-01	1.71E-03	6.25E-02	5.00E-02	1.71E-03	5.36E-05	4.29E-05
3	Colorado River	0.02	<1.00E+00	5.00E-01	2.62E-05	6.25E-02	5.00E-02	2.62E-05	8.19E-07	6.55E-07
4	Hillcrest Elementary School	0.08	<1.00E+00	5.00E-01	1.14E-04	6.25E-02	5.00E-02	1.14E-04	3.56E-06	2.85E-06
5	Brown Schools	0.18	<1.00E+00	5.00E-01	2.49E-04	6.25E-02	5.00E-02	2.49E-04	7.78E-06	6.23E-06
6	Karst Preserve	0.08	<1.00E+00	5.00E-01	1.13E-04	6.25E-02	5.00E-02	1.13E-04	3.52E-06	2.82E-06
7	Shiloh Subdivision	0.80	<1.00E+00	5.00E-01	1.11E-03	6.25E-02	5.00E-02	1.11E-03	3.46E-05	2.77E-05
8	Cedar Valley Pump Station	0.07	<1.00E+00	5.00E-01	5.56E-02	6.25E-02	5.00E-02	5.56E-02	1.74E-03	1.39E-03
9	Edwards Aquifer - General	7.40	<1.00E+00	5.00E-01	1.02E-02	6.25E-02	5.00E-02	1.02E-02	3.20E-04	2.56E-04
10	Cenozoic Pecos Aquifer A	62.01	<1.00E+00	5.00E-01	8.58E-02	6.25E-02	5.00E-02	8.58E-02	2.68E-03	2.14E-03
11	For Any Mile	1.00	<1.00E+00	5.00E-01	1.38E-03	6.25E-02	5.00E-02	1.38E-03	4.32E-05	3.46E-05

PS = probability that a leak or spill of designated size range might occur somewhere on the pipeline or at a pump station
PA = probability that the total quantity of the leak or spill might reach the surface
PL = probability that the leak or spill might occur at the specified location if one occurs on the pipeline
PF = probability that the leak or spill might ignite resulting in a fire
PE = probability that the leak or spill might ignite and result in an explosion
PSPILL = probability that a leak or spill might occur at the specified location
PFIRE = probability that a spill and fire might occur at the specified location
PEXPL = probability that a spill and explosion might occur at the specified location

Table 6-15. Pipeline Release Locations and Maximum Release Quantities for Cases Modeled

Release Location	Topographical Maximum Spill Surface Area, ft^2	Worst-Case Release Quantity, bbls
Hillcrest Elementary	1,020,632	1,269
Brown Schools	764,601	4,777
Shiloh Subdivision	982,217	3,448
Cedar Valley Pump Station	1,245,944	6,024

Table 6-16. Estimated Maximum Product Release at Selected Locations

Location	Station, ft	Upstream Valve	Downstream Valve	Detection + Valve Closure Time[a], Minutes		Maximum Drain Volume		Loss During Detection and Pipeline Shutdown[b]		Total Maximum Release	
				Upstream Valve	Downstream Valve	bbl	gal	bbl	Gal	bbl	gal
Fonwood Elementary, Northwood Elementary, and Langstead Primary Schools	75600 to 76400	Remote-controlled block valve	Manual block valve	5	120[c]	3,903	164,000	781	32,800	4,684	196,800
Buescher State Park	673338 to 679884	Manual block valve	Remote-controlled block valve	120[c]	5	2,333	98,000	781	32,800	3,114	130,800
Colorado River Crossing	710033	Remote-controlled block valve MLV G-1	Check valve and manually-operated block valve	5	5	1,245	52,300	781	32,800	2,026	85,100
Onion Creek Crossing	865867	Remote-controlled block valve	Remote-controlled block valve	5	5	4,310	179,600	781	32,800	5,091	212,400
Hillcrest Elementary School	861050	Remote-controlled block valve	Remote-controlled block valve	5	5	488	20,500	781	32,800	1,269	53,300
Brown Schools	888000	Remote-controlled block valve	Remote-controlled block valve	5	5	3,996	167,800	781	32,800	4,777	200,600
Shiloh Oaks Subdivision	891264	Remote-controlled block valve	Remote-controlled block valve	5	5	2,667	112,014	781	32,800	3,448	144,814
Karst Preserve	901500	Remote-controlled block valve	Remote-controlled block valve	5	5	3,964	166,500	781	32,800	4,745	199,300
Edwards Aquifer – General	875615 to 914682	Remote-controlled block valve[d]	Remote-controlled block valve	5	5	5,240	220,080	781	32,800	6,021	252,880

Table 6-16. (Continued)

Location	Station, Ft	Upstream Valve	Downstream Valve	Detection + Valve Closure Time[a], Minutes		Maximum Drain Volume		Loss During Detection & Pipeline Shutdown[b]		Total Maximum Release	
				Upstream Valve	Downstream Valve	bbl	gal	bbl	gal	bbl	gal
Cedar Valley Pump Station	959033	Remote-controlled block valve	Manual block valve	5	120[c]	5,470	229,740	781	32,800	6,251	262,540
Cenozoic Pecos Alluvium - A	2358249 to 2685651	Manual Block Valve	Remote-controlled block valve	120[c]	5	18,000	756,000	781	32,800	18,781	788,800
Cenozoic Pecos Alluvium - B	2727629 to 2940056	Manual Block Valve	Manual block valve	120[c]	120[c]	35,500	1,490,000	781	32,800	36,200	1523000

[a] Detection and closure of remote-controlled valves assumed to be 5 minutes (from Williams Facility Response Plan)
[b] Based on maximum flow of 225,000 barrels per day
[c] Assumes that leak is detected and line (including remote-controlled valve) is shut down in 5 minutes, manual block valve(s) is closed within 2 hours
[d] Upstream remote-controlled valve is located at stationing 879965

Table 6-17. Meteorological Data for CHARM® Impact Modeling

Parameter	Value
Relative Humidity	68.93%
Ambient Temperature	67.8°F
Ambient Pressure	1 atm
Pasquill Stability Classification	D
Solar Radiation	300 W/m^2
Surface Roughness Length	30 cm
Wind Direction (wind is *from*)	SSE[1]
Wind Speed	7.66 mph

[1] CHARM® modeling was conducted irrespective of wind direction. Where influenced by wind direction, resulting plumes and pool fire impact footprints can be rotated about their source to examine the potential for impact at a specific location with any given wind direction.

Table 6-18. Summary of Consequence Modeling Results (maximum distances measured from pool centroid)

Release Location	Release Volume, bbls	Spill Surface Area, ft^2	Maximum Impact Distance from Pool Centroid, ft					
			Flash Fire		Pool Fire			
					Oil		Gasoline	
			Oil	Gasoline	1 kW/m^2	4 kW/m^2	1 kW/m^2	4 kW/m^2
Hillcrest Elementary School	50	4140	36	165	396	207	476	246
	500	12800	60	482	685	353	819	415
	1269[1]	20300	73	514	858	439	1019	511
Brown Schools	50	4140	36	165	396	207	476	246
	500	12800	60	482	685	353	819	415
	1500	22100	76	491	894	458	1061	530
	4777	39000	96	603	1178	598	1390	686
Shiloh Subdivision	50	4140	36	165	396	207	476	246
	500	12800	60	482	685	353	819	415
	1500	22100	76	491	894	458	1061	530
	3448	33200	90	613	1089	555	1282	633
Cedar Valley Pump Station	50	4140	36	165	396	207	476	246
	500	12800	60	482	685	353	819	415
	1500	22100	76	491	894	458	1061	530
	6024	43700	100	668	1244	631	1471	727

[1] The worst-case release quantity for the Hillcrest segment (1,269 bbls) is less than the 1,500 bbl case; therefore, the 1,500 bbl case was not modeled.

Table 6-19. Summary of Consequence Modeling Results (maximum distances measured from pipeline)

Release Location	Release Volume, bbls	Spill Surface Area, ft^2	Modeled Impact Distance (From Pipeline), ft					
			Flash Fire		Pool Fire			
					Oil		Gasoline	
			Oil	Gasoline	1 kW/m^2	4 kW/m^2	1 kW/m^2	4 kW/m^2
Hillcrest Elementary School	50	4140	321	450	681	492	761	531
	500	12800	345	767	970	638	1104	700
	1269[1]	20300	358	799	1143	724	1304	797
Brown Schools	50	4140	66	195	426	237	506	276
	500	12800	90	572	715	383	849	445
	1500	22100	106	521	924	488	1091	560
	4777	39000	126	633	1208	628	1420	716
Shiloh Subdivision	50	4140	249	378	609	420	689	459
	500	12800	273	695	898	566	1032	628
	1500	22100	289	704	1107	671	1274	743
	3448	33200	303	826	1302	768	1495	846
Cedar Valley Pump Station	50	4140	965	1094	1325	1136	1405	1175
	500	12800	989	1411	1614	1282	1748	1344
	1500	22100	1005	1420	1823	1387	1990	1459
	6024	43700	1029	1597	2173	1560	2400	1656

[1] The worst-case release quantity for the Hillcrest segment (1,269 bbls) is less than the 1,500 bbl case; therefore, the 1,500 bbl case was not modeled.

Table 6-20. Common Societal and Individual Risks

Event	Annual Count	Estimated Exposed Population	Chance for one Individual in a 50-year Span
Motor vehicle deaths	43,300 deaths	265 million	1 in 123
Motor vehicle injuries	2,600,000 disabling injuries	265 million	1 in 2
Motor vehicle deaths for drivers	43,300 deaths	177.8 million licensed drivers	1 in 82
Pedestrian Deaths	6,100 deaths	265 million	1 in 870
Falling Deaths	5,300 deaths	265 million	1 in 250
Deaths from Firearms in Public Places	500 deaths (in public places)	265 million	1 in 10,000
Recreational Boating Deaths	716 deaths	133 million	1 in 3,700
Tornado Deaths	30 deaths	66.25 million	1 in 45,500
Lightning Deaths	85 deaths	265 million	1 in 62,500

Source: Unintentional Injuries as Cited in **Accident Facts, 1997 Edition, National Safety Council**
Note: Not all of the population is exposed to all of the risks. In some cases an assumption of exposed population was made to generate more realistic risk values.
Assumed values were made for recreational boating (50% of U.S. population) and tornado exposures (25% of U.S. population).

Table 6-21. Probabilistic Risk Assessment Results for Selected Highly Sensitive Areas

	Sensitive Area	Area Type	Route Area/Type	Event Probability Ranges Over 50-Year Operational Span of Pipeline		
				Leak/Spill	Fire	Explosion
1	Fonwood Elementary, Northwood Elementary and Langstead Primary Schools	SSA	Houston/Urban	3.7E-04	1.2E-05 to 9.1E-05	9.2E-06
2	Buescher State Park	ESA	Bastrop/Rural	1.4E-03	5.4E-05 to 4.3E-04	4.3E-05
3	Colorado River	ESA	River Crossing	2.6E-05	8.2E-07 to 6.5E-06	6.6E-07
4	Hillcrest Elementary School	PSA	Austin/School	1.1E-04	3.6E-06 to 2.8E-05	2.8E-06
5	Brown Schools	PSA	Austin/Medical	2.5E-04	7.8E-06 to 6.2E-05	6.2E-06
6	Karst Preserve	ESA	Edwards Aquifer	1.1E-04	3.5E-06 to2.8E-05	2.8E-06
7	Shiloh Subdivision	PSA	Austin/Neighborhood	1.1E-03	3.5E-05 to 2.8E-04	2.8E-05
8	Cedar Valley Pump Station	ESA	Edwards Aquifer	2.6E-02 to 5.6E-02	1.7E-03 to 6.6E-03	1.3E-03 to 6.6E-04
9	Edwards Aquifer - General	ESA	Edwards Aquifer	1.0E-02	3.2E-04 to 2.6E-03	2.6E-04
10	Cenozoic Pecos Aquifer	ESA	Cenozoic Pecos Aquifer	8.6E-02	2.7E-03 to 2.1E-02	2.1E-03
11	Any Mile	PSA/ESA		1.4E-03	4.3E-05 to 3.4E-04	3.5E-05