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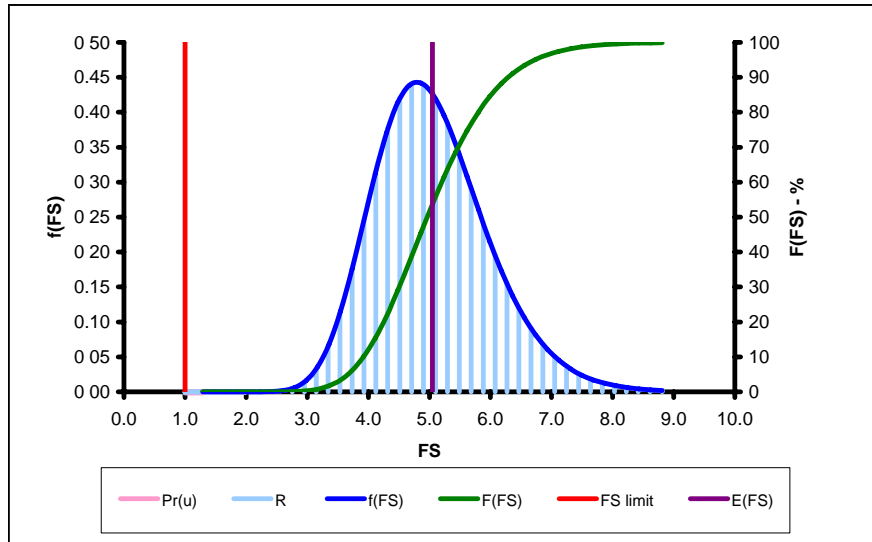
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** **Pool Elevation (ft)** **Probability of Unsatisfactory Performance Due To Under Seepage**

5+00 964

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>X<sub>fg</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>X<sub>fs</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>Y<sub>fs</sub>/K<sub>X<sub>fs</sub></sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	5.05		
Mean + 1σ K <sub>X<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	5.05		
Mean - 1σ K <sub>X<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	5.05	0.00000	0.00
Mean + 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	908.5	5.05		
Mean - 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	908.5	5.05	0.00000	0.00
Mean + 1σ K <sub>Y<sub>fs</sub>/K<sub>X<sub>fs</sub></sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	908.5	5.44		
Mean - 1σ K <sub>Y<sub>fs</sub>/K<sub>X<sub>fs</sub></sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	908.5	4.42	0.26010	29.45
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	908.5	5.41		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	908.5	4.70	0.12603	14.27
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	908.5	5.05		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	908.5	5.05	0.00000	0.00
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	911.3	6.24		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	905.7	4.83	0.49703	56.28
<b>Total</b>								<b>0.88315</b>	<b>100.00</b>



E(FS) =	5.05
σ(FS) =	0.94
V(FS) =	18.6%
E(ln FS) =	1.60
σ(ln FS) =	0.18
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	8.7
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

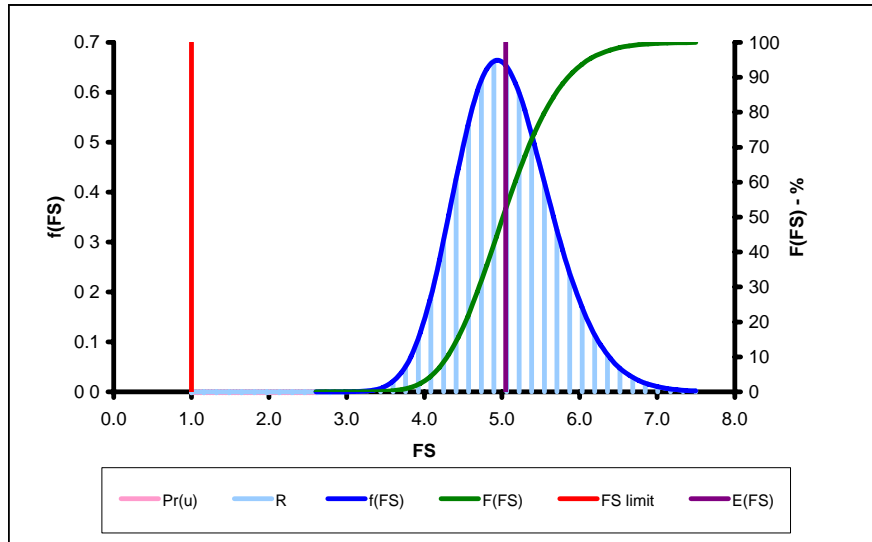
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Under Seepage**

5+00 | 982

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>X<sub>fg</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>X<sub>fs</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	5.05		
Mean + 1σ K <sub>X<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	5.74		
Mean - 1σ K <sub>X<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	4.66	0.29160	78.00
Mean + 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	930.0	5.05		
Mean - 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	930.0	5.05	0.00000	0.00
Mean + 1σ K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	930.0	5.02		
Mean - 1σ K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	930.0	5.20	0.00810	2.17
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	930.0	5.32		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	930.0	4.78	0.07290	19.50
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	930.0	5.05		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	930.0	5.05	0.00000	0.00
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	933.3	5.04		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	926.7	5.11	0.00123	0.33
<b>Total</b>								<b>0.37383</b>	<b>100.00</b>



E(FS) =	5.05
σ(FS) =	0.61
V(FS) =	12.1%
E(ln FS) =	1.61
σ(ln FS) =	0.12
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	13.4
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

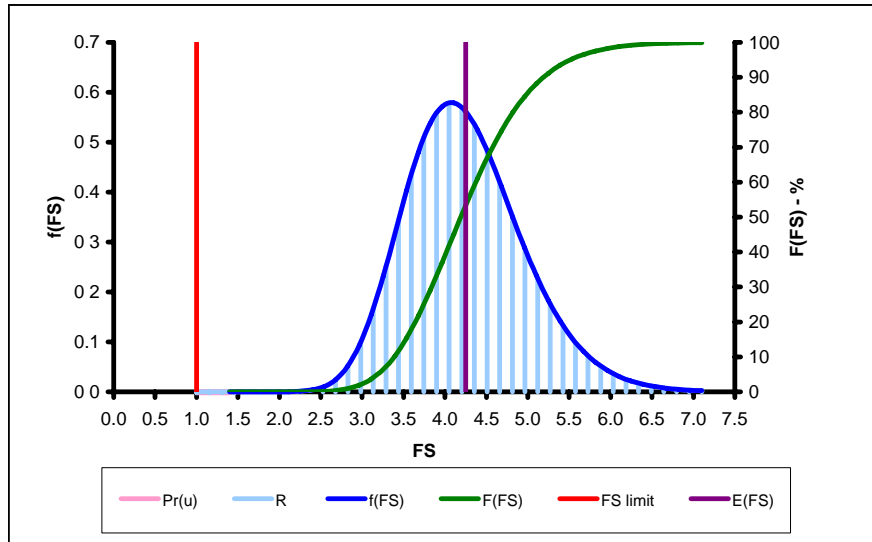
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** **Pool Elevation (ft)** **Probability of Unsatisfactory Performance Due To Under Seepage**

20+00 982

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	4.25		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	5.14		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	3.88	0.39690	78.13
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	930.0	4.25		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	930.0	4.25	0.00000	0.00
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	930.0	4.25		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	930.0	4.32	0.00123	0.24
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	930.0	4.44		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	930.0	4.07	0.03423	6.74
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	930.0	4.25		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	930.0	4.25	0.00000	0.00
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	933.3	4.01		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	926.7	4.56	0.07563	14.89
<b>Total</b>								<b>0.50798</b>	<b>100.00</b>



E(FS) =	4.25
σ(FS) =	0.71
V(FS) =	16.8%
E(ln FS) =	1.43
σ(ln FS) =	0.17
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	8.6
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

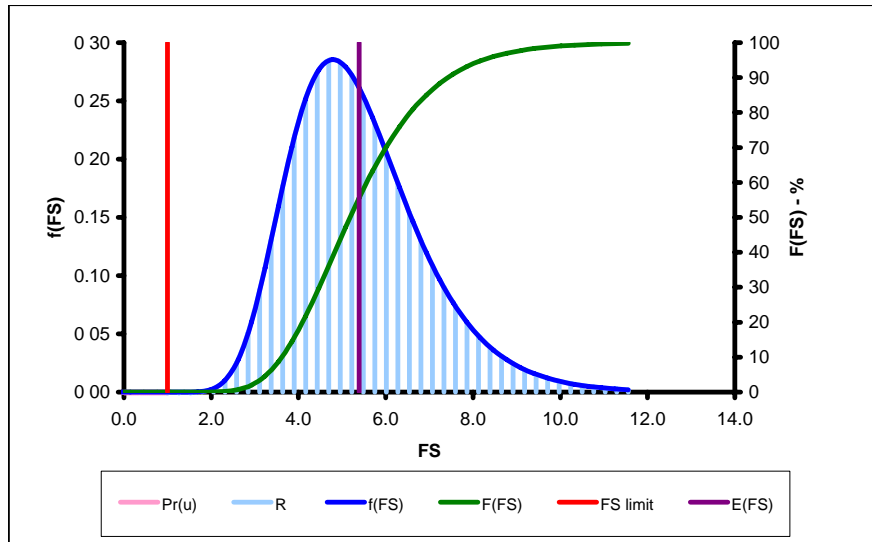
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
27+00	949	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	Y <sub>sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	8.5	1.6E-01	896.0	5.39		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	8.5	1.6E-01	896.0	5.39		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	8.5	1.6E-01	896.0	5.36	0.00022	0.01
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	8.5	1.6E-01	896.0	5.44		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	8.5	1.6E-01	896.0	4.25	0.35403	14.89
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	8.5	1.6E-01	896.0	5.76		
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	8.5	1.6E-01	896.0	5.01	0.14063	5.92
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	10.5	1.6E-01	896.0	5.39		
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	6.5	1.6E-01	896.0	3.42	0.97023	40.82
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	8.5	3.0E-01	896.0	5.39		
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	8.5	1.6E-02	896.0	5.39	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	8.5	8.9E+02	897.3	6.63		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	8.5	1.6E-01	894.7	4.72	0.91203	38.37
<b>Total</b>								<b>2.37713</b>	<b>100.00</b>



E(FS) =	5.39
σ(FS) =	1.54
V(FS) =	28.6%
E(ln FS) =	1.65
σ(ln FS) =	0.28
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.9
Pr(u) =	0.00000%
R =	100.00000%

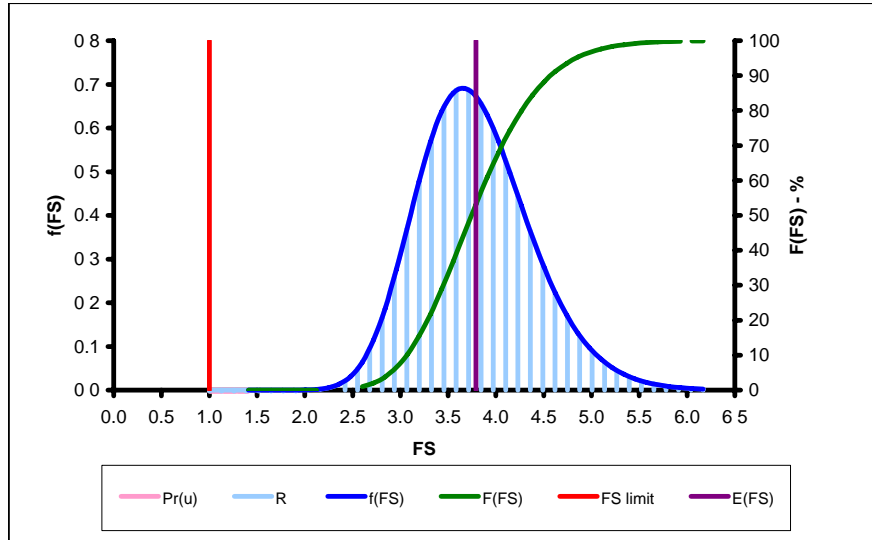
E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
27+00	982	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	8.5	1.6E-01	930.0	3.79		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	8.5	1.6E-01	930.0	3.79		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	8.5	1.6E-01	930.0	3.66	0.00422	1.19
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	8.5	1.6E-01	930.0	3.79		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	8.5	1.6E-01	930.0	3.54	0.01563	4.42
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	8.5	1.6E-01	930.0	4.05		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	8.5	1.6E-01	930.0	3.53	0.06760	19.11
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	10.5	1.6E-01	930.0	3.79		
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	6.5	1.6E-01	930.0	2.92	0.18923	53.48
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	8.5	3.0E-01	930.0	3.79		
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	8.5	1.6E-02	930.0	3.66	0.00422	1.19
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	8.5	1.6E-01	933.3	4.08		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	8.5	1.6E-01	926.7	3.54	0.07290	20.60
<b>Total</b>								<b>0.35380</b>	<b>100.00</b>



E(FS) =	3.79
σ(FS) =	0.59
V(FS) =	15.7%
E(ln FS) =	1.32
σ(ln FS) =	0.16
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	8.5
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

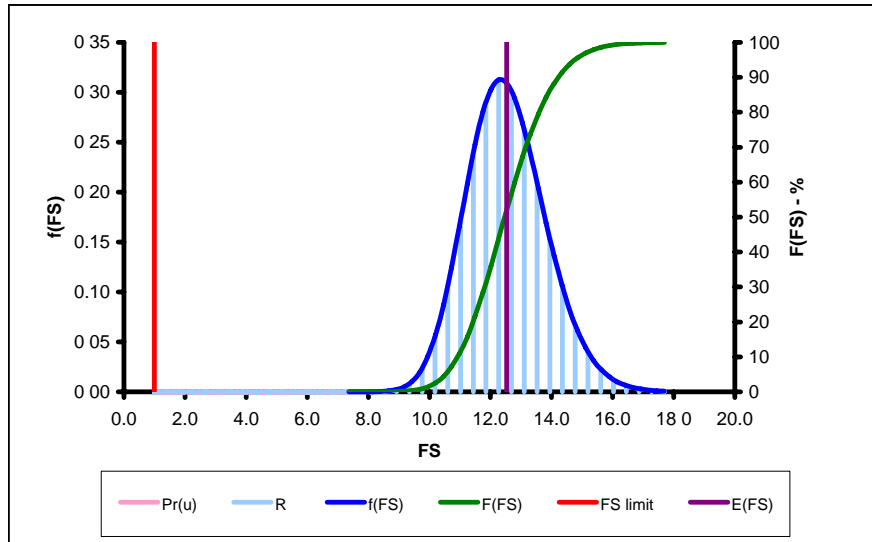
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

43+00 | 929

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>X<sub>fg</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>X<sub>fs</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	12.53		
Mean + 1σ K <sub>X<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	12.53		
Mean - 1σ K <sub>X<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	12.53	0.00000	0.00
Mean + 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	888.0	12.53		
Mean - 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	888.0	12.53	0.00000	0.00
Mean + 1σ K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	888.0	12.53		
Mean - 1σ K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	888.0	12.53	0.00000	0.00
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	888.0	13.40		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	888.0	11.66	0.75690	45.35
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	888.0	13.51		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	888.0	11.60	0.91203	54.65
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	888.7	12.53		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	887.3	12.53	0.00000	0.00
<b>Total</b>								<b>1.66893</b>	<b>100.00</b>



E(FS) =	12.53
σ(FS) =	1.29
V(FS) =	10.3%
E(ln FS) =	2.52
σ(ln FS) =	0.10
FS limit =	1.00
ln FS limit =	0.00

β <sub>in</sub> =	24.5
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>in</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

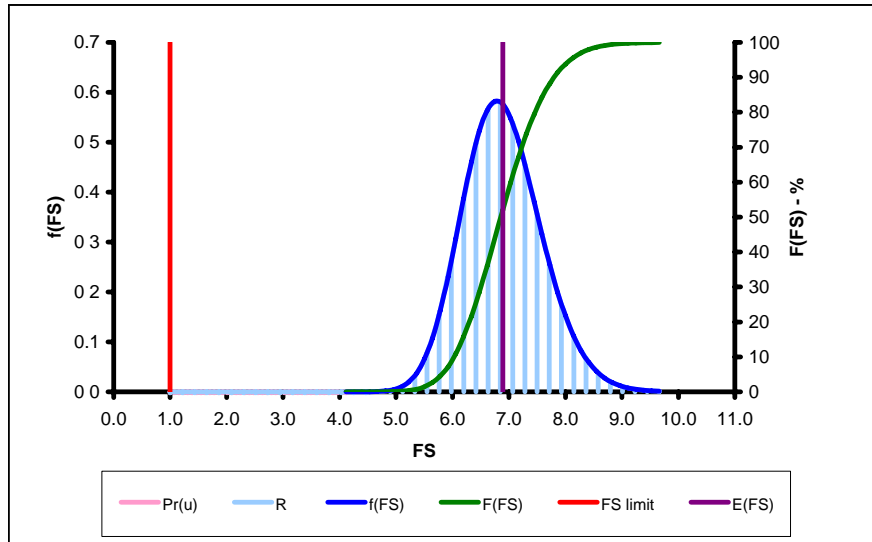
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** **Pool Elevation (ft)** **Probability of Unsatisfactory Performance Due To Through Seepage**

43+00 936

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>X<sub>ig</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>X<sub>iss</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>Y<sub>iss</sub>/K<sub>X<sub>iss</sub></sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	6.89		
Mean + 1σ <sub>K<sub>X<sub>ig</sub></sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	6.89		
Mean - 1σ <sub>K<sub>X<sub>ig</sub></sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	6.89	0.00000	0.00
Mean + 1σ <sub>K<sub>X<sub>iss</sub></sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	894.0	6.89		
Mean - 1σ <sub>K<sub>X<sub>iss</sub></sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	894.0	6.89	0.00000	0.00
Mean + 1σ <sub>K<sub>Y<sub>iss</sub>/K<sub>X<sub>iss</sub></sub></sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	894.0	6.89		
Mean - 1σ <sub>K<sub>Y<sub>iss</sub>/K<sub>X<sub>iss</sub></sub></sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	894.0	6.27	0.09610	19.99
Mean + 1σ <sub>γ<sub>sat</sub></sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	894.0	7.37		
Mean - 1σ <sub>γ<sub>sat</sub></sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	894.0	8.03	0.10890	22.66
Mean + 1σ <sub>φ</sub>	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	894.0	7.43		
Mean - 1σ <sub>φ</sub>	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	894.0	6.38	0.27563	57.35
Mean + 1σ <sub>TW</sub>	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.7	6.89		
Mean - 1σ <sub>TW</sub>	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	893.3	6.89	0.00000	0.00
<b>Total</b>								<b>0.48063</b>	<b>100.00</b>



E(FS) =	6.89
σ(FS) =	0.69
V(FS) =	10.1%
E(ln FS) =	1.93
σ(ln FS) =	0.10
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	19.2
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed



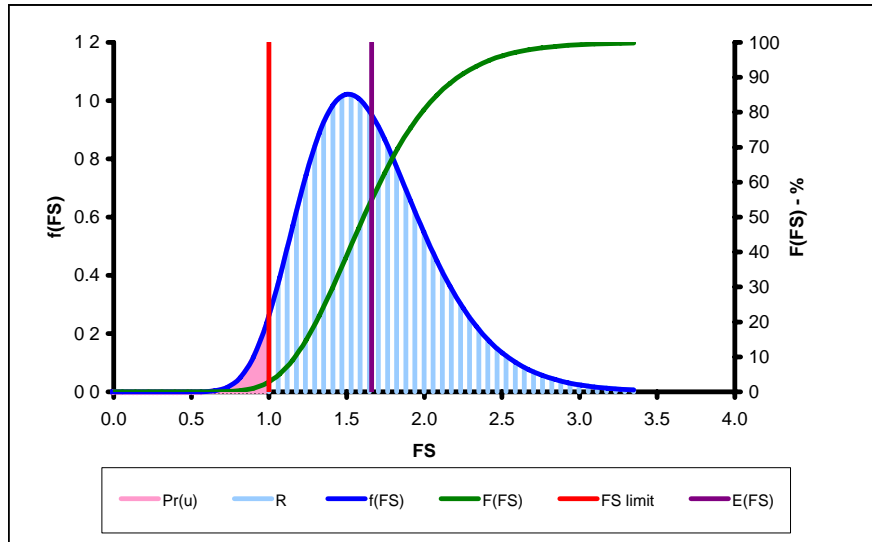
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

43+00 | 949

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>x<sub>ig</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>x<sub>iss</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>y<sub>iss</sub></sub> /K <sub>x<sub>iss</sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	1.66		
Mean + 1σ K <sub>x<sub>ig</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	1.47		
Mean - 1σ K <sub>x<sub>ig</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	1.97	0.06250	35.04
Mean + 1σ K <sub>x<sub>iss</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	896.0	1.83		
Mean - 1σ K <sub>x<sub>iss</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	896.0	1.47	0.03240	18.17
Mean + 1σ K <sub>y<sub>iss</sub></sub> /K <sub>x<sub>iss</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	896.0	1.93		
Mean - 1σ K <sub>y<sub>iss</sub></sub> /K <sub>x<sub>iss</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	896.0	1.40	0.07023	39.37
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	896.0	1.77		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	896.0	1.54	0.01323	7.42
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	896.0	1.66		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	896.0	1.66	0.00000	0.00
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	897.3	1.66		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.7	1.66	0.00000	0.00
<b>Total</b>								<b>0.17835</b>	<b>100.00</b>



E(FS) =	1.66
σ(FS) =	0.42
V(FS) =	25.4%
E(ln FS) =	0.48
σ(ln FS) =	0.25
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	1.9
Pr(u) =	2.88094%
R =	97.11906%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

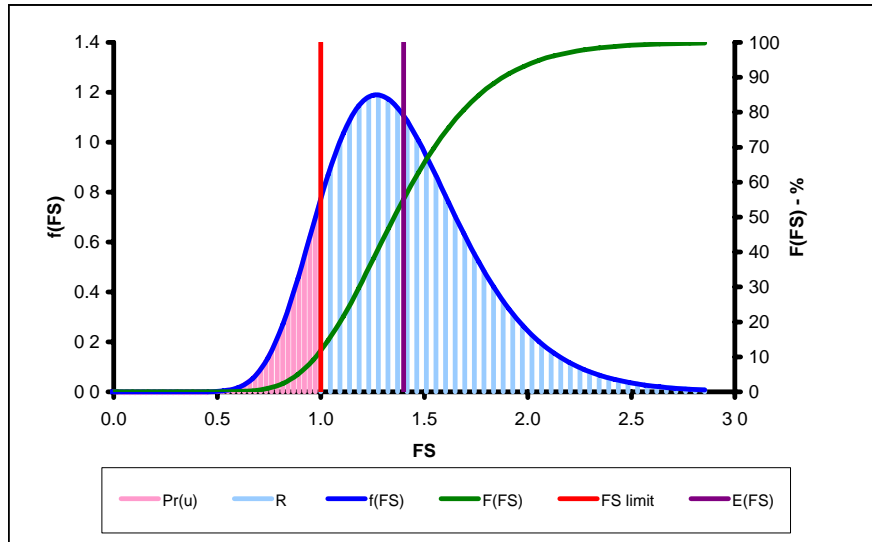
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

43+00 | 952

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	1.40		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	1.40		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	1.90	0.06250	47.25
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	906.0	1.74		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	906.0	1.40	0.02890	21.85
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	906.0	1.68		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	906.0	1.33	0.03063	23.15
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	906.0	1.49		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	906.0	1.30	0.00902	6.82
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	906.0	1.40		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	906.0	1.40	0.00000	0.00
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.0	1.47		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	904.0	1.40	0.00123	0.93
<b>Total</b>								<b>0.13228</b>	<b>100.00</b>



E(FS) =	1.40
σ(FS) =	0.36
V(FS) =	26.0%
E(ln FS) =	0.30
σ(ln FS) =	0.26
FS limit =	1.00
ln FS limit =	0.00

β <sub>in</sub> =	1.2
Pr(u) =	11.72464%
R =	88.27536%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>n</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

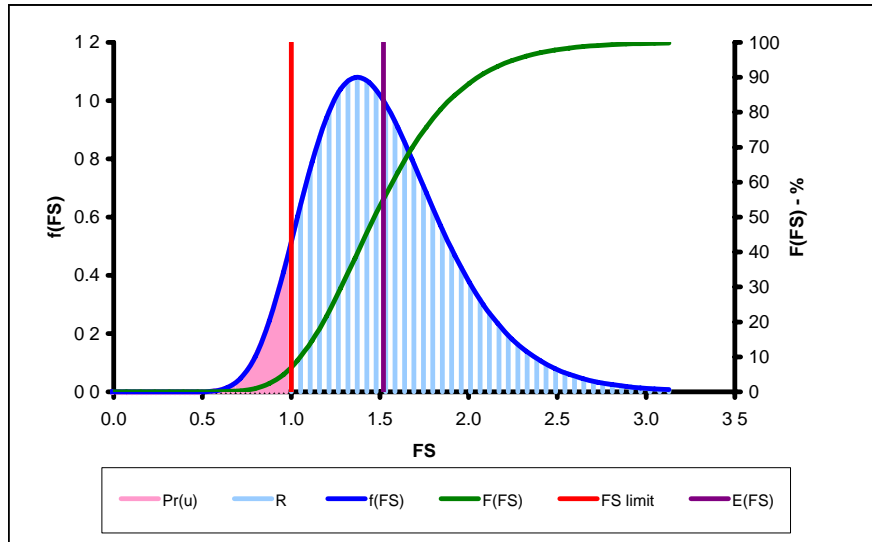
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

43+00 | 962

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>x<sub>fg</sub></sub> , foundation gravel Kx (ft/s)	K <sub>x<sub>fs</sub></sub> , foundation silty sand Kx (ft/s)	K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.52		
Mean + 1σ K <sub>x<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.52		
Mean - 1σ K <sub>x<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	2.07	0.07563	46.76
Mean + 1σ K <sub>x<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	908.5	1.88		
Mean - 1σ K <sub>x<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	908.5	1.52	0.03240	20.03
Mean + 1σ K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	908.5	1.82		
Mean - 1σ K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	908.5	1.45	0.03423	21.16
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	908.5	1.62		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	908.5	1.41	0.01103	6.82
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	908.5	1.52		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	908.5	1.45	0.00123	0.76
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	911.3	1.60		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	905.7	1.43	0.00723	4.47
<b>Total</b>								<b>0.16173</b>	<b>100.00</b>



E(FS) =	1.52
σ(FS) =	0.40
V(FS) =	26.5%
E(ln FS) =	0.38
σ(ln FS) =	0.26
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	1.5
Pr(u) =	6.94786%
R =	93.05214%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

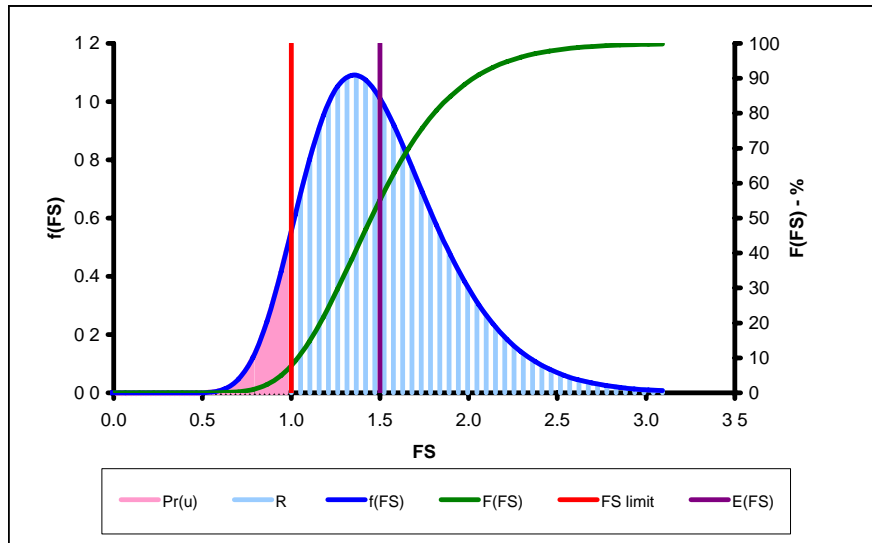
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** **Pool Elevation (ft)** **Probability of Unsatisfactory Performance Due To Through Seepage**

43+00 964

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.50		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.50		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	2.04	0.07290	46.02
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	908.5	1.86		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	908.5	1.50	0.03240	20.45
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	908.5	1.80		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	908.5	1.43	0.03423	21.61
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	908.5	1.60		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	908.5	1.39	0.01103	6.96
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	908.5	1.50		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	908.5	1.45	0.00063	0.39
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	911.3	1.58		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	905.7	1.41	0.00723	4.56
<b>Total</b>								<b>0.15840</b>	<b>100.00</b>



E(FS) =	1.50
σ(FS) =	0.40
V(FS) =	26.5%
E(ln FS) =	0.37
σ(ln FS) =	0.26
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	1.4
Pr(u) =	7.72084%
R =	92.27916%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

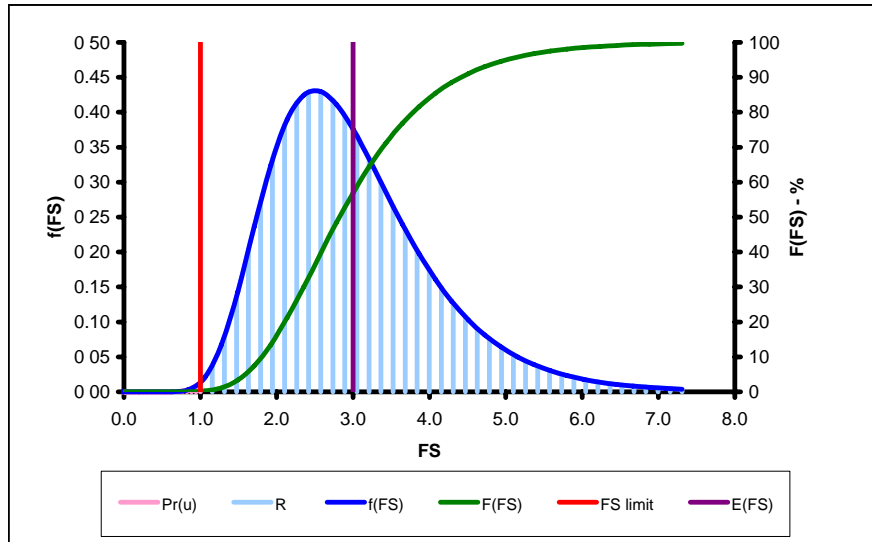
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** **Pool Elevation (ft)** **Probability of Unsatisfactory Performance Due To Through Seepage**

43+00 982

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>xiss</sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	3.00		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	2.76		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	3.28	0.06760	5.82
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	930.0	3.13		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	930.0	2.87	0.01690	1.46
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	930.0	3.28		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	930.0	2.76	0.06760	5.82
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	930.0	3.21		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	930.0	2.79	0.04410	3.80
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	930.0	3.23		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	930.0	2.77	0.05290	4.56
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	933.3	4.06		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	926.7	2.15	0.91203	78.55
<b>Total</b>								<b>1.16113</b>	<b>100.00</b>



E(FS) =	3.00
σ(FS) =	1.08
V(FS) =	35.9%
E(ln FS) =	1.04
σ(ln FS) =	0.35
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	3.0
Pr(u) =	0.14430%
R =	99.85570%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

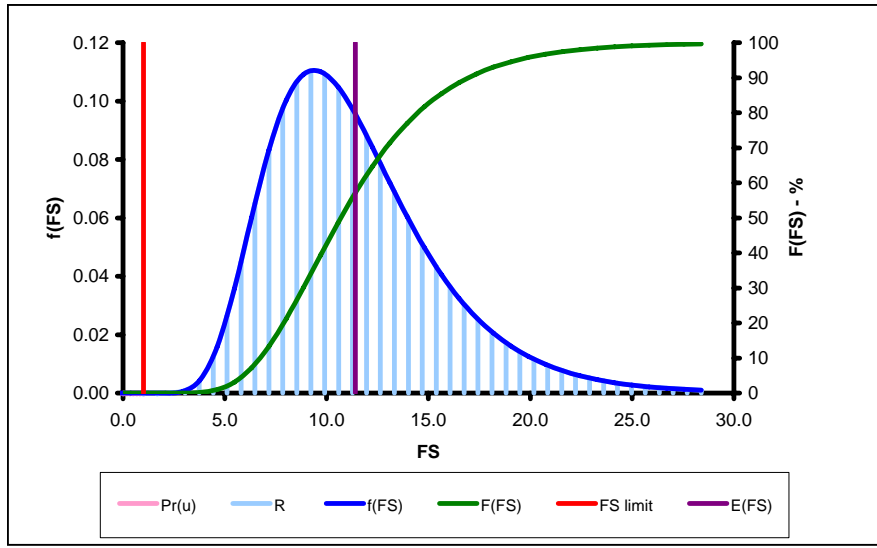
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
43+00	929	

**Taylor's Series Results**

Case	Random Variables					FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>x</sub> , relief well Kx (ft/s)	K <sub>y</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>D/S</sub> , D/S blanket thickness (ft)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	888.0	11.41		
Mean + 1σ K <sub>x</sub>	6.3E-03	1.7E-04	120.0	6.0	888.0	11.41		
Mean - 1σ K <sub>x</sub>	3.3E-04	1.7E-04	120.0	6.0	888.0	11.41	0.00000	0.00
Mean + 1σ K <sub>y</sub>	3.3E-03	3.3E-04	120.0	6.0	888.0	11.41		
Mean - 1σ K <sub>y</sub>	3.3E-03	7.0E-06	120.0	6.0	888.0	11.41	0.00000	0.00
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	888.0	12.21		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	888.0	10.62	0.63203	3.51
Mean + 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	888.0	11.41		
Mean - 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	888.0	3.07	17.38890	96.49
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	888.7	11.41		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	887.3	11.41	0.00000	0.00
<b>Total</b>							<b>18.02093</b>	<b>100.00</b>



E(FS) =	11.41
σ(FS) =	4.25
V(FS) =	37.2%
E(ln FS) =	2.37
σ(ln FS) =	0.36
FS limit =	1.00
ln FS limit =	0.00
β <sub>ln</sub> =	6.6
Pr(u) =	0.00000%
R =	100.00000%

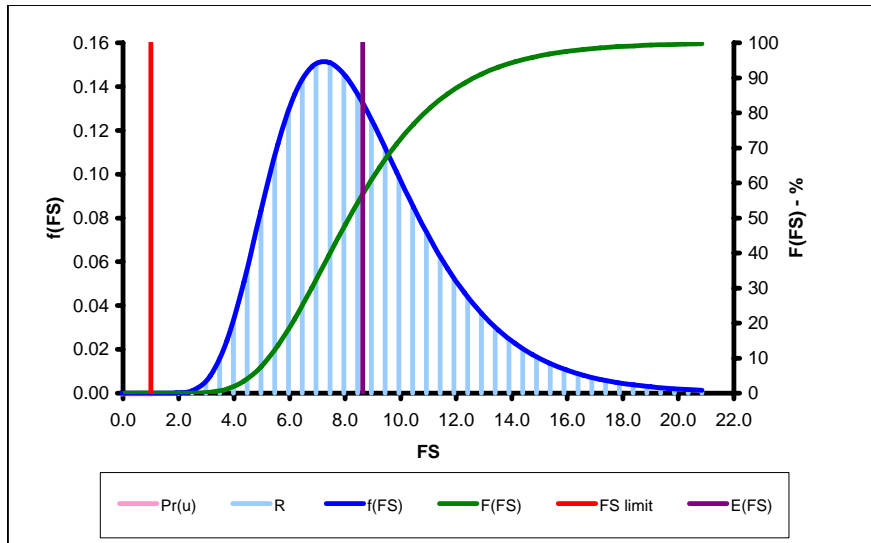
E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
43+00	936	

**Taylor's Series Results**

Case	Random Variables					FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket (ft/s)	Ky <sub>S</sub> , unit weight (pcf)	B <sub>D/S</sub> , D/S blanket thickness (ft)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	894.0	8.63		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	894.0	8.63		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	894.0	8.63	0.00000	0.00
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	894.0	8.63		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	894.0	8.63	0.00000	0.00
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	894.0	9.23		
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	894.0	8.03	0.36000	3.86
Mean + 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	894.0	8.63		
Mean - 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	894.0	2.64	8.97003	96.14
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	894.7	8.63		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	893.3	8.63	0.00000	0.00
<b>Total</b>							<b>9.33003</b>	<b>100.00</b>



E(FS) =	8.63
σ(FS) =	3.05
V(FS) =	35.4%
E(ln FS) =	2.10
σ(ln FS) =	0.34
FS limit =	1.00
ln FS limit =	0.00
β <sub>ln</sub> =	6.1
Pr(u) =	0.00000%
R =	100.00000%

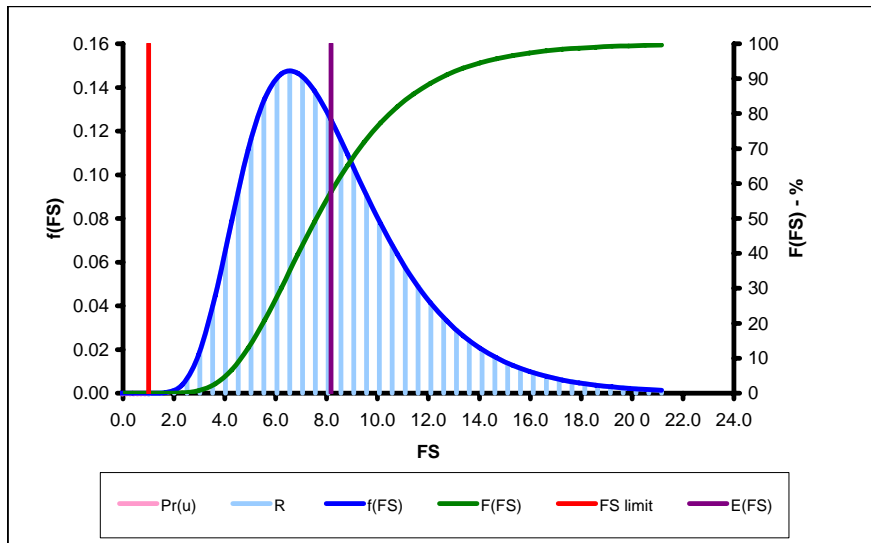
E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
43+00	949	

**Taylor's Series Results**

Case	Random Variables					FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket (ft/s)	Ky <sub>S</sub> , unit weight (pcf)	B <sub>D/S</sub> , D/S blanket thickness (ft)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	896.0	8.17		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	896.0	8.17		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	896.0	6.43	0.75690	7.17
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	896.0	8.17		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	896.0	7.08	0.29703	2.81
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	896.0	8.73		
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	896.0	7.60	0.31923	3.02
Mean + 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	896.0	8.17		
Mean - 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	896.0	2.11	9.18090	86.99
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	897.3	8.17		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	894.7	8.17	0.00000	0.00
<b>Total</b>							<b>10.55405</b>	<b>100.00</b>



E(FS) =	8.17
σ(FS) =	3.25
V(FS) =	39.8%
E(ln FS) =	2.03
σ(ln FS) =	0.38
FS limit =	1.00
ln FS limit =	0.00
β <sub>in</sub> =	5.3
Pr(u) =	0.00001%
R =	99.99999%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>n</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

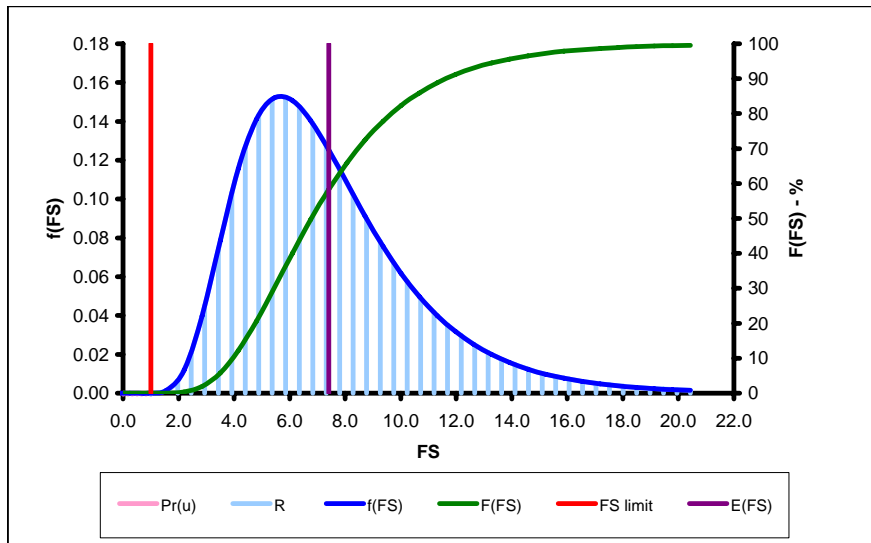


**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
43+00	952	

**Taylor's Series Results**

Case	Random Variables					FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket (ft/s)	Ky <sub>S</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	906.0	7.41		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	906.0	7.58		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	906.0	5.74	0.84640	7.98
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	906.0	8.61		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	906.0	6.24	1.40423	13.24
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	906.0	7.92		
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	906.0	6.89	0.26523	2.50
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	906.0	7.41		
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	906.0	2.02	7.26303	68.47
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	908.0	9.23		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	904.0	7.41	0.82810	7.81
<b>Total</b>							<b>10.60698</b>	<b>100.00</b>



E(FS) =	7.41
σ(FS) =	3.26
V(FS) =	44.0%
E(ln FS) =	1.91
σ(ln FS) =	0.42
FS limit =	1.00
ln FS limit =	0.00
β <sub>in</sub> =	4.6
Pr(u) =	0.00026%
R =	99.99974%

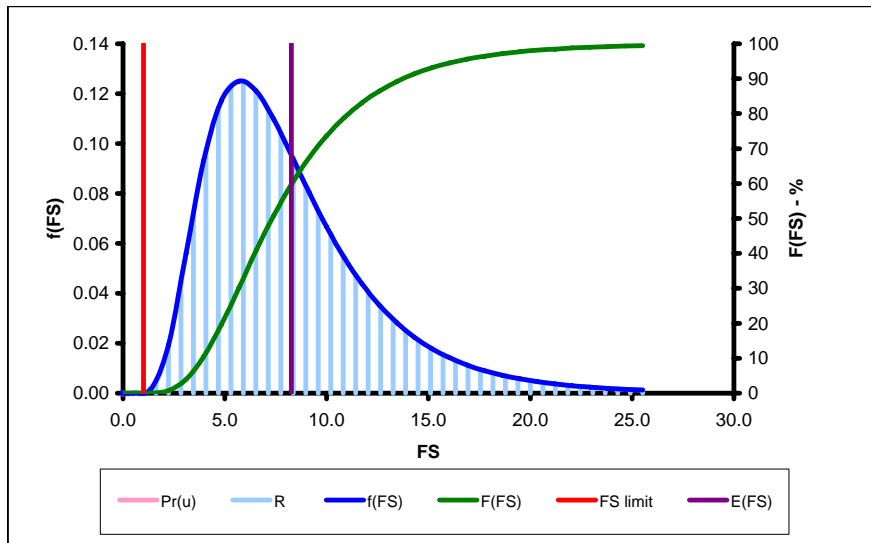
E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>n</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
43+00	962	

**Taylor's Series Results**

Case	Random Variables					FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>x</sub> , relief well Kx (ft/s)	K <sub>y</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>t/D/S</sub> , D/S blanket thickness (ft)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	908.5	8.27		
Mean + 1σ K <sub>x</sub>	6.3E-03	1.7E-04	120.0	6.0	908.5	8.49		
Mean - 1σ K <sub>x</sub>	3.3E-04	1.7E-04	120.0	6.0	908.5	6.31	1.18810	6.39
Mean + 1σ K <sub>y</sub>	3.3E-03	3.3E-04	120.0	6.0	908.5	9.65		
Mean - 1σ K <sub>y</sub>	3.3E-03	7.0E-06	120.0	6.0	908.5	7.00	1.75563	9.44
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	908.5	8.85		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	908.5	7.70	0.33063	1.78
Mean + 1σ B <sub>t/D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	908.5	8.27		
Mean - 1σ B <sub>t/D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	908.5	2.10	9.51723	51.17
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	911.3	10.11		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	905.7	5.29	5.80810	31.23
<b>Total</b>							<b>18.59968</b>	<b>100.00</b>



E(FS) =	8.27
σ(FS) =	4.31
V(FS) =	52.1%
E(ln FS) =	1.99
σ(ln FS) =	0.49
FS limit =	1.00
ln FS limit =	0.00
β <sub>ln</sub> =	4.1
Pr(u) =	0.00243%
R =	99.99757%

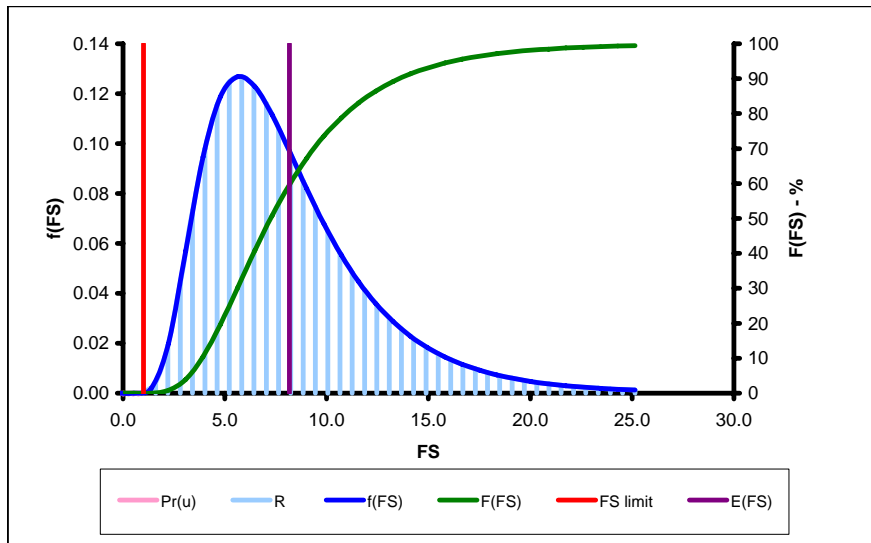
E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
43+00	964	

**Taylor's Series Results**

Case	Random Variables					FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket (ft/s)	Ky <sub>Sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	908.5	8.17		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	908.5	8.39		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	908.5	6.01	1.41610	7.87
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	908.5	9.23		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	908.5	6.70	1.60023	8.89
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	908.5	8.73		
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	908.5	7.60	0.31923	1.77
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	908.5	8.17		
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	908.5	2.10	9.21123	51.18
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	911.3	9.80		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	905.7	5.13	5.45223	30.29
<b>Total</b>							<b>17.99900</b>	<b>100.00</b>



E(FS) =	8.17
σ(FS) =	4.24
V(FS) =	51.9%
E(ln FS) =	1.98
σ(ln FS) =	0.49
FS limit =	1.00
ln FS limit =	0.00
β <sub>in</sub> =	4.1
Pr(u) =	0.00251%
R =	99.99749%

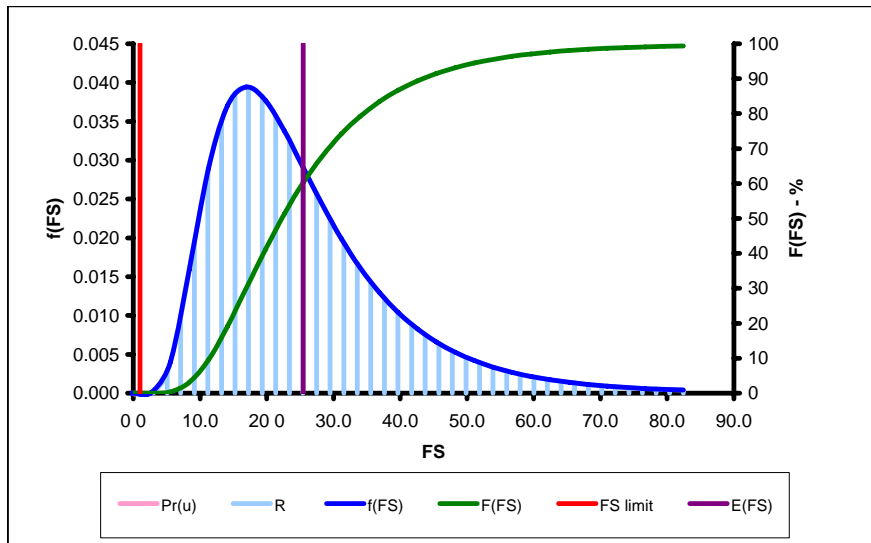
E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>in</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
43+00	982	

**Taylor's Series Results**

Case	Random Variables					FS <sub>(progressive erosion)</sub> (Under Seepage)	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket (ft/s)	Ky <sub>S</sub> , unit weight (pcf)	B <sub>D/S</sub> , D/S blanket thickness (ft)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	930.0	25.48		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	930.0	26.54		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	930.0	18.20	17.38890	8.58
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	930.0	31.85		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	930.0	21.96	24.45303	12.07
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	930.0	27.25		
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	930.0	23.71	3.13290	1.55
Mean + 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	930.0	25.48		
Mean - 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	930.0	2.73	129.39063	63.88
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	933.3	31.85		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	926.7	21.23	28.19610	13.92
<b>Total</b>							<b>202.56155</b>	<b>100.00</b>



E(FS) =	25.48
σ(FS) =	14.23
V(FS) =	55.9%
E(ln FS) =	3.10
σ(ln FS) =	0.52
FS limit =	1.00
ln FS limit =	0.00
β <sub>in</sub> =	6.0
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>n</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

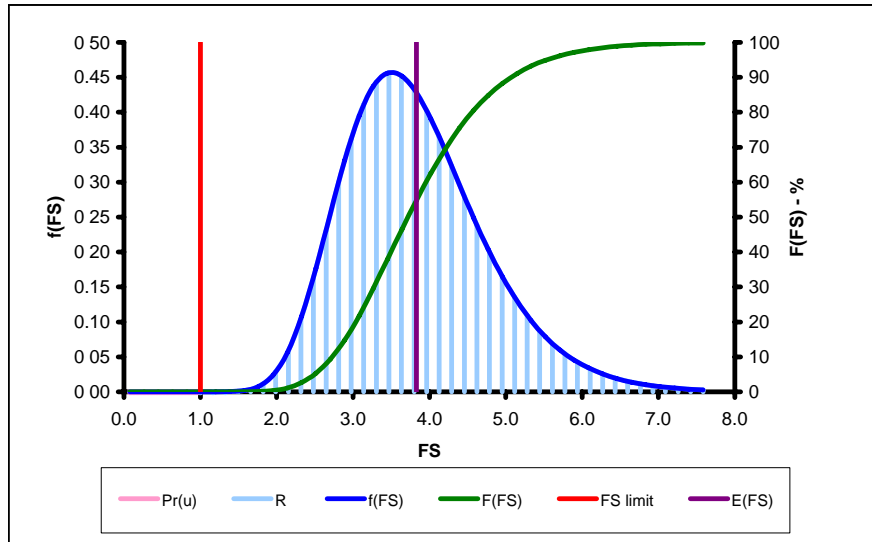
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** **Pool Elevation (ft)** **Probability of Unsatisfactory Performance Due To Through Seepage**

49+00 929

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	3.83		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	3.60		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	4.72	0.31360	35.57
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	888.0	4.58		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	888.0	3.48	0.30250	34.31
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	888.0	4.32		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	888.0	3.67	0.10563	11.98
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	888.0	4.10		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	888.0	3.56	0.07290	8.27
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	888.0	4.13		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	888.0	3.54	0.08703	9.87
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	888.7	3.83		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	887.3	3.83	0.00000	0.00
<b>Total</b>								<b>0.88165</b>	<b>100.00</b>



E(FS) =	3.83
σ(FS) =	0.94
V(FS) =	24.5%
E(ln FS) =	1.31
σ(ln FS) =	0.24
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.4
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

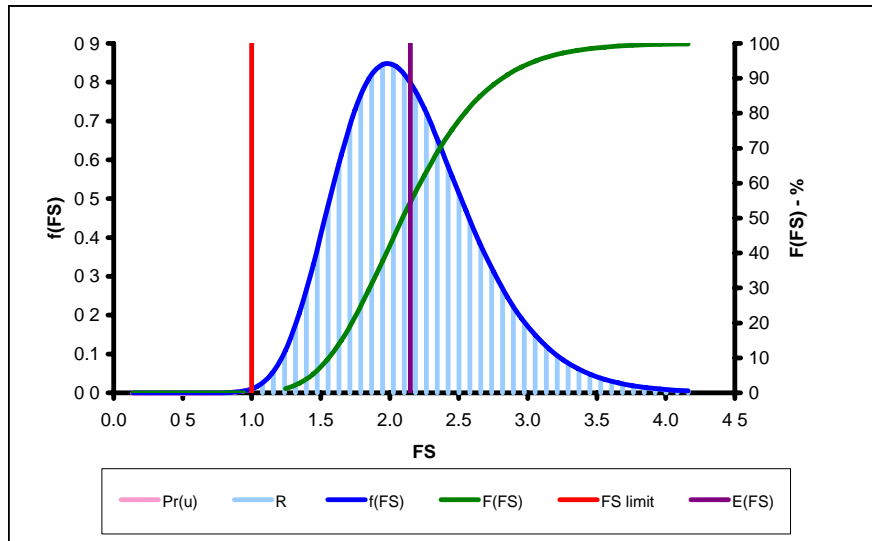
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

49+00 | 936

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>X<sub>fg</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>X<sub>fs</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>Y<sub>fs</sub>/K<sub>X<sub>fs</sub></sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	2.15		
Mean + 1σ K <sub>X<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	1.96		
Mean - 1σ K <sub>X<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	2.58	0.09610	38.04
Mean + 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	894.0	2.49		
Mean - 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	894.0	1.92	0.08123	32.15
Mean + 1σ K <sub>Y<sub>fs</sub>/K<sub>X<sub>fs</sub></sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	894.0	2.34		
Mean - 1σ K <sub>Y<sub>fs</sub>/K<sub>X<sub>fs</sub></sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	894.0	2.02	0.02560	10.13
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	894.0	2.30		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	894.0	2.00	0.02250	8.91
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	894.0	2.32		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	894.0	1.99	0.02723	10.78
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.7	2.15		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	893.3	2.15	0.00000	0.00
<b>Total</b>								<b>0.25265</b>	<b>100.00</b>



E(FS) =	2.15
σ(FS) =	0.50
V(FS) =	23.4%
E(ln FS) =	0.74
σ(ln FS) =	0.23
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	3.2
Pr(u) =	0.06802%
R =	99.93198%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

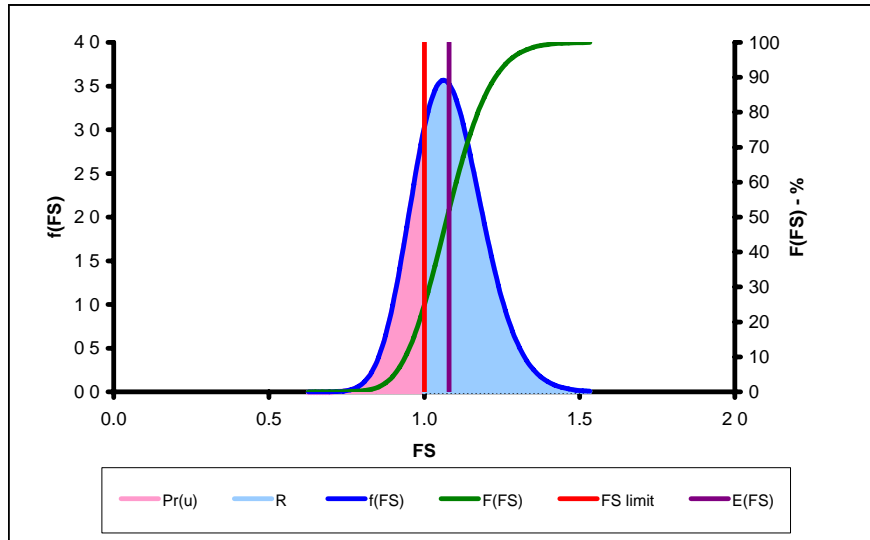
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** **Pool Elevation (ft)** **Probability of Unsatisfactory Performance Due To Through Seepage**

49+00 949

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	1.08		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	1.06		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	1.08	0.00010	0.78
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	896.0	1.09		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	896.0	1.04	0.00063	4.86
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	896.0	1.06		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	896.0	1.08	0.00010	0.78
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	896.0	1.15		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	896.0	1.00	0.00562	43.77
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	896.0	1.16		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	896.0	1.00	0.00640	49.81
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	897.3	1.08		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.7	1.08	0.00000	0.00
<b>Total</b>								<b>0.01285</b>	<b>100.00</b>



E(FS) =	1.08
σ(FS) =	0.11
V(FS) =	10.5%
E(ln FS) =	0.07
σ(ln FS) =	0.10
FS limit =	1.00
ln FS limit =	0.00

β <sub>in</sub> =	0.7
Pr(u) =	24.73315%
R =	75.26685%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>in</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

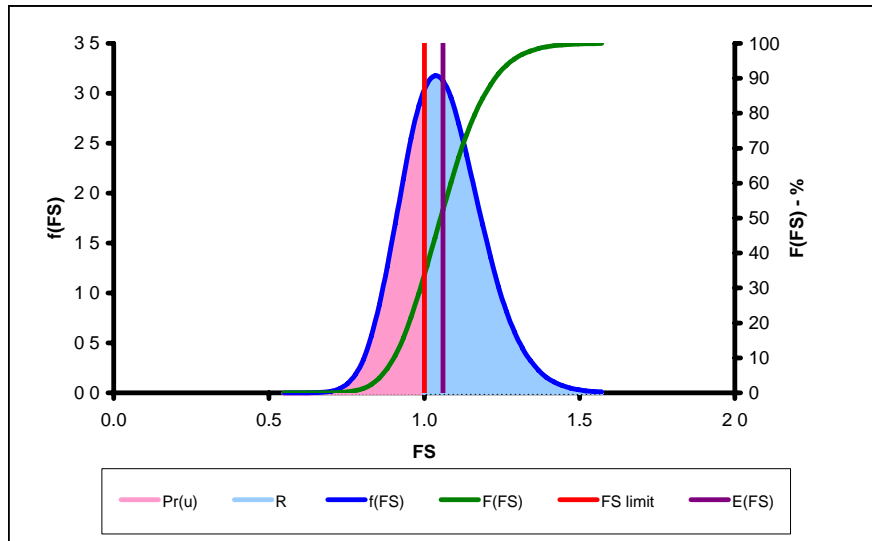
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

49+00 | 952

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	1.06		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	1.06		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	1.08	0.00010	0.61
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	906.0	1.09		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	906.0	1.04	0.00063	3.82
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	906.0	1.06		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	906.0	1.08	0.00010	0.61
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	906.0	1.13		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	906.0	0.99	0.00490	29.97
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	906.0	1.14		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	906.0	0.98	0.00640	39.14
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.0	1.19		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	904.0	1.06	0.00422	25.84
<b>Total</b>								<b>0.01635</b>	<b>100.00</b>



E(FS) =	1.06
σ(FS) =	0.13
V(FS) =	12.1%
E(ln FS) =	0.05
σ(ln FS) =	0.12
FS limit =	1.00
ln FS limit =	0.00

β <sub>in</sub> =	0.4
Pr(u) =	33.55300%
R =	66.44700%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>in</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed



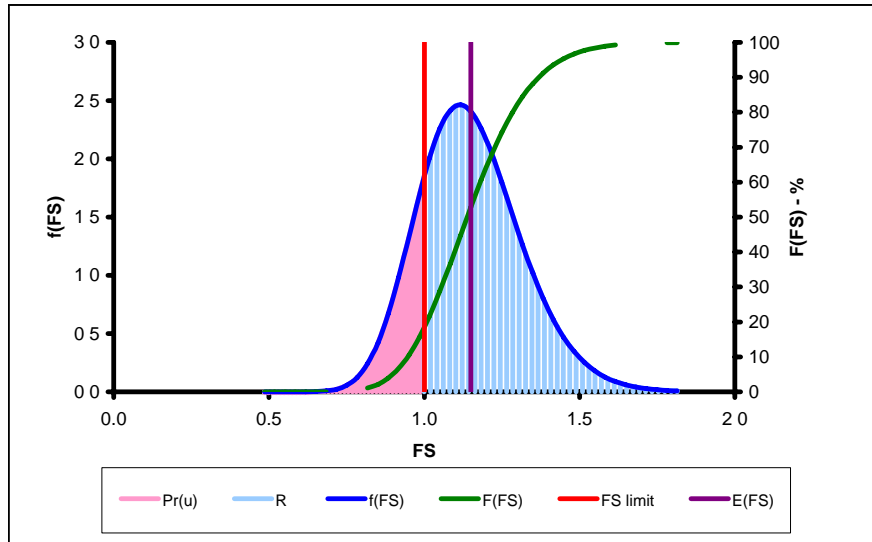
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

49+00 | 962

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>x<sub>fg</sub></sub> , foundation gravel Kx (ft/s)	K <sub>x<sub>ss</sub></sub> , foundation silty sand Kx (ft/s)	K <sub>y<sub>ss</sub></sub> /K <sub>x<sub>ss</sub></sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.15		
Mean + 1σ K <sub>x<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.15		
Mean - 1σ K <sub>x<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.17	0.00010	0.36
Mean + 1σ K <sub>x<sub>ss</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	908.5	1.19		
Mean - 1σ K <sub>x<sub>ss</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	908.5	1.11	0.00160	5.79
Mean + 1σ K <sub>y<sub>ss</sub></sub> /K <sub>x<sub>ss</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	908.5	1.13		
Mean - 1σ K <sub>y<sub>ss</sub></sub> /K <sub>x<sub>ss</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	908.5	1.17	0.00040	1.45
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	908.5	1.23		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	908.5	1.07	0.00640	23.17
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	908.5	1.24		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	908.5	1.06	0.00810	29.32
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	911.3	1.25		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	905.7	1.04	0.01103	39.91
<b>Total</b>								<b>0.02763</b>	<b>100.00</b>



E(FS) =	1.15
σ(FS) =	0.17
V(FS) =	14.5%
E(ln FS) =	0.13
σ(ln FS) =	0.14
FS limit =	1.00
ln FS limit =	0.00

β <sub>in</sub> =	0.9
Pr(u) =	18.40205%
R =	81.59795%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>n</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

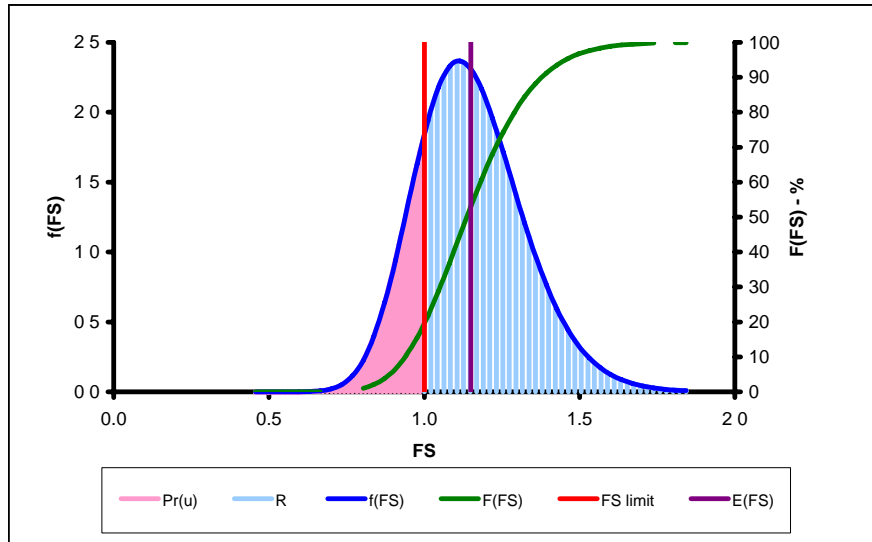
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

49+00 | 964

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>X<sub>fg</sub></sub> , foundation gravel Kx (ft/s)	K <sub>X<sub>fs</sub></sub> , foundation silty sand Kx (ft/s)	K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.15		
Mean + 1σ K <sub>X<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.09		
Mean - 1σ K <sub>X<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	1.17	0.00160	5.33
Mean + 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	908.5	1.19		
Mean - 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	908.5	1.09	0.00250	8.33
Mean + 1σ K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	908.5	1.13		
Mean - 1σ K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	908.5	1.17	0.00040	1.33
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	908.5	1.23		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	908.5	1.07	0.00640	21.32
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	908.5	1.24		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	908.5	1.06	0.00810	26.98
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	911.3	1.25		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	905.7	1.04	0.01103	36.72
<b>Total</b>								<b>0.03003</b>	<b>100.00</b>



E(FS) =	1.15
σ(FS) =	0.17
V(FS) =	15.1%
E(ln FS) =	0.13
σ(ln FS) =	0.15
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	0.9
Pr(u) =	19.54789%
R =	80.45211%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

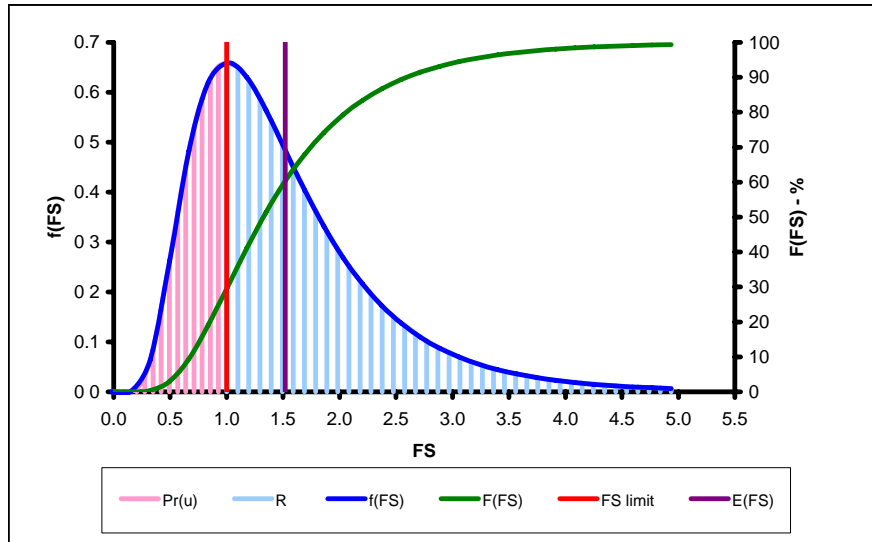
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

49+00 | 982

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>x<sub>fg</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>x<sub>fs</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	1.52		
Mean + 1σ K <sub>x<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	1.50		
Mean - 1σ K <sub>x<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	1.63	0.00422	0.58
Mean + 1σ K <sub>x<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	930.0	1.52		
Mean - 1σ K <sub>x<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	930.0	1.51	0.00003	0.00
Mean + 1σ K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	930.0	1.52		
Mean - 1σ K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	930.0	1.56	0.00040	0.05
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	930.0	1.62		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	930.0	1.41	0.01103	1.51
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	930.0	1.52		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	930.0	1.52	0.00000	0.00
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	933.3	0.51		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	926.7	2.20	0.71403	97.85
<b>Total</b>								<b>0.72970</b>	<b>100.00</b>



E(FS) =	1.52
σ(FS) =	0.85
V(FS) =	56.2%
E(ln FS) =	0.28
σ(ln FS) =	0.52
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	0.5
Pr(u) =	29.55403%
R =	70.44597%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

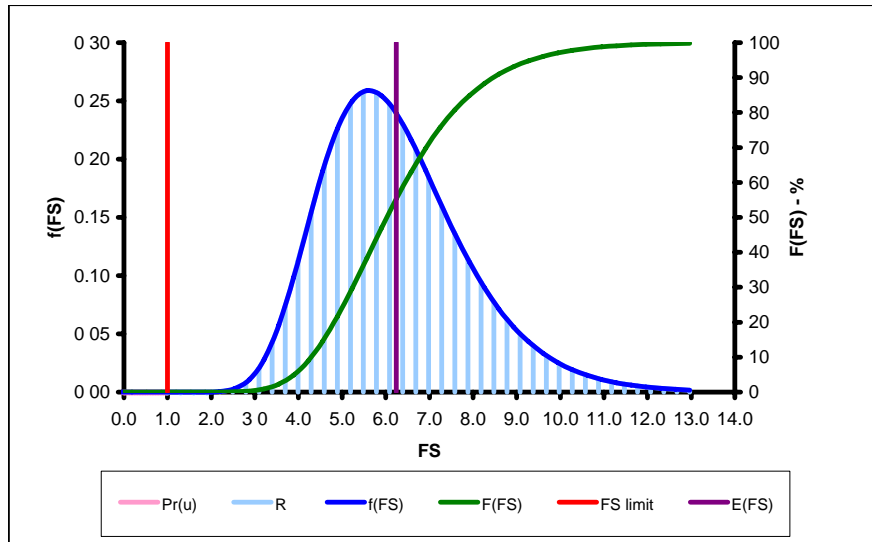
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
49+00	929	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	888.0	6.24		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	888.0	6.24		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	888.0	6.24	0.00000	0.00
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	888.0	6.24		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	888.0	6.24	0.00000	0.00
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	888.0	6.68		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	888.0	5.81	0.18923	6.69
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	888.0	6.24		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	888.0	2.99	2.64063	93.31
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	888.0	6.24		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	888.0	6.24	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	888.7	6.24		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	887.3	6.24	0.00000	0.00
<b>Total</b>							<b>2.82985</b>	<b>2.82985</b>	<b>100.00</b>



E(FS) =	6.24
σ(FS) =	1.68
V(FS) =	27.0%
E(ln FS) =	1.80
σ(ln FS) =	0.26
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	6.8
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

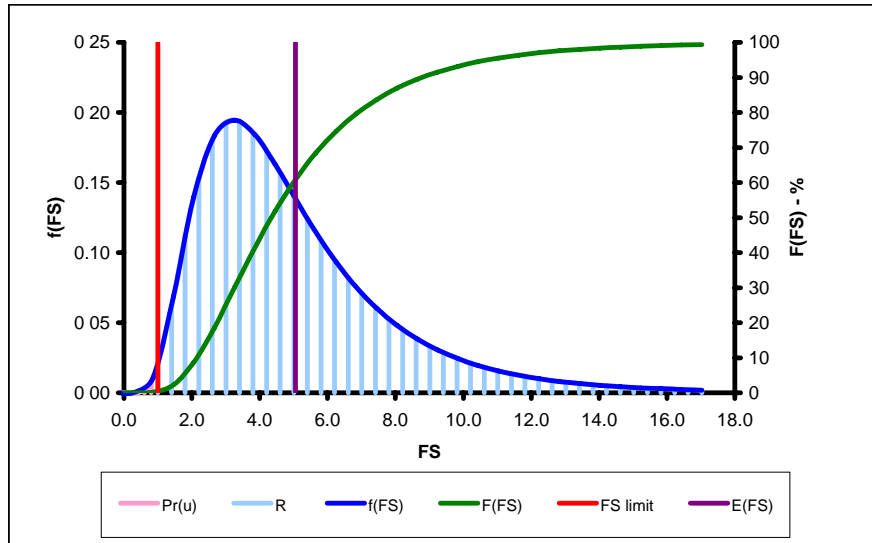
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
49+00	936	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>x</sub> <sub>rw</sub> , relief well Kx (ft/s)	K <sub>y</sub> <sub>B</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>t</sub> <sub>D/S</sub> , D/S blanket thickness (ft)	K <sub>x</sub> <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	894.0	5.05		
Mean + 1σ K <sub>x</sub> <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	894.0	5.05		
Mean - 1σ K <sub>x</sub> <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	894.0	5.05	0.00000	0.00
Mean + 1σ K <sub>y</sub> <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	894.0	5.05		
Mean - 1σ K <sub>y</sub> <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	894.0	5.05	0.00000	0.00
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	894.0	5.41		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	894.0	4.70	0.12603	1.41
Mean + 1σ B <sub>t</sub> <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	894.0	5.05		
Mean - 1σ B <sub>t</sub> <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	894.0	2.97	1.08160	12.07
Mean + 1σ K <sub>x</sub> <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	894.0	5.05		
Mean - 1σ K <sub>x</sub> <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	894.0	5.05	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	894.7	10.62		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	893.3	5.05	7.75623	86.53
<b>Total</b>								<b>8.96385</b>	<b>100.00</b>



E(FS) =	5.05
σ(FS) =	2.99
V(FS) =	59.3%
E(ln FS) =	1.47
σ(ln FS) =	0.55
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	2.7
Pr(u) =	0.37226%
R =	99.62774%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

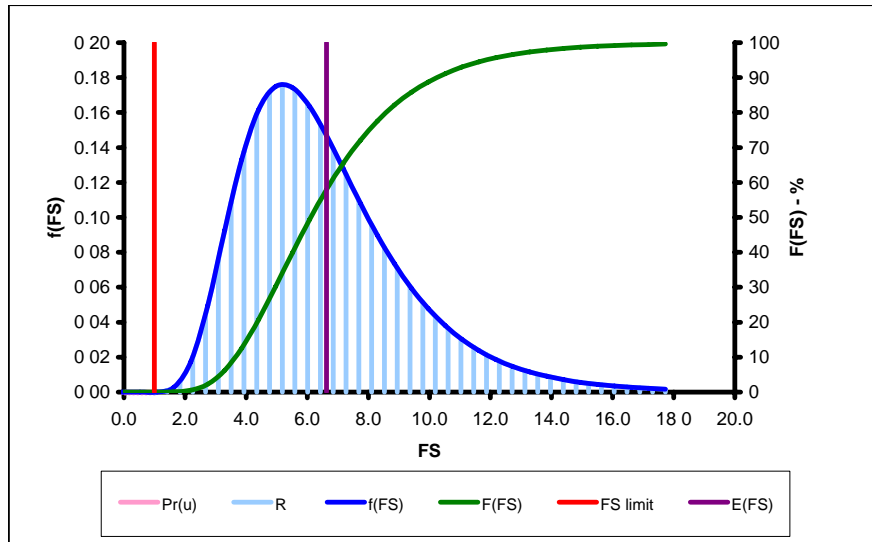
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
49+00	949	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	896.0	6.63		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	896.0	6.63		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	896.0	6.63	0.00000	0.00
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	896.0	6.63		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	896.0	2.72	3.82203	49.67
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	896.0	7.10		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	896.0	6.17	0.21623	2.81
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	896.0	6.63		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	896.0	2.95	3.38560	44.00
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	896.0	6.63		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	896.0	6.63	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	897.3	6.63		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	894.7	5.59	0.27040	3.51
<b>Total</b>								<b>7.69425</b>	<b>100.00</b>



E(FS) =	6.63
σ(FS) =	2.77
V(FS) =	41.8%
E(ln FS) =	1.81
σ(ln FS) =	0.40
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	4.5
Pr(u) =	0.00033%
R =	99.99967%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

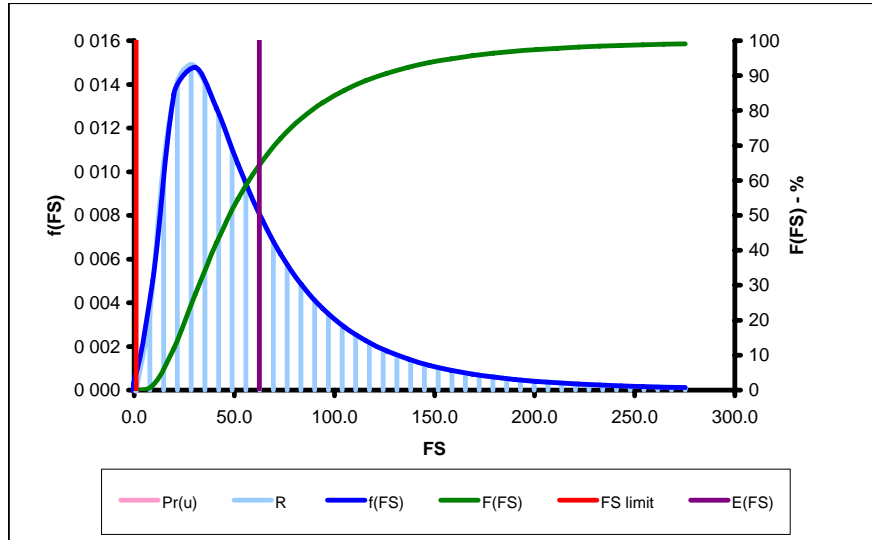
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
49+00	952	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)	
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	Y <sub>sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)				
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	906.0	62.44			
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	906.0	62.44			
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	906.0	58.97	3.01023	0.11	
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	906.0	63.69			
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	906.0	17.69	529.00000	18.70	
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	906.0	66.78			
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	906.0	58.11	18.79223	0.66	
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	906.0	62.44			
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	906.0	2.99	883.57563	31.24	
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	906.0	62.44			
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	906.0	12.74	617.52250	21.83	
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.0	66.35			
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	904.0	10.62	776.45823	27.45	
<b>Total</b>							<b>2828.35880</b>	<b>100.00</b>		



E(FS) =	62.44
σ(FS) =	53.18
V(FS) =	85.2%
E(ln FS) =	3.86
σ(ln FS) =	0.74
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.2
Pr(u) =	0.00001%
R =	99.99999%

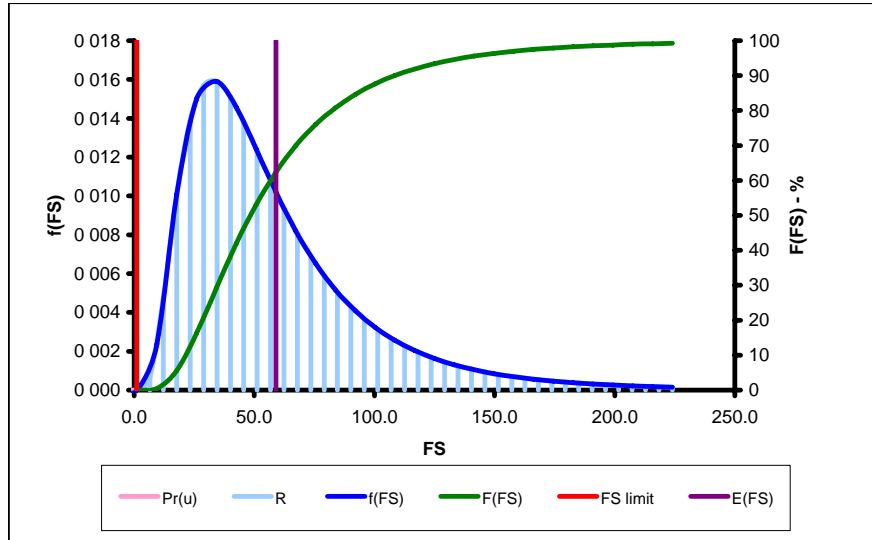
E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
49+00	962	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	K <sub>x</sub> <sub>rw</sub> , relief well Kx (ft/s)	K <sub>y</sub> <sub>B</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>t</sub> <sub>D/S</sub> , D/S blanket thickness (ft)	K <sub>x</sub> <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.5	58.97		
Mean + 1σ K <sub>x</sub> <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.5	58.97		
Mean - 1σ K <sub>x</sub> <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	908.5	48.25	28.72960	1.69
Mean + 1σ K <sub>y</sub> <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	908.5	62.44		
Mean - 1σ K <sub>y</sub> <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	908.5	17.12	513.47560	30.17
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	908.5	63.07		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	908.5	54.88	16.76903	0.99
Mean + 1σ B <sub>t</sub> <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	908.5	58.97		
Mean - 1σ B <sub>t</sub> <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	908.5	3.12	779.80563	45.81
Mean + 1σ K <sub>x</sub> <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	908.5	58.97		
Mean - 1σ K <sub>x</sub> <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	908.5	24.50	297.04523	17.45
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	911.3	62.44		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	905.7	46.15	66.34103	3.90
<b>Total</b>								<b>1702.16610</b>	<b>100.00</b>



E(FS) =	58.97
σ(FS) =	41.26
V(FS) =	70.0%
E(ln FS) =	3.88
σ(ln FS) =	0.63
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	6.1
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

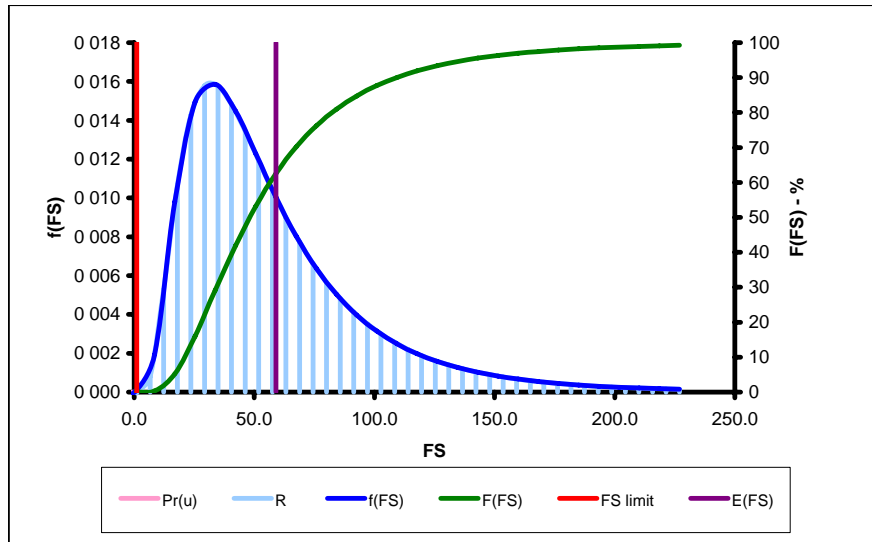


**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
49+00	964	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.5	58.97		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.5	58.97		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	908.5	46.15	41.08810	2.33
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	908.5	62.44		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	908.5	16.33	531.53303	30.11
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	908.5	63.07		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	908.5	54.88	16.76903	0.95
Mean + 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	908.5	58.97		
Mean - 1σ B <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	908.5	3.12	779.80563	44.18
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	908.5	58.97		
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	908.5	23.59	312.93610	17.73
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	911.3	62.44		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	905.7	44.23	82.90103	4.70
<b>Total</b>								<b>1765.03290</b>	<b>100.00</b>



E(FS) =	58.97
σ(FS) =	42.01
V(FS) =	71.2%
E(ln FS) =	3.87
σ(ln FS) =	0.64
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	6.0
Pr(u) =	0.00000%
R =	100.00000%

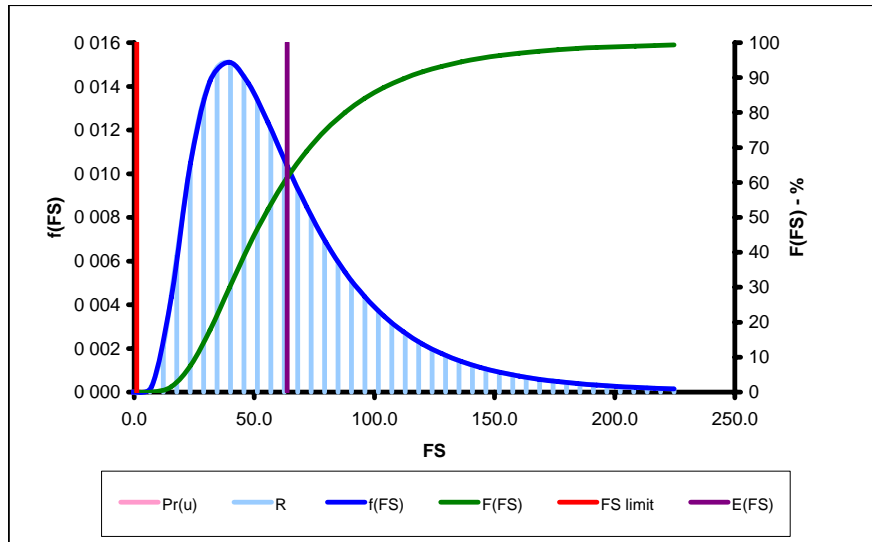
E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state  
 Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index  
 f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
49+00	982	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	930.0	63.69		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	930.0	63.69		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	930.0	63.69	0.00000	0.00
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	930.0	63.69		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	930.0	21.23	450.71290	27.84
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	930.0	68.12		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	930.0	59.27	19.58063	1.21
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	930.0	70.77		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	930.0	2.99	1148.53210	70.95
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	930.0	63.69		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	930.0	63.69	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	933.3	63.69		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	926.7	63.69	0.00000	0.00
<b>Total</b>								<b>1618.82563</b>	<b>100.00</b>



E(FS) =	63.69
σ(FS) =	40.23
V(FS) =	63.2%
E(ln FS) =	3.99
σ(ln FS) =	0.58
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	6.9
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

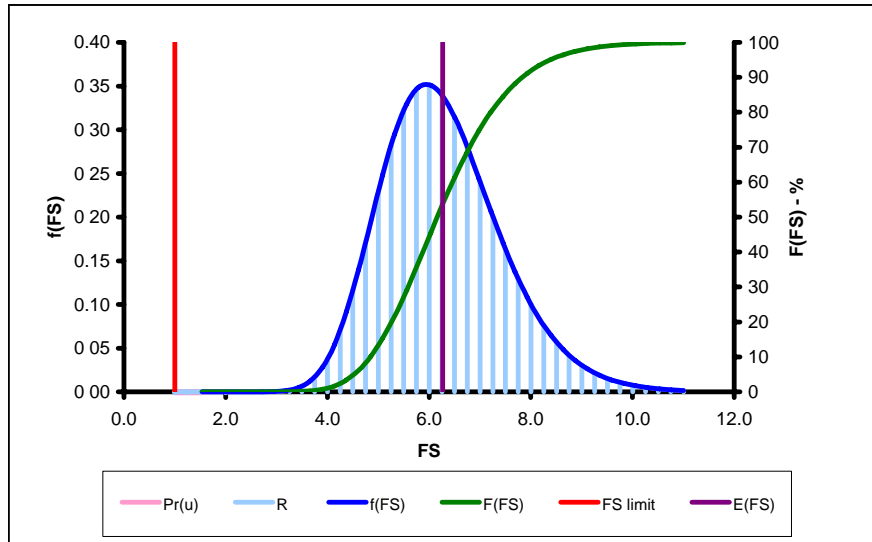
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** **Pool Elevation (ft)** **Probability of Unsatisfactory Performance Due To Through Seepage**

51+00 929

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>X<sub>ig</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>X<sub>iss</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>Y<sub>iss</sub>/K<sub>X<sub>iss</sub></sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	6.27		
Mean + 1σ K <sub>X<sub>ig</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	5.57		
Mean - 1σ K <sub>X<sub>ig</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	888.0	7.24	0.69723	49.74
Mean + 1σ K <sub>X<sub>iss</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	888.0	6.71		
Mean - 1σ K <sub>X<sub>iss</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	888.0	5.72	0.24503	17.48
Mean + 1σ K <sub>Y<sub>iss</sub>/K<sub>X<sub>iss</sub></sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	888.0	6.48		
Mean - 1σ K <sub>Y<sub>iss</sub>/K<sub>X<sub>iss</sub></sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	888.0	6.08	0.04000	2.85
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	888.0	6.70		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	888.0	5.83	0.18923	13.50
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	888.0	6.76		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	888.0	5.80	0.23040	16.44
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	888.7	6.27		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	887.3	6.27	0.00000	0.00
<b>Total</b>								<b>1.40188</b>	<b>100.00</b>



E(FS) =	6.27
σ(FS) =	1.18
V(FS) =	18.9%
E(ln FS) =	1.82
σ(ln FS) =	0.19
FS limit =	1.00
ln FS limit =	0.00

β <sub>in</sub> =	9.7
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>in</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

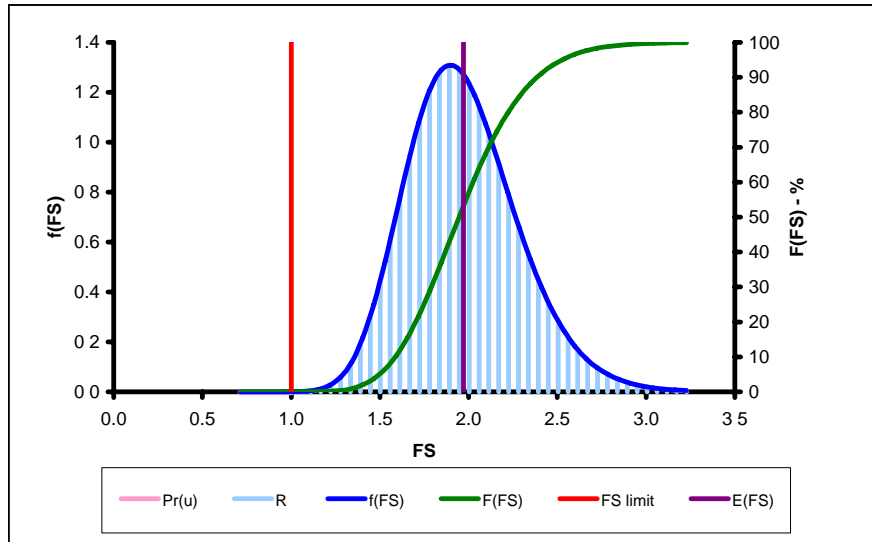
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

51+00 | 936

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	1.97		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	1.86		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	894.0	2.03	0.00722	7.30
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	894.0	2.22		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	894.0	1.91	0.02403	24.28
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	894.0	2.16		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	894.0	1.84	0.02560	25.87
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	894.0	2.11		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	894.0	1.83	0.01960	19.81
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	894.0	2.12		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	894.0	1.82	0.02250	22.74
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.7	1.97		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	893.3	1.97	0.00000	0.00
<b>Total</b>								<b>0.09895</b>	<b>100.00</b>



E(FS) =	1.97
σ(FS) =	0.31
V(FS) =	16.0%
E(ln FS) =	0.67
σ(ln FS) =	0.16
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	4.2
Pr(u) =	0.00137%
R =	99.99863%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

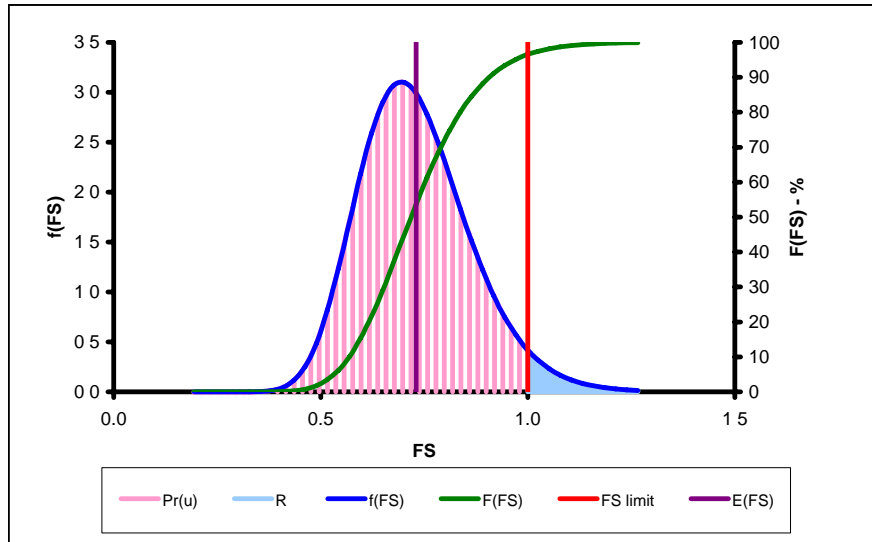
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

51+00 | 949

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	0.73		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	0.68		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	896.0	0.85	0.00722	40.25
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	896.0	0.80		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	896.0	0.68	0.00360	20.06
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	896.0	0.78		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	896.0	0.70	0.00160	8.91
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	896.0	0.78		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	896.0	0.68	0.00250	13.93
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	896.0	0.79		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	896.0	0.68	0.00303	16.85
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	897.3	0.73		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	894.7	0.73	0.00000	0.00
<b>Total</b>								<b>0.01795</b>	<b>100.00</b>



E(FS) =	0.73
σ(FS) =	0.13
V(FS) =	18.4%
E(ln FS) =	-0.33
σ(ln FS) =	0.18
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	-1.8
Pr(u) =	96.56253%
R =	3.43747%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

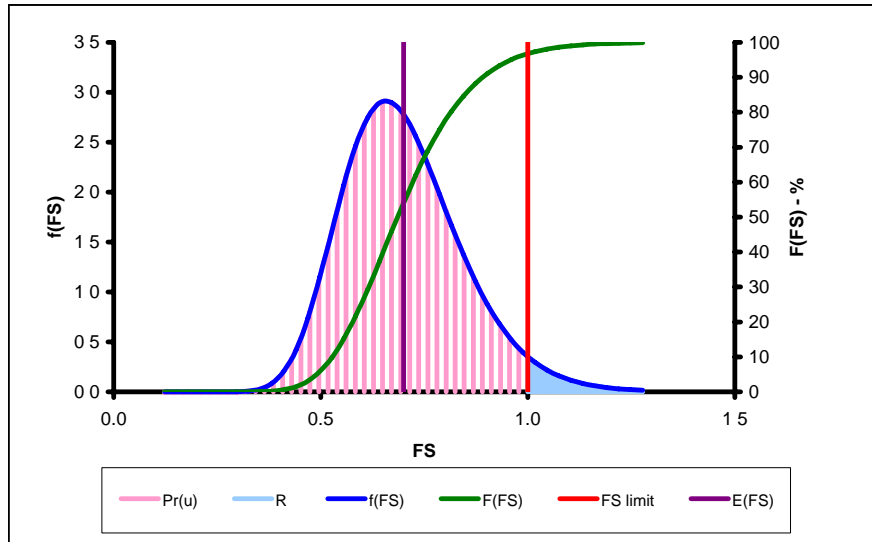
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

51+00 | 952

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	0.70		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	0.62		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	906.0	0.81	0.00903	43.34
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	906.0	0.76		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	906.0	0.65	0.00303	14.53
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	906.0	0.73		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	906.0	0.66	0.00123	5.88
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	906.0	0.74		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	906.0	0.65	0.00203	9.72
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	906.0	0.75		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	906.0	0.64	0.00303	14.53
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.0	0.79		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	904.0	0.69	0.00250	12.00
<b>Total</b>								<b>0.02083</b>	<b>100.00</b>



E(FS) =	0.70
σ(FS) =	0.14
V(FS) =	20.6%
E(ln FS) =	-0.38
σ(ln FS) =	0.20
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	-1.9
Pr(u) =	96.78644%
R =	3.21356%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

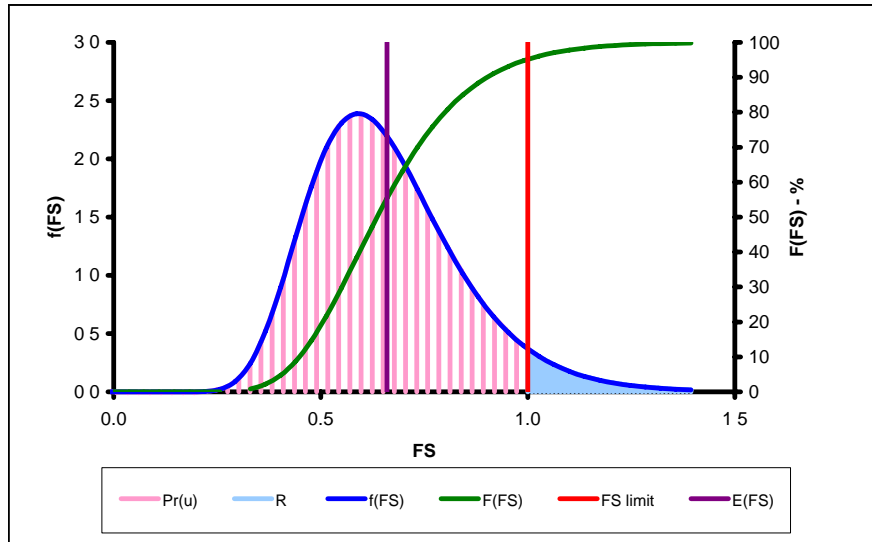
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

51+00 | 962

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xig</sub> , foundation gravel Kx (ft/s)	K <sub>xiss</sub> , foundation silty sand Kx (ft/s)	K <sub>yiss</sub> /K <sub>xiss</sub> , foundation silty sand Ky/Kx	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	0.66		
Mean + 1σ K <sub>xig</sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	0.57		
Mean - 1σ K <sub>xig</sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	0.79	0.01210	35.96
Mean + 1σ K <sub>xiss</sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	908.5	0.73		
Mean - 1σ K <sub>xiss</sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	908.5	0.60	0.00423	12.56
Mean + 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	908.5	0.78		
Mean - 1σ K <sub>yiss</sub> /K <sub>xiss</sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	908.5	0.62	0.00640	19.02
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	908.5	0.71		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	908.5	0.62	0.00203	6.02
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	908.5	0.71		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	908.5	0.61	0.00250	7.43
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	911.3	0.73		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	905.7	0.57	0.00640	19.02
<b>Total</b>								<b>0.03365</b>	<b>100.00</b>



E(FS) =	0.66
σ(FS) =	0.18
V(FS) =	27.8%
E(ln FS) =	-0.45
σ(ln FS) =	0.27
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	-1.7
Pr(u) =	95.15056%
R =	4.84944%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

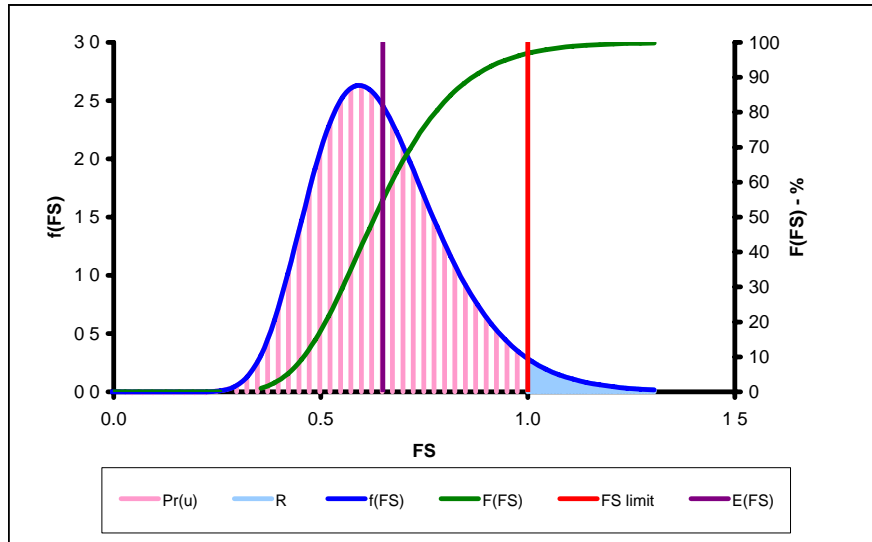
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

51+00 | 964

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>x<sub>fg</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>x<sub>fs</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	0.65		
Mean + 1σ K <sub>x<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	0.57		
Mean - 1σ K <sub>x<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	908.5	0.79	0.01210	45.11
Mean + 1σ K <sub>x<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	908.5	0.73		
Mean - 1σ K <sub>x<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	908.5	0.61	0.00360	13.42
Mean + 1σ K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	908.5	0.68		
Mean - 1σ K <sub>y<sub>fs</sub></sub> /K <sub>x<sub>fs</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	908.5	0.63	0.00063	2.33
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	908.5	0.70		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	908.5	0.62	0.00160	5.96
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	908.5	0.70		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	908.5	0.60	0.00250	9.32
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	911.3	0.73		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	905.7	0.57	0.00640	23.86
<b>Total</b>								<b>0.02683</b>	<b>100.00</b>



E(FS) =	0.65
σ(FS) =	0.16
V(FS) =	25.2%
E(ln FS) =	-0.46
σ(ln FS) =	0.25
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	-1.9
Pr(u) =	96.85808%
R =	3.14192%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed



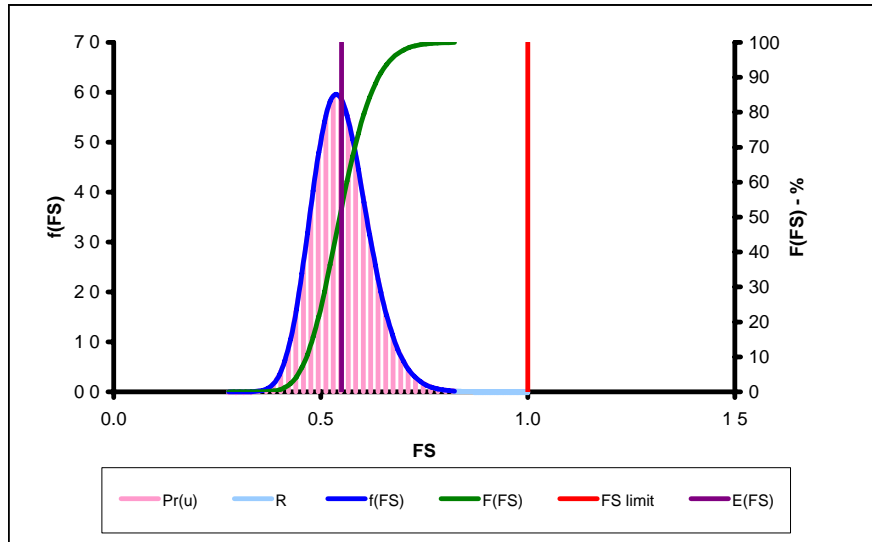
**Bolivar Dam Seepage Reliability Analysis - Base Condition**

**Station** | **Pool Elevation (ft)** | **Probability of Unsatisfactory Performance Due To Through Seepage**

51+00 | 982

**Taylor's Series Results**

Case	Random Variables						FS <sub>(progressive erosion)</sub> (Through Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>X<sub>fg</sub></sub> , foundation gravel K <sub>x</sub> (ft/s)	K <sub>X<sub>fs</sub></sub> , foundation silty sand K <sub>x</sub> (ft/s)	K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub> , foundation silty sand K <sub>y</sub> /K <sub>x</sub>	γ <sub>sat</sub> , unit weight (pcf)	φ, friction angle (degrees)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	0.55		
Mean + 1σ K <sub>X<sub>fg</sub></sub>	4.1E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	0.51		
Mean - 1σ K <sub>X<sub>fg</sub></sub>	2.5E-02	2.8E-03	8.5E-02	120.0	33.0	930.0	0.60	0.00203	43.55
Mean + 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	3.4E-03	8.5E-02	120.0	33.0	930.0	0.56		
Mean - 1σ K <sub>X<sub>fs</sub></sub>	3.3E-02	2.2E-03	8.5E-02	120.0	33.0	930.0	0.54	0.00010	2.15
Mean + 1σ K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub>	3.3E-02	2.8E-03	1.1E-01	120.0	33.0	930.0	0.55		
Mean - 1σ K <sub>Y<sub>fs</sub></sub> /K <sub>X<sub>fs</sub></sub>	3.3E-02	2.8E-03	6.4E-02	120.0	33.0	930.0	0.54	0.00003	0.54
Mean + 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	124.0	33.0	930.0	0.59		
Mean - 1σ γ <sub>sat</sub>	3.3E-02	2.8E-03	8.5E-02	116.0	33.0	930.0	0.51	0.00160	34.41
Mean + 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	35.0	930.0	0.55		
Mean - 1σ φ	3.3E-02	2.8E-03	8.5E-02	120.0	31.0	930.0	0.55	0.00000	0.00
Mean + 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	933.3	0.59		
Mean - 1σ TW	3.3E-02	2.8E-03	8.5E-02	120.0	33.0	926.7	0.53	0.00090	19.35
<b>Total</b>								<b>0.00465</b>	<b>100.00</b>



E(FS) =	0.55
σ(FS) =	0.07
V(FS) =	12.4%
E(ln FS) =	-0.61
σ(ln FS) =	0.12
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	-4.9
Pr(u) =	99.99995%
R =	0.00005%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

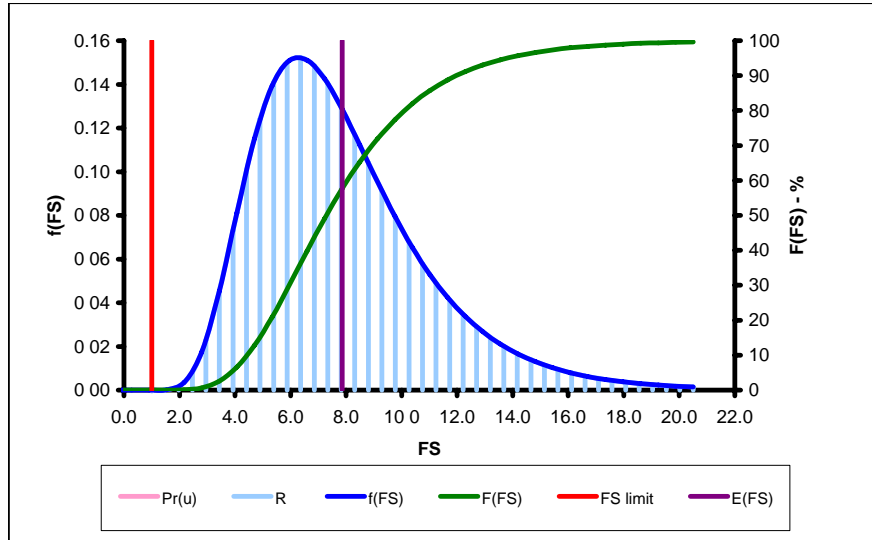
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
51+00	929	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	Y <sub>sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	888.0	7.86		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	888.0	7.86		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	888.0	7.86	0.00000	0.00
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	888.0	8.17		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	888.0	4.25	3.84160	38.44
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	888.0	8.41		
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	888.0	7.32	0.29703	2.97
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	888.0	7.86		
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	888.0	3.02	5.85640	58.59
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	888.0	7.86		
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	888.0	7.86	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	888.7	7.86		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	887.3	7.86	0.00000	0.00
							<b>Total</b>	<b>9.99503</b>	<b>100.00</b>



E(FS) =	7.86
σ(FS) =	3.16
V(FS) =	40.2%
E(ln FS) =	1.99
σ(ln FS) =	0.39
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.1
Pr(u) =	0.00001%
R =	99.99999%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

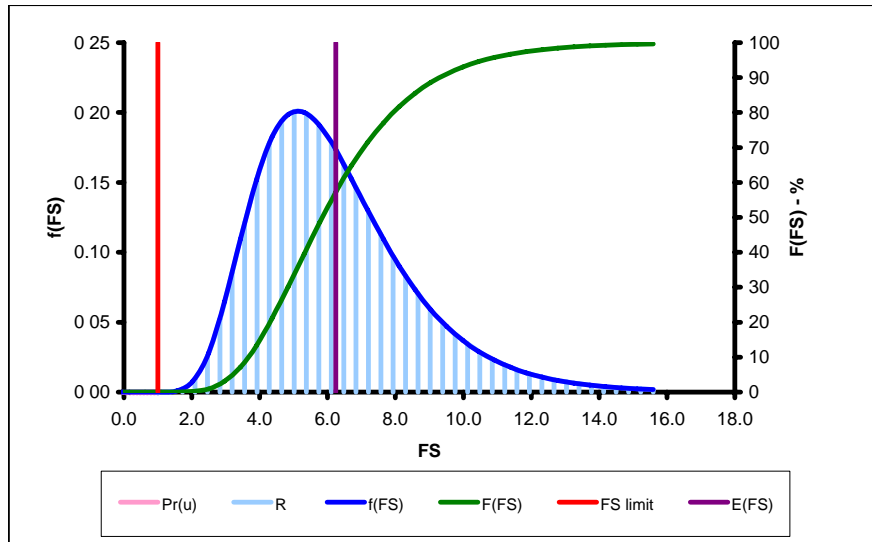
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
51+00	936	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	894.0	6.24		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	894.0	6.24		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	894.0	6.24	0.00000	0.00
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	894.0	6.63		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	894.0	3.54	2.38703	43.63
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	894.0	6.68		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	894.0	5.81	0.18923	3.46
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	894.0	6.24		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	894.0	3.00	2.62440	47.97
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	894.0	6.24		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	894.0	6.24	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	894.7	6.63		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	893.3	5.59	0.27040	4.94
<b>Total</b>								<b>5.47105</b>	<b>100.00</b>



E(FS) =	6.24
σ(FS) =	2.34
V(FS) =	37.5%
E(ln FS) =	1.77
σ(ln FS) =	0.36
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	4.9
Pr(u) =	0.00006%
R =	99.99994%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

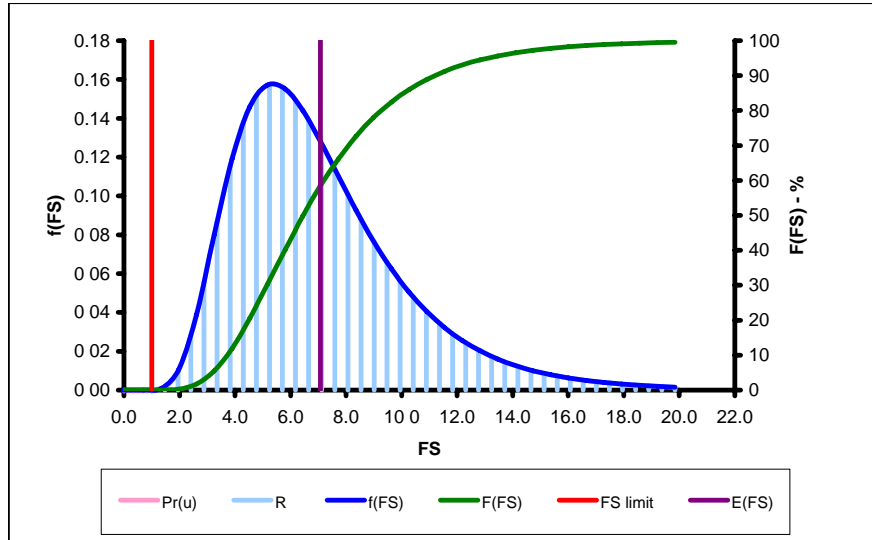
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
51+00	949	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)	
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	Y <sub>sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)				
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	896.0	7.08			
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	896.0	7.08			
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	896.0	6.63	0.05063	0.50	
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	896.0	7.08			
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	896.0	2.36	5.56960	54.74	
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	896.0	7.57			
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	896.0	6.59	0.24010	2.36	
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	896.0	7.08			
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	896.0	2.95	4.26423	41.91	
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	896.0	7.08			
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	896.0	7.08	0.00000	0.00	
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	897.3	7.08			
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	894.7	6.63	0.05063	0.50	
<b>Total</b>							<b>10.17518</b>	<b>100.00</b>		



E(FS) =	7.08
σ(FS) =	3.19
V(FS) =	45.1%
E(ln FS) =	1.86
σ(ln FS) =	0.43
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	4.3
Pr(u) =	0.00072%
R =	99.99928%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

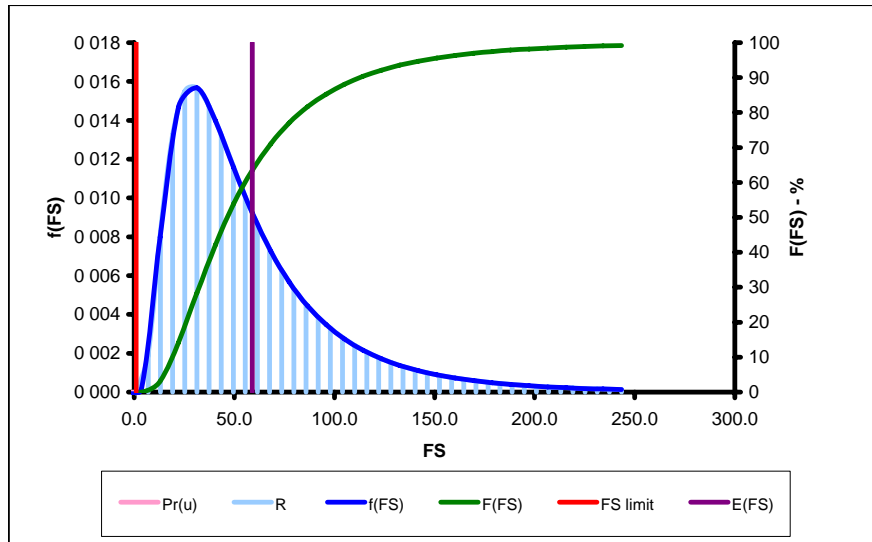
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
51+00	952	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	906.0	58.97		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	906.0	58.97		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	906.0	50.55	17.72410	0.83
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	906.0	63.69		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	906.0	13.27	635.54410	29.91
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	906.0	63.07		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	906.0	54.88	16.76903	0.79
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	906.0	58.97		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	906.0	2.99	783.44010	36.87
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	906.0	58.97		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	906.0	58.97	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.0	62.44		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	904.0	10.62	671.32810	31.59
Total							2124.80543	100.00	



E(FS) =	58.97
σ(FS) =	46.10
V(FS) =	78.2%
E(ln FS) =	3.84
σ(ln FS) =	0.69
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.6
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

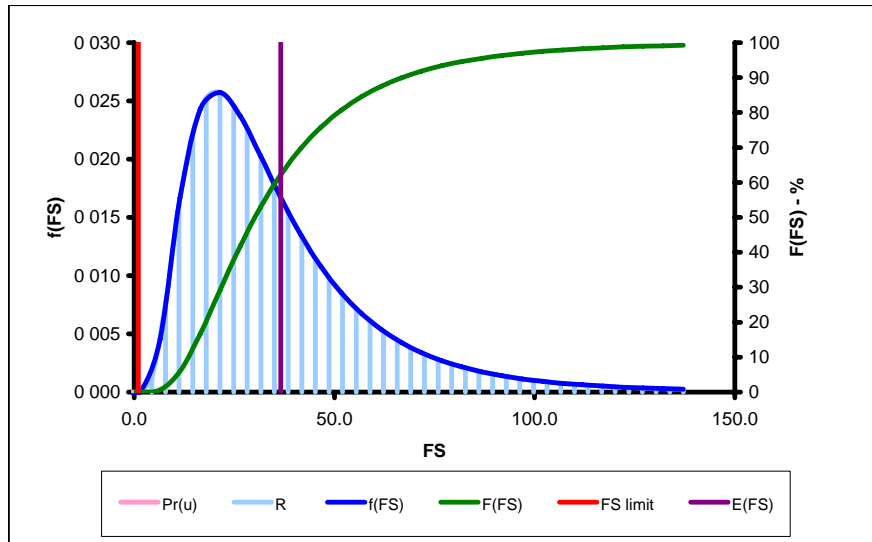
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
51+00	962	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.5	36.60		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.5	36.60		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	908.5	31.22	7.23610	1.15
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	908.5	44.23		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	908.5	7.58	335.80563	53.14
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	908.5	39.15		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	908.5	34.06	6.47702	1.02
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	908.5	36.60		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	908.5	3.12	280.22760	44.34
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	908.5	36.60		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	908.5	35.38	0.37210	0.06
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	911.3	39.32		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	905.7	36.60	1.84960	0.29
<b>Total</b>								<b>631.96805</b>	<b>100.00</b>



E(FS) =	36.60
σ(FS) =	25.14
V(FS) =	68.7%
E(ln FS) =	3.41
σ(ln FS) =	0.62
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.5
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

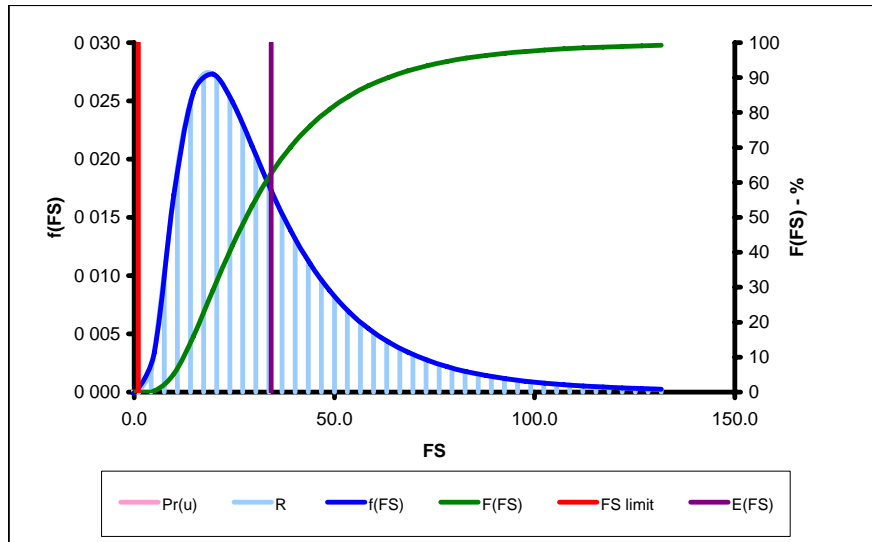
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
51+00	964	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.5	34.24		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	908.5	34.24		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	908.5	30.77	3.01023	0.51
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	908.5	44.23		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	908.5	7.32	340.58703	57.43
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	908.5	36.62		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	908.5	31.87	5.64062	0.95
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	908.5	34.24		
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	908.5	3.12	242.11360	40.83
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	908.5	34.24		
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	908.5	33.17	0.28623	0.05
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	911.3	36.60		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	905.7	34.24	1.39240	0.23
<b>Total</b>								<b>593.03010</b>	<b>100.00</b>



E(FS) =	34.24
σ(FS) =	24.35
V(FS) =	71.1%
E(ln FS) =	3.33
σ(ln FS) =	0.64
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.2
Pr(u) =	0.00001%
R =	99.99999%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

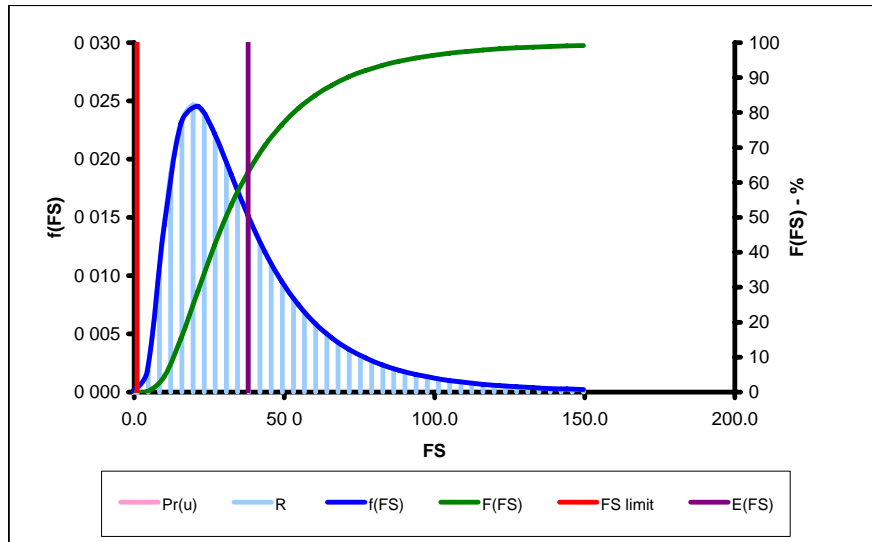
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
51+00	982	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	930.0	37.91		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	6.0	1.6E-01	930.0	37.91		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	6.0	1.6E-01	930.0	35.38	1.60022	0.21
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	6.0	1.6E-01	930.0	50.55		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	6.0	1.6E-01	930.0	8.17	449.01610	57.57
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	6.0	1.6E-01	930.0	40.54		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	6.0	1.6E-01	930.0	32.58	15.84040	2.03
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	7.5	1.6E-01	930.0	37.91		
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	4.5	1.6E-01	930.0	2.99	304.85160	39.09
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	3.0E-01	930.0	37.91		
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	6.0	1.6E-02	930.0	37.91	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	933.3	42.46		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	6.0	1.6E-01	926.7	36.60	8.58490	1.10
<b>Total</b>							<b>779.89323</b>	<b>779.89323</b>	<b>100.00</b>



E(FS) =	37.91
σ(FS) =	27.93
V(FS) =	73.7%
E(ln FS) =	3.42
σ(ln FS) =	0.66
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.2
Pr(u) =	0.00001%
R =	99.99999%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

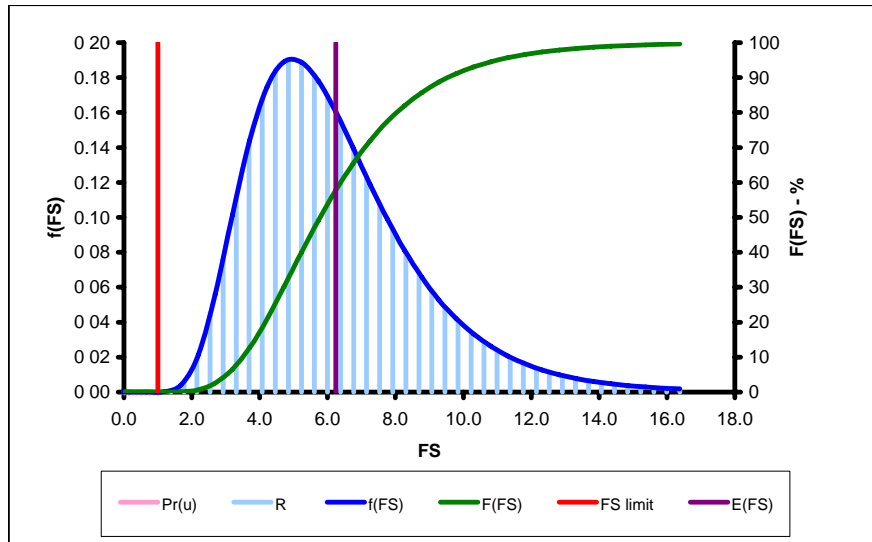


**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
57+00	929	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	888.0	6.24		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	11.0	1.6E-01	888.0	6.24		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	11.0	1.6E-01	888.0	6.24	0.00000	0.00
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	11.0	1.6E-01	888.0	6.63		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	11.0	1.6E-01	888.0	2.99	3.31240	51.55
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	11.0	1.6E-01	888.0	6.68		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	11.0	1.6E-01	888.0	5.81	0.18923	2.94
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	14.0	1.6E-01	888.0	6.24		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	8.0	1.6E-01	888.0	2.82	2.92410	45.51
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	3.0E-01	888.0	6.24		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	1.6E-02	888.0	6.24	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	888.7	6.24		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	887.3	6.24	0.00000	0.00
<b>Total</b>							<b>6.42573</b>	<b>6.42573</b>	<b>100.00</b>



E(FS) =	6.24
σ(FS) =	2.53
V(FS) =	40.6%
E(ln FS) =	1.75
σ(ln FS) =	0.39
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	4.5
Pr(u) =	0.00036%
R =	99.99964%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

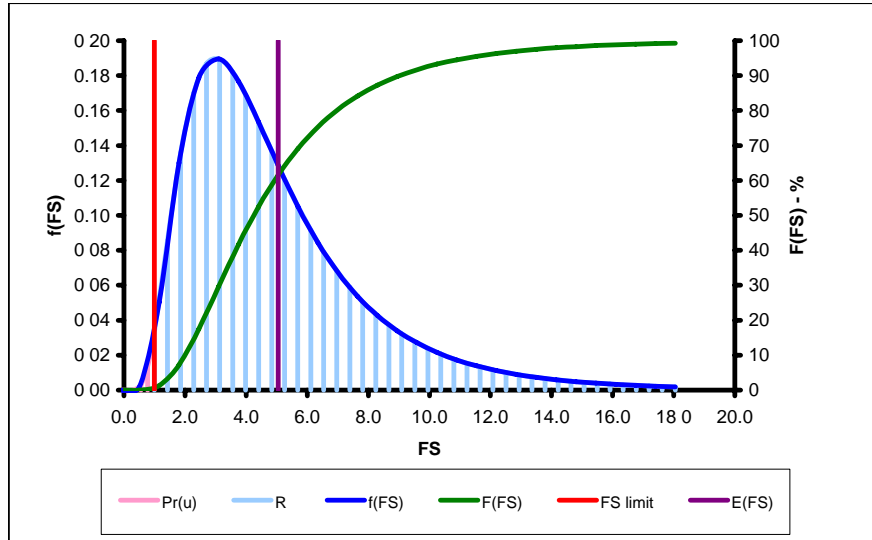
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
57+00	936	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	K <sub>x</sub> <sub>rw</sub> , relief well Kx (ft/s)	K <sub>y</sub> <sub>B</sub> , D/S blanket Ky (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>t</sub> <sub>D/S</sub> , D/S blanket thickness (ft)	K <sub>x</sub> <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	894.0	5.05		
Mean + 1σ K <sub>x</sub> <sub>rw</sub>	6.3E-03	1.7E-04	120.0	11.0	1.6E-01	894.0	5.05		
Mean - 1σ K <sub>x</sub> <sub>rw</sub>	3.3E-04	1.7E-04	120.0	11.0	1.6E-01	894.0	5.05	0.00000	0.00
Mean + 1σ K <sub>y</sub> <sub>B</sub>	3.3E-03	3.3E-04	120.0	11.0	1.6E-01	894.0	7.58		
Mean - 1σ K <sub>y</sub> <sub>B</sub>	3.3E-03	7.0E-06	120.0	11.0	1.6E-01	894.0	1.52	9.18090	86.93
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	11.0	1.6E-01	894.0	5.41		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	11.0	1.6E-01	894.0	4.70	0.12603	1.19
Mean + 1σ B <sub>t</sub> <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	14.0	1.6E-01	894.0	5.05		
Mean - 1σ B <sub>t</sub> <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	8.0	1.6E-01	894.0	2.81	1.25440	11.88
Mean + 1σ K <sub>x</sub> <sub>rt</sub>	3.3E-03	1.7E-04	120.0	11.0	3.0E-01	894.0	5.05		
Mean - 1σ K <sub>x</sub> <sub>rt</sub>	3.3E-03	1.7E-04	120.0	11.0	1.6E-02	894.0	5.05	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	894.7	5.05		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	893.3	5.05	0.00000	0.00
<b>Total</b>								<b>10.56133</b>	<b>100.00</b>



E(FS) =	5.05
σ(FS) =	3.25
V(FS) =	64.4%
E(ln FS) =	1.45
σ(ln FS) =	0.59
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	2.5
Pr(u) =	0.70115%
R =	99.29885%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

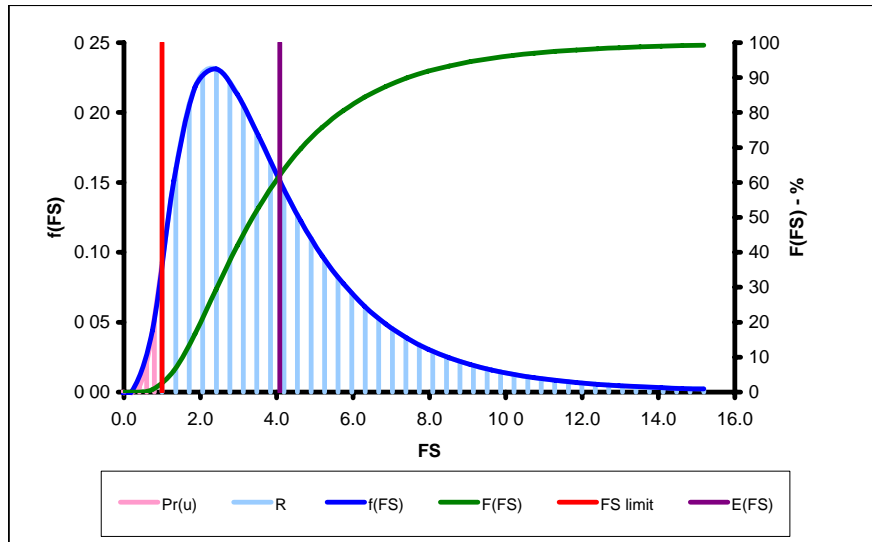
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
57+00	949	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	Kx <sub>rw</sub> , relief well Kx (ft/s)	Ky <sub>B</sub> , D/S blanket Ky (ft/s)	Y <sub>sat</sub> , unit weight (pcf)	Bt <sub>D/S</sub> , D/S blanket thickness (ft)	Kx <sub>rt</sub> , rock toe Kx (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	896.0	4.08		
Mean + 1σ Kx <sub>rw</sub>	6.3E-03	1.7E-04	120.0	11.0	1.6E-01	896.0	4.08		
Mean - 1σ Kx <sub>rw</sub>	3.3E-04	1.7E-04	120.0	11.0	1.6E-01	896.0	4.08	0.00000	0.00
Mean + 1σ Ky <sub>B</sub>	3.3E-03	3.3E-04	120.0	11.0	1.6E-01	896.0	6.63		
Mean - 1σ Ky <sub>B</sub>	3.3E-03	7.0E-06	120.0	11.0	1.6E-01	896.0	1.29	7.12890	92.52
Mean + 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	124.0	11.0	1.6E-01	896.0	4.37		
Mean - 1σ Y <sub>sat</sub>	3.3E-03	1.7E-04	116.0	11.0	1.6E-01	896.0	3.80	0.08123	1.05
Mean + 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	14.0	1.6E-01	896.0	4.08		
Mean - 1σ Bt <sub>D/S</sub>	3.3E-03	1.7E-04	120.0	8.0	1.6E-01	896.0	2.78	0.42250	5.48
Mean + 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	11.0	3.0E-01	896.0	4.08		
Mean - 1σ Kx <sub>rt</sub>	3.3E-03	1.7E-04	120.0	11.0	1.6E-02	896.0	4.08	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	897.3	4.62		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	894.7	4.08	0.07290	0.95
<b>Total</b>								<b>7.70553</b>	<b>100.00</b>



E(FS) =	4.08
σ(FS) =	2.78
V(FS) =	68.0%
E(ln FS) =	1.22
σ(ln FS) =	0.62
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	2.0
Pr(u) =	2.43419%
R =	97.56581%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

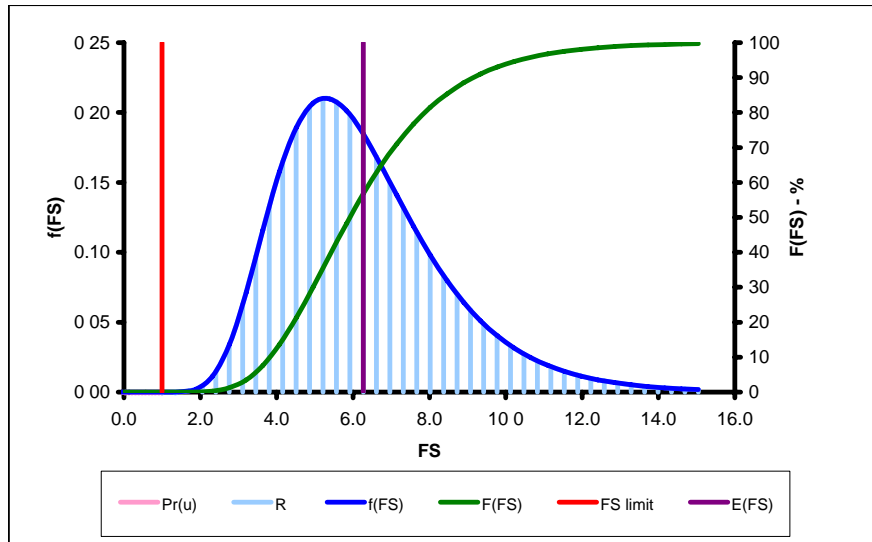
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
57+00	952	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	906.0	6.27		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	11.0	1.6E-01	906.0	6.27		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	11.0	1.6E-01	906.0	6.27	0.00000	0.00
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	11.0	1.6E-01	906.0	6.27		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	11.0	1.6E-01	906.0	4.25	1.02010	21.22
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	11.0	1.6E-01	906.0	6.70		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	11.0	1.6E-01	906.0	5.83	0.18923	3.94
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	14.0	1.6E-01	906.0	6.27		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	8.0	1.6E-01	906.0	2.74	3.11523	64.80
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	3.0E-01	906.0	6.27		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	1.6E-02	906.0	6.27	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	908.0	7.66		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	904.0	6.27	0.48303	10.05
<b>Total</b>								<b>4.80758</b>	<b>100.00</b>



E(FS) =	6.27
σ(FS) =	2.19
V(FS) =	35.0%
E(ln FS) =	1.78
σ(ln FS) =	0.34
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.2
Pr(u) =	0.00001%
R =	99.99999%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

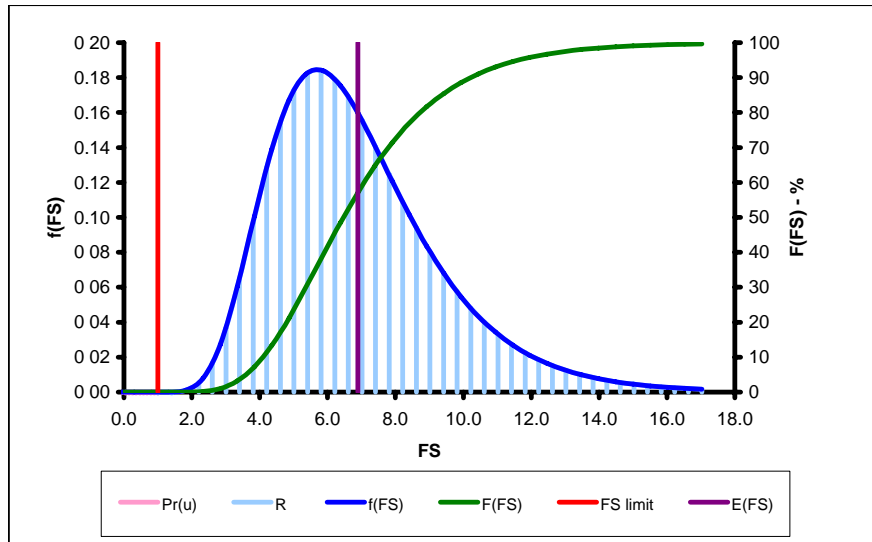
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
57+00	962	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	908.5	6.89		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	11.0	1.6E-01	908.5	6.89		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	11.0	1.6E-01	908.5	6.24	0.10563	1.64
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	11.0	1.6E-01	908.5	7.34		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	11.0	1.6E-01	908.5	5.30	1.04040	16.19
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	11.0	1.6E-01	908.5	7.37		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	11.0	1.6E-01	908.5	6.41	0.23040	3.59
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	14.0	1.6E-01	908.5	6.89		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	8.0	1.6E-01	908.5	2.79	4.20250	65.41
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	3.0E-01	908.5	6.89		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	1.6E-02	908.5	6.89	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	911.3	7.58		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	905.7	5.74	0.84640	13.17
<b>Total</b>								<b>6.42533</b>	<b>100.00</b>



E(FS) =	6.89
σ(FS) =	2.53
V(FS) =	36.8%
E(ln FS) =	1.87
σ(ln FS) =	0.36
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.2
Pr(u) =	0.00001%
R =	99.99999%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

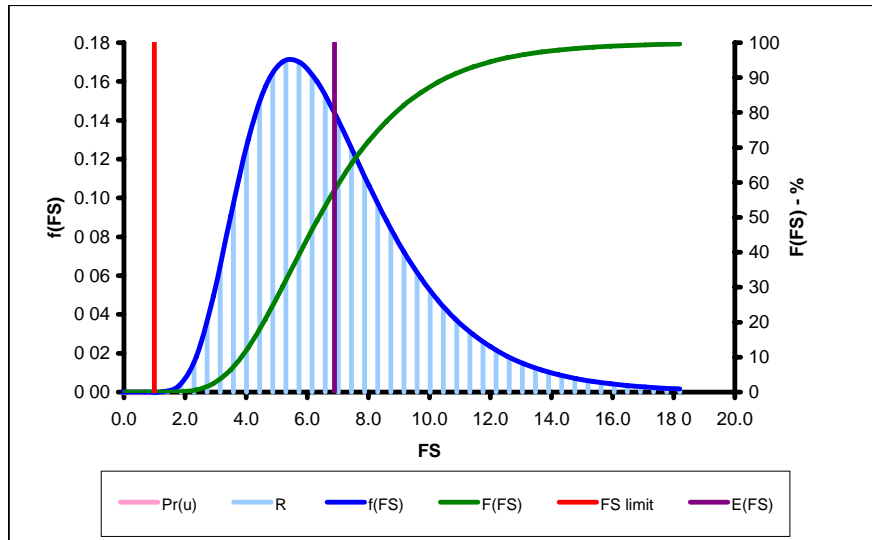
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

<b>Station</b>	<b>Pool Elevation (ft)</b>	<b>Probability of Unsatisfactory Performance Due To Under Seepage</b>
57+00	964	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> <b>(Under Seepage)</b>	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	908.5	6.89		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	11.0	1.6E-01	908.5	6.89		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	11.0	1.6E-01	908.5	5.74	0.33063	4.13
Mean + 1σ K <sub>yB</sub>	3.3E-03	1.0E+00	120.0	11.0	1.6E-01	908.5	7.34		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	11.0	1.6E-01	908.5	4.25	2.38703	29.85
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	11.0	1.6E-01	908.5	7.37		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	11.0	1.6E-01	908.5	6.41	0.23040	2.88
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	14.0	1.6E-01	908.5	6.89		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	8.0	1.6E-01	908.5	2.79	4.20250	52.55
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	3.0E-01	908.5	6.89		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	1.6E-02	908.5	6.89	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	911.3	7.58		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	905.7	5.74	0.84640	10.58
<b>Total</b>								<b>7.99695</b>	<b>100.00</b>



E(FS) =	6.89
σ(FS) =	2.83
V(FS) =	41.0%
E(ln FS) =	1.85
σ(ln FS) =	0.39
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	4.7
Pr(u) =	0.00013%
R =	99.99987%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

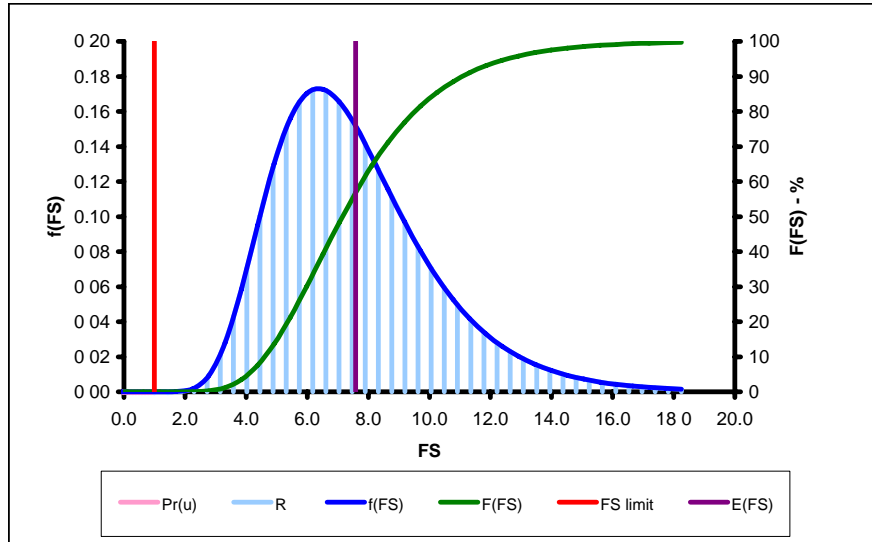
f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed

**Bolivar Dam Seepage Reliability Analysis - Base Condition**

Station	Pool Elevation (ft)	Probability of Unsatisfactory Performance Due To Under Seepage
57+00	982	

**Taylor's Series Results**

Case	Random Variables						FS <sup>(progressive erosion)</sup> (Under Seepage)	Variance (FS)	% of Variance (FS)
	K <sub>xrw</sub> , relief well K <sub>x</sub> (ft/s)	K <sub>yB</sub> , D/S blanket K <sub>y</sub> (ft/s)	γ <sub>sat</sub> , unit weight (pcf)	B <sub>tD/S</sub> , D/S blanket thickness (ft)	K <sub>xrt</sub> , rock toe K <sub>x</sub> (ft/s)	TW, tail water elevation (ft)			
Mean (Expected)	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	930.0	7.58		
Mean + 1σ K <sub>xrw</sub>	6.3E-03	1.7E-04	120.0	11.0	1.6E-01	930.0	7.58		
Mean - 1σ K <sub>xrw</sub>	3.3E-04	1.7E-04	120.0	11.0	1.6E-01	930.0	7.58	0.00000	0.00
Mean + 1σ K <sub>yB</sub>	3.3E-03	3.3E-04	120.0	11.0	1.6E-01	930.0	7.58		
Mean - 1σ K <sub>yB</sub>	3.3E-03	7.0E-06	120.0	11.0	1.6E-01	930.0	5.59	0.99003	13.90
Mean + 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	124.0	11.0	1.6E-01	930.0	8.11		
Mean - 1σ γ <sub>sat</sub>	3.3E-03	1.7E-04	116.0	11.0	1.6E-01	930.0	7.06	0.27563	3.87
Mean + 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	14.0	1.6E-01	930.0	7.58		
Mean - 1σ B <sub>tD/S</sub>	3.3E-03	1.7E-04	120.0	8.0	1.6E-01	930.0	2.74	5.85640	82.23
Mean + 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	3.0E-01	930.0	7.58		
Mean - 1σ K <sub>xrt</sub>	3.3E-03	1.7E-04	120.0	11.0	1.6E-02	930.0	7.58	0.00000	0.00
Mean + 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	933.3	7.58		
Mean - 1σ TW	3.3E-03	1.7E-04	120.0	11.0	1.6E-01	926.7	7.58	0.00000	0.00
<b>Total</b>								7.12205	100.00



E(FS) =	7.58
σ(FS) =	2.67
V(FS) =	35.2%
E(ln FS) =	1.97
σ(ln FS) =	0.34
FS limit =	1.00
ln FS limit =	0.00

β <sub>ln</sub> =	5.8
Pr(u) =	0.00000%
R =	100.00000%

E(X) = expected (mean) value for X; σ(X) = standard deviation for X; V(X) = coefficient of variation for X; FS = factor of safety; FS limit = FS limit state

Pr(u) = probability of unsatisfactory performance = probability that FS against progressive erosion is less than 1.0; R = reliability = 1-Pr(u); β<sub>ln</sub> = reliability index

f(FS) is a probability density function (PDF); F(FS) is a cumulative distribution function (CDF); FS assumed lognormally distributed