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ANNUAL EROSION POTENTIAL FOR DESERT HARBOR ALONG NEW RIVER

MATHEWS KESSLER & ASSOCIATES, INC.

371.949

MATHEWS KESSLER & ASSOCIATES, INC.
4045 E. McDOWELL ROAD, PHOENIX, ARIZONA 85008-4405
602/244-2664

March 15, 1989

Mr. Elden Johansen, P.E.
City Engineer
City of Peoria
P.O. Box 38
Peoria, Arizona 85345

ATTN: Dan L. Nissen, P.E.

RE: Annual Erosion Potential for Desert Harbor Along New River

Dear Dan,

As you requested, we have reviewed the Ellis-Murphy report entitled "DESERT HARBOR EROSION STUDY", September 1988, in an effort to develop an estimate of the annual costs that the City of Peoria might incur in maintaining approximately 8,000 L.F. of unprotected bankline along New River.

We are submitting with this letter an estimate of the annual volume of bank material that might be lost. Although we have no knowledge of your force account capability for replacing eroded material, we have assumed that the City would probably contract for such repair. Based on recent figures that we have used in construction estimates with similar haul distances and working area, we would estimate that the in-place cost of fill material would be somewhere in the $2.00 to $5.00 range depending upon source and conveyance method of the fill material. Whatever unit cost the City feels is reasonable can be applied directly to the annual erosion volume listed in Tables 1, 2, 3, or 4 to get an annual maintenance cost.

We did not review the Ellis-Murphy report with the intent of providing a technical critique of methodology, however, we did leave a few red-lined comments in the margins of the report. They conclude (page 8) that erosion will probably occur, but that they prefer to delay construction of any permanent bank protection until after major damage is documented.

The Ellis-Murphy report appears to have one major error. Page 18 of the HEC-2 output data indicates a Q_{100} = 19,000 cfs was used for Skunk Creek, above the confluence with New River, while Q_{100} = 35,000 cfs was used for New River above the confluence. The data in the 1985 SLA report (*Final Sediment Transport Study for New River & Skunk Creek*) indicates these numbers should be reversed, i.e., 35,000 cfs up Skunk Creek and 19000 cfs up New River. In fact, page 3 of the Ellis-Murphy report also acknowledges the 19,000 cfs value for New River. Perhaps their cross-section numbering on the vicinity map has been mixed up. They should be asked to check this.

Enclosed is the complete documentation for the technical procedure that has been developed to estimate the annual erosion potential. The approach is based on the probability that specific amounts of erosion will occur for floods of different frequencies. This is similar to an average annual benefit calculation, i.e., the volume of erosion for different flood events is plotted as a function of the annual probability of occurrence. The area under the resulting curve is the volume (c.y.) of erosion per year.

To assist in review of this documentation, the major steps in the procedure are outlined as follows:

1. Determine Q_p for 100-, 50-, 25-, 10-, 5-, and 2-year events. The Q_{100}, Q_{50}, Q_{25}, and Q_{10} were taken from the 1985 SLA report. This data was plotted on log-normal probability paper to extrapolate values for Q_{10}, Q_5, and Q_2.

2. A typical trapezoidal cross-section was developed for this reach of New River using data in the Ellis-Murphy report, the 1985 SLA report, and site photos.

   Using the range of Q_p values developed in Step 1, normal-depth calculations (Mannings Equation) were performed for this "typical" cross-section.

3. The hydraulic data from Step 2 was used to compute a maximum cross-sectional shear stress corresponding to each of the peak discharge values from Step 1.

4. Using sieve analysis data from the Ellis-Murphy report, a D_{50} = 2mm was determined to be representative of the west river bank adjacent to Desert Harbor. The critical shear stress (at incipient motion) was computed for this particle size and compared to the predicted cross-sectional shear stresses

computed for each flood event (Step 3). If the actual shear stress was greater than the critical particle shear stress, erosion was assumed to occur. As you will note from the technical documentation, erosion is predicted for all events because of the extremely low allowable (critical) shear stress for a 2mm diameter particle.

5. Using the data from Steps 3 and 4, an estimate was made of the anticipated erosion geometry. This geometry was developed as a function of the flow depth and the angle of repose of the bank material. As will be seen from reviewing Tables 1, 2, 3, and 4, several ratios of the maximum flow depth were examined during this analysis. Obviously, considerable judgement is involved in selecting this geometry.

6. Again, using engineering judgement, an estimate was made of the percentage of bank line (L.F.) that would be eroded during a specific flood event. This length was then multiplied by the erosion volume (c.y.) that would occur during each flood event. The erosion lengths that were used in this step were a function of flood return interval.

   A total west bank length of 8,000 L.F. was measured from the Ellis-Murphy vicinity map. This length extends from Greenway Road to about 1,300 feet south of Thunderbird Road. A total length of 6,600 feet was used below the Skunk Creek confluence, and 1,400 feet was used above the confluence. Ellis-Murphy HEC-2 XSEC 35.0 was used as the break point for the New River/Skunk Creek confluence.

7. The erosion volumes from Step 6 were plotted as a function of the annual probability of occurrence and the computed area under the resulting curve was taken as the annual volume of bank erosion.

Due to the substantial amount of judgement that was involved in this procedure, we recommend using the figures in Table 4. This table is the most conservative of the four scenarios, since it assumes an erosion depth equal to the full depth of flow, and also uses greater percentages of eroded bank length for each event.

If you would like to discuss this in any more detail, give me a call. Thanks for asking MKA to prepare this analysis.

Sincerely,

W. D. Mathews

William D. Mathews, P.E., R.L.S.
President
Mathews Kessler & Associates, Inc.

WDM:ss
Enclosures: Technical Documentation

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DESERT HARBOR
ANNUAL EROSION ANALYSIS

Technical Documentation

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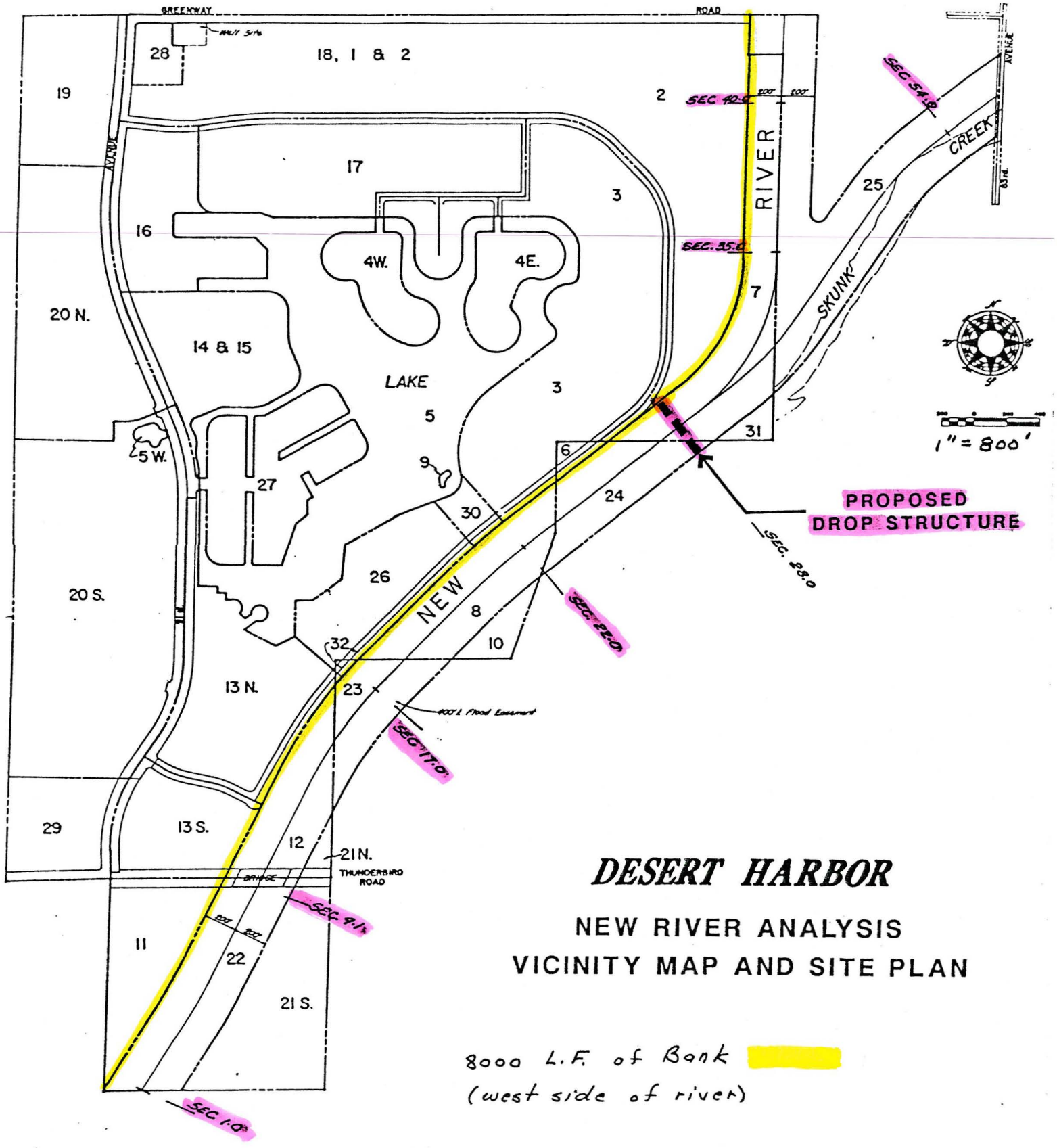

DESERT HARBOR

NEW RIVER ANALYSIS
VICINITY MAP AND SITE PLAN

8000 L.F. of Bank
(west side of river)

Client City of Peoria
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Peak Discharge Values to be Used For Erosion Analysis at Desert Harbor

Procedure:

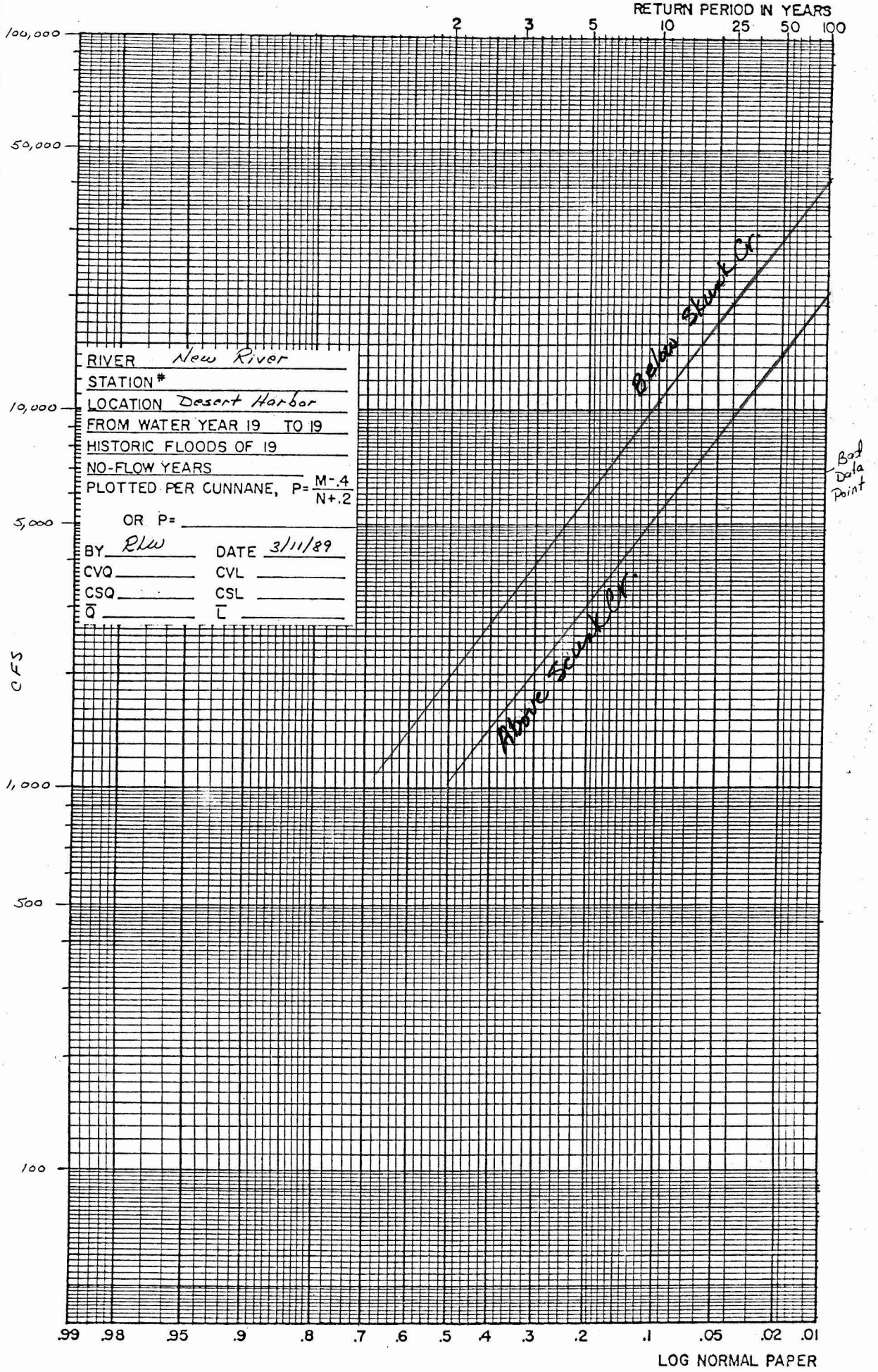
1. The 100-, 50-, 25-, & 10-year peak discharge values for New River & Skunk Creek are listed in Table 3.3 of the 1985 SLA report

   Data from these four events will be plotted on Log-Normal probility paper to generate an estimate of the peak discharge for the 5- & 2-year events (see Figure 1, attached).

2. The published Q_{25} in the SLA report for New River, u/s of the confluence with Skunk Creek, appears to be in error. This data point plots well off of a linear relationship through the remaining data points. The Q_{25}/Q_{50} for this site was only 42.1% compared to about 66% for the other sites. Accordingly, the SLA data point was discarded & a value of 9900 cfs was used for Q_{25}. This revised value (9900 cfs) fits the linear relation generated by the remaining data points.

Return Interval (yr.)	New River, u/s of Confluence with Skunk Creek	New River, D/S of Confluence with Skunk Creek
100	19,000	41,000
50	14,000	29,000
25	9,900 (5900)[1]	19,000
10	5,100	10,500
5	3,050	6,000
2	1,030	1,995

[1] 5900 cfs was published in SLA report.


RETURN PERIOD IN YEARS
2
3
5
10
25
50
100
100,000
50,000
10,000
5,000
1,000
500
100
CFS
RIVER New River
STATION #
LOCATION Desert Harbor
FROM WATER YEAR 19 TO 19
HISTORIC FLOODS OF 19
NO-FLOW YEARS
PLOTTED PER CUNNANE, P= M-.4 / N+.2
OR P=
BY RLW
DATE 3/11/89
CVQ
CVL
CSQ
CSL
Q̄
L̄
Below Skunk Cr
Above Skunk Cr
Bad Data Point
.99
.98
.95
.9
.8
.7
.6
.5
.4
.3
.2
.1
.05
.02
.01
LOG NORMAL PAPER

Development of Hydraulic Data For Erosion Analysis at Desert Harbor

Procedure:

1. Since no channel geometry was provided with the HEC-2 run included in the Ellis-Murphy (EM) report, a probable channel cross-section was developed on the basis of site photos, site descriptions in the EM & 1985 SLA reports, and trial & error hydraulic calculations that resulted in a trapezoidal section that produced similiar hydraulic parameters as the EM HEC-2 run.

   The geometry of this typical section is summarized as follows:

   BW = 150 ft.
   Z = 5H:1V (both sides)
   n = 0.024
   S = 0.0015 ft/ft (avg. energy slope from HEC-2, Q_{100})

2. Using the trapezoidal geometry listed above, Mannings Equation was used to develop depth and velocity estimates for the 100-, 50-, 25-, 10-, 5-, and 2-yr. events. This hydraulic data was used to develop an estimate of the maximum shear stress that could be used to determine the thresh-hold of incipient motion at the toe of the bank slope. This analysis was performed by computing the boundary shear stress required to initiate particle motion for a D_{50} = 2 mm. If the actual shear stress is greater than the incipient motion shear stress, erosion is assumed to occur.

   2 mm = 0.0066 ft.

   Critical Shear Stress for 2mm particle = $\tau_c = 0.047\, D_{50} (\gamma_s - \gamma)$
   $\tau_c = (0.047)(0.0066)(165.4 - 62.4)$
   $\tau_c = 0.03\ lb/ft^2$

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Summary of Hydraulic & Shear Stress Calculations for Typical Trapezoidal Cross-Section

New River Below Confluence With Skunk Creek

Return Interval	Q (cfs)	Depth (ft)	Velocity (fps)	$0.97 \gamma D S$ [1] (lb/ft^2)	τ_c (lb/ft^2)	Erosion
100	41,000	15.12	12.02	1.37	0.03	Yes
50	29,000	12.57	10.84	1.14	↓	↓
25	19,000	9.98	9.53	0.91	↓	↓
10	10,500	7.16	7.89	0.65	↓	↓
5	6,000	5.21	6.55	0.47	↓	↓
2	1,995	2.74	4.44	0.25	↓	↓

New River Above Confluence With Skunk Creek

100	19,000	9.98	9.53	0.91	0.03	Yes
50	14,000	8.42	8.66	0.76	↓	↓
25	9,900	6.93	7.74	0.63	↓	↓
10	5,100	4.74	6.19	0.43	↓	↓
5	3,050	3.52	5.18	0.32	↓	↓
2	1,030	1.86	3.48	0.17	↓	↓

[1] Average energy slope = 0.0015 ft/ft.
This value correlates well with both the bed slope & energy gradient from Ellis-Murphy HEC-2 run.

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Hydraulic Calculations For Typical Trapezoidal Section

```
Q= 41000.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 15.12
N=0.024
S=0.001500
A= 3412.26
P= 304.23
R= 11.22
TW= 301.24
V= 12.02
FR= 0.63
VH= 2.24
EG= 17.37
HYD DEPTH= 11.33
UNK VAR WAS D

Q= 29000.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 12.57
N=0.024
S=0.001500
A= 2674.48
P= 278.15
R= 9.62
TW= 275.66
V= 10.84
FR= 0.61
VH= 1.83
EG= 14.39
HYD DEPTH= 9.70
UNK VAR WAS D

Q= 19000.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 9.98
N=0.024
S=0.001500
A= 1993.96
P= 251.73
R= 7.92
TW= 249.76
V= 9.53
FR= 0.59
VH= 1.41
EG= 11.39
HYD DEPTH= 7.98
UNK VAR WAS D

Q= 10500.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 7.16
N=0.024
S=0.001500
A= 1330.94
P= 223.05
R= 5.97
TW= 221.63
V= 7.89
FR= 0.57
VH= 0.97
EG= 8.13
HYD DEPTH= 6.01
UNK VAR WAS D

Q= 6000.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 5.21
N=0.024
S=0.001500
A= 916.33
P= 203.09
R= 4.51
TW= 202.06
V= 6.55
FR= 0.54
VH= 0.67
EG= 5.87
HYD DEPTH= 4.54
UNK VAR WAS D

Q= 1995.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 2.74
N=0.024
S=0.001500
A= 448.94
P= 177.97
R= 2.52
TW= 177.42
V= 4.44
FR= 0.49
VH= 0.31
EG= 3.05
HYD DEPTH= 2.53
UNK VAR WAS D

Q= 19000.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 9.98
N=0.024
S=0.001500
A= 1993.96
P= 251.73
R= 7.92
TW= 249.76
V= 9.53
FR= 0.59
VH= 1.41
EG= 11.39
HYD DEPTH= 7.98
UNK VAR WAS D

Q= 14000.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 8.42
N=0.024
S=0.001500
A= 1617.45
P= 235.87
R= 6.86
TW= 234.20
V= 8.66
FR= 0.58
VH= 1.16
EG= 9.58
HYD DEPTH= 6.91
UNK VAR WAS D

Q= 9900.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 6.93
N=0.024
S=0.001500
A= 1279.25
P= 220.65
R= 5.80
TW= 219.28
V= 7.74
FR= 0.56
VH= 0.93
EG= 7.86
HYD DEPTH= 5.83
UNK VAR WAS D

Q= 5100.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 4.74
N=0.024
S=0.001500
A= 823.37
P= 198.34
R= 4.15
TW= 197.40
V= 6.19
FR= 0.53
VH= 0.60
EG= 5.34
HYD DEPTH= 4.17
UNK VAR WAS D

Q= 3050.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 3.52
N=0.024
S=0.001500
A= 589.31
P= 185.86
R= 3.17
TW= 185.17
V= 5.18
FR= 0.51
VH= 0.42
EG= 3.93
HYD DEPTH= 3.18
UNK VAR WAS D

Q= 1030.00
BW= 150.00
Z1= 5.00
Z2= 5.00
D= 1.86
N=0.024
S=0.001500
A= 295.72
P= 168.93
R= 1.75
TW= 168.57
V= 3.48
FR= 0.46
VH= 0.19
EG= 2.04
HYD DEPTH= 1.75
UNK VAR WAS D
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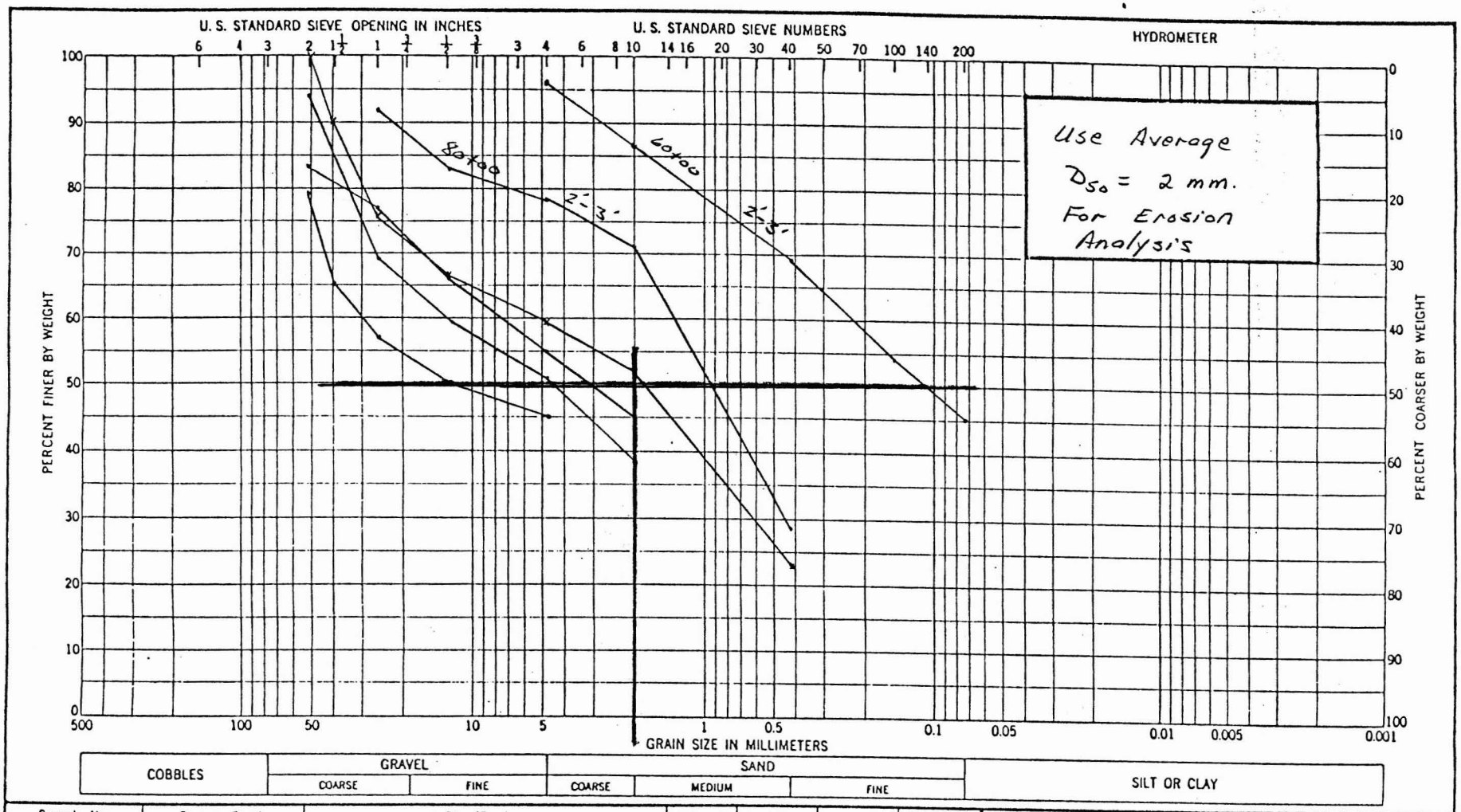

COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI

Project New River @ Desert Harbor, Sta 10+50, 35+00, 60+00, 80+00 - West Bank

Area

Boring No. Data From Construction Inspection & Testing Co.,

Date Ellis-Murphy Report - Sept. 1988

GRADATION CURVES

ENG FORM 1 MAY 63 2087

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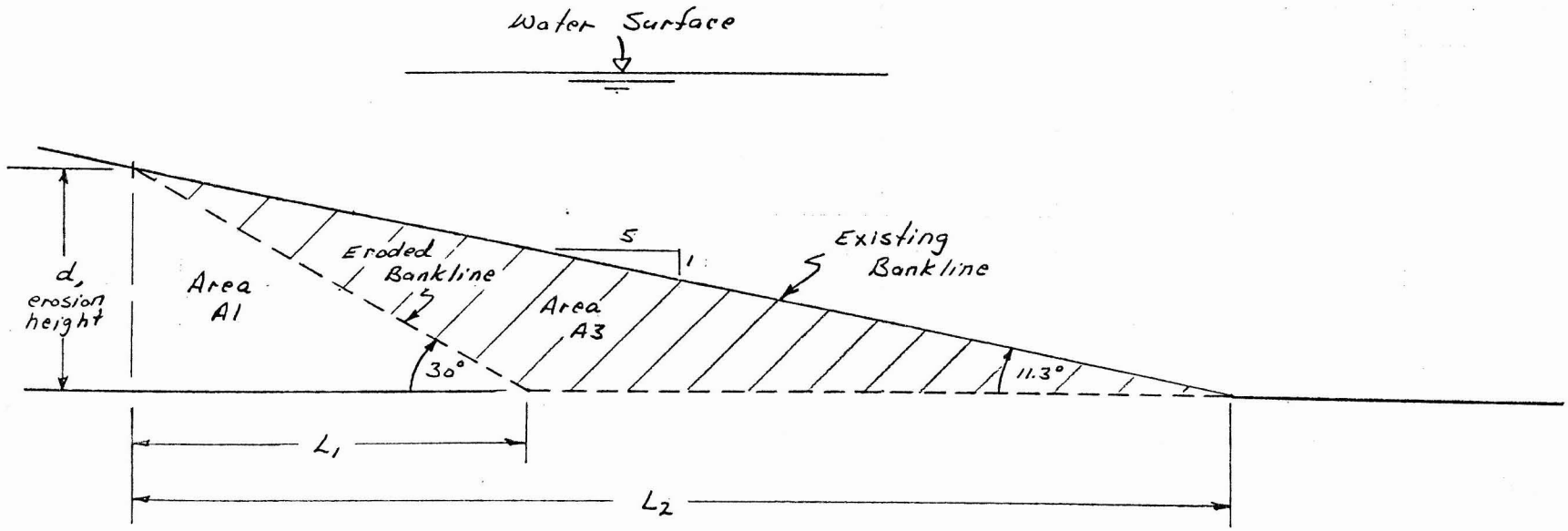

Assumptions:

1. Existing bank slope = 5H:1V.
2. Existing bank will erode to an angle of repose of 30°.
3. Erosion height, d, will be selected on the basis of engineering judgement.

Calculation Procedure:

1. $A2 = A1 + A3$
2. $L_1 = d/\tan 30°$, $L_2 = d/\tan 11.3°$
3. $A1 = (0.5)(d)(L_1) = (0.5)(d^2/\tan 30°)$
4. $A2 = (0.5)(d)(L_2) = (0.5)(d^2/\tan 11.3°)$
5. $A3 = A2 - A1$

$$A3 = (0.5)(d^2/\tan 11.3°) - (0.5)(d^2/\tan 30°)$$
$$A3 = 0.5\,d^2\left(\frac{1}{\tan 11.3°} - \frac{1}{\tan 30°}\right)$$
$$A3 = 1.636\,d^2$$

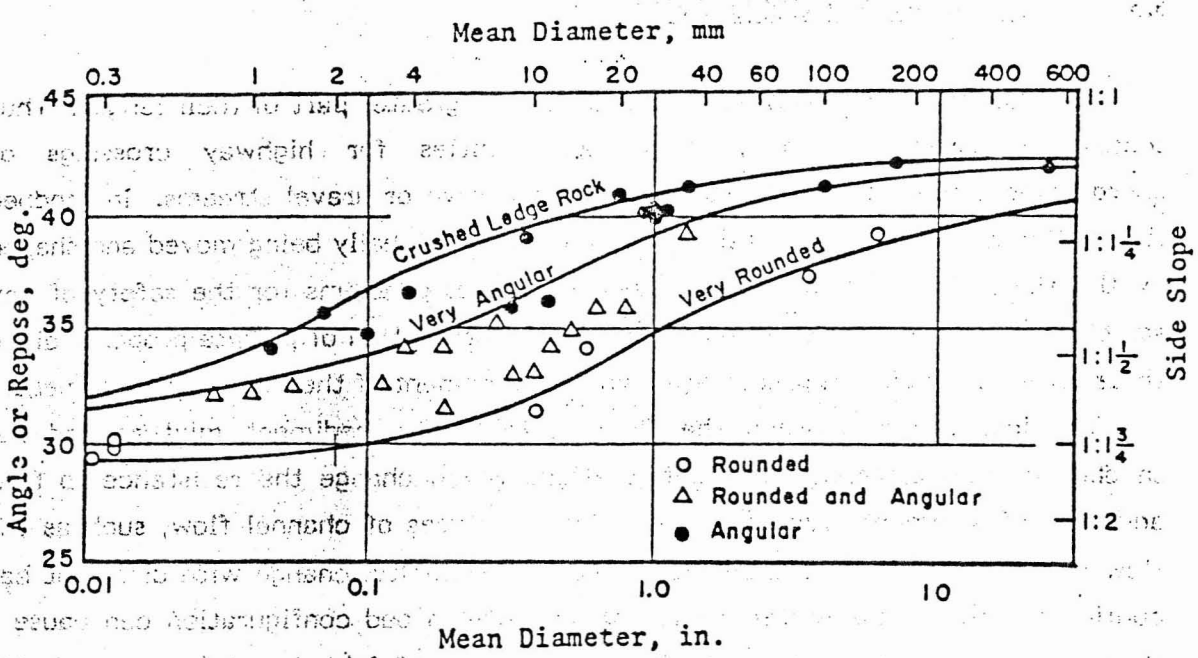

Fig. 3.2.4 Angle of Repose

Source: "Highways In The River Environment" FHA, January 1987

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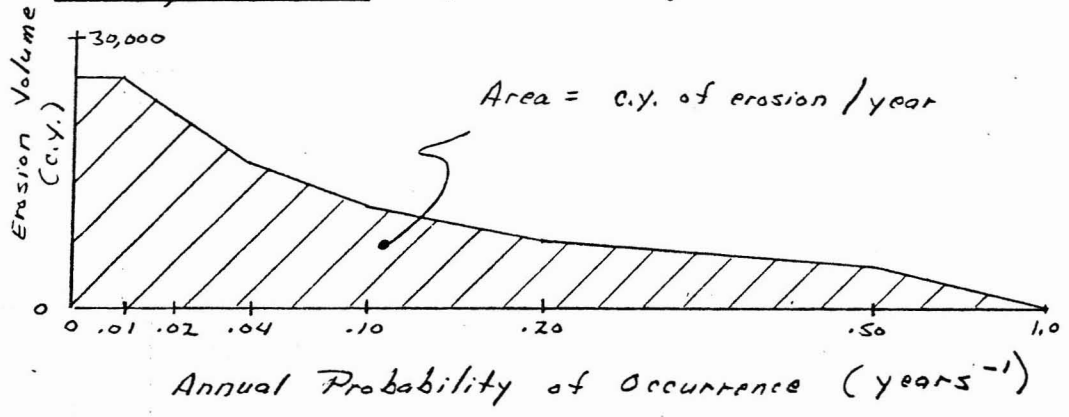
Determine Average Annual Erosion Volume

Procedure:

1. Plot total erosion volume per flood event versus the annual probability of occurrence of each event. The area under this curve will yield cubic yards of erosion / year.

Example Plot (not to scale)



The area under this curve can be computed from the following formula:

$$\text{Avg. Annual Erosion Volume (c.y./year)} = 0.01(V_{100}) + 0.5\Big[(.01)(V_{100}+V_{50}) + (.02)(V_{50}+V_{25}) + (.06)(V_{25}+V_{10}) + (.10)(V_{10}+V_{5}) + (.30)(V_{5}+V_{2}) + (.50)(V_{2})\Big]$$

2. This procedure assumes floods larger than Q_{100} will produce the same volume of erosion as from Q_{100}. It also assumes a linear decrease to "zero erosion" will occur between the 2-year event & the 1-year event.

Table 1

Summary of Estimated Erosion Volume
Desert Harbor, West Bank of New River

Percent of Flow Depth to Use For Erosion Height: 67

Return Interval (years)	Annual Probability of Occurrence (1/years)	Assumed Percent of Bankline Eroded (L.F.)	Length of Eroded Bankline (L.F.)	Flow Depth (ft)	Assumed Erosion Height (ft)	Erosion Volume (cu.ft.) per L.F. of Bankline	Total Erosion Volume for This Event (cu.yd.)
(New River Below Confluence With Skunk Creek)							
100	0.01	60	3960	15.12	10.13	167.9	24625
50	0.02	40	2640	12.57	8.42	116.0	11346
25	0.04	30	1980	9.98	6.69	73.1	5364
10	0.10	20	1320	7.16	4.80	37.6	1841
5	0.20	10	660	5.21	3.49	19.9	487
2	0.50	5	330	2.74	1.84	5.5	67
(New River Above Confluence With Skunk Creek)							
100	0.01	60	840	9.98	6.69	73.1	2276
50	0.02	40	560	8.42	5.64	52.1	1080
25	0.04	30	420	6.93	4.64	35.3	549
10	0.10	20	280	4.74	3.18	16.5	171
5	0.20	10	140	3.52	2.36	9.1	47
2	0.50	5	70	1.86	1.25	2.5	7

Average Annual Erosion Volume = 1122 cu. yd.

Table 2

Summary of Estimated Erosion Volume
Desert Harbor, West Bank of New River

Percent of Flow Depth to Use For Erosion Height: 75

Return Interval (years)	Annual Probability of Occurrence (1/years)	Assumed Percent of Bankline Eroded (L.F.)	Length of Eroded Bankline (L.F.)	Flow Depth (ft)	Assumed Erosion Height (ft)	Erosion Volume (cu.ft.) per L.F. of Bankline	Total Erosion Volume for This Event (cu.yd.)
(New River Below Confluence With Skunk Creek)							
100	0.01	60	3960	15.12	11.34	210.4	30856
50	0.02	40	2640	12.57	9.43	145.4	14217
25	0.04	30	1980	9.98	7.49	91.7	6722
10	0.10	20	1320	7.16	5.37	47.2	2306
5	0.20	10	660	5.21	3.91	25.0	611
2	0.50	5	330	2.74	2.06	6.9	84
(New River Above Confluence With Skunk Creek)							
100	0.01	60	840	9.98	7.49	91.7	2852
50	0.02	40	560	8.42	6.32	65.2	1353
25	0.04	30	420	6.93	5.20	44.2	687
10	0.10	20	280	4.74	3.56	20.7	214
5	0.20	10	140	3.52	2.64	11.4	59
2	0.50	5	70	1.86	1.40	3.2	8

Average Annual Erosion Volume = 1406 cu. yd.

Table 3

Summary of Estimated Erosion Volume
Desert Harbor, West Bank of New River

Percent of Flow Depth to Use For Erosion Height: 75

Return Interval (years)	Annual Probability of Occurrence (1/years)	Assumed Percent of Bankline Eroded (L.F.)	Length of Eroded Bankline (L.F.)	Flow Depth (ft)	Assumed Erosion Height (ft)	Erosion Volume (cu.ft.) per L.F. of Bankline	Total Erosion Volume for This Event (cu.yd.)
(New River Below Confluence With Skunk Creek)							
100	0.01	75	4950	15.12	11.34	210.4	38570
50	0.02	50	3300	12.57	9.43	145.4	17772
25	0.04	40	2640	9.98	7.49	91.7	8962
10	0.10	30	1980	7.16	5.37	47.2	3460
5	0.20	20	1320	5.21	3.91	25.0	1221
2	0.50	10	660	2.74	2.06	6.9	169
(New River Above Confluence With Skunk Creek)							
100	0.01	75	1050	9.98	7.49	91.7	3564
50	0.02	50	700	8.42	6.32	65.2	1691
25	0.04	40	560	6.93	5.20	44.2	917
10	0.10	30	420	4.74	3.56	20.7	322
5	0.20	20	280	3.52	2.64	11.4	118
2	0.50	10	140	1.86	1.40	3.2	17

Average Annual Erosion Volume = 1960 cu. yd.

Table 4

Summary of Estimated Erosion Volume
Desert Harbor, West Bank of New River

Percent of Flow Depth to Use For Erosion Height: 100

Return Interval (years)	Annual Probability of Occurrence (1/years)	Assumed Percent of Bankline Eroded (L.F.)	Length of Eroded Bankline (L.F.)	Flow Depth (ft)	Assumed Erosion Height (ft)	Erosion Volume (cu.ft.) per L.F. of Bankline	Total Erosion Volume for This Event (cu.yd.)
(New River Below Confluence With Skunk Creek)							
100	0.01	75	4950	15.12	15.12	374.0	68569
50	0.02	50	3300	12.57	12.57	258.5	31594
25	0.04	40	2640	9.98	9.98	162.9	15933
10	0.10	30	1980	7.16	7.16	83.9	6151
5	0.20	20	1320	5.21	5.21	44.4	2171
2	0.50	10	660	2.74	2.74	12.3	300
(New River Above Confluence With Skunk Creek)							
100	0.01	75	1050	9.98	9.98	162.9	6337
50	0.02	50	700	8.42	8.42	116.0	3007
25	0.04	40	560	6.93	6.93	78.6	1630
10	0.10	30	420	4.74	4.74	36.8	572
5	0.20	20	280	3.52	3.52	20.3	210
2	0.50	10	140	1.86	1.86	5.7	29

Average Annual Erosion Volume = 3484 cu. yd.