

Attachment D

**Borrow Area Mixing Zone Study
Bathtub Beach Restoration Project**

**Prepared for
Florida Department of Environmental Protection
Joint Coastal Permit Application RAI
JCP File Number: 0163447-002-JC**

by

**Taylor Engineering, Inc.
10151 Deerwood Park Blvd
Bldg 300, Suite 300
Jacksonville, Florida 32256
(904) 731-7040**

December 2008

DREDGE Module Mixing Zone Study for Bathtub Beach Borrow Area

JCP File Number: 0163447-002-JC, Martin County

Taylor Engineering, Inc.

December 2008

Taylor Engineering conducted a mixing zone study to estimate the distance that the project may generate turbidity during dredging. The DREDGE Module, developed by the U.S. Army Corps of Engineers (USACE) provided the analysis tool to predict total suspended solids (TSS) resulting from dredge operation. Taylor Engineering ran the DREDGE Module for a hydraulic cutterhead dredge under the conditions listed below.

Dredge Characteristics:

1. A 16 in (0.41 m) hydraulic cutterhead dredge
2. Settling velocity of 0.001 m/sec
3. An in-situ dry density of 1,000 kg/m³

Site characteristics of the proposed borrow area:

1. 0.00 m water depth (removing a shoal – worst case scenario)
2. Specific gravity of 2.65
3. Ambient water velocity of 0.27 m/sec (0.9 ft/sec)
4. Mean particle size of 410 μm (0.41 mm)
5. 0.2% particles smaller than 74 μm (fines) average
6. 0.8% particles smaller than 74 μm (fines) “worst case” scenario
7. 25% particles smaller than particles with critical settling velocity, again a “worst case” scenario

The DREDGE Module produces TSS values as output, but the Florida Administrative Code uses turbidity (in Nephelometric Turbidity Units or NTU) as a water quality standard related to TSS. Each location or sediment provides a somewhat different relationship between turbidity and TSS and no relationship exists for the proposed borrow site. Thus, general equations of the relationship between TSS and turbidity must provide results useful for predictive purposes. To estimate expected turbidity from dredging the proposed borrow area, Taylor Engineering used equations relating TSS concentration (mg/l) to NTU values from four technical papers (see below for reference citations). We input each TSS value generated by the DREDGE Module to each of the four equations. We selected the highest resulting turbidity value as the appropriate result for this analysis.

The following pages provide a tabular and graphical representation of the anticipated water-surface plume results from the DREDGE Module. The models predict that maximum turbidity nearest the dredge head will not exceed 0.79 mg/L TSS or 0.7 NTU. The lateral diffusion cross current reduces TSS (and turbidity) to less than 0.27 TSS or 0.3 NTU 50 meters from the dredge head. At a distance of 150 meters downcurrent from the dredge head, the models predict less than 0.05 TSS or 0.1 NTU.

Hydraulic Dredge Characteristics for Cutter head

Input	Value	Units
Cutter head Diameter	0.41	m
Cutter head Length	1.22	m
Thickness of cut	0.30	m
Swing Velocity of Cutter	0.30	m/sec
In situ Dry Density	1000	kg/m ³

Site Characteristics

Input	Value	Units
Water Depth	0.00	m
Ambient Water Velocity	0.27	m/sec
Mean Particle Size	410	μm
Specific Gravity	2.65	--
Fraction of particles smaller than 74 μm	0.002	--
Fraction of particles smaller than particles with critical settling velocity	0.25	--

Cutter head - TGU

Input	Value	Units
Cutter head Length	1.22	m
Thickness of Cut	0.30	m
Width of Turbidity Area	257.7	m
Turbidity Generation Unit*	300	g/m ³

*Turbidity Generation Unit gathered from Nakai's TGU Values presented in the DREDGE Module User's Guide Help Menu

Far Field Model Data

Input	Value	Units
Lateral Diffusion Coefficient	100,000	cm ² /sec
Vertical Diffusion Coefficient	10	cm ² /sec
Settling Velocity	0.001	m/sec
Downstream Locations	300	m
Downstream Step	10	m
Lateral Locations	150	m
Lateral Step	25	m
Desired Water Depth	0.00	m

<< Input Data Summary >>

<< Input Data File >> = C:\ADDAMS\DREDGE\BT.DAT
<< Dredge Type >> = Cutterhead

<< Cutterhead Dredge Data >>

Cutterhead diameter = 0.4 (m)
Cutterhead length = 1.2 (m)
Thickness of cut = 0.3 (m)
Swing velocity at cutter = 0.3 (m / sec)
In-situ dry density = 1000 (kg/m³)

<< Near-Field Model - TGU method >>

Cutterhead length = 1.2 (m)
Thickness of cut = 0.3 (m)
Width of turbid area = 250 (m²)
Turbidity generation unit = 300 (g/m³)

<< Far-Field Model >>

Lateral diff. coeff. = 100000 (cm²/sec)
Vertical diff. coeff. = 10 (cm²/sec)
Settling velocity = .001 (m/sec)
Downstream locations = 300 (m)
X-step = 10 (m)
Lateral locations = 150 (m)
Y-step = 10 (m)
Desired water depth = 0 (m)

<< Site Characteristics >>

Water depth = 0.1 (m)
Ambient water velocity = 0.27 (m/sec)
Mean particle size = 410 (um)
Specific gravity of sedi. = 2.65
R74 = 0.1
Ro = 0.25

<< DREDGE Model Output Summary >>

Resuspended material selected : Total Suspended Solid

Downstream Distance(m)	Lateral Position(m)							Unit:(mg/l)
	-150	-140	-130	-120	-110	-100	-90	
10	.000	.000	.000	.000	.000	.001	.003	
20	.000	.001	.001	.003	.007	.013	.025	
30	.002	.003	.006	.010	.017	.027	.042	
40	.004	.007	.011	.017	.025	.035	.049	
50	.007	.011	.016	.022	.030	.039	.051	
60	.010	.014	.019	.025	.032	.041	.050	
70	.012	.016	.021	.027	.033	.041	.049	
80	.014	.018	.022	.027	.033	.040	.047	
90	.015	.019	.023	.028	.033	.038	.044	
100	.016	.019	.023	.027	.032	.037	.042	
110	.016	.020	.023	.027	.031	.035	.040	
120	.017	.020	.023	.026	.030	.034	.038	
130	.017	.020	.023	.026	.029	.032	.036	
140	.017	.019	.022	.025	.028	.031	.034	
150	.017	.019	.022	.024	.027	.029	.032	
160	.017	.019	.021	.023	.026	.028	.030	
170	.016	.018	.020	.023	.025	.027	.029	
180	.016	.018	.020	.022	.024	.026	.028	
190	.016	.018	.019	.021	.023	.025	.026	
200	.015	.017	.019	.020	.022	.024	.025	
210	.015	.017	.018	.020	.021	.023	.024	
220	.015	.016	.018	.019	.020	.022	.023	
230	.014	.016	.017	.018	.020	.021	.022	
240	.014	.015	.017	.018	.019	.020	.021	
250	.014	.015	.016	.017	.018	.019	.020	
260	.013	.014	.016	.017	.018	.019	.019	
270	.013	.014	.015	.016	.017	.018	.019	
280	.013	.014	.015	.015	.016	.017	.018	
290	.012	.013	.014	.015	.016	.017	.017	
300	.012	.013	.014	.015	.015	.016	.017	

<< DREDGE Model Output Summary >>

Resuspended material selected : Total Suspended Solid

Downstream Distance(m)	Lateral Position(m)							Unit:(mg/l)
	-80	-70	-60	-50	-40	-30	-20	
10	.010	.029	.069	.146	.268	.429	.602	
20	.045	.075	.116	.168	.228	.288	.341	
30	.061	.086	.115	.147	.180	.211	.236	
40	.065	.084	.104	.126	.146	.165	.179	
50	.064	.078	.093	.108	.122	.135	.144	
60	.061	.072	.084	.095	.105	.113	.120	
70	.057	.066	.075	.084	.091	.098	.103	
80	.054	.061	.068	.075	.081	.086	.089	
90	.050	.056	.062	.067	.072	.076	.079	
100	.047	.052	.057	.061	.065	.068	.071	
110	.044	.048	.052	.056	.059	.062	.064	
120	.041	.045	.048	.052	.054	.056	.058	
130	.039	.042	.045	.048	.050	.052	.053	
140	.037	.039	.042	.044	.046	.048	.049	
150	.035	.037	.039	.041	.043	.044	.045	
160	.033	.035	.037	.039	.040	.041	.042	
170	.031	.033	.035	.036	.038	.039	.039	
180	.029	.031	.033	.034	.035	.036	.037	
190	.028	.030	.031	.032	.033	.034	.035	
200	.027	.028	.029	.030	.031	.032	.033	
210	.025	.027	.028	.029	.030	.030	.031	
220	.024	.025	.026	.027	.028	.029	.029	
230	.023	.024	.025	.026	.027	.027	.028	
240	.022	.023	.024	.025	.025	.026	.026	
250	.021	.022	.023	.024	.024	.025	.025	
260	.020	.021	.022	.023	.023	.024	.024	
270	.020	.020	.021	.022	.022	.022	.023	
280	.019	.019	.020	.021	.021	.021	.022	
290	.018	.019	.019	.020	.020	.021	.021	
300	.017	.018	.019	.019	.019	.020	.020	

<< DREDGE Model Output Summary >>

Resuspended material selected : Total Suspended Solid

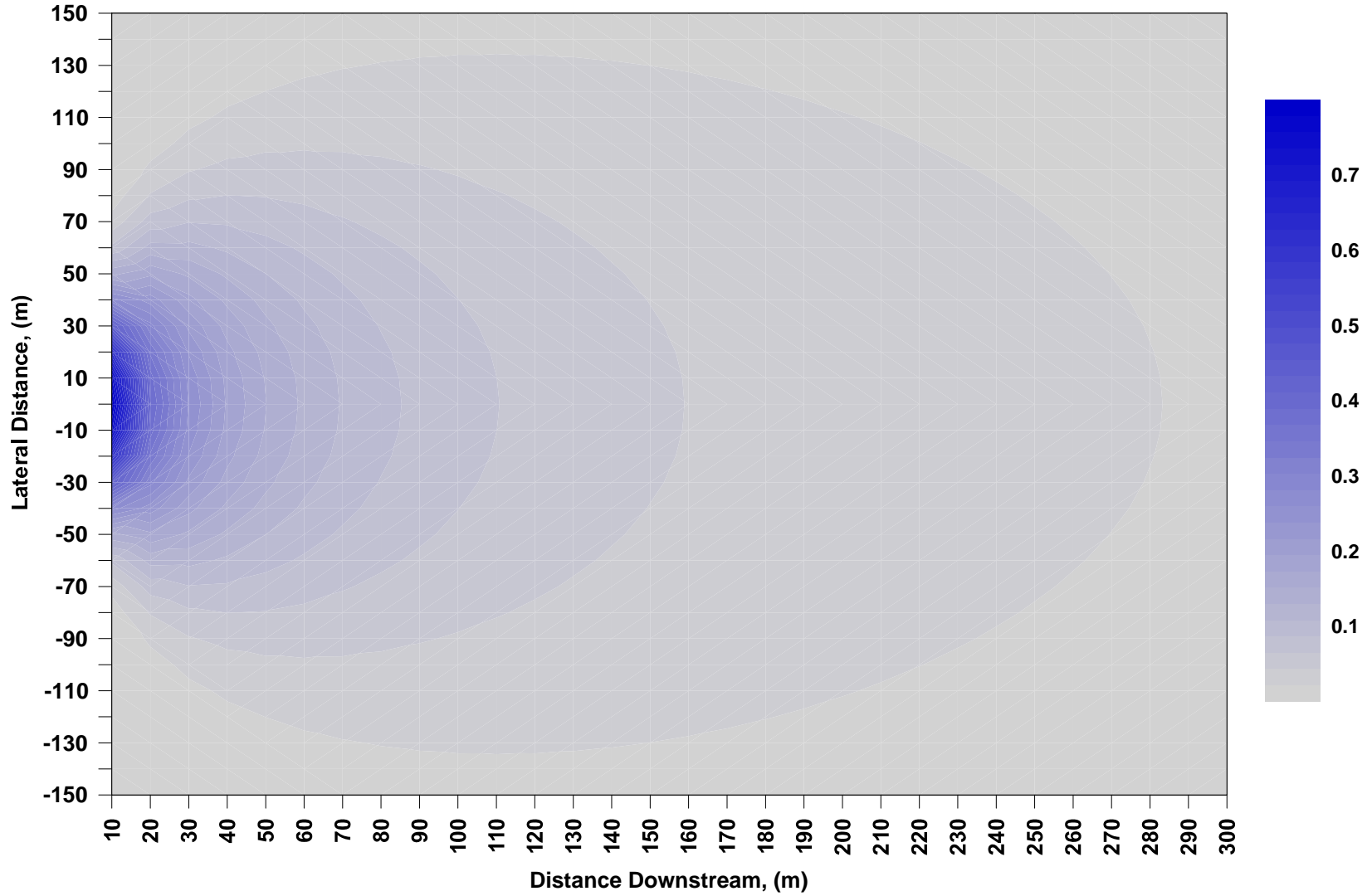
Downstream Distance(m)	Lateral Position(m)							Unit:(mg/l)
	60	70	80	90	100	110	120	
10	.069	.029	.010	.003	.001	.000	.000	
20	.116	.075	.045	.025	.013	.007	.003	
30	.115	.086	.061	.042	.027	.017	.010	
40	.104	.084	.065	.049	.035	.025	.017	
50	.093	.078	.064	.051	.039	.030	.022	
60	.084	.072	.061	.050	.041	.032	.025	
70	.075	.066	.057	.049	.041	.033	.027	
80	.068	.061	.054	.047	.040	.033	.027	
90	.062	.056	.050	.044	.038	.033	.028	
100	.057	.052	.047	.042	.037	.032	.027	
110	.052	.048	.044	.040	.035	.031	.027	
120	.048	.045	.041	.038	.034	.030	.026	
130	.045	.042	.039	.036	.032	.029	.026	
140	.042	.039	.037	.034	.031	.028	.025	
150	.039	.037	.035	.032	.029	.027	.024	
160	.037	.035	.033	.030	.028	.026	.023	
170	.035	.033	.031	.029	.027	.025	.023	
180	.033	.031	.029	.028	.026	.024	.022	
190	.031	.030	.028	.026	.025	.023	.021	
200	.029	.028	.027	.025	.024	.022	.020	
210	.028	.027	.025	.024	.023	.021	.020	
220	.026	.025	.024	.023	.022	.020	.019	
230	.025	.024	.023	.022	.021	.020	.018	
240	.024	.023	.022	.021	.020	.019	.018	
250	.023	.022	.021	.020	.019	.018	.017	
260	.022	.021	.020	.019	.019	.018	.017	
270	.021	.020	.020	.019	.018	.017	.016	
280	.020	.019	.019	.018	.017	.016	.015	
290	.019	.019	.018	.017	.017	.016	.015	
300	.019	.018	.017	.017	.016	.015	.015	

<< DREDGE Model Output Summary >>

Resuspended material selected : Total Suspended Solid

Downstream Distance(m)	Lateral Position(m)			Unit:(mg/l)			
	130	140	150				
10	.000	.000	.000	.000	.000	.000	.000
20	.001	.001	.000	.000	.000	.000	.000
30	.006	.003	.002	.000	.000	.000	.000
40	.011	.007	.004	.000	.000	.000	.000
50	.016	.011	.007	.000	.000	.000	.000
60	.019	.014	.010	.000	.000	.000	.000
70	.021	.016	.012	.000	.000	.000	.000
80	.022	.018	.014	.000	.000	.000	.000
90	.023	.019	.015	.000	.000	.000	.000
100	.023	.019	.016	.000	.000	.000	.000
110	.023	.020	.016	.000	.000	.000	.000
120	.023	.020	.017	.000	.000	.000	.000
130	.023	.020	.017	.000	.000	.000	.000
140	.022	.019	.017	.000	.000	.000	.000
150	.022	.019	.017	.000	.000	.000	.000
160	.021	.019	.017	.000	.000	.000	.000
170	.020	.018	.016	.000	.000	.000	.000
180	.020	.018	.016	.000	.000	.000	.000
190	.019	.018	.016	.000	.000	.000	.000
200	.019	.017	.015	.000	.000	.000	.000
210	.018	.017	.015	.000	.000	.000	.000
220	.018	.016	.015	.000	.000	.000	.000
230	.017	.016	.014	.000	.000	.000	.000
240	.017	.015	.014	.000	.000	.000	.000
250	.016	.015	.014	.000	.000	.000	.000
260	.016	.014	.013	.000	.000	.000	.000
270	.015	.014	.013	.000	.000	.000	.000
280	.015	.014	.013	.000	.000	.000	.000
290	.014	.013	.012	.000	.000	.000	.000
300	.014	.013	.012	.000	.000	.000	.000

Contour Graph for TSS Concentration (mg/l)



[Dredge Type : Cutterhead] [Near-Field Model : TGU Method] [Far-Field Model : Kuo's Model] [Unit : mg/l]

Total Suspended Solids (TSS, mg/l) ↔ Turbidity (NTU) Conversion

convert from TSS mg/l Select "convert from" with dropdown box
to Turb NTU

TSS 0.788 mg/l Enter quantity to convert

Walker	0.0	NTU
Christensen	0.4	NTU
Gray	0.4	NTU
Packman	0.7	NTU

References

Walker: Atcafalaya Bay, LA

Walker, N. (2001) "Tropical Storm and Hurricane Wind Effects on Water Level, Salinity and Sediment Transport in the River-Influenced Atchafalaya-Vermilion Bay System, Louisiana, USA." Estuaries, Vol. 24, No. 4, p. 498-508, August 2001

Christensen: L. Arkansas R., KS

Christensen, V.G., Ziegler, A.C., and Jian, X. (2001) "Continuous Turbidity Monitoring and Regression Analysis to Estimate Total Time Suspended Solids and Fecal Coliform Bacteria Loads in Real Time." USGS Kansas Water Quality Center, 4821 Quail Crest Place, Lawrence, KS 66049

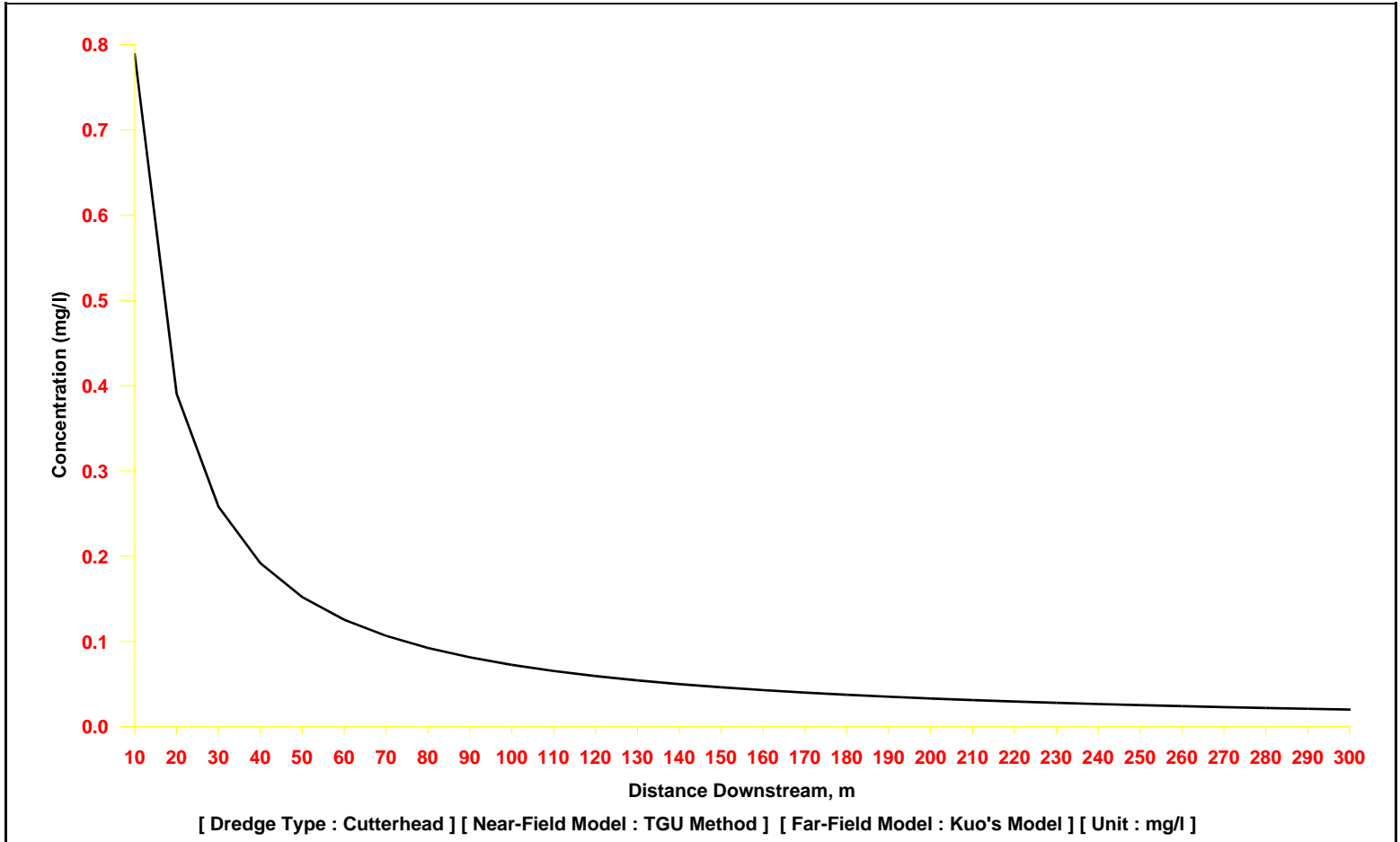
Gray: Kansas R., KS

Gray, J.R., Melis, T.S., Patino, E., Larsen, M.C., Topping, D.J., Rasmussen, P.P., and Figueroa-Alamo, C. (2003) "U.S. Geological Survey Research on Surrogate Measurements for Suspended Sediment." First Interagency Conference on Research in the Watersheds, October 27-30, 2003. U.S. Department of Agriculture, Agricultural Research Service

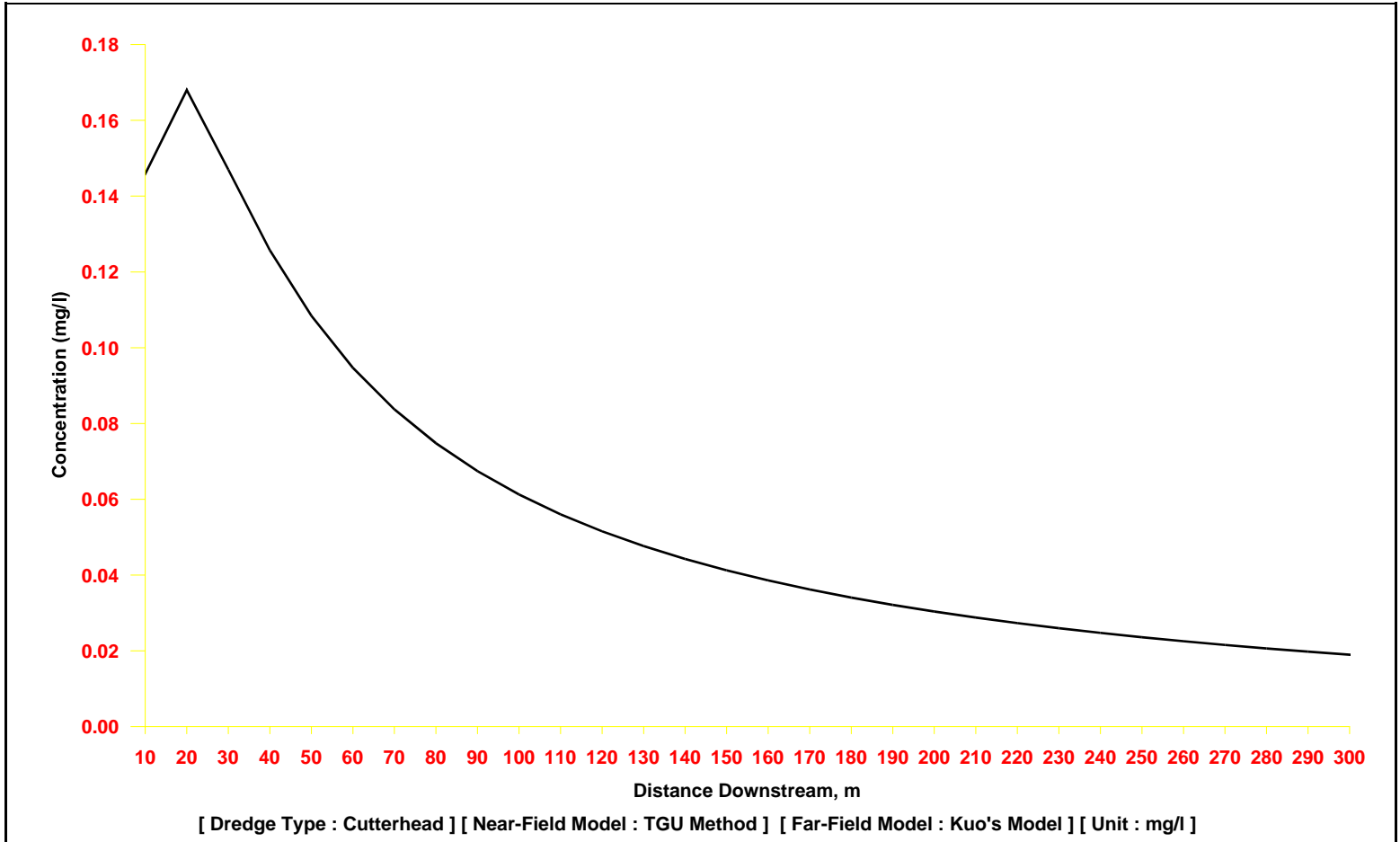
Packman: King Co., WA

Packman, J.J., Comings, K.J., and Booth, D.B. (1999) "Using Turbidity to Determine Total Suspended Solids in Urbanized Streams in the Puget Lowlands." Center for Water and Watershed Studies, University of Washington, Civil and Environmental Engineering Department.

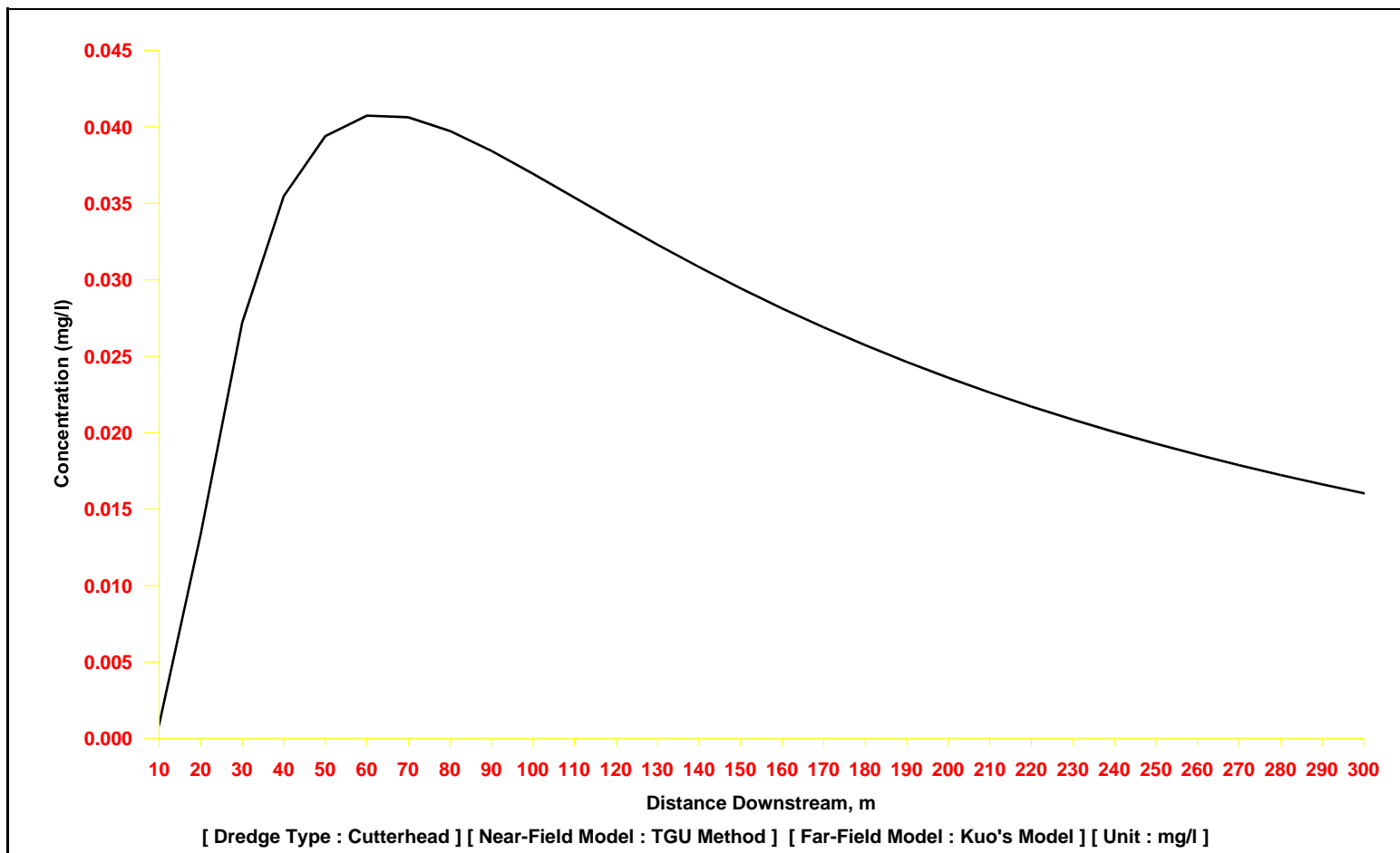
TSS concentration at 0 (m)



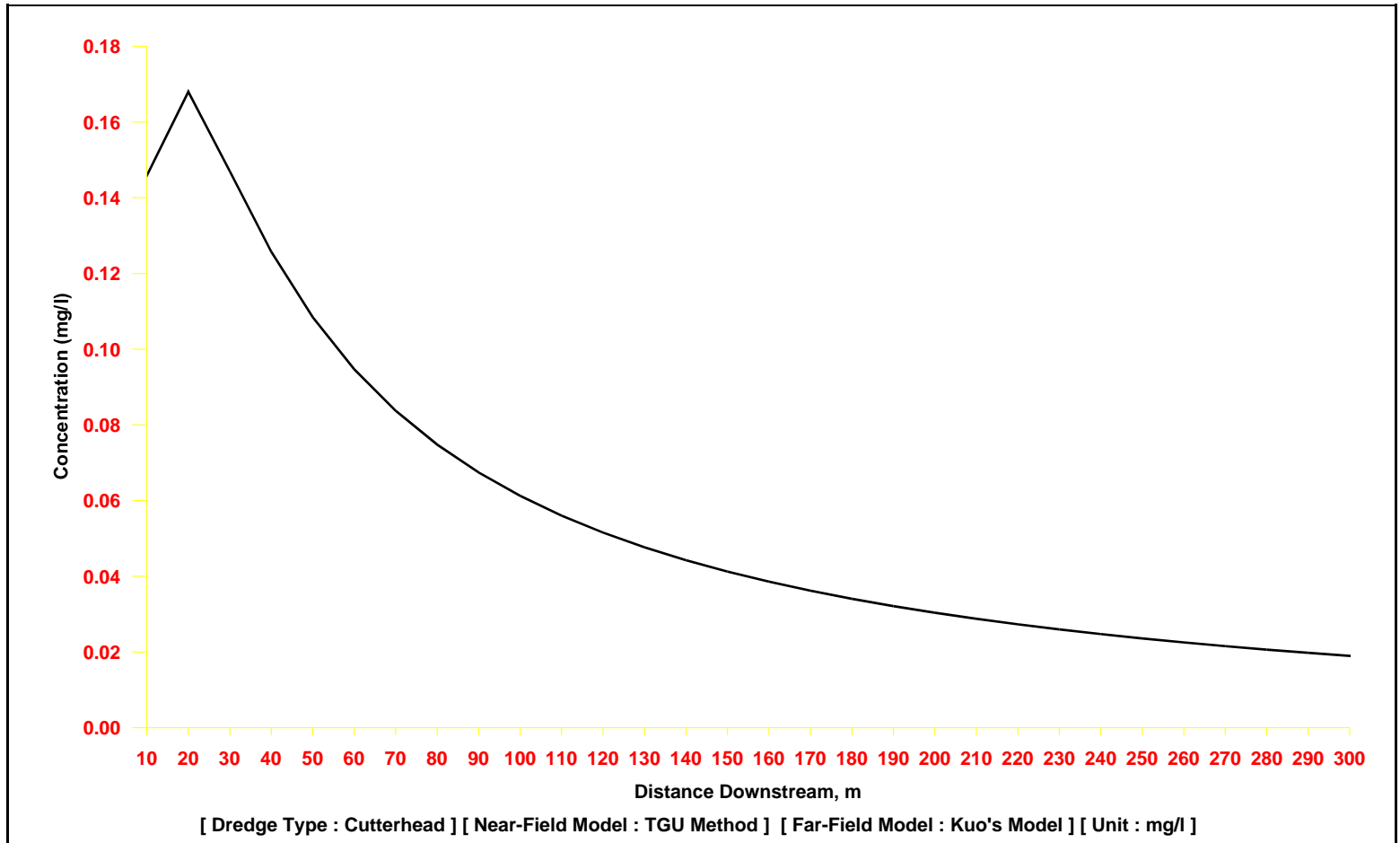
TSS concentration at -50 (m)



TSS concentration at -100 (m)



TSS concentration at 50 (m)



TSS concentration at 100 (m)

