PIMA COUNTY REGIONAL FLOOD CONTROL DISTRICT
TECHNICAL POLICY

POLICY NAME: Applicability of and Acceptable Methods for Sediment Transport Analysis

POLICY NUMBER: Technical Policy, TECH-017

EFFECTIVE DATE: November 24, 2014

PURPOSE: To standardize the applicability and use of sediment transport analyses for development located within a regulatory watercourse and/or erosion hazard area, and to provide guidance for the use of sediment transport analyses previously approved by the Regional Flood Control District (District).

BACKGROUND: Sediment transport analysis is a procedure to evaluate scour or deposition along a watercourse by mathematical modeling of the physical processes affecting sediment movement. These models predict the response of sediment supply and transport capacity to various geologic, hydrologic and development constraints. The analysis typically involves calculation of sediment supply and sediment transport capacity, and the use of these parameters to route sediment and floodwaters along a watercourse over time. With proper assumptions, sediment transport processes may be considered to apply either vertically (depth of scour/deposition) or laterally (erosion hazard setback distance).

A sediment transport analysis may be used to predict general scour, contraction scour, and/or long-term aggradation/degradation. Its usefulness is limited, however, in evaluating scour or deposition in areas of local high turbulence such as at piers, abutments, below grade control structures, culvert outlets, or sharp channel bends. Instead of using a sediment transport analysis, empirical equations for predicting these scour components, in addition to other scour components such as amplitude of sand waves and development of a low-flow channel, are presented in Chapter VI of the *Standards Manual for Drainage Design and Floodplain Management* (SMDDFM). These empirical equations are functions of average hydraulic characteristics during peak flow, and assume that the flow duration is long enough to establish equilibrium scour depth. Chapter VI also presents empirical equations for general scour on watercourses with base flood discharge < 10,000 cfs, and for long-term aggradation/degradation when particular simplifying assumptions apply. As allowed by this Policy, these empirical equations may supplement or substitute a sediment transport analysis to evaluate design scour depth. Technical Policy 012, titled: *Methods to Estimate Maximum Anticipated Scour Depth including Optional Adjustment for Flood Duration* (TECH 012) outlines the procedure for application of these empirical equations.

Chapter 16.28 of the Ordinance presents default erosion hazard setback (EHSB) distances for structures, and specifies that an alternate safe EHSB, if proposed, must be determined by an engineering study, prepared by an Arizona-registered civil engineer. This study may be based on a sediment transport analysis. However, Chapter VII of the SMDDFM presents various simplified procedures for evaluation of an alternative safe EHSB distance, based on average hydraulic characteristics during peak flow. Technical Policy 020, titled: *Engineering Analysis Requirements for Determining an Alternative Safe Erosion Hazard Setback Limit* (TECH 020) outlines the procedure for application of these simplified procedures.

Several software packages are available to assist in performing a sediment transport analysis. This policy describes when particular analysis methods are acceptable for submittal to the District. Analysis protocols and accepted modeling features are generally discussed, with additional reference to various Application Guides and User's Manuals for the referenced software packages, and Design Manuals.

POLICY:

A sediment transport analysis must be performed by an Arizona-registered civil engineer, and must be summarized in writing in a bound and sealed report presented to the District for review and approval. Submittal must include electronic copies of the input files to the selected computer models in order to facilitate the District's review.

A. ***A Sediment Transport Analysis*** shall be provided for evaluation of:

a. General scour for watercourses with a base flood discharge > 10,000 cfs;

b. Scour or deposition associated with in-stream sand & gravel mining operations;

c. Safe aggregate extraction rate for new in-stream sand & gravel mining operations;

d. Long-term aggradation/degradation when assumptions implicit in equations 6.25 or 6.26 of the SMDDFM are not applicable, or where other information is not available to estimate long-term aggradation/degradation;

e. Safe alternative erosion hazard setback (EHSB) distance less than that afforded by equations 7.7 and 7.8 of the SMDDFM, or by application of the allowable velocity, tractive stress, or tractive power approach; or

f. Scour or deposition associated with any development which, due to either its location within the floodplain or the presence of unusual conditions in the watercourse, is not adequately reflected in standard scour depth or EHSB equations presented in the SMDDFM.

B. ***Sediment transport analysis*** shall incorporate both qualitative and quantitative methods:

a. Results of qualitative analysis must support the results of the quantitative analysis;

b. Qualitative methods shall apply geomorphic relationships & historic aerial photos, ground surveys, vegetation patterns, channel profiles, and discharge history to predict the general response of the watercourse to the development; and

c. Quantitative methods shall estimate scour or deposition using dynamic or quasi-dynamic physical process models of water & sediment movement along a watercourse over time.

C. Sediment transport analysis may utilize the Corps of Engineers' (COE) HEC-6 or HEC-RAS, or FLO-2D. Other methods acceptable to the District for sediment transport analysis may be used as follows:

a. ***Watercourses where the District has conducted analyses:*** Results may be used in lieu of a new sediment transport analysis. The District will review these analyses to ensure that the methods employed do not conflict with current regulations, that they are in conformance with standard engineering practice, and that new data are not available which could potentially alter the results of the analyses. If this review indicates a new analysis is appropriate, the District will inform the Applicant.

b. ***Watercourses where previous analyses have been accepted by the District:*** Sediment transport analyses from drainage reports that have been accepted by the District may be acceptable in lieu

of a new sediment transport analysis. These sediment transport analyses shall be reviewed and verified as valid by the Applicant's engineer. The applicant must obtain written permission from the District to utilize any analysis performed 5 years or more prior to the review submittal date.

c. ***Other models or methods for performing sediment transport analysis:*** Approval of the use of other models or methods shall be obtained in writing from the District prior to the submittal of the sediment transport analysis. Adequate documentation must be provided to demonstrate these other models or methods are more appropriate to the situation than the models specifically identified in this Policy. A copy of the written permission must be included with the submittal.

D. Modeling guidelines:

a. ***The sediment transport analysis will generally incorporate:*** dynamic or quasi-dynamic modeling of water and sediment movement along a watercourse using moveable bed or banks, flow hydrograph(s), particle size gradations of bed or bank material, and selection of an appropriate sediment transport capacity relationship. The study reach shall extend beyond the development to demonstrate flow and sediment boundary conditions are independent of the development.

b. ***The sediment transport analysis shall use at least three sediment transport capacity relationships.*** The most appropriate relationship will be utilized for design. The applicant must compare the results of the three selected relationships, and must justify in writing why the relationship chosen is appropriate for the specific design situation under review.

c. ***Flow hydrograph shall be appropriate for the purpose of the analysis:***

i. Hydrograph for the 1 % or 0.2 % chance flood event depending on the critical facility classification of the development. Development of the flood hydrograph shall be in accordance with Technical Policies 010 *Using NOAA 14 Rainfall*, 015 *Selection of Hydrologic Models for Discharge*, and 018 *Model Parameterization for Peak Discharges*;

ii. For demonstration of aggrading reach, history of recorded discharges shall apply; or

iii. For evaluation of long-term aggradation/degradation, the 10 % chance flood event, or a string of anticipated future discharges shall apply.

d. ***Simplifying assumptions may be allowed to the extent that they produce conservative results:*** Technical justification for each simplifying assumption shall be presented in writing.

e. ***Available and appropriate information and studies shall be considered including:*** *Evaluation of Flow and Sediment Models for the Rillito River:* Report by Jennifer Duan and Students from the University of Arizona using the July 2006 flood data (available from the District) and software application guides and design manuals**,** including those listed in References section of this Policy.

REFERENCES

ADWR, 1985. *Design Manual for Engineering Analysis of Fluvial Systems*, Arizona Department of Water Resources, Phoenix, AZ

ADWR, 1996. *State Standard for Watercourse System Sediment Balance*, SS 5-96, Arizona Department of Water Resources, Phoenix AZ.

City of Tucson Department of Transportation, 1989; revised 1998. *Standards Manual for Drainage Design and Floodplain Management in Tucson, Arizona*

Duan, J., Acarya, A, Yeager, M., Zhang, S. and Salguero, M. 2008. *Evaluation of Flow and Sediment Models for the Rillito River:* Unpublished report prepared for the District (available from the District)

Pima County Regional Flood Control District, 1981. *Theoretically-Derived Sediment Transport Equations for Pima County, Arizona*, Simons, Li & Associates, Inc., Ft Collins, CO

Pima County Regional Flood Control District. 1984. *Drainage and Channel Design Standards for Local Drainage for Floodplain Management within Pima County, Arizona*

Pima County Regional Flood Control District, 2007. *Selection of Hydrologic Models for Disc*harge, Technical Policy 015, Tucson AZ

Pima County Regional Flood Control District, 2013. *Model Parameterization for Peak Discharges*, Technical Policy 018, Tucson AZ

Pima County Regional Flood Control District, 2005. *Engineering Analysis Requirements for Erosion Hazard Setback Evaluation*. Technical Policy 020, Tucson AZ

USACE, 1992. *Training Document -13 Guidelines for the Calibration and Application of Computer Program HEC 6,*. (NTIS) #AD-A106 706.

USACE, 1995. *HEC6 V. 4.1, Scour and Deposition in Rivers and Reservoirs: User's Manual.* Hydrologic Engineering Center, Davis, CA National Technical Information Service (NTIS) # PB94-501202.

USACE, 2008. *HEC-RAS River Analysis System, User's Manual for Version 4.0. Report CPD-68*, Hydrologic Engineering Center, Davis, CA.

USACE, 2008. *HEC-RAS River Analysis System, Reference Manual for Version 4.0. Report CPD-69*, Hydrologic Engineering Center, Davis, CA.

USACE, 2008. *HEC-RAS River Analysis System, Applications Guide for Version 4.0. Report CPD-70*, Hydrologic Engineering Center, Davis, CA.

APPROVED BY:

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