

**WWE**  
**TECHNICAL MEMORANDUM**

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**To:** Laura Kroeger, UDFCD  
David Bennett, UDFCD

**From:** Wright Water Engineers, Inc.

**Date:** July 3, 2012

**Re:** Technical Review Guidelines for Gravel Mining Activities

This memo is intended to provide a basis for a letter report to the Urban Drainage and Flood Control District (UDFCD) that would summarize the status of the Guidelines and to provide a scope of services to bring the Guidelines up-to-date and to answer UDFCD's questions.

The guidelines were initially conceptually formulated for the South Platte River Master Plan, and then for Adams County. A final document was completed for Adams County in November 1985. Two years later, in 1987, the UDFCD published its Guidelines. The parameters and design guides in the 1987 publication received wide support by June 1985 from the industry, from the State of Colorado, and others after four to five months of intense meetings and negotiations.

The originally proposed top widths of riverside and lateral berms were significantly reduced from about January to June 1985 as criteria were negotiated and worked out with diverse interests, including parks and recreation people with interests in trails and boating. Supporting computations and procedures can be developed to support the 1987 parameters and to prepare procedures for considering hardship variances for reservoirs.

## **FINDINGS**

- **Reasonableness of Guidelines.** The 1987 gravel guidelines are well accepted and reasonable and with general support from those interviewed.
- **Main Concerns with Use of Guidelines.** A significant concern with the use of the guidelines is that of a catastrophic multi-pit failure that, while causing a downstream flood surge, would allow the river to be routed through a series of gravel pits with a resulting adverse river regime change.
- **Technical Basis.** There are no specific sets of calculations and/or processes that can be directly connected to most of the twelve berm top width parameters in Table 2.1 and 2.2, although there were calculations in the file that formed the basis of initially recommended parameters. The parameters as published, instead, represent the combined knowledge and experience of the many dozens of individuals who conferred on original and early WWE draft documents and criteria.

The specific criteria of the guidelines were originally intended to be based upon scientific principles and practical objectives related to rock product mining of the 1980s. Original and initial guideline drafts in early 1985 were modified via significant industry and regulatory agency input during the spring of 1985. The technical criteria given in the 1987 guidelines are based upon principles, policy and criteria from the 1969 UDFCD, the 1984-1985 Master Plan, industry practices and economics, regulatory agency needs and the civil and geotechnical engineering professions. The parameters are supportable.

- **Water Storage Facilities.** The 1987 guidelines were formulated primarily for gravel mining, not for large municipal public work reservoirs that are operated and maintained by governmental agencies. Nevertheless, the guidelines are applicable to water storage facilities for the river protection purposes.
- **Variations.** As with most guidelines for public works design and construction, variations may be accommodated so long as they meet or exceed the intent and function of the published standards.

Variations are acceptable for the 1987 guidelines for the “Typical Minimum Maintenance Alignment (Figure 2.1).

Referring to the guideline Figures 2.2 through 2.10 for protection and stabilization, variations are allowable if the intent and objectives of the figures are met.

In regard to the top widths of riverside berms it would appear that variations could be considered if public health, safety and welfare were not compromised, the test being the meeting of specific objectives and design criteria, but not compromising on safety factors or the berm top width needed for maintenance, emergency and rescue operations or stability for floods of up to the standard project flood (500-year) and when the gravel pit, water storage facility, or adjacent pit, was empty.

For the purpose of evaluating variance requests to the UDFCD guidelines, sets of evaluation and technical criteria and computations would need to be provided for each parameter in the guideline that is proposed for change.

## **CONSULTATIONS**

Interviews were conducted to obtain comments and suggestions on the gravel mining guidelines. Pertinent comments are listed.

**Tim J. Randle, U.S. Bureau of Reclamation,** Manager, Sedimentation and River Hydraulics Group, Denver Federal Center

- The guideline berm top widths are quite reasonable.
- There are numerous mechanisms that could cause a gravel pit berm failure.

- Dynamic river cutting and filling
  - Overtopping of berm
  - Animal burrows
  - Erosion of river bank at outside of curve.
- Concern was expressed for domino-like set of lateral berm failures.
  - $Q_{500}$  may not be a critical condition; test many conditions/recurrence intervals.
  - South Platte River south of 104<sup>th</sup> Avenue appeared especially susceptible to failures due to the lake storage density.
  - Riprap protection must be adequate.
  - There is concern about continued maintenance once the gravel operator is gone, i.e., who would repair a failure?
  - The river bed in Adams County seems to have a gravel bed, based on photos reviewed.

**Mike Stevens, Geomorphologist**, Consultant to UDFCD since 1982

- Do not let gravel pit berms fail. Keep river out of pits.
- Avoid piping failures (animal burrows can be especially problematic).
- Do not change from 1984 Master Plan discharges.
- Rely on State Engineer Dam Safety criteria for failure analysis and USBR Design of Small Dams.
- River breached a gravel pit dike near Chatfield, the river flowed in and then out. This is an example, on a relatively small scale, of the potential for what could happen in the event of failure.
- Top widths must be adequate to facilitate emergency repairs.

**Bill McCormick, Chief Dam Safety Branch**, Colorado Division of Water Resources

- Dam Safety Branch has gravel pit concerns primarily when the lake level is higher than the river.

**Ben Urbonas, Private Consultant**, Former Chief of Master Planning for UDFCD

- Many meetings were held in 1985 on the guidelines.
- Original top widths tended to be more conservative than those listed in the June 1985 draft and the November 1985 Adams County Guidelines.
- The main concern about the gravel pit layouts are the lateral berms and the potential stair-step/domino failure.

**Berhan Keffelew, Colorado Mined Land Reclamation Board (MLRB)** – in charge of Adams County gravel reviews

- MLRB uses the UDFCD 1987 guidelines.
- The Guidelines are satisfactory; they are good.
- The top width of berms are per the 1987 guide, but they are open to negotiation if adequacy of a variance can be demonstrated.
- Lesser top widths are infrequent due to cost of proving equivalency.
- Thornton reported to Berhan Keffelew -- “fair” with top width design; however, one cannot be too conservative on berm design.
- A deficiency in design reviews is that only one gravel pit considered at a time. It is important to look at the cumulative effect on safety of gravel pits.
- However, Thornton has only one gravel mine permit in its name. M1986-146 is for wildlife habitat. Thornton takes over gravel mines that have already been converted to a storage lake and the reclamation is complete and the permit/project is released.
- The Division of Reclamation, Mining and Safety (DRMS)/MLRB does not track properties after final reclamation. At that point it is the owner and Adams County that are in charge.

**Jessica Barbier, Project Engineer**, Denver Water

- Jessica was project engineer during Denver Water conversion from pits to reservoirs. She handled Cat Reservoir and is familiar with Miller Reservoir.
- No “setback” issue on Cat Reservoir due to Xcel land buffer.
- For Miller Reservoir, Denver Water worked with UDFCD to stabilize river due to small existing setback (pre-1987).
- Hazelton pit may have been filled to meet setback.

- Gravel pit storage is now under Greg Gulley of Dam Safety.

## **TECHNICAL BASIS FOR PARAMETERS**

The 1987 gravel mining guidance stemmed from UDFCD's concerns about river channel stability, Mike Steven's geomorphological report of 1983, the 1984-1985 Master Plan for the South Platte River, and the desire of Adams County and the Colorado Rock Products Association for order. Formulation of the guidance document was supported by Adams County and financially by the Colorado Rock Product Association.

The early work of WWE (March 1984) on riverside berm top widths for the South Platte River Master Plan dealt with ordinary gravel mining with embankments of native soil. Criteria testing in 1984 included test cases with various input data.

From this 1984 analysis by Mark Glidden, P.E. (who was with WWE at this time) it was concluded that the berms would need armoring to resist failure during the 100-year flood event.

Using a  $D_{75}$  of one inch as a test case, it was concluded that a top width of 385 feet was required based on a safety factor of 2.0 plus a minimum buffer of 50 feet. However, when the armoring was raised to 3 inch gravel, the top width was reduced greatly. The resulting conclusion was that riverside berms would have a riprap face with filter and a slope of 3:1, including a 50 foot buffer and a top width of 100 feet for the Master Plan.

Early analyses of berm top widths demonstrated that if the riverside berms are protected against failure with adequate riprap and toe protection, the theoretical top width could be much reduced.

It is evident that the designated berm top widths were not controlled solely by erosion and sedimentation science, but by the following considerations.

- Need to provide for bank side river recreation trails.
- Importance of providing for emergency repair staging and work
- Desirability of providing a long and reasonable riparian river corridor that would not have the character of a narrow flood control channel.
- Allowing for development of water recreation boating with suitable put-ins and take-outs coupled with provisions for water rescue operators.

The 100-foot minimum width for fully protected riverside berms is a reasonable non-technical based parameter. Using technical analyses only, one could likely show that a narrow top width of say 30 feet, would suffice. However, this would not be consistent with good river corridor planning and was not the objective in the 1985-1987 period.

## **STORAGE VS. MINING GUIDANCE**

The general mining guidance criteria are applicable for use with the gravel pits for water storage from the standpoint of protecting the river. However, as a result of the dense and numerous reservoirs built and planned for the South Platte River in Adams County, and because of their proximity to each other, it would be wise to suggested an analysis of cumulative impacts as desired by the Colorado DMRS.

## **ALLOWABLE VARIANCES**

The guideline criteria for review of gravel mining are reasonable. They have been approved by the gravel industry and many agencies and have withstood the test of time. However, variances can be considered. The supporting documentation for proposed variances from the guidelines should be thorough and exacting and should be based upon a cumulative effect and compatibility with upstream and downstream development, as suggested by the DMRS. Considering the many factors involved with the basis for the guidance criteria, it would seem unlikely that the 2012 revision to the 1987 document would reduce the 100-foot top width for riverbank berms, the 100-foot top width for Type A lateral berms, or the 200-foot top width for Type B lateral berms.

## **CONCLUSIONS**

The 1987 Guidelines for gravel mining do not have readily available detailed supporting technical calculations for the berm top widths. However, a technical basis can be prepared coupled with the logic and policy to support the parameters. Since 1987, the use of gravel pits for municipal storage has become common. The guidelines are suitable for water storage facilities. There is no reason that variances cannot be requested and considered, however, non-structural constraints would likely forestall any change to the top widths of fully protected berms to less than the stated values.