DRAINAGE TECHNICAL DESIGN MEMORANDUM

Registered Professional Engineer (Civil)
CERTIFICATE NO.
50959
ZACHARY R.
SCHMIDT
Date Signed 2/11/15
ARIZONA, U.S.A.
EXPIRES: 06-30-16

To: City of Buckeye

From: Zach Schmidt, P.E., CFM

Kimley-Horn and Associates, Inc.

Date: February 11, 2015

Subject: Sundance Parcel 48 and 49A Channel Improvements

BACKGROUND

An existing earthen channel is located along the north and east side of the Sundance Residential development. The channel was designed by RBF Consulting in 2005 and constructed as part of two phases of the development, Parcel 48 and 49A. The channel conveys offsite runoff from the box culvert crossing Dean Road to the existing retention basin located at the southeast portion of the Sundance development. Refer to the Location Map provided as **Figure 1**.

The channel is located on Sundance Homeowner's Association property. As part of the agreement between the City of Buckeye (City) and the Sundance Residential development, the City will construct channel protection to prevent future scour in the channel. Based on a comparison of the 2006 as-builts, the 2014 topographic survey and a field visit conducted in December 2014, it appears that both the channel longitudinal slope, side slopes and vegetation have changed with time.

PURPOSE

The purpose of this memorandum is to evaluate potential channel improvement alternatives for providing scour protection. Channel protection alternatives were evaluated based on several factors including anticipated hydraulic impacts and preliminary Opinions of Probable Cost (OPCs).

PROJECT DESIGN CRITERIA

The following document was used for the conceptual design and analysis of channel improvement alternatives.

- *Drainage Design Manual of Maricopa County, Arizona* – Hydraulics (August 2013) (FCDMC Hydraulics Manual)

HYDROLOGY

The hydrology for this channel improvement analysis was from the offsite hydrology for the original channel design, which utilized a peak discharge of 1,087 cubic feet per second (cfs) for the 100-year storm. This hydrology was based on modeling prepared as part of *The Sundance Infrastructure Master Drainage Report* and *The Sundance Phase II Infrastructure Master Drainage Study*, portions of which are included in **Attachment A**. No modifications were made to the hydrology.

HYDRAULICS

A hydraulic analysis was prepared to evaluate the potential impacts of providing riprap channel protection. Impacts were assessed by comparing velocities, water surface elevations (WSELs) and inundation limits with and without riprap protection. Normal depth calculations were performed for three scenarios: (1) the original channel design, (2) existing conditions per the 2014 survey, and (3) proposed conditions with riprap protection. Five cross sections were used to evaluate the channel at representative locations based on the channel bend and changes in channel slope. Refer to the Drainage Map provided as **Figure 2**.

Design Condition

The design condition matches the hydraulics prepared as part of the *Final Drainage Report for Sundance Parcel 48 (2005)* and *Final Drainage Report for Sundance Parcel 49A (2006).* A normal depth analysis was prepared for the channel design. The hydraulic parameters from the original design were not changed as part of this analysis. The original design of the channel was an earthen lined trapezoidal channel. The trapezoidal channel includes a bottom width of 42 feet with 4:1 side slopes. As-built plans indicate that the channel was constructed with a minimum of one foot of freeboard. Parts of the channel constructed with the Parcel 48 phase included a turf reinforcement mat in the bottom of the channel. Refer to the hydraulic analysis provided in **Attachment B**.

Existing Condition

The existing conditions model is based on the current condition of the channel per a detailed topographic survey obtained December 5, 2014 and a field visit conducted on December 28, 2014. The survey indicates that the channel slope has changed over time to a more equalized slope throughout the channel. Steeper slopes have flattened out, therefore the channel depth is shallower than what is shown on the as-built plans in some locations. Additionally, based on the field review, there is a significant amount of vegetation located in the bottom of the channel. Due to the vegetation, the Manning's "n" roughness coefficient for the channel bottom has increased. As a result, the velocities have decreased, the normal depths have increased, and the current freeboard is less than one foot in areas near the outfall of the channel.

Scour Analysis

As part of the existing conditions analysis a scour analysis was completed to estimate the amount of scour associated with the 100-year storm event. The scour analysis is used to determine the depth of toe down for the proposed riprap protection. The scour was calculated following the FCDMC Hydraulics Manual. According to the FCDMC Hydraulics Manual, equation 11.41, total scour (Zt) can be expressed as:

$$Z_t = FS\left(Z_{long-term} + Z_{general} + Z_{bend} + Z_{bedform} + Z_{low-flow}\right) + FS_{local} * Z_{local}$$

Total scour was analyzed at two locations to account for both the straight and curved reaches of the channel. For this project, local scour is considered to be zero. No bend scour is included with the straight section, whereas bend scour is included in the general scour calculation for the curved reach.

A factor of safety of 1.3 was used for this analysis. **Table 1** provides a summary of the scour results. Refer to **Attachment C** for the scour analysis.

Table 1: Scour Summary

Cross Section	Long Term Scour [ft]	General Scour [ft]	Bedform Scour [ft]	Low Flow Scour	Factor of Safety	Total Scour
Straight	1.3	0.6	0.3	1	1.3	4.2
Curved	1.3	2.4	0.3	1	1.3	6.6

Proposed Condition

The purpose of the proposed conditions analysis is to evaluate potential hydraulic impacts from the proposed riprap channel protection. The design of the channel protection was completed using the FCDMC Hydraulics Manual. The existing conditions analysis was used as the basis for determining the size of the rock. Two sections were analyzed to size the rock riprap for both the straight and curved reaches of the channel. The design calculations indicate D_{50} sizes of 9 inches and 18 inches for the straight and curved sections respectively. The new cross section was analyzed with the riprap protection. Manning's "n" coefficient was selected from the FCDMC Hydraulics Manual. In addition to the rock riprap, the channel sides were modified to have 3:1 side slopes to increase capacity. Based on the side slope changes, the bottom width will increase to approximately 55 feet. Two proposed alternatives were evaluated: Alternative #1 with riprap protection along the channel bottom and side slopes, Alternative #2 with riprap protection just on the side slopes. Alternative #2 would also include a toe down for the bank protection to protect the banks from undermining. The toe down depth was estimated based on the scour depths calculated for the 100-year storm event. The calculation requirements for "launchable" riprap detailed in the FCDMC Hydraulics Manual were used to determine the toe down depths. The "launchable riprap design is used to minimize earthwork to construct the toe down depth to the full scour depth. The design calculations include the total volume of riprap required to protect the channel to the full scour depth. If the channel protection starts to undermine, the riprap will "launch" to a deeper depth. Refer to **Figure 3, Attachment B** and **Attachment D**.

Hydraulic Summary

Table 2 provides a summary of the hydraulic calculations. Full protection of the channel in Alternative #1 results in significant increases in WSEL at multiple locations, with channel overtopping at XS-4 and XS-5. For Alternative #2, only the side slopes are armored and vegetation is removed from the channel bottom. The calculations indicate that although the Alternative #2 channel does not have the one foot of freeboard in each of the cross sections, it has the capacity to convey the 100-year storm event. Refer to **Attachment B**.

Kimley»Horn

Table 2: Hydraulic Summary

Cross-Section	Left Bank		Main Channel		Right Bank		Normal Depth	Velocity	Top of Bank	WSEL	Freeboard
	Slope	Manning's n	Long. Slope	Manning's n*	Slope	Manning's n					
	[H:V]		[ft/ft]		[H:V]		[ft]	[ft/sec]	[ft]	[ft]	[ft]
XS-1 (Straight)											
Design (XS-1D)	4.0	0.030	0.0052	0.030	4.0	0.030	3.07	6.53	N/A	N/A	>1
Existing (XS-1E)	4.5	0.030	0.0067	0.040	4.3	0.030	3.12	6.03	1023.37	1022.73	0.64
Alternative #1 (XS-1PF)	3.0	0.058	0.0067	0.058	3.0	0.058	3.58	4.42	1023.37	1023.19	0.18
Alternative #2 (XS-1PH)	3.0	0.058	0.0067	0.030	3.0	0.058	2.83	5.79	1023.37	1022.44	0.93
XS-2 (Curved)											
Design (XS-2D)	4.0	0.030	0.0052	0.030	4.0	0.030	3.07	6.53	N/A	N/A	>1
Existing (XS-2E)	5.0	0.030	0.0065	0.040	3.8	0.030	3.34	6.13	1021.5	1020.36	1.14
Alternative #1 (XS-2PF)	3.0	0.077	0.0065	0.077	3.0	0.077	4.48	3.71	1021.5	1021.50	0.00
Alternative #2 (XS-2PH)	3.0	0.077	0.0065	0.030	3.0	0.077	3.47	5.01	1021.5	1020.49	1.01
XS-3 (Straight)											
Design (XS-3D)	4.0	0.030	0.0091	0.030	4.0	0.030	2.62	7.90	N/A	N/A	>1
Existing (XS-3E)	4.0	0.030	0.0077	0.045	4.8	0.030	3.30	5.99	1015.21	1015.08	0.13
Alternative #1 (XS-3PF)	3.0	0.058	0.0077	0.058	3.0	0.058	3.54	4.68	1015.21	1015.32	-0.11
Alternative #2 (XS-3PH)	3.0	0.058	0.0077	0.030	3.0	0.058	2.81	6.11	1015.21	1014.59	0.62
XS-4 (Straight)											
Design (XS-4D)	4.0	0.030	0.0050	0.030	4.0	0.030	3.10	6.44	N/A	N/A	>1
Existing (XS-4E)	4.2	0.030	0.0066	0.045	3.7	0.030	3.57	5.82	1010.38	1010.30	0.08
Alternative #1 (XS-4PF)	3.0	0.056	0.0066	0.056	3.0	0.056	3.84	4.67	1010.38	1010.57	-0.19
Alternative #2 (XS-4PH)	3.0	0.056	0.0066	0.030	3.0	0.056	3.15	5.9	1010.38	1009.88	0.50
XS-5 (Straight)											
Design (XS-5D)	4.0	0.030	0.0091	0.030	4.0	0.030	2.62	7.90	N/A	N/A	>1
Existing (XS-5E)	3.8	0.030	0.0079	0.040	3.7	0.030	3.08	6.51	1005.69	1005.54	0.15
Alternative #1 (XS-5PF)	3.0	0.058	0.0079	0.058	3.0	0.058	3.68	4.84	1005.69	1006.14	-0.45
Alternative #2 (XS-5PH)	3.0	0.058	0.0079	0.030	3.0	0.058	2.97	6.19	1005.69	1005.43	0.26

Design – Cross section based on 2005 RBF Design **Existing** – Cross Section based on 2014 survey **Alternative #1** – Cross section based on full protection **Alternative #2** – Cross Section based on side slope protection