TERAKEE MEADOW
APPROX. 900 SOUTH 4500 WEST
WEST WEBER, UTAH 84404
IRRIGATION WATER PASS-THROUGH ANALYSIS
Project No. 16N719
2-3-2021

General Information:

The proposed Terakee Meadow site is located on the east side of 4700 West Street just south of 900 South Street in West Weber, Utah. As part of construction, an existing irrigation ditch will be re-routed slightly to accommodate lot placement in this proposed residential development. It is understood that the re-routed ditch and pipe crossing are to be sized/sloped to accommodate a design flow rate of no less than 3.0 cfs.

Irrigation water has historically entered the section of ditch from the north side of the property and flows to the south across the property through the existing ditch alignment. The proposed alignment will divert the flows easterly for about 140 feet. The ditch will then turn to the south and proceed about 250 feet to the proposed cul-de-sac. The water will be piped across the street and then proceed southerly about 250 feet to the south boundary of the property. Flows will turn to the west along the west property line for about 100 feet, where they will be intercepted by the original alignment and proceed southerly in a historical fashion. The attached figure shows the project site and location of the re-aligned irrigation ditch. Flow calculations have been provided for the ditch and pipe crossing utilizing the design flow requirement of 3.0 cfs. (See calculations below and Sheet 4 of the design plans for reference of the corresponding profile view).

Calculations:

Manning's Equation is used for determining the depth of water in the ditch when flowing with Q=3cfs. The proposed ditch and 18" diam. RCP culvert are sloped at S=0.04%. The ditch is designed as a trapezoidal channel approximately 2.0' deep. The base of the ditch is b = 2' wide, with side slopes of 3H:2V (m=1.5). Solving Manning's Equation for depth yields y = 1.033'. Verification of this solution is provided here. Cross sectional Area, A, equals y*(b+my) = 3.667 sf. Wetted Perimeter, P, equals b + 2y*(m^2+1)^0.5 = 5.725 ft. We enter Manning's equation using alpha = 1.4859 and n = 0.027 (corresponding to an excavated channel with a few weeds). Manning's Equation yields the following:

$$\textit{After substituting values, we have ...}$$
$$Q = \frac{\text{alpha}}{n} * \frac{A^{5/3}}{P^{2/3}} * S^{1/2} = \frac{1.4859}{0.027} * \frac{3.667^{5/3}}{5.725^{2/3}} * 0.0004^{1/2} = 3\ cfs$$

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Manning's equation was also used to determine the "gravity only" capacity of the 18" diameter RCP (n = 0.013) culvert. It was found to have a "gravity only" capacity of 2.1 cfs. Therefore, Bernoulli's Equation was used to determine the additional hydraulic head that will build up in order to pass the entire 3 cfs.

Bernoulli's Equation is applied from immediately upstream of the upstream flared end section (Location 1) to immediately downstream of the downstream flared end section (Location 2) across the culvert. Since p1 = p2 and v1 = v2, Bernoulli's Equation simplifies to the following:

$$z1 = z2 + hL$$

Where $\Delta z = z1 - z2 = hL = f*(L/D)*(V^2/2g)$ headloss along the length of the pipe is calculated using the Swamee/Jain formula for the friction factor, f, as:

$$hL = \frac{0.25}{\left(\log\left(\frac{ks}{3.7*D} + \frac{5.74}{\left(\frac{V*D}{nu}\right)^{0.9}}\right)\right)^2}\left(\frac{L}{D}\right)\left(\frac{V^2}{2g}\right)$$

The diameter D = 1.5 ft. Pipe specific roughness is set to ks = 0.004' for concrete. Velocity is calculated as $V = Q/A = 3/(\pi 0.75^2) = 1.698$ ft/s. The kinematic viscosity is found to have a value of nu = 0.0000141 ft^2/s, assuming a water temperature of 50° F. The total length through the 18" diameter pipe is L = 5.5 + 78.9 + 5.4 = 89.8 ft. The value of g is set to 32.2 ft/s^2.

$$hL = \frac{0.25}{\left(\log\left(\frac{0.004}{3.7*1.5} + \frac{5.74}{\left(\frac{1.698*1.5}{0.0000141}\right)^{0.9}}\right)\right)^2}\left(\frac{89.8}{1.5}\right)\left(\frac{1.698^2}{2(32.2)}\right) = 0.071\ ft$$

Thus, the top of water elevation immediately upstream of the culvert is 0.071 ft higher than immediately downstream of the culvert. The downstream top of water is calculated as the depth in the downstream trapezoidal channel (1.033 ft) plus the flowline elevation of 4234.10. This yields the downstream side z2 = 4235.133. This means the upstream z1 = 4235.133 + 0.071 = 4235.204. Comparing this value to the upstream flowline of 4234.13, we find that the depth immediately upstream of the culvert is 4235.204 – 4234.13 = 1.074 ft. This is only an additional 0.041 ft additional head built up above the upstream trapezoidal channel depth of 1.033.

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Conclusions:

Both the trapezoidal channel and RCP culvert can convey the required design flow of 3 cfs, while still maintaining almost a foot of freeboard in the 2.0’ deep trapezoidal channel.

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