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Technical Memorandum

To: Ted Suss & Dave Minge
From: Jennifer Koehler, PE, Philip Solseng, PE, & Len Kremer
Subject: Lyon County Ditch 14 – Storage Evaluation
Date: 8/31/2020

Introduction

The Cottonwood and Minnesota Rivers are being impaired for turbidity by the sustained river flows that have been significantly increased by agricultural drainage improvement projects along these river systems. The turbidity in these river systems are likewise adversely impacting downstream waters including the Mississippi River System and Lake Pepin. One method to abate turbidity is to reduce the peak discharge from new drainage projects and store more water within local watersheds. Although County Ditch 14 (CD 14) is small in comparison to these large river systems, it is the cumulative effect of drainage of many small watersheds that is causing the impairments to these river systems. Therefore, improving storage in CD 14 watershed is a small but important step to mitigate adverse downstream impacts.

This Technical Memorandum presents the results of the storage and modeling performed on CD 14 to evaluate storage alternatives within the watershed of County Ditch 14 and thereby reduce the peak discharges from the proposed drainage project. The memorandum includes (1) background to the proposed increased drainage of CD 14, (2) a review of the existing conditions and (3) a conceptual level analysis of storage alternatives and the impacts storage has on reducing peak discharge from the proposed project. A summary of the analysis is provided at the end of the Technical Memorandum.

Background

In January 2020, a Preliminary Engineer's Report for the Improvement of CD 14 in Lyon County was submitted to the Lyon County Board. The report evaluated the existing capacity of the CD 14 drain tile system and concluded it needed extensive repair because of its age, was undersized and did not meet the current NRCS drawdown rate of ½" of runoff per day from the contributing watershed. Several alternatives were evaluated looking at the required upsizing of the tile line to current (increased) farm drainage standards, including upsizing the tile system as well as developing additional storage around an existing low area. Hydrologic modeling performed to evaluate alternatives indicated that the proposed improvement project would result in increased peak flows to the Cottonwood and Minnesota Rivers for the smaller, more frequent events (e.g. 2-year to 25-year events) with minor reductions in the peak discharges for the larger storm events (e.g. 50-year to 100-year events). Ideally, the proposed solution would decrease peak discharges to minimize impacts to downstream public waters, and especially to reduce peak discharges for the more frequent events.

Both the Cottonwood and Minnesota Rivers are impaired for turbidity caused by bank erosion due to high sustained flows. As part of the 2015, Minnesota Pollution Control Agencies (MPCA) investigation of the excess turbidity in the Minnesota River Watershed, the MPCA established goals to reduce both the magnitude and duration of peak stream flows that will reduce turbidity in the watersheds' streams and rivers. The flow magnitude goal is to reduce the two-year annual peak flow by 25% and the duration goal is to reduce the number of days that the peak flow is exceeded by 25%. The proposed CD 14 improvement project needs additional storage to reduce increases in peak discharges and a reduction in the magnitude of those peak discharges to the Cottonwood and Minnesota Rivers.

Existing Conditions Review

The existing conditions HydroCAD model utilized for the preliminary engineering report was provided by the Engineer and watershed and storage inputs from this model were used to evaluate storage opportunities along CD 14. Figure 1 shows the general watersheds as provided from the preliminary engineering report analysis.

Utilizing the watershed areas and routing from the existing HydroCAD model, an evaluation of the cumulative contributing watershed moving downstream along CD 14 was performed. Based on conversations with county staff, runoff from watershed 29S was not included in this analysis as the existing storage and tile system already provides extended detention of runoff and limits discharge to the CD 14 tile system. Based on the cumulative contributing watershed area, the ½" runoff volume at each point in the watershed was estimated along with existing overflow elevations (as included in the HydroCAD model, typically representing road overflows or ground overflows) and storage volume available to this elevation. This information is summarized in Table 1, along with the evaluation of storage opportunities discussed in the following section.

Storage Alternatives

Topography in the watershed suggests there may be opportunities to better utilize storage in the watershed, providing extended detention of runoff and reducing the size of the proposed CD 14 tile line. This could ultimately reduce project costs and downstream impacts to the Cottonwood and Minnesota Rivers.

There are several locations within the watershed where there may be opportunities to maximize use of existing topography to increase storage with raising of low roads (as applicable), the addition of extended detention outlets to detain runoff for longer periods and reduce discharge rates to both the surface and/or tile drainage systems, and potential grading within some of the proposed storage areas to maximize the available storage at the critical elevations. The Minnesota Department of Natural Resources (MnDNR), Local Area Wildlife Manager was contacted, and she confirmed that it would be acceptable to temporarily store storm runoff in the watersheds' Wildlife Management Areas.

Two proposed storage alternatives were evaluated and development of additional storage along CD 14 was optimized moving from upstream to downstream along system. Figure 1 shows these proposed storage areas. Table 1 summarizes the results of the preliminary storage analysis.

- Alternative 1 assumes that additional storage and extended detention would be created in:
    - (MnDNR) Deer Lane Wildlife Management Area (WMA) (watershed 16S) including Public Water Lake (42003000, P, Hanson Slough)
    - MnDNR Dayland Marsh WMA west of 230th Ave (watershed 18S) along with low area to east of 230th Ave (watershed 14S), located on private property
- Alternative 2 assumed that additional storage and extended detention would be created as outlined in Alternative 1 as well as:
    - on private land in the wetland areas around the intersection of 150th Street and 230th Avenue (located in watersheds 20S, 22S, 24S, and 12S)
    - on private land in the low area upstream of 150th Avenue and 240th Street (watersheds 7S and 10S)

In general, overflow elevations were optimized from upstream to downstream such that additional storage equivalent to the 1/2" of cumulative runoff to that point in the watershed would be created. If additional storage were able to be created (and associated extended detention time) to achieve the ½" of runoff to that point in the watershed, it was assumed that these areas would not contribute significant flows to the downstream tile system within the standard 24 hour drawdown period. This assumption serves to reduce the sizing of the downstream CD 14 tile system.

Summary

Ultimately, with raises in roads and modifications to discharge from key points in the watershed to provide extended detention, there appears to be opportunities to create more storage and detention in the watershed that could reduce the sizing of the proposed tile system. The following is a comparison of the required pipe sizes between the preliminary engineering report and the two high level alternatives analyzed.

1. The preliminary engineering report (by others) suggested that to convey ½" of runoff per day, the main tile line along CD 14 would range from 48"-54" (or dual 36" pipes), from 230th Avenue to 160th Avenue. With the creation of storage and sizing to convey ¼" of runoff per day, the main tile line along CD 14 would range from 24 to 42"
2. For storage Alternative 1 which primarily maximizes storage within the MnDNR WMAs and a small area on private land, the main tile line along CD 14 could potentially be reduced to an 18"-30" from 230th Avenue to 160th Avenue, assuming similar slopes as outlined in the preliminary engineering report.

3. For storage Alternative 2, which maximizes storage within the MnDNR WMAs and on downstream private properties, the main tile line along CD 14 could potentially be reduced to an 18"-24" from 230th Avenue to 160th Avenue.

As shown above, there is the potential for a significant reduction in pipe sizes if storage is optimized within the watershed.

The existing HydroCAD model was updated for the two alternatives to reflect this preliminary storage analysis, primarily updating the overflow elevations, incorporating extended detention outlets at culverts and modified overflow locations (to allow for restricted discharge at existing surface discharge locations), and revising the tile size and slope along the main ditch alignment to demonstrate impact on the discharges at the Cottonwood and Minnesota Rivers. Table 2 summarizes the existing peak discharges for the various design storm events, along with the estimated peak discharges for the alternatives evaluated in the preliminary engineering report, and the estimated peak discharges for the two alternatives evaluated as part of this assessment. The following table provides an example of the reduced peak discharges with Alternates 1 and 2 as compared to the existing and proposed peak discharges (by others) some of the smaller storm events.

		Preliminary Engineering Report (January 2020)	Current Analysis	
	Existing Conditions	1/2" Design	Alternative 1	Alternative 2
Storm Event	Peak Discharge (cfs)	Peak Discharge (cfs)	Peak Discharge (cfs)	Peak Discharge (cfs)
2-Year	78.1	152.5	93.2	82.8
5-Year	123.5	209.5	138.5	128.8
10-Year	157.2	247.6	172.5	162.6
25-Year	209.1	310.5	225.1	214.9

As shown above, the alternatives analyzed don't quite achieve the existing peak discharges for the smaller design storm events, they are nearly the same, and very much lower than the proposed design (by others). Therefore, it shows that optimizing the utilization of storage can offer a significant improvement to reduce the peak discharges over the proposed design.

In summary, this is a conceptual level planning analysis that demonstrates there are opportunities to utilize existing storage within the watershed to (1) reduce the CD 14 drain tile system size (and tile construction cost), (2) minimize peak discharges and thereby, (3) minimize adverse impacts to the Cottonwood and Minnesota Rivers. Further engineering and economic analyses will be needed to further optimize the storage and hydraulics of the proposed system, evaluate project costs and feasibility, to include costs such as road raises, storage area outlet cost and easements.

Cottonwood River

Alternative 2: Storage on Private Lane
Potential Changes: Raise roads, Modify Culvert Crossings and Surface Overflow/ Extended Detention

Alternative 2: Storage on Private Lane
Potential Changes: Raise road, Grading to Maximize storage, Modify Culvert Crossings/Extended Detention

Alternative 1 & 2: MnDNR Dayland Marsh WMA
Potential Changes: Raise road, Modify Culvert Crossing/Extended Detention

Alternative 1 & 2: MnDNR Deer Lane WMA
Potential Changes: Modify Surface Overflow/ Extended Detention

Alternative 1 & 2: Storage on Private Lane
Potential Changes: Modify Surface Overflow/ Extended Detention, Grading to Maximize Storge, Modification to Tile inlets in low area

WS 29S not included in analysis per conversation with County staff

1S
4S
4S
4S
6S
7S
10S
12S
12S
12S
20S
22S
24S
31S
16S
14S
18S
26S
29S

160th St
150th St
140th St
220th Ave
230th Ave
240th Ave
250th Ave
260th Ave
63 COUNTY
67 COUNTY
7

Subwatersheds (Prelim Engineering)
Potential Storage Areas
10 ft Contour

0 1,500 3,000
Feet

SUBWATERSHED DIVIDES & STORAGE AREAS
Lyon Co. Ditch 14

FIGURE 1

Barr Footer:
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Table 1: County Ditch 14 Storage Summary

Tile/Branch	Location	HydroCAD SWS	Total Tributary Area - not including WS 29S (ac)	Total Tributary Estimated 1/2 inch Runoff Volume (acre-ft)	NRCS Flow - not including WS 29S (cfs) (1/2"/day)	Existing Conditions Storage Overtopping Elevation (ft MSL)	Existing Storage Volume to Overtopping Elevation (acre-ft)	Optimized Proposed Storage Overtopping Elevation (ft MSL)	Proposed Storage Volume to Overtopping Elevation (acre-ft)	Increase in Storage (acre-ft)	Cumulative Increase in Storage (acre-ft)	Adjusted Total Tributary 1/2 inch Runoff Volume (acre-ft)	Adjusted NRCS Flow (cfs) (adjusted runoff/day)	Proposed Tile Grade (%)	Proposed Tile Size (in)
Alternative 1: Storage on MnDNR Property (WS 18S (MnDNR), 16S (MnDNR), 14S (private))															
CD 14 Main	**DNR WMA**	16S	292	12.2	6.1	1489.4	16.5	1490.2	28.6	12.0	12.0	0.1	0.1	0.12	18
	West Side of 230th Ave/DNR Wetland (WMA)	18S	826	34.4	17.4	1484.3	51.4	1485.6	85.8	34.4	34.4	0.0	0.0	0.16	18
	East Side of 230th Ave	14S	1938	101.3	40.7	1483.0	17.8	1486.3	52.5	34.7	81.2	-0.4	-0.2	0.12	18
	Main Prior to Branch 1	12S	2145	109.9	45.1	1476.3	52.8	1476.3	52.8	0.0	81.2	8.2	4.1	0.12	18
	N 1/2 of NW Quarter of Section 7	10S	2210	112.6	46.4	1475.6	3.5	1476.5	3.5	0.0	81.2	10.9	5.5	0.14	21
	South Side of 150th St.	7S	2292	116.0	48.1	1476.5	11.3	1476.5	11.3	0.0	81.2	14.3	7.2	0.14	24
	North Side of 150th St.	6S	2322	117.3	48.8	1476.2	13.3	1476.2	13.3	0.0	81.2	15.6	7.9	0.14	24
	Main Prior to Branch 2	4S	2477	123.8	52.0	1479.2	237.1	1479.2	237.1	0.0	81.2	22.0	11.1	0.10	30
	West Side of CSAH 7	4S	2477	123.8	52.0	1479.2	237.1	1479.2	237.1	0.0	81.2	22.0	11.1	0.10	30
	South Side of 160th St.	1S	2635	130.3	55.4	1459.5	1.5	1459.5	1.5	0.0	81.2	28.6	14.4	0.10	30
Alternative 2: Storage at all locations (WS 18S (MnDNR), 16S (MnDNR), 14S (private), 12S (private), 10S (private), 7S (private))															
CD 14 Main	**DNR WMA**	16S	292	12.2	6.1	1489.4	16.5	1490.2	28.6	12.0	12.0	0.1	0.1	0.12	18
	West Side of 230th Ave/DNR Wetland (WMA)	18S	826	34.4	17.4	1484.3	51.4	1485.6	85.8	34.4	34.4	0.0	0.0	0.16	18
	East Side of 230th Ave	14S	1938	101.3	40.7	1483.0	17.8	1486.3	52.5	34.7	81.2	-0.4	-0.2	0.12	18
	Main Prior to Branch 1	12S	2145	109.9	45.1	1476.3	52.8	1476.5	59.9	7.2	88.3	1.1	0.5	0.12	18
	N 1/2 of NW Quarter of Section 7	10S	2210	112.6	46.4	1475.6	3.5	1477.3	6.7	3.1	91.4	0.6	0.3	0.14	18
	South Side of 150th St.	7S	2292	116.0	48.1	1476.5	11.3	1477.3	16.5	5.2	96.7	-1.2	-0.6	0.14	18
	North Side of 150th St.	6S	2322	117.3	48.8	1476.2	13.3	1476.2	13.3	0.0	96.7	0.1	0.0	0.14	18
	Main Prior to Branch 2	4S	2477	123.8	52.0	1479.2	237.1	1479.2	237.1	0.0	96.7	6.5	3.3	0.10	18
	West Side of CSAH 7	4S	2477	123.8	52.0	1479.2	237.1	1479.2	237.1	0.0	96.7	6.5	3.3	0.10	18
	South Side of 160th St.	1S	2635	130.3	55.4	1459.5	1.5	1459.5	1.5	0.0	96.7	13.1	6.6	0.10	24

Table 2: Summary of Peak Discharges

	Existing Conditions	Preliminary Engineering Report (January 2020)						Current Analysis			
		1/2" Design		3/8" Design		1/4" Design		Alternative 1		Alternative 2	
Storm Event	Peak Discharge (cfs)	Peak Discharge (cfs)	Change in discharge (cfs)	Peak Discharge (cfs)	Change in discharge (cfs)	Peak Discharge (cfs)	Change in discharge (cfs)	Peak Discharge (cfs)	Change in discharge (cfs)	Peak Discharge (cfs)	Change in discharge (cfs)
1-Year	66.6	--	--	--	--	--	--	82.4	15.8	72.5	5.8
2-Year	78.1	152.5	74.5	145.3	67.3	134.8	56.8	93.2	15.1	82.8	4.8
5-Year	123.5	209.5	86.0	187.6	64.1	165.8	42.3	138.5	15.0	128.8	5.3
10-Year	157.2	247.6	90.4	225.3	68.1	195.5	38.3	172.5	15.3	162.6	5.4
25-Year	209.1	310.5	101.4	271.3	62.2	242.7	33.6	225.1	16.0	214.9	5.8
50-Year	467.0	389.4	-77.6	323.3	-143.7	296.1	-170.9	268.6	-198.4	260.2	-206.8
100-Year	905.2	814.1	-91.1	610.8	-294.4	371.6	-533.6	637.6	-267.6	652.7	-252.5