Memorandum

To: Kip Petersen, General Manager, Donala Water and Sanitation District

From: Mark Mitisek P.H. and Patrick O'Brien, Leonard Rice Engineers, Inc.

Reviewed by: Katie Fendel P.E., , Leonard Rice Engineers, Inc.

Date: January 3, 2017

Project: Willow Creek Ranch, Long-Term Excess Capacity Contracts Environmental Assessment

Subject: Donala Stormwater Runoff Analysis

This document was prepared on behalf of Donala Water and Sanitation District (DWSD) in support of their Long-Term Excess Capacity Contracts Environmental Assessment (EA). This document describes the approach, data sources, and refinements used to quantify the stormwater runoff associated with the current and predicted future development within the DWSD service area using a standard curve number approach. Below are a summary of key assumptions specific to the analysis presented herein:

- Stormwater runoff volumes presented are based on daily historical precipitation, not design storms.
- Stormwater runoff volumes presented herein take into account variations in antecedent moisture conditions using standard TR-55 methods. Therefore, the results presented are conservative compared to an analysis using only average moisture conditions II as recommended in the Floodplain and Stormwater Criteria Manual (CWCB, 2006).
- Stormwater runoff volumes presented are un-routed and do not take into account existing stormwater facilities that currently attenuate all storm flows.

APPROACH

A spatial analysis was performed for DWSD current land use conditions using GIS. This GIS analysis was used to determine the DWSD service area boundary, the land use parcels within the boundary, hydrologic soil group associated with those parcels, and finally the published curve numbers associated with each land use-soil complex.

To quantify historical stormwater runoff under currently developed and future planned conditions, a NRCS curve number analysis was completed based on standard methods and equations defined in Technical Release 55 (TR-55) (NRCS, 1999). The curve number analysis approach requires the use of historical climate, land use, and soils data within the DWSD service area. The developed site specific curve numbers were then refined to more accurately represent current conditions.

CLIMATE DATA - The BLACK FOREST 6 WNW climate station is located approximately 2 miles southeast of the DWSD service area. Daily precipitation data were obtained from this station (1/1/2004 to 12/31/2015) using the Applied Climate Information NOAA-RCC web-service (ACIS, 2016) and missing daily values were filled with zeroes. Over the study period the average annual precipitation for this station is 19.66 inches. **Attachment A** is the summary of monthly precipitation for this station.

LAND USE DATA- DWSD land use parcel data was developed from the El Paso County Assessor's Office. The County Assessor shapefile and associated attribute data allowed for classification of

designated neighborhoods and land use within the DWSD service area. A generalized land use determination was then made for each parcel, with the categorization being either Developed (Residential), Open Space, Road, or Commercial.

- ***Developed (Residential)*** - The residential parcels represent approximately 61% of the current DWSD total area. To be able to affectively assign curve numbers to individual parcels, the residential characteristics were defined as either single family homes, or multi-family/town home complexes. Single family homes were then classified based on their lot size and matched to the size classes listed in the NRCS TR-55 (NRCS, 1999) to determine associated curve numbers.
- ***Open Space -*** Undeveloped/Open Space/Easement parcels represent approximately 20% of the current DWSD total area. Open space is spread throughout the DWSD service area, with the largest contributor being a golf course in the southeastern portion.
- ***Roads -*** Roadways represent approximately 16% of the current DWSD service area. Approximately 41% of the roads within the DWSD service area have curb and gutter features. The remaining roads are paved or hard pack dirt/gravel with unlined barrow ditches. Road type was determined through Google Earth street view, and confirmed via site visitation.
- ***Commercial -*** Commercial parcels represent approximately 3% of the current DWSD service area. Commercial areas are focused along the outer portions of the DWSD in the northern and southern areas.

SOILS DATA – The NRCS Soil Survey Geographic Database (SSURGO) was used to characterize hydrologic soil groups for each land use parcel within the DWSD service area (NRCS, 2016). Based on SSURGO, the predominant Hydrologic Soil Group is B making up 94% of the service area.

Attachment B is the published table of NRCS curve numbers for urban areas used in the analysis. A final weighted curve number was developed to determine runoff from historical precipitation data for the study period 1/1/2004 to 12/31/2015 using Equations 2.2, 2.3, and 2.4 defined in Chapter 2 of TR-55 SCS curve number runoff method (NRCS, 1999).

SITE SPECIFIC CURVE NUMBER REFINEMENTS - The following site specific curve number refinements were made based on additional information gathered during a site visit on September 22, 2016 and further investigation using Google Earth Street View:

- In areas where vegetation is established [Developed (Residential) and Undeveloped/Open Space/Easement] a determination of "Pasture Good Condition" (grass cover >75%)" was made.
- In residential neighborhoods in the northeast section of DWSD, a determination of "Wood Good Cover" was made based on abundant forest cover.
- Multi-family/town home parcels data within the DWSD service area have variable overall lot sizes and building footprint size within each lot. Using this data directly would result in an under estimate of impervious area and associated curve number. To account for these discrepancies, all multi-family/town home parcels were assigned an impervious cover of 50%. This impervious cover estimate was determined by averaging the impervious covers associated with <1/8 acre (65% impervious) and 1/4 acre (38% impervious) lot size classes

listed in the TR-55 (NRCS, 1999). The associated curve number for all multi-family/town home parcels was determined based on the calculated relationship between impervious cover and curve number ($CN = CN_{perv} + (\%_{imperv} /100) (98 - CN_{perv})$).

- The northwestern neighborhood in the DWSD service area known as Chaparral Hills is unique due to the fact that the land use parcels are almost entirely large (>1 acre) rural residential, and the roads are dirt as opposed to paved. A Muller Engineering study titled "Douglas County Large Lot Runoff Evaluation" found that stormwater runoff from large lot single-family homes is not measurable (Muller, 2012). The study concluded that a representative storm event of 0.50 inches infiltrates completely from all directly connected impervious areas. Each Chaparral Hills lot has been contoured to collect stormflow resulting from larger events attenuating flows locally using onsite BMP's or barrow ditches. For this reason the entire neighborhood was determined to be disconnected impervious area. The associated curve numbers for the Chaparral Hills parcels have been adjusted based on the following equation for calculating curve numbers in disconnected impervious areas: ($CN = CN_{perv} + (\%_{imperv} /100) (98 - CN_{perv})(1-0.5R)$, where R is the ratio of disconnected impervious area).

SCENARIOS

Weighted curve numbers for the DWSD service area were calculated and analyzed along with historical daily precipitation for two scenarios, current land use and planned future land use. Current land use was represented by the spatial analysis and land use parcel definition discussed above. Future planned land uses were developed and reviewed based on information provided by DWSD staff. The following adjustments were made to the current land use to represent future conditions. Note that the adjustments and associated locations are also outlined in **Figure 2**:

- For the Chaparral Hills neighborhood in the northwest, a determination was made that the parcels defined as Undeveloped/Open Space under the current land use conditions would become developed as Residential Single-Family - Large Lot (>1 acre) parcels to match the characteristics of the neighborhood.
- For the former Glen Eagle golf course in the southeast, 56 developed Residential Single-Family – Small Lot (1/4-1/2 acre) parcels will replace an equivalent sized portion of the golf course designated as Undeveloped/Open Space under the current land use conditions. An area of associated residential roadway for a similar size development was extrapolated based on characteristic lot sizes and roads in the neighborhood, amounting to an additional 5.2 acres of roads with curb and gutter.
- Commercial development is planned in the near future. The corridor adjacent to the southwest DWSD boundary designated as Undeveloped/Open Space under the current land use conditions will be converted to commercial.
- DWSD has agreed to annex the Western Museum of Mining and Industry located at the southern boundary of their service area. This large Commercial lot was appended on to the DWSD service area. This Commercial parcel has runoff characteristics and an impervious area most representative of a Residential Single Family-Large Lot parcel.

RESULTS

CURRENT LAND USE SCENARIO

Figure 1 represents the current land use types for the DWSD service area. The associated impervious percentages for each of the current land use types are summarized in **Table A** below. The areal extents of the various hydrologic soil groups associated with the land use types are summarized in **Table B** below. Combining the land use types and soil groups into land use-soil complexes allowed for curve numbers to be assigned to each complex based on methodology explained in TR-55 (NRCS, 1999). Curve numbers for each complex were then weighted based on their fractional area of the DWSD. An overall weighted curve number of 73 was calculated to represent the DWSD area under current land use conditions.

Table A - Donala Water Sanitation District Current Land Use and % Impervious

Lot Types	Lot Class	% Impervious	Area (Acres)	% Total Impervious*
SINGLE-FAMILY - SMALL LOT	< 1/8 acres	65%	22.9	0.9%
	1/8 - 1/4 acres	38%	104.6	2.4%
	1/4 - 1/2 acres	30%	390.4	7.1%
	1/2 - 1 acres	25%	189.9	2.9%
SINGLE-FAMILY - LARGE LOT	> 1 acres	20%	225.0	2.7%
COMMERCIAL	Variable	85%	45.2	2.3%
MULTI-FAMILY/TOWN HOME	Variable	50%	76.9	2.3%
ROADS	Curbed	100%	108.0	6.6%
	Dirt	100%	17.5	1.1%
	Non-curbed	100%	135.0	8.2%
UNDEVELOPED/OPEN SPACE/EASEMENT	Variable	0%	329.6	0.0%
Total		-	1,645.1	36.6%

Table B - Donala Water Sanitation District Hydrologic Soil Groups (Current)

Hydrologic Soil Group	Area (Acres)	Percent (%)
B	1,544.3	94%
C	67.3	4%
D	33.5	2%
Total	1,645.1	100%

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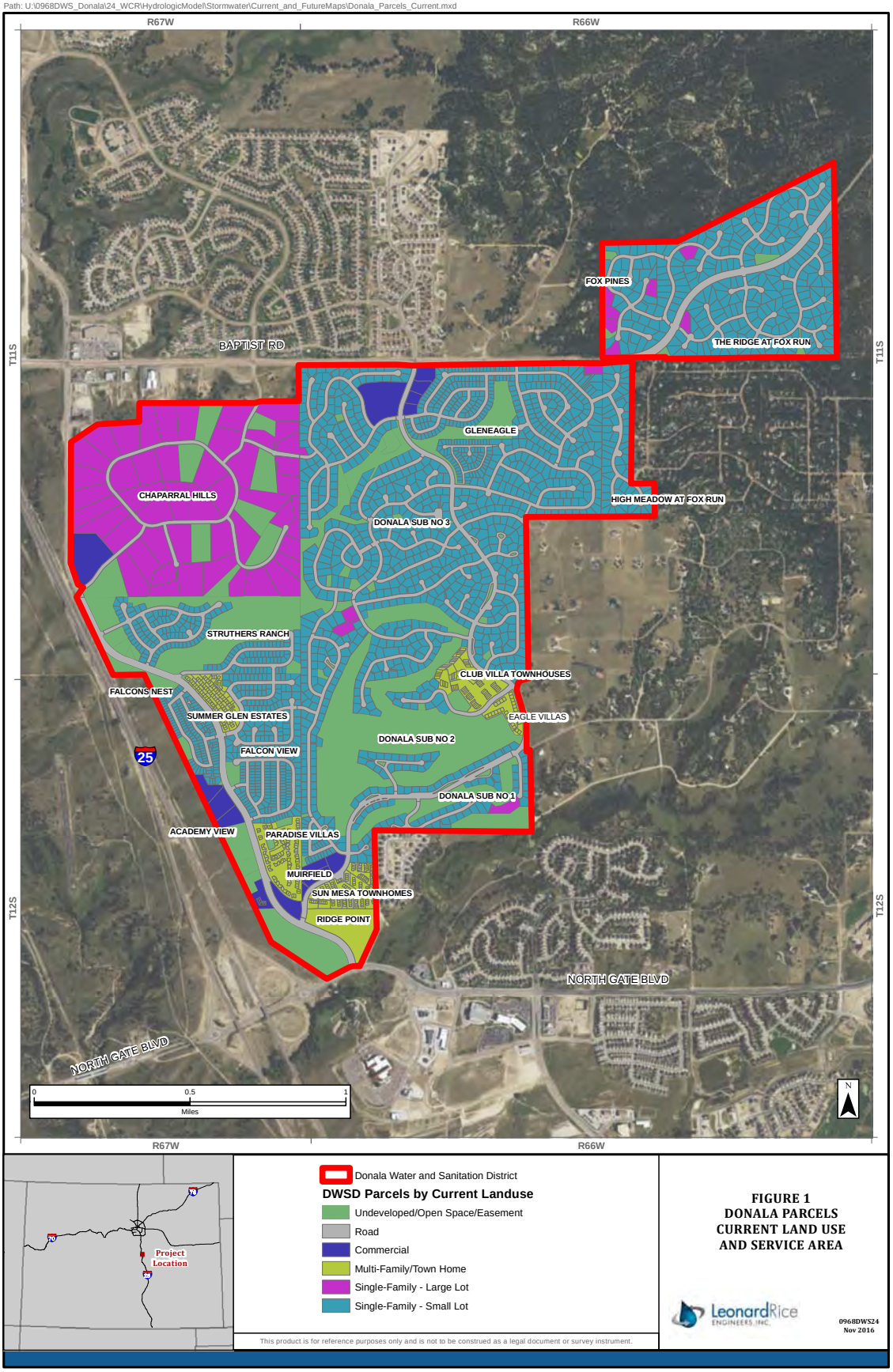

FIGURE 1
DONALA PARCELS
CURRENT LAND USE
AND SERVICE AREA

FUTURE LAND USE SCENARIO

Figure 2 represents the future land use types for the DWSD service area. The associated impervious percentages for each of the future land use types are summarized in **Table C** below. The areal extents of the various hydrologic soil groups associated with the land use types are summarized in **Table D** below. Combining the land use types and soil groups into land use-soil complexes allowed for curve numbers to be assigned to each complex based on methodology explained in TR-55 (NRCS, 1999). Curve numbers for each complex were then weighted based on their fractional area of the DWSD. An overall weighted curve number of 74 was calculated to represent the DWSD area under future land use conditions.

Table C - Donala Water Sanitation District Future Land Use and % Impervious

Lot Types	Lot Class	% Impervious	Area (Acres)	% Total Impervious*
SINGLE-FAMILY - SMALL LOT	< 1/8 acres	65%	22.9	0.9%
	1/8 - 1/4 acres	38%	104.6	2.4%
	1/4 - 1/2 acres	30%	411.7	7.4%
	1/2 - 1 acres	25%	189.9	2.8%
SINGLE-FAMILY - LARGE LOT	> 1 acres	20%	298.2	3.6%
COMMERCIAL	Variable	85%	71.7	3.6%
MULTI-FAMILY/TOWN HOME	Variable	50%	76.9	2.3%
ROADS	Curbed	100%	113.2	6.8%
	Dirt	100%	17.5	1.0%
	Non-curbed	100%	136.3	8.1%
UNDEVELOPED/OPEN SPACE/EASEMENT	Variable	0%	232.5	0.0%
Total		-	1,675.3	38.9%

Table D - Donala Water Sanitation District Hydrologic Soil Groups (Future)

Hydrologic Soil Group	Area (Acres)	Percent (%)
B	1,574.5	94%
C	67.3	4%
D	33.5	2%
Total	1,675.3	100%

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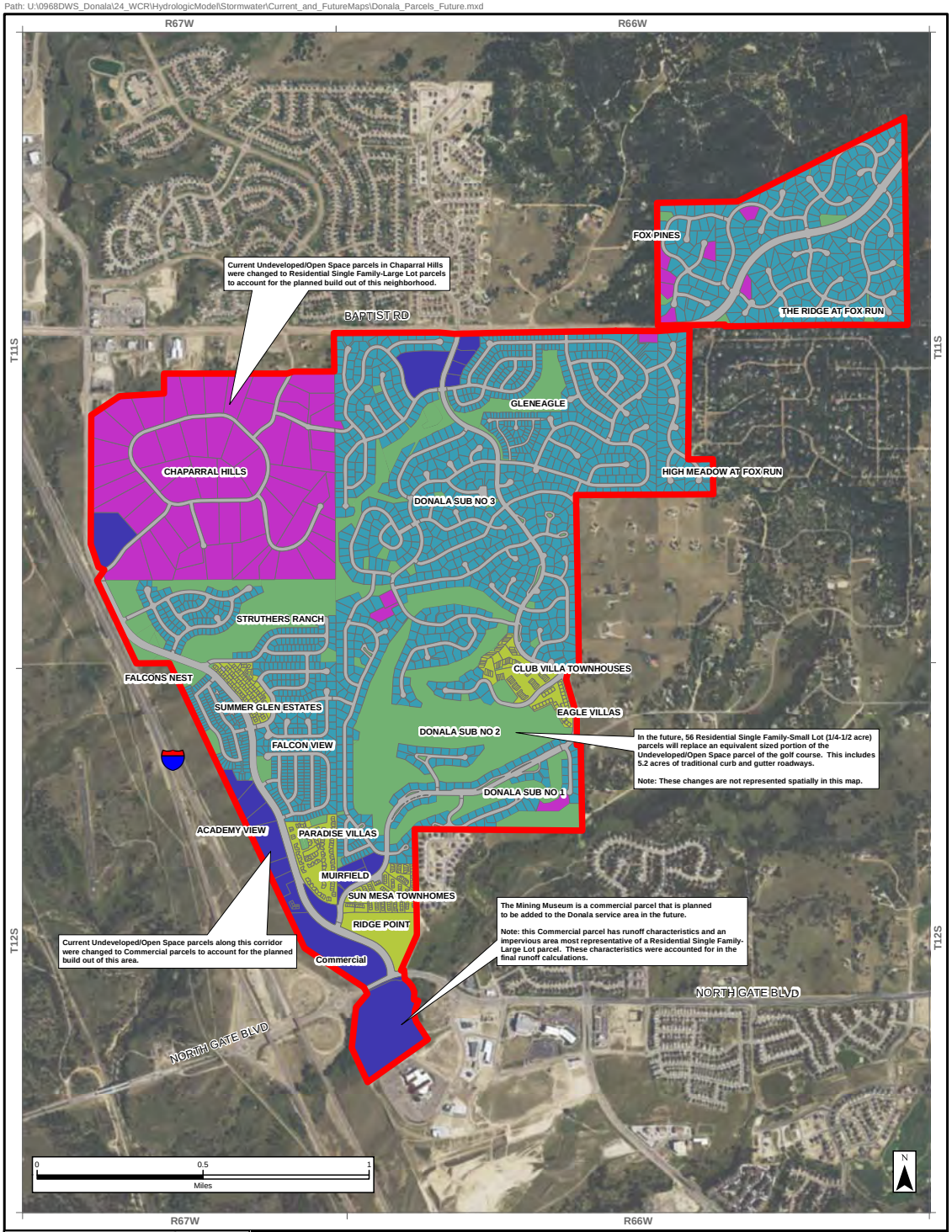

FIGURE 2
DONALA PARCELS
FUTURE LAND USE
AND SERVICE AREA

HISTORICAL STORMWATER RUNOFF ANALYSIS RESULTS

A stormwater runoff analysis was performed on daily historical precipitation data for the entire study period. Runoff was calculated under both current and future land use scenarios using the curve number methodology as described in TR-55 (NRCS, 1999). Monthly averages and annual average totals are summarized in **Table E** below for runoff under both scenarios. The percent change in runoff between the future scenario and current scenario is calculated below. The final result shows a **5.4% increase** in total annual runoff under future land use conditions.

Table E – Monthly and Annual Average Runoff (1/1/2004 to 12/31/2015)

Scenario	Unit	Curve Number	Area (Acres)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Total
Current Runoff	Inches	73	1645	0.00	0.00	0.02	0.08	0.14	0.05	0.05	0.29	0.10	0.05	0.00	0.07	0.86
	ACFT			0.00	0.00	2.12	10.87	20.24	7.56	7.20	40.49	14.05	7.43	0.25	10.33	120.55
Future Runoff	Inches	74	1675	0.00	0.00	0.02	0.08	0.14	0.05	0.05	0.29	0.10	0.05	0.00	0.07	0.86
	ACFT			0.00	0.00	2.33	11.73	21.21	7.90	8.03	42.01	14.84	7.99	0.35	10.73	127.11
Percent Change in Runoff	-	-	-	0.0%	0.0%	10.1%	7.9%	4.8%	4.4%	11.4%	3.8%	5.6%	7.5%	37.4%	3.9%	5.4%

Annual average unit runoff volumes under current and future conditions, as well as a comparison to a typical urbanized area is summarized in **Table F**. Under current conditions historical runoff was calculated to be 0.073 AF/Ac. Future runoff, including future land use and the addition of 30.2 ac to the DWSD service area, would be 0.076 AF/Ac. In comparison, the amount of runoff that is derived from a typical urbanized area is estimated to be 0.103 AF/Ac. While the amount of stormwater runoff for future land use within the DWSD service area is expected to increase, runoff volumes from the DWSD service area under current and future land use conditions remain well below average for a typical urbanized area.

Table F - Summary Results

Scenario	Area (Acres)	% Impervious	Curve Number	Annual Average Runoff (AF)	Annual Average Runoff (AF/Ac)
Current Runoff	1645.1	36.6%	73	120.55	0.073
Future Runoff	1675.3	38.9%	74	127.11	0.076
Typical Urban Runoff W/Future Service Area*	1675.3	50.0%	80	172.80	0.103

* Typical Urban Runoff = Moderate to high denstiy development (50% impervious); remaining pervious area assumed to be grass pasture in good condition (CN = 61). 61 + (50/100) (98-61) = 80

References

Colorado Water Conservation Board, 2006. Flood Plain and Stormwater Criteria Manual, Chapter 9 Hydrologic Analysis, Section 5 Runoff (CH9-515). January 6, 2012 http://cwcb.state.co.us/technical-resources/floodplain-stormwater-criteria-manual/Documents/Chapter%209/Chapter%209%20Section%205.pdf

Applied Climate Information System (ACIS) NOAA-RCC Web-Service, Black Forest 6 WNW daily precipitation data (1/1/2004 -12/31/2015) accessed using TSTool. Accessed August 2016.

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Natural Resources Conservation Service. 1999. Urban Hydrology for Small Watersheds – TR-55. Available at: https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044171.pdf

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Attachment A. BLACK FOREST 6 WNW Monthly Precipitation Summary (01/01/2004. 12/31/2015)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2004	0.66	1.04	0.79	2.74	0.54	4.21	3.27	2.75	0.93	0.27	1.06	0.52	18.78
2005	0.66	0.06	1.55	3.88	1.31	1.65	0.79	3.23	0.30	1.84	0.35	0.81	16.43
2006	0.34	0.33	0.97	0.32	0.46	1.70	6.71	2.50	3.48	3.14	0.27	3.28	23.50
2007	1.27	0.53	0.74	3.38	2.66	1.19	1.99	4.14	0.64	0.51	0.21	1.06	18.32
2008	0.87	0.44	1.14	1.39	0.99	0.37	1.51	5.96	1.26	1.20	0.56	1.09	16.78
2009	0.61	0.24	1.25	4.79	2.08	1.98	4.18	1.46	2.41	1.80	1.06	0.83	22.69
2010	0.26	0.75	2.00	3.18	1.18	0.60	3.18	3.18	0.15	0.35	0.40	0.51	15.74
2011	0.24	0.87	0.42	1.97	1.49	0.95	2.69	3.77	3.94	1.41	0.60	0.55	18.90
2012	0.16	1.37	0.10	2.33	1.27	0.14	3.23	0.34	2.30	0.37	0.00	0.56	12.17
2013	0.36	1.70	1.09	0.85	2.24	0.51	4.94	5.64	5.25	0.42	0.31	0.70	24.01
2014	0.83	0.77	1.33	1.91	2.60	1.08	4.62	3.62	0.94	1.64	0.38	0.78	20.50
2015	0.69	1.61	1.14	1.60	9.81	2.63	3.08	2.78	0.44	1.30	2.09	0.97	28.14
Average	0.58	0.81	1.04	2.36	2.22	1.42	3.35	3.28	1.84	1.19	0.61	0.97	19.66

Attachment B – Table 2-2a –Runoff Curve Numbers for Urban Areas

Table 2-2a Runoff curve numbers for urban areas [1]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.
[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.