



## MDDP & DBPS AMENDMENT

### **BENT GRASS DEVELOPMENT**

El Paso County, Colorado

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PREPARED FOR:  
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Galloway responses

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PUDSP-20-005



**Basin D-8** (1.69 AC, Q5 = 1.3 cfs, Q100 = 4.5 cfs): a basin that is west of the existing channel & south of Bent Grass Meadows Drive. It encompasses the back half of single-family residential lots. Runoff will flow from each lot and discharge into a proposed drainage ditch. The drainage ditch (Swale C) will then convey flows, ultimately discharging into the proposed south WQCV pond at **DP 44**.

**Basin B-2** (4.16 AC, Q5 = 1.4 cfs, Q100 = 9.1 cfs): a basin that is in the south area of the site and encompasses the existing channel RWT210. Flows will sheet flow into the existing channel where they will then be conveyed to **DP CC** exiting the site.

Basins E-1 thru E-5 are the same as discussed under the Existing Conditions Section, as these basins represent the already built Bent Grass Meadows Drive through the proposed site.

The Bent Grass West development accounts for 2 additional water quality facilities to be built. These items were preliminarily designed in the Falcon Meadows for Bent Grass PDR and will be final designed with the FDR's for **Falcon Meadows at Bent Grass Meadows Filing No. 1 & No. 2**.

Final flows exiting the site from the West Tributary based on rational method calculations at **DP CC** for the future design analysis are 266.2 cfs for the 5-year storm and 1183.4 cfs for the 100-year storm. This includes flows from RWT202, RWT 204 and Basin WT200. These flows are less than the current conditions (Q100=1224.7 cfs, Q5=278.3 cfs) at this location, due to the additional WQ ponds being built and storm infrastructure with the future development. This allows for additional flow to be "held back" and longer routing of flows through the site. Flows will continue offsite through the West Tributary, eventually reaching the existing Pond WU. Flows exiting the project site correspond to channel reach RWT210 in the HEC HMS models.

192 / 1075

1,045 / 186 HEC-HMS

Upon exiting the Falcon Meadows development at **DP CC**, the basin hydrology and routing remains the unchanged from the Current Conditions Section. From the Future HEC-HMS model, which accounts for Basin BG being fully developed, there is a minor flow of 191.9 cfs and a major flow of 1075.3 cfs. These flows are larger than the previous HMS flows (minor 186.2 cfs and major 1,044.6 cfs).

At design point **JWT210**, located at Woodmen Road, HMS flows are 195.7 cfs for the 5-year storm and 1093.7 cfs for the 100-year storm. DBPS flows under future conditions at this location are 250 cfs and 1,300 cfs for the minor and major storm events. The HMS model flows are less than the future (developed) DBPS flows (250 cfs and 1,300 cfs) at this location but are greater than the existing (undeveloped) DBPS flows (50 cfs and 950 cfs).

Paragraph deleted as discussion of DP CC with HEC-HMS flows occurs in following paragraph.

This still doesn't make sense.

A future conditions drainage map has been prepared and is included in Appendix D.

Use only the HEC-HMS values for these comparisons. Rational calculations can't be added to NRCS calculations. A Rational comparison of onsite-only flows can be provided if desired.

## VIII. Proposed Channel Improvements

### MIDDLE TRIBUTARY

Although the existing channel and culverts are undersized and improvements will need to be made in the future, minimal channel improvements are being proposed at this time, along Meridian Road. With the construction of the right turn lane on Bent Grass Meadows Drive, the three RCP culverts will be extended approximately 15' to span the extended width of the roadway. Additionally, two more 45"x29" Elliptical RCP pipes will be installed under Bent Grass Meadows Drive to convey the flows for DP 20. The existing channel will need to lined with a temporary turf reinforcement mat (TRM) due to the excessive velocities

(9.91 fps), high shear stress (5.11lbs/ft<sup>2</sup>) & high Froude Number (1.12). With the TRM added to the channel sides, the allowable velocity is 25 fps and permissible shear stress is 12 lbs/ft<sup>2</sup>. An analysis of the channel with the TRM is provided in the Appendix.

In the future, El Paso County will need to improve the existing culverts and channel to adequately convey the flow outlined in the DBPS. These necessary improvements and associated calculations are described further below. A preliminary grading exhibit has been prepared showing these improvements and included in Appendix C.

Similar to the existing channel, Bentley Flowmaster was also used to design the future proposed channel section. The future channel was designed to have a maximum depth of 5' per the criteria manual and have a maximum velocity of 5 ft/s with a maximum Froude number of 0.6. The flow rate used for the design, 925 cfs, was taken from the Falcon DBPS flow combined with the additional off-site drainage coming from the "School Site" and

The future channel section was designed as trapezoidal shape with a 15' bottom width, 4:1 side slope, and 0.3% longitudinal slope. The total depth of the channel will be 6', providing 1' of freeboard for the 5' of water depth. The velocity of the proposed channel is 4.93 ft/s.

The Federal Highway Administration's HY-8 program was also utilized to design the future culverts that will run beneath Bent Grass Meadows Drive. The calculations included in Appendix C show that in order to adequately convey the 915 cfs in the future conditions, two 16'x4' concrete box culverts will need to replace the existing elliptical RCP's. In order to construct the box culverts, the channel will need to be flattened from downstream to create roughly 5' of additional clearance below the road.

## WEST TRIBUTARY

The Falcon Area DBPS made recommendations for the channels as reference to pre-Bent Grass development added RWT202 was rerouted on the north property lone to convey flows to designed as part of the Bent Grass Residential Filing No. 2 develop

Existing RWT204 is grossly oversized for the actual flows expected through it, with a 5-year flow of 7 cfs and a 100-year flow for 43 cfs from the DBPS study. The future rational calculations have a total flow of 267 cfs for the 5-year flow and 1189 cfs for the 100-year flow at DP AA, the location of the proposed box culvert crossing at Bent Grass Meadows Drive in Reach RWT204. The FEMA flow reported in this section of channel is 1,400 cfs. Improvements to this section of the channel will adhere and be equivalent to the recommendations in the Falcon Basin DBPS.

RWT204 will generally stay in a location similar to where it is in existing conditions but will have new designed channel sections. The channels will have longitudinal slopes flattened to reduce the scour potential of the channel. Grouted Sloping Boulder Drops may be channel as grade controls (maximum height of 4' with 4:1 slope). It is anticipated that structures will be utilized within the channel. This may change when final design of completed.

RWT210 is the section of the channel south of Bent Grass Meadows Drive and continues south to Woodmen Road. The channel location will shift slightly to the east and "straighten" out the overall flow path. It will be located within a drainage easement. The channel will have a design with a longitudinal slope less than 1.5%, bottom width of 38', and 4:1 side slopes. The Falcon DBPS recommendations for

reference to pre-Bent Grass development added

pre-BG development (?)

Use the HEC-HMS calculations

changed to reference HMS flows at DP 40, where channel flows enter site. HMS model does not have a corresponding DP AA.

### XIII. Floodplain Statement

According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map number 08041C0553G, effective December 7, 2018, there is a floodplain in a portion of the project area. A copy of the FIRM Panel is included in Appendix A.

The portion of channel that has a floodplain designation is only the RWT210 and RWT204 portions of the channel. It is unknown why the western channel, RWT202 is unmapped since it is the larger contributor regarding flow rates. Since there is a discrepancy between the DPBS and FEMA maps, the RWT202 channel has been rerouted to follow the north Bent Grass property line and connect to the RWT204 channel. No-rise certifications are complete, and **reference to culverts at BGMD added** anticipated or proposed at this time.

**reference to culverts at BGMD added**  
**through the residential development?**

### XIV. Fee Development

At this time, it is being requested to add the improvement of the culverts at the Bent Grass Meadows Drive/Meridian Road intersection to the reimbursable list of storm facilities presented in the Falcon DBPS. Based on the estimate shown below, the box culvert would add **\$429,749.00** to the overall bridge construction costs.

**updated cost**

Item	Quantity	Unit	Unit Cost	Cost
<b>Culvert (Concrete Box Culvert) (Public) – Bent Grass Meadows Drive</b>				
6' x 16' Concrete Box Culvert (Double)	120	LF	\$ 2,000.00	\$ 240,000.00
30" Grouted Boulders	164	SY	\$ 190.00	\$ 31,160.00
Soil Rip Rap - Type M	55	CY	\$ 100.00	\$ 5,500.00
Headwalls - Concrete	35	CY	\$ 850.00	\$ 29,750.00
Wingwalls - Concrete	60	CY	\$ 850.00	\$ 51,000.00
Headwalls - Steel Reinforcement	1300	LBS	\$ 1.50	\$ 1,950.00
Wingwalls - Steel Reinforcement	4430	LBS	\$ 1.50	\$ 6,645.00
<b>Subtotal</b>				<b>\$ 366,005.00</b>
<b>Culvert (Concrete Box Culvert) (Public) – Meridian Road</b>				
4' x 16' Concrete Box Culvert (Double)	190	LF	\$ 1,600.00	\$ 304,000.00
Soil Rip Rap - Type M	45	CY	\$ 100.00	\$ 4,500.00
Headwalls - Concrete	30	CY	\$ 850.00	\$ 25,500.00
Wingwalls - Concrete	60	CY	\$ 850.00	\$ 51,000.00
Headwalls - Steel Reinforcement	975	LBS	\$ 1.50	\$ 1,462.50
Wingwalls - Steel Reinforcement	4430	LBS	\$ 1.50	\$ 6,645.00
<b>Subtotal</b>				<b>\$ 393,107.50</b>
<b>Total</b>				<b>\$ 759,112.50</b>

In Section 7.0 Fee Development of the Falcon Basin DBPS, it was shown that the Development Cost for Bridge Improvements was \$2,058,474. With the addition of the box culvert at Bent Grass Meadows Drive/Meridian Road, this estimate would raise to **\$2,488,223**. The Drainage Improvement costs shown in the DBPS for Development were \$14,988,251. The DBPS also shows **updated cost** of 645.58 impervious acres. (Refer to DBPS for detailed information on area by category).

Include both culverts

**added this wording in place of actual cost**

The Bridge Fee per Impervious acre was \$3,189 and Drainage Fee was \$23,217. There are no improvements to facilities falling under the Drainage Fee criteria. The Bridge fee will increase. Based on the new overall bridge development fee of \$2,488,223, the fee per impervious acre will be \$3,793, an increase of \$604 per impervious acre. **This cost will need to be verified with the final platted areas.**

It is requested that the Drainage Board will approve the above increase to the Falcon Basin Bridge Fees.

## XV. Conclusion

**Add a statement regarding anticipated drainage fee offsets for channel construction onsite and offsite RWT204 and RWT210. statement added**

This report has been prepared using the criteria and methods as set forth in the County Drainage Criteria Manual. For the Middle Tributary portion of the site, it has been shown that under current conditions, existing facilities will function. Recommendations for future facilities have been provided for an EURV pond on the "school site", Bent Grass Meadows Drive/Meridian Road intersection and the Owl Place crossing. Also, it has been noted that any new development in this area will need to provide their own on-site water quality and detention. Under the current conditions, there are no adverse impacts to the sub-regional SR4 pond or the Regional Pond MN, further downstream.

For the West Tributary areas, several water quality facilities are being proposed/constructed. These items will treat developed flows prior to being released into the channel for the West Tributary. The West Tributary Channel will meet the design requirements of the Falcon DBPS. Bent Grass Metropolitan District will maintain the channel. If after a pre-determined amount of the time, current property owners have not initiated any of channel improvements themselves, the developer will build the remaining channel improvements to Woodmen Road. Or the developer may work with the current property owners to reach a pre-approved agreement on design/construction, costs and timing of these channel improvements, which would need to be "in-place" prior to the approval for the first plat of the Falcon Meadows at Bent Grass development. An agreement and schedule will be in place prior to approval of Falcon Meadows at Bent Grass Filing No. 1.

Upon entering the channel, flows will leave the Bent Grass property and continue south, eventually reaching the Regional Pond WU. There are no adverse impacts to this facility.

## XVI. References

1. *City of Colorado Springs/County of El Paso Drainage Criteria Manual*, October 1991.
2. *Drainage Criteria Manual, Volume 2*, City of Colorado Springs, November 2002.
3. *Urban Storm Drainage Criteria Manual*, Urban Drainage and Flood Control District, January 2016 (with current revisions).
4. *Falcon Drainage Basin Planning Study*, by Matrix Design Group, September 2015.
5. *Master Development Drainage Plan and Preliminary Drainage Plan – Bent Grass Subdivision*, by Kiowa Engineering Corporation, December 2006.
6. *Final Drainage Report for Bent Grass Residential (Filing No. 1)*, by Classic Consulting Engineers & Surveyors, LLC, August 2014.
7. *Final Drainage Report Addendum for Bent Grass Residential (Filing No. 1)*, by Classic Consulting Engineers & Surveyors, LLC, August 2015.
8. *Master Development Drainage Plan – Bent Grass Residential Subdivision*, by Galloway & Company, May 2019.
9. *Final Drainage and Erosion Control for The Meadows Filing 3 Subdivision*, by LADD Engineering, July 2000.

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FUTURE 100-YEAR STORM

Hydrologic Element	Drainage Area (MI2)	Peak Discharge (CFS)	Time of Peak	Volume (AC-FT)
WT020	0.0671383	41.9	01Jan2011, 06:21	4.8
JWT020	0.0671383	41.9	01Jan2011, 06:21	4.8
RWT030	0.0671383	41.9	01Jan2011, 06:29	4.8
WT030	0.0764732	75.3	01Jan2011, 06:07	5.5
JWT030	0.1436115	85.4	01Jan2011, 06:09	10.3
RWT042	0.1436115	85.3	01Jan2011, 06:15	10.3
WT010	0.1353300	88.9	01Jan2011, 06:17	9.3
JWT010	0.1353300	88.9	01Jan2011, 06:17	9.3
RWT044	0.1353300	88.8	01Jan2011, 06:24	9.3
JWT042	0.2789415	167.0	01Jan2011, 06:21	19.6
RWT046	0.2789415	166.7	01Jan2011, 06:28	19.6
WT040	0.1850600	92.7	01Jan2011, 06:28	12.8
JWT044	0.4640015	259.4	01Jan2011, 06:28	32.4
RWT054	0.4640015	258.8	01Jan2011, 06:35	32.3
WT060	0.1956300	116.8	01Jan2011, 06:26	15.1
WT050	0.1899300	139.4	01Jan2011, 06:19	15.3
JWT050	0.8495615	475.4	01Jan2011, 06:31	62.7
RWT092	0.8495615	475.2	01Jan2011, 06:32	62.7
WT070	0.1711000	133.9	01Jan2011, 06:12	11.8
JWT070	0.1711000	133.9	01Jan2011, 06:12	11.8
RWT080	0.1711000	133.4	01Jan2011, 06:22	11.8
WT080	0.0691596	67.3	01Jan2011, 06:10	5.6
Sub Regional Pond SR1	1.0898211	513.2	01Jan2011, 06:40	78.4
JWT080	1.0898211	513.2	01Jan2011, 06:40	78.4
RWT094	1.0898211	512.4	01Jan2011, 06:45	78.3
WT100-REV	0.1292700	203.0	01Jan2011, 06:04	12.9
W26-REV	0.0720000	103.6	01Jan2011, 06:03	6.4
WS3-1	0.0720000	102.8	01Jan2011, 06:10	6.4
Paint Brush Hills Pond C	0.2012700	64.4	01Jan2011, 06:26	19.2
WT090	0.1533300	162.4	01Jan2011, 06:09	12.8
JWT090	1.4444211	595.9	01Jan2011, 06:44	110.2
RWT122	1.4444211	595.5	01Jan2011, 06:45	110.2
WT110	0.1942800	169.9	01Jan2011, 06:14	16.2
JWT110	1.6387011	651.0	01Jan2011, 06:43	126.4
RWT124	1.6387011	650.8	01Jan2011, 06:47	126.3
WT130-REV	0.1016250	130.0	01Jan2011, 06:11	10.9
Paint Brush Hills Pond A	0.1016250	53.8	01Jan2011, 06:32	10.9
WT120-REV	0.0430300	51.1	01Jan2011, 06:08	3.8



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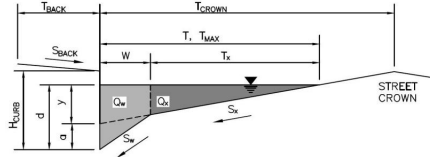
Version 4.05 Released March 2017

**ALLOWABLE CAPACITY FOR ONE-HALF OF STREET (Minor & Major Storm)**

(Based on Regulated Criteria for Maximum Allowable Flow Depth and Spread)

Project: **Bent Grass Residential Filing No. 2**

Inlet ID: **Street Capacity - 1/2 Street Section of Bent Grass Meadows Drive**



**Gutter Geometry (Enter data in the blue cells)**

Maximum Allowable Width for Spread Behind Curb  $T_{BACK} = 14.0$  ft

Side Slope Behind Curb (leave blank for no conveyance credit behind curb)  $S_{BACK} = 0.020$  ft/ft

Manning's Roughness Behind Curb (typically between 0.012 and 0.020)  $n_{BACK} = 0.013$

Height of Curb at Gutter Flow Line  $H_{CURB} = 6.00$  inches

Distance from Curb Face to Street Crown  $T_{CROWN} = 26.0$  ft

Gutter Width  $W = 2.00$  ft

Street Transverse Slope  $S_x = 0.020$  ft/ft

Gutter Cross Slope (typically 2 inches over 24 inches or 0.083 ft/ft)  $S_w = 0.083$  ft/ft

Street Longitudinal Slope - Enter 0 for sump condition  $S_o = 0.010$  ft/ft

Manning's Roughness for Street Section (typically between 0.012 and 0.020)  $n_{STREET} = 0.016$

Max. Allowable Spread for Minor & Major Storm

	Minor Storm	Major Storm	
$T_{MAX} =$	16.0	26.0	ft
$d_{MAX} =$	6.0	8.3	inches

Allow Flow Depth at Street Crown (leave blank for no)   check = yes

**Maximum Capacity for 1/2 Street based On Allowable Spread**

Water Depth without Gutter Depression (Eq. ST-2)

	Minor Storm	Major Storm	
$y =$	3.84	6.24	inches
$d_c =$	2.0	2.0	inches
$a =$	1.51	1.51	inches
$d =$	5.35	7.75	inches
$T_x =$	14.0	24.0	ft
$E_o =$	0.372	0.225	
$Q_x =$	5.9	24.7	cfs
$Q_w =$	3.5	7.2	cfs
$Q_{BACK} =$	0.0	1.3	cfs
$Q_t =$	9.4	33.2	cfs
$V =$	4.8	6.4	fps
$V*d =$	2.1	4.1	

Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)

Discharge outside the Gutter Section W, carried in Section  $T_x$

Discharge within the Gutter Section W ( $Q_x - Q_w$ )

Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)

**Maximum Flow Based On Allowable Spread**

Flow Velocity within the Gutter Section

$V*d$  Product: Flow Velocity times Gutter Flowline Depth

**Maximum Capacity for 1/2 Street based on Allowable Depth**

Theoretical Water Spread

	Minor Storm	Major Storm	
$T_{TH} =$	18.7	28.3	ft
$T_{xTH} =$	16.7	26.3	ft
$E_o =$	0.318	0.206	
$Q_{xTH} =$	9.4	31.5	cfs
$Q_x =$	9.4	31.5	cfs
$Q_w =$	4.4	8.2	cfs
$Q_{BACK} =$	0.0	2.6	cfs
$Q =$	13.8	42.3	cfs
$V =$	5.2	6.7	fps
$V*d =$	2.6	4.7	
$R =$	1.00	1.00	
$Q_d =$	13.8	42.3	cfs
$d =$	6.00	8.30	inches
$d_{CROWN} =$	0.00	0.55	inches

Theoretical Spread for Discharge outside the Gutter Section W ( $T - W$ )

Gutter Flow to Design Flow Ratio by FHWA HEC-22 method (Eq. ST-7)

Theoretical Discharge outside the Gutter Section W, carried in Section  $T_{xTH}$

Actual Discharge outside the Gutter Section W, (limited by distance  $T_{CROWN}$ )

Discharge within the Gutter Section W ( $Q_d - Q_x$ )

Discharge Behind the Curb (e.g., sidewalk, driveways, & lawns)

Total Discharge for Major & Minor Storm (Pre-Safety Factor)

Average Flow Velocity Within the Gutter Section

$V*d$  Product: Flow Velocity Times Gutter Flowline Depth

Slope-Based Depth Safety Reduction Factor for Major & Minor ( $d \geq 6"$ ) Storm

**Max Flow Based on Allowable Depth (Safety Factor Applied)**

Resultant Flow Depth at Gutter Flowline (Safety Factor Applied)

Resultant Flow Depth at Street Crown (Safety Factor Applied)

**MINOR STORM Allowable Capacity is based on Spread Criterion**

**MAJOR STORM Allowable Capacity is based on Spread Criterion**

	Minor Storm	Major Storm	
$Q_{allow} =$	9.4	33.2	cfs

**WARNING: MINOR STORM max. allowable capacity is less than the design flow given on sheet 'Inlet Management'**

**WARNING: MAJOR STORM max. allowable capacity is less than the design flow given on sheet 'Inlet Management'**



**Table 3 - Downstream Channel Rating Curve (Crossing: Owl Place - Fut RCBC)**

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
248.60	6910.36	2.36	4.05	2.21	0.66
316.24	6910.58	2.58	4.31	2.42	0.67
383.88	6910.78	2.78	4.52	2.60	0.68
451.52	6910.95	2.95	4.71	2.76	0.68
519.16	6911.11	3.11	4.87	2.91	0.69
586.80	6911.26	3.26	5.03	3.05	0.69
654.44	6911.39	3.39	5.16	3.18	0.70
722.08	6911.52	3.52	5.29	3.30	0.70
789.72	6911.64	3.64	5.41	3.41	0.71
850.00	6911.74	3.74	5.51	3.50	0.71
925.00	6911.86	3.86	5.63	3.62	0.71

**FutDBPS Flow (850 cfs)**

**Tailwater Channel Data - Owl Place - Fut RCBC FutDBPS Flow (850 cfs)**

Tailwater Channel Option: Triangular Channel

Side Slope (H:V): 11.00 (\_:1)

Channel Slope: 0.0150

Channel Manning's n: 0.0500

Channel Invert Elevation: 6908.00 ft

**Roadway Data for Crossing: Owl Place - Fut RCBC FutDBPS Flow (850 cfs)**

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 100.00 ft

Crest Elevation: 6917.00 ft

Roadway Surface: Paved

Roadway Top Width: 28.00 ft

Analysis for Owl  
Place & DW included

Replace:

**HY-8 Culvert Analysis Report**

**Future Culvert @ Owl Place & Private Driveway-West of  
Meridian Road (DBPS FLOWS)**



