May 15, 2024
AVO 37449.004

Ms. Ramie Hammonds
Development Services Director/Building Official
City of Sanger
201 Bolivar Street
P.O. Box 1729
Sanger, Texas 76266

Re: **Lane Ranch Phase 1 – Drainage Review #3**

Dear Ms. Hammonds,

Halff Associates, Inc. was requested by the City of Sanger to review the Flood Study in support of the engineering plans for the Lane Ranch located east of Sanger High School, between E Chapman Dr (FM 445 W) and McReynolds Rd. The subject tract is located within the City of Sanger. The 1st submittal was prepared by Cardinal Strategies Engineering Services, LLC and completed on December 22, 2023. The 2nd submittal was received on March 8, 2024. The 3rd submittal was received on April 30, 2024.

We have finished our review and offer comments as follows. Please note that additional comments may be forthcoming with new submittal.

General Comments

1. Please address comments on attached markups and provide annotated responses on markups. Please note, not all comments are included in this letter since some comments are easier to show and explain on the markups.
2. Please address construction plans comments provided separately. Please note, an accepted flood study is required prior to plan acceptance.

Hydrology and Hydraulics

1. Please note an Environmental Assessment will be needed on the existing tributaries to determine existing impact on wetlands. Provide memorandum once you acquire it.

   2nd Comments: Accepted.

2. Please provide supporting data including but not limited to land use, longest flood path, curve number, and time of concentration.

   2nd Comments: not received yet.

   3rd Comments: See below items on the Hydrologic Calculation.

   a. There are some blank cells that need to be filled or explained.
   b. If calculated Time of Concentration is smaller than the min. TC required in the ordinance please use the min. TC.
   c. Please verify that the velocities are correct and reconcile with RAS results.

d. Please reconcile the drainage area maps in civil set with the flood study. The delineation doesn't appear to match in both pre- and post- development conditions.

e. Please address other comments. (see mark-ups)

3. Please provide the digital version of the hydrologic model.

   2nd Comments: not received yet.

   3rd Comments: received.

4. Please provide the digital version of hydraulic model.

   2nd Comments: not received yet.

   3rd Comments: received.

5. Page 1, please move the LOMR and Zone AE discussion to section 1.3.

   2nd Comments: addressed.

6. Figure 1, please clearly define the project site boundary and offsite drainage areas. If there is off-site development not included in the current project site, please revise the boundary lines.

   2nd Comments: addressed.

7. Please try to use the same routing method within the project unless necessary to use multiple.

   2nd Comments: accepted.

8. Please apply minimum time of concentration to your calculations per city ordinance.

   2nd Comments: addressed.

9. Page 6, please clarify the extent of Phases 1 and 2 in the report. The civil set submittal only has Phase 1.

   2nd Comments: Addressed pending on reception and review of Appendix A.

   3rd Comments: received.

10. Please note that the pre- vs post- project comparisons appears to be incorrect. Off-site drainage areas shall remain the same for pre- vs post- project analysis. The analysis shall focus on the impact of the proposed development within the project site boundary.

    2nd Comments: addressed.

11. Off-site detention pond shall not be used as the basis to determine the detention facility for this project. Please disregard the detention pond and reassess the hydrology and hydraulics.

    2nd Comments: addressed.

12. Please revise land use color scheme for clarity.

    2nd Comments: addressed.

13. The Civil Set and the Flood Study report both mentioned changes from effective floodplain to fully developed floodplain. Please contact the local floodplain administrator regarding the need of a CLOMR or LOMR.

    2nd Comments: addressed.

14. Page 27, please adjust Manning's n values for proposed conditions.

    2nd Comments: Addressed pending on reception and review of digital data.

    3rd Comments: From aerial image and street views, the site is very vegetated with heavy brushes. Please verify that the post-project will remain the same as the pre-project conditions.

15. Page 27, please add additional cross-sections at proposed fills in effective floodplain.

2nd Comments: Addressed pending on reception and review of digital data.

3rd Comments: Addressed.

16. Table numbers in the paragraphs not matching the table titles. Please revise.

    2nd Comments: Addressed.

17. HMS Comments:
    a. J003AC is the confluence of two branches, but no drainage divide was shown. Please revise.
    b. A003 shall be split at the confluence (J003AC), with upper section drain to J003AC and lower section drain to J003.
    c. Please update the flow data in RAS accordingly after the revision from above comments.
    d. Subbasin B002 doesn't have a reach but was modeled in RAS. Please add the reach to match RAS.
    e. There's a flow change near XS 3393. The inflow data at XS 6211 shall be smaller than what's been used in the current model.
18. RAS Comments
    a. There're substantial grading activities within 100-yr floodplain. Please ensure that the side slope of proposed channels and embankments meet the ordinance. Some appears to be steeper than requirement.
    b. Please add ineffective flow areas where appropriate, such as XS 3205, 3028.
    c. Some bank stations are hundreds of feet outside of the top of bank according to the cross-section view, such as XS 3880-3436. Please revise or explain.
    d. Please update manning's n and centerlines for the proposed channels, such as XS 4012 thru 3205.
19. Please provide a maintenance agreement.

The Engineer shall revise the hydrologic study and/or plans in accordance with the above comments and/or provide a written response that addresses each comment. If you have any questions or need additional information, please do not hesitate to call me at (214) 937-3921.

Sincerely,
HALFF
TBPELS Firm No. 312

Yangbin Tong, PE, CFM
Project Manager

Attachments:

- Flood Study mark-ups
- Hydrologic Calculations mark-ups

Table 1 – Pre-Project Hydrologic Parameters

HMS Element	Area (ac)	Lag Time (min.)	Curve Number
A001	76.28	14.5	79.4
A002	101.99	13.2	85.9
A003	41.62	15.4	85.1
A004	111.42	20.9	80.2
A005	132.10	17.9	82.3
A006	28.22	9	89.3
A007	29.82	13.3	83.7
A008	47.32	16.1	82.3
A009	10.00	6	89.7
B001	139.44	13.4	82.1
B002	191.68	15.4	78.9
C001	21.98	9.1	82.7
C002	26.84	8.8	82
C003	27.18	17.14	89

2.2 Post-Project Ph 1

The Pre-Project hydrologic model was used as the starting point for this analysis. The areas being updated are Phases 1 and 2 as shown on the Lane Ranch site plan in Appendix A. These two phases constitute the hydrologic and hydraulic Post-Project Ph 1 condition. The land use for Phase 1 was updated to reflect single family 1/8th acre residential developments. Phase 2 had land use updated to reflect townhomes as a 1/8th acre residential development. The post-project Ph 1 watershed map can be seen in Figure 5 and the land use can be seen in Figure 6.

Phase 1 Pre. Plat shows 43.82 ac, same as drainage area map in civil set. Post-project Ph1 should be larger than that. Please reconcile.

The zone of influence was established using the to of approx. 35.9 acres. For the Ph 1 development to constitute 10% of the watershed, the overall watershed would need to be approx. 359 acres. The total area of subbasins A002 – A009 is approx. 578 acres, exceeding the minimum size for the development to no longer have a significant impact upon the receiving stream, Ranger Branch Tributary 2. The watershed was extended farther downstream to conceptually model the full build out post-project conditions and to develop flows for the entire length of the hydraulic models. As a result, the flow comparison between Pre-Project and Post-Project Ph 1 will show subbasins A002 – A009 and their corresponding junctions.

The off-site area upstream of Ph 1, along Rangers Branch Tributary 2.2, remained existing conditions for the purpose of this analysis. The proposed High School Addition and accompanying pond were not considered for this analysis. The delineations of on-site drainage areas are assumed to be unchanged from the pre-project condition. The delineations of off-site drainage areas also remained unchanged from pre-project conditions.

It makes sense for A003 and C001. But A004's longest flow path is outside of Phase 1 and Phase 2. It's expected to remain from pre- to post ph1. Please clarify or revise.

The longest flow paths within Phases 1 and 2 were updated to reflect the proposed site plan. A 1% slope was assumed for sheet flow. All other flowpaths remained the same as in pre-project conditions. The calculations can be found in Appendix B. The time of concentration for each basin is provided in Table 2.

Modified-Puls routing reaches were updated using an intermediate conditions geometry used to develop storage-discharge tables to reflect the change in attenuation in the Ranger Branch Tributary 2.0 and Tributary 2.2. All other routing reaches remained the same. The post-project Ph 1 hydrologic parameters can be found below in Table 2.

Table 2 – Post-Project Ph 1 Hydrologic Parameters

HMS Element	Area (ac)	Lag Time (min.)	Curve Number
A001	76.28	14.5	79.4
A002	102.08	13.2	86.0
A003	50.62	11.5	89.2
A004	105.30	17.6	81.8
A005	132.10	17.9	82.3
A006	28.22	9	89.3
A007	29.82	13.3	83.7
A008	47.32	16.1	82.3
A009	10.00	6	89.7
B001	139.44	13.4	82.1
B002	191.68	15.4	78.9
C001	19.00	8.8	83.5
C002	26.84	8.8	82.0
C003	27.18	17.14	89.0

2.3 Hydrologic Results

The result in peak discharges between the pre-project and post-project Ph 1 is shown below in Tables 3 – 8. The proposed single family and townhome developments in Phases 1 and 2 are demonstrated to create lower peak discharge downstream of the project site and through to the outfall of the watershed. This is a result of the reduction in post-project Ph 1 lag times due to the proposed development in basins C001 and A003. Due to the reductions in peak discharge shown, and the increase in attenuation along Tributary 2.2 due to the proposed Butterfield Dr crossing, detention is not recommended for the proposed Post-Project Ph 1 condition.

HMS Element	Pre-Project Discharge (cfs)	Post-Project Discharge (cfs)	Difference (cfs)	% Difference
J005	1,241.3	1,241.3	0.0	0.0%
J006	616.2	616.2	0.0	0.0%
J007	210.6	210.6	0.0	0.0%
J008	481.2	481.2	0.0	0.0%
J009	258.1	258.1	0.0	0.0%
J010	248.8	248.8	0.0	0.0%
J011	87.3	87.3	0.0	0.0%

2.4 Post-Project (Full Build Out)

The Post-Project Ph 1 hydrologic model was used as the starting point for the Post-Project Full Build Out hydrologic analysis. The full build out condition reflects proposed land use for all phases of the Lane Ranch site plan. The delineations along Tributary 2.1 were updated to reflect proposed grading changes to increase the attenuation through Tributary 2.1. The watershed can be found in Figure 7.

The land use of the remaining proposed Phases within the project area were updated to reflect 1/8th acre residential and commercial land use, reflecting the site plan provided in Appendix A. This land use can be seen in Figure 8.

The flowpaths for the remaining proposed Phases were updated to reflect the proposed site plan. All other flowpaths remained the same. Calculations can be found in Appendix B. The time of concentration for each basin is provided in Table 9.

The Modified-Puls storage discharge tables have been updated to reflect the proposed Post-Project Full Build Out hydraulic geometry through the studied streams. Proposed inline ponds along Tributary 2.1 were modeled using Modified-Puls to reflect the increased attenuation in the stream. The storage discharge tables can be found in Appendix B. The hydrologic parameters can be found below in Table 9.

Updates to the full build out (Post-Project) hydrologic modeling may be required for future phases to reflect detailed design or changes to the development plan.

Table 9 – Post-Project Full Build Out Hydrologic Parameters

HMS Element	Area (ac)	Lag Time (min.)	Curve Number
A001	76.28	14.5	79.4
A002	102.08	13.5	86.6
A003	50.62	11.8	89.2
A004	105.30	10.7	89.2
A005	132.10	17.9	82.3
A006	28.22	9	89.3
A007	29.82	13.3	83.7
A008	47.32	16.1	82.3

The area remains the same from Ph1, but the lag time increased. This appears to be opposite of what's expected from more impervious development. Please verify or clarify.

Time of Concentration Calculations

Pre-Project Existing Conditions

Flow Path Parameters							Minimum Slope 0.25%	Sheet Flow Travel Time			Shallow Concentrated Flow Travel Time				Channel Flow Travel Time		
								$T_t = \frac{0.007\,(nL)0.8}{(P_2)^{0.5}\,s^{0.4}}$		Denton County iSWM $P_2 = 3.63$ (in)	$V = K\sqrt{s}$		$T_t = \frac{L}{3600V}$		$T_t = \frac{L}{3600V}$		
Basin Name	Flow Path ID	Flow Type	Flow Type Description	Length [L] (ft)	US Elevation (ft, NAVD88)	DS Elevation (ft, NAVD88)	Slope [s] (% ft/ft)	Mannings N-Value [n]	Sheet Flow Travel Time [T_t] (hr)	Sheet Flow Travel Time (min)	Shallow Flow K-Value [K]	Shallow Flow Velocity [V] (ft/s)	Shallow Flow Travel Time [T_t] (hr)	Shallow Flow Travel Time (min)	Channel Flow Velocity [V] (ft/s)	Channel Flow Travel Time [T_t] (hr)	Channel Flow Travel Time (min)
A001	1	Sheet	Short Grass Prairie	100.0	706.25	704.05	2.20%	0.15	0.148	**8.9**	-	-	-	-	-	-	-
A001	2	Shallow	Unpaved	424.5	704.05	679.57	5.77%	-	-	-	16.1345	3.87	0.030	**1.8**	-	-	-
A001	3	Channel	Channel	608.2	679.57	658.08	3.53%	-	-	-	-	-	-	-	6.41	0.026	**1.6**
A001	4	Channel	Pipe	80.8	658.08	655.20	3.56%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A001	5	Channel	Channel	329.2	655.20	643.51	3.55%	-	-	-	-	-	-	-	2.23	0.041	**2.5**
A001	6	Channel	Swale	268.6	643.51	635.49	2.99%	-	-	-	-	-	-	-	4.00	0.019	**1.1**
A001	7	Channel	Swale	664.2	635.49	633.01	0.37%	-	-	-	-	-	-	-	4.00	0.046	**2.8**
A001	8	Channel	Channel	1,017.3	633.01	627.66	0.53%	-	-	-	-	-	-	-	3.17	0.089	**5.3**
A002	9	Sheet	Short Grass Prairie	100.0	692.09	689.87	2.22%	0.15	0.147	**8.8**	-	-	-	-	-	-	-
A002	10	Channel	Swale	1,116.1	689.87	677.48	1.11%	-	-	-	-	-	-	-	4.00	0.078	**4.7**
A002	11	Channel	Channel	274.8	677.48	670.82	2.42%	-	-	-	-	-	-	-	6.00	0.013	**0.8**
A002	12	Channel	Pipe	784.5	670.82	656.27	1.85%	-	-	-	-	-	-	-	8.00	0.027	**1.6**
A002	13	Channel	Pond	66.6	656.27	651.69	6.88%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	14	Channel	Pond	42.5	651.69	650.97	1.69%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	15	Channel	Pond	11.8	650.97	649.93	8.84%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	16	Channel	Channel	490.8	650.10	645.35	0.97%	-	-	-	-	-	-	-	3.70	0.037	**2.2**
A002	17	Channel	Pipe	144.9	649.93	650.10	0.25%	-	-	-	-	-	-	-	8.00	0.005	**0.3**
A002	18	Channel	Channel	1,220.0	645.35	637.50	0.64%	-	-	-	-	-	-	-	5.69	0.060	**3.6**
A003	19	Sheet	Short Grass Prairie	100.0	682.19	681.63	0.56%	0.15	0.255	**15.3**	-	-	-	-	-	-	-
A003	20	Shallow	Unpaved	613.5	681.63	665.95	2.56%	-	-	-	16.1345	2.58	0.066	**4.0**	-	-	-
A003	21	Channel	Swale	102.6	679.63	660.52	18.63%	-	-	-	-	-	-	-	4.00	0.007	**0.4**
A003	22	Channel	Swale	133.0	-	-	-	-	-	-	-	-	-	-	4.00	0.009	**0.6**
A003	23	Channel	Swale	979.5	660.52	649.68	1.11%	-	-	-	-	-	-	-	4.60	0.059	**3.5**
A003	24	Channel	Channel	835.6	-	-	-	-	-	-	-	-	-	-	7.51	0.031	**1.9**
A004	25	Sheet	Short Grass Prairie	100.0	711.44	710.79	0.65%	0.15	0.240	**14.4**	-	-	-	-	-	-	-
A004	26	Shallow	Unpaved	68.2	710.79	709.89	1.32%	-	-	-	16.1345	1.85	0.010	**0.6**	-	-	-
A004	27	Channel	Channel	624.4	709.89	683.99	4.15%	-	-	-	-	-	-	-	6.70	0.026	**1.6**
A004	28	Channel	Swale	1,214.2	683.99	667.04	1.40%	-	-	-	-	-	-	-	4.00	0.084	**5.1**
A004	29	Channel	Channel	453.5	667.04	665.81	0.27%	-	-	-	-	-	-	-	1.23	0.102	**6.1**
A004	30	Channel	Swale	1,443.0	665.81	653.38	0.86%	-	-	-	-	-	-	-	3.45	0.116	**7.0**
A005	31	Sheet	Short Grass Prairie	100.0	715.29	713.50	1.79%	0.15	0.160	**9.6**	-	-	-	-	-	-	-
A005	32	Shallow	Unpaved	171.6	713.50	704.67	5.15%	-	-	-	16.1345	3.66	0.013	**0.8**	-	-	-
A005	33	Channel	Swale	1,214.3	704.67	696.71	0.66%	-	-	-	-	-	-	-	4.00	0.084	**5.1**
A005	34	Channel	Swale	2,607.7	696.71	671.75	0.96%	-	-	-	-	-	-	-	3.02	0.240	**14.4**
A006	35	Sheet	Short Grass Prairie	51.7	721.62	719.00	5.07%	0.15	0.062	**3.7**	-	-	-	-	-	-	-
A006	36	Channel	Swale	870.9	719.00	701.13	2.05%	-	-	-	-	-	-	-	4.00	0.060	**3.6**
A006	37	Channel	Pipe	193.1	701.13	690.88	5.31%	-	-	-	-	-	-	-	8.00	0.007	**0.4**
A006	38	Channel	Pond	64.3	690.88	690.63	0.39%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A006	39	Channel	Pipe	71.9	690.63	696.86	0.25%	-	-	-	-	-	-	-	8.00	0.002	**0.1**
A007	40	Sheet	Short Grass Prairie	100.0	734.09	732.77	1.32%	0.15	0.181	**10.9**	-	-	-	-	-	-	-
A007	41	Shallow	Unpaved	121.5	732.77	732.03	0.61%	-	-	-	16.1345	1.26	0.027	**1.6**	-	-	-
A007	42	Channel	Swale	205.6	732.03	728.40	1.77%	-	-	-	-	-	-	-	4.00	0.014	**0.9**
A007	43	Channel	Swale	710.2	728.40	701.42	3.80%	-	-	-	-	-	-	-	3.01	0.066	**3.9**
A007	44	Channel	Pipe	50.3	701.42	701.12	0.60%	-	-	-	-	-	-	-	8.00	0.002	**0.1**
A007	45	Channel	Channel	987.8	701.12	687.28	1.40%	-	-	-	-	-	-	-	3.89	0.071	**4.2**
A007	46	Channel	Pipe	93.6	687.28	686.84	0.47%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A007	47	Channel	Channel	116.6	686.84	685.07	1.52%	-	-	-	-	-	-	-	7.03	0.005	**0.3**
A007	48	Channel	Pipe	40.9	685.37	690.26	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A008	49	Sheet	Short Grass Prairie	100.0	734.23	733.11	1.12%	0.15	0.193	**11.6**	-	-	-	-	-	-	-
A008	50	Shallow	Unpaved	763.6	733.11	720.15	1.70%	-	-	-	16.1345	2.10	0.101	**6.1**	-	-	-
A008	51	Channel	Swale	284.7	720.15	714.19	2.09%	-	-	-	-	-	-	-	4.00	0.020	**1.2**
A008	52	Channel	Swale	385.5	714.41	705.21	2.39%	-	-	-	-	-	-	-	4.00	0.027	**1.6**
A008	53	Channel	Pond	161.0	714.19	714.41	0.25%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A008	54	Channel	Channel	309.6	705.21	701.04	1.35%	-	-	-	-	-	-	-	2.86	0.030	**1.8**
A008	55	Channel	Pipe	73.9	701.04	698.70	3.17%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A008	56	Channel	Channel	237.9	698.70	695.24	1.45%	-	-	-	-	-	-	-	2.89	0.023	**1.4**
A008	57	Channel	Pipe	34.1	695.24	694.82	1.23%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A008	58	Channel	Channel	618.6	694.82	685.74	1.47%	-	-	-	-	-	-	-	4.00	0.043	**2.6**
A008	59	Channel	Pipe	90.1	685.74	684.95	0.88%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A008	60	Channel	Channel	31.1	684.95	684.77	0.58%	-	-	-	-	-	-	-	6.00	0.001	**0.1**
A008	61	Channel	Pipe	38.5	684.77	691.99	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A009	62	Sheet	Short Grass Prairie	54.8	725.82	720.90	8.99%	0.15	0.052	**3.1**	-	-	-	-	-	-	-
A009	63	Channel	Pipe	72.7	701.66	700.89	1.06%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A009	64	Channel	Channel	77.0	700.89	699.55	1.74%	-	-	-	-	-	-	-	6.00	0.004	**0.2**
A009	65	Channel	Pipe	25.6	699.55	703.09	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A009	66	Channel	Swale	913.0	-	-	-	-	-	-	-	-	-	-	4.00	0.063	**3.8**
B001	67	Sheet	Short Grass Prairie	100.0	706.23	705.15	1.08%	0.15	0.196	**11.8**	-	-	-	-	-	-	-
B001	68	Shallow	Unpaved	420.8	705.15	688.87	3.87%	-	-	-	16.1345	3.17	0.037	**2.2**	-	-	-
B001	69	Channel	Swale	74.2	688.87	684.98	5.24%	-	-	-	-	-	-	-	4.00	0.005	**0.3**
B001	70	Channel	Pipe	74.2	684.98	682.99	2.68%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
B001	71	Channel	Swale	1,521.7	682.99	652.99	1.97%	-	-	-	-	-	-	-	4.00	0.106	**6.3**
B001	72	Channel	Pond	701.5	652.99	651.71	0.25%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
B001	73	Channel	Swale	594.5	651.71	643.12	1.44%	-	-	-	-	-	-	-	6.54	0.025	**1.5**
B001	74	Channel	Pond	743.8	643.12	636.35	0.91%	-	-	-	-	-	-	-	N/A	0.000	**0.0**

Basin Name	Sheet Flow Total Travel Time (min)	Shallow Flow Total Travel Time (min)	Channel Flow Total Travel Time (min)	Total Travel Time (min)	Lag Time (min)
A001	8.9	1.8	13.4	24.1	**14.5**
A002	8.8	0.0	13.1	22.0	**13.2**
A003	15.3	4.0	6.4	25.7	**15.4**
A004	14.4	0.6	19.7	34.8	**20.9**
A005	9.6	0.8	19.4	29.8	**17.9**
A006	3.7	0.0	4.2	7.9	**4.8**
A007	10.9	1.6	9.7	22.2	**13.3**
A008	11.6	6.1	9.1	26.8	**16.1**
A009	3.1	0.0	4.2	7.3	**4.4**
B001	11.8	2.2	8.3	22.3	**13.4**
B002	8.5	2.5	14.7	25.7	**15.4**
C001	7.4	1.8	6.0	15.2	**9.1**
C002	4.9	4.0	5.7	14.6	**8.8**

This seems much higher than a natural swale. Please verify

Please fill the blanks

If the calculated TC is smaller than min. TC required by city ordinance, please use the min. TC

It appears that the slope doesn't affect the velocity here. Please verify.

This doesn't appear to match the report. Need to reconcile.

General Comments:
It is not clear how the channel velocity was calculated. Please verify with RAS results for those that were modeled. Need to reconcile for pre-, post- and fully developed conditions.

CARDINAL STRATEGIES

Time of Concentration Calculations

Pre-Project Existing Conditions

Flow Path Parameters							Minimum Slope 0.25%	Sheet Flow Travel Time			Shallow Concentrated Flow Travel Time				Channel Flow Travel Time		
								$T_t = \frac{0.007\,(nL)0.8}{(P_2)^{0.5}\,s^{0.4}}$		Denton County iSWM P_2 = 3.63 (in)	$V = K\sqrt{s}$		$T_t = \frac{L}{3600V}$		$T_t = \frac{L}{3600V}$		
Basin Name	Flow Path ID	Flow Type	Flow Type Description	Length [L] (ft)	US Elevation (ft, NAVD88)	DS Elevation (ft, NAVD88)	Slope [s] (% ft/ft)	Mannings N-Value [n]	Sheet Flow Travel Time [T_t] (hr)	Sheet Flow Travel Time (min)	Shallow Flow K-Value [K]	Shallow Flow Velocity [V] (ft/s)	Shallow Flow Travel Time [T_t] (hr)	Shallow Flow Travel Time (min)	Channel Flow Velocity [V] (ft/s)	Channel Flow Travel Time [T_t] (hr)	Channel Flow Travel Time (min)
B002	75	Sheet	Short Grass Prairie	100.0	714.23	711.79	2.44%	0.15	0.142	**8.5**	-	-	-	-	-	-	-
B002	76	Shallow	Unpaved	300.8	711.79	707.01	1.59%	-	-	-	16.1345	2.03	0.041	**2.5**	-	-	-
B002	77	Channel	Swale	646.5	707.01	700.13	1.06%	-	-	-	-	-	-	-	4.00	0.045	**2.7**
B002	78	Channel	Pipe	87.1	700.13	695.72	5.06%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
B002	79	Channel	Swale	513.3	695.72	685.72	1.95%	-	-	-	-	-	-	-	6.72	0.021	**1.3**
B002	80	Channel	Channel	1,493.3	685.72	671.92	0.92%	-	-	-	-	-	-	-	5.80	0.071	**4.3**
B002	81	Channel	Swale	1,132.9	668.82	661.50	0.65%	-	-	-	-	-	-	-	3.03	0.104	**6.2**
B002	82	Channel	Pipe	12.6	661.39	657.71	29.20%	-	-	-	-	-	-	-	8.00	0.000	**0.0**
C001	83	Sheet	Short Grass Prairie	100.0	686.49	683.00	3.49%	0.15	0.123	**7.4**	-	-	-	-	-	-	-
C001	84	Shallow	Paved	236.0	683.00	680.28	1.15%	-	-	-	20.3282	2.18	0.030	**1.8**	-	-	-
C001	85	Channel	Swale	586.6	680.28	670.04	1.75%	-	-	-	-	-	-	-	4.00	0.041	**2.4**
C001	86	Channel	Swale	503.9	670.64	662.95	1.53%	-	-	-	-	-	-	-	2.37	0.059	**3.6**
C001	87	Channel	Pipe	25.4	670.04	670.64	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
C002	88	Sheet	Short Grass Prairie	100.0	729.06	719.46	9.60%	0.15	0.082	**4.9**	-	-	-	-	-	-	-
C002	89	Shallow	Unpaved	747.5	719.46	691.42	3.75%	-	-	-	16.1345	3.12	0.066	**4.0**	-	-	-
C002	90	Channel	Pipe	84.0	-	-	-	-	-	-	-	-	-	-	8.00	0.003	**0.2**
C002	91	Channel	Swale	1,337.3	-	-	-	-	-	-	-	-	-	-	4.00	0.093	**5.6**

This seems much higher than a common pipe. Please verify

Basin Name	Sheet Flow Total Travel Time (min)	Shallow Flow Total Travel Time (min)	Channel Flow Total Travel Time (min)	Total Travel Time (min)	Lag Time (min)

Time of Concentration Calculations

Post-Project Intermediate Conditions

Flow Path Parameters								Sheet Flow Travel Time			Shallow Concentrated Flow Travel Time				Channel Flow Travel Time		
							Minimum Slope 0.25%	$T_t = \frac{0.007\ (nL)0.8}{(P_2)^{0.5}\ s^{0.4}}$		Denton County iSWM P_2 = 3.63 (in)	$V = K\sqrt{s}$		$T_t = \frac{L}{3600V}$		$T_t = \frac{L}{3600V}$		
Basin Name	Flow Path ID	Flow Type	Flow Type Description	Length [L] (ft)	US Elevation (ft, NAVD88)	DS Elevation (ft, NAVD88)	Slope [s] (% ft/ft)	Mannings N-Value [n]	Sheet Flow Travel Time [T_t] (hr)	Sheet Flow Travel Time (min)	Shallow Flow K-Value [K]	Shallow Flow Velocity [V] (ft/s)	Shallow Flow Travel Time [T_t] (hr)	Shallow Flow Travel Time (min)	Channel Flow Velocity [V] (ft/s)	Channel Flow Travel Time [T_t] (hr)	Channel Flow Travel Time (min)
A001	1	Sheet	Short Grass Prairie	100.0	706.25	704.05	2.20%	0.15	0.148	**8.9**	-	-	-	-	-	-	-
A001	2	Shallow	Unpaved	424.5	704.05	679.57	5.77%	-	-	-	16.1345	3.87	0.030	**1.8**	-	-	-
A001	3	Channel	Channel	608.2	679.57	658.08	3.53%	-	-	-	-	-	-	-	6.41	0.026	**1.6**
A001	4	Channel	Pipe	80.8	658.08	655.20	3.56%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A001	5	Channel	Channel	329.2	655.20	643.51	3.55%	-	-	-	-	-	-	-	2.23	0.041	**2.5**
A001	6	Channel	Swale	268.6	643.51	635.49	2.99%	-	-	-	-	-	-	-	4.00	0.019	**1.1**
A001	7	Channel	Swale	664.2	635.49	633.01	0.37%	-	-	-	-	-	-	-	4.00	0.046	**2.8**
A001	8	Channel	Channel	1,017.3	633.01	627.66	0.53%	-	-	-	-	-	-	-	3.17	0.089	**5.3**
A002	9	Sheet	Short Grass Prairie	100.0	692.09	689.87	2.22%	0.15	0.147	**8.8**	-	-	-	-	-	-	-
A002	10	Channel	Swale	1,116.1	689.87	677.48	1.11%	-	-	-	-	-	-	-	4.00	0.078	**4.7**
A002	11	Channel	Channel	274.8	677.48	670.82	2.42%	-	-	-	-	-	-	-	6.00	0.013	**0.8**
A002	12	Channel	Pipe	784.5	670.82	656.27	1.85%	-	-	-	-	-	-	-	8.00	0.027	**1.6**
A002	13	Channel	Pond	66.6	656.27	651.69	6.88%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	14	Channel	Pond	42.5	651.69	650.97	1.69%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	15	Channel	Pond	11.8	650.97	649.93	8.84%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	16	Channel	Channel	490.8	650.10	645.35	0.97%	-	-	-	-	-	-	-	3.70	0.037	**2.2**
A002	17	Channel	Pipe	144.9	649.93	650.10	0.25%	-	-	-	-	-	-	-	8.00	0.005	**0.3**
A002	18	Channel	Channel	1,220.0	645.35	637.50	0.64%	-	-	-	-	-	-	-	5.69	0.060	**3.6**
A003	19	Sheet	Short Grass Prairie	100.0	685.27	682.63	2.64%	0.15	0.137	**8.2**	-	-	-	-	-	-	-
A003	20	Channel	Swale	450.2	682.63	678.45	0.93%	-	-	-	-	-	-	-	4.00	0.031	**1.9**
A003	21	Channel	Pipe	808.8	678.45	661.00	2.16%	-	-	-	-	-	-	-	3.71	0.061	**3.6**
A003	22	Channel	Swale	1,003.8	661.00	649.25	1.17%	-	-	-	-	-	-	-	4.79	0.058	**3.5**
A003	23	Channel	Channel	835.6	649.25	645.57	0.44%	-	-	-	-	-	-	-	7.51	0.031	**1.9**
A004	24	Sheet	Short Grass Prairie	100.0	711.44	710.79	0.65%	0.15	0.240	**14.4**	-	-	-	-	-	-	-
A004	25	Shallow	Unpaved	68.2	710.79	709.89	1.32%	-	-	-	16.1345	1.85	0.010	**0.6**	-	-	-
A004	26	Channel	Channel	624.4	709.89	683.99	4.15%	-	-	-	-	-	-	-	6.70	0.026	**1.6**
A004	27	Channel	Swale	1,214.2	683.99	667.04	1.40%	-	-	-	-	-	-	-	4.00	0.084	**5.1**
A004	28	Channel	Channel	453.5	667.04	665.81	0.27%	-	-	-	-	-	-	-	5.20	0.024	**1.5**
A004	29	Channel	Swale	1,548.8	665.81	653.38	0.80%	-	-	-	-	-	-	-	4.19	0.103	**6.2**
A005	30	Sheet	Short Grass Prairie	100.0	715.29	713.50	1.79%	0.15	0.160	**9.6**	-	-	-	-	-	-	-
A005	31	Shallow	Unpaved	171.6	713.50	704.67	5.15%	-	-	-	16.1345	3.66	0.013	**0.8**	-	-	-
A005	32	Channel	Swale	1,214.3	704.67	696.71	0.66%	-	-	-	-	-	-	-	4.00	0.084	**5.1**
A005	33	Channel	Swale	2,607.7	696.71	671.75	0.96%	-	-	-	-	-	-	-	3.02	0.240	**14.4**
A006	34	Sheet	Short Grass Prairie	51.7	721.62	719.00	5.07%	0.15	0.062	**3.7**	-	-	-	-	-	-	-
A006	35	Channel	Swale	870.9	719.00	701.13	2.05%	-	-	-	-	-	-	-	4.00	0.060	**3.6**
A006	36	Channel	Pipe	193.1	701.13	690.88	5.31%	-	-	-	-	-	-	-	8.00	0.007	**0.4**
A006	37	Channel	Pond	64.3	690.88	690.63	0.39%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A006	38	Channel	Pipe	71.9	690.63	696.86	0.25%	-	-	-	-	-	-	-	8.00	0.002	**0.1**
A007	39	Sheet	Short Grass Prairie	100.0	734.09	732.77	1.32%	0.15	0.181	**10.9**	-	-	-	-	-	-	-
A007	40	Shallow	Unpaved	121.5	732.77	732.03	0.61%	-	-	-	16.1345	1.26	0.027	**1.6**	-	-	-
A007	41	Channel	Swale	205.6	732.03	728.40	1.77%	-	-	-	-	-	-	-	4.00	0.014	**0.9**
A007	42	Channel	Swale	710.2	728.40	701.42	3.80%	-	-	-	-	-	-	-	3.01	0.066	**3.9**
A007	43	Channel	Pipe	50.3	701.42	701.12	0.60%	-	-	-	-	-	-	-	8.00	0.002	**0.1**
A007	44	Channel	Channel	987.8	701.12	687.28	1.40%	-	-	-	-	-	-	-	3.89	0.071	**4.2**
A007	45	Channel	Pipe	93.6	687.28	686.84	0.47%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A007	46	Channel	Channel	116.6	686.84	685.07	1.52%	-	-	-	-	-	-	-	7.03	0.005	**0.3**
A007	47	Channel	Pipe	40.9	685.37	690.26	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A008	48	Sheet	Short Grass Prairie	100.0	734.23	733.11	1.12%	0.15	0.193	**11.6**	-	-	-	-	-	-	-
A008	49	Shallow	Unpaved	763.6	733.11	720.15	1.70%	-	-	-	16.1345	2.10	0.101	**6.1**	-	-	-
A008	50	Channel	Swale	284.7	720.15	714.19	2.09%	-	-	-	-	-	-	-	4.00	0.020	**1.2**
A008	51	Channel	Swale	385.5	714.41	705.21	2.39%	-	-	-	-	-	-	-	4.00	0.027	**1.6**
A008	52	Channel	Pond	161.0	714.19	714.41	0.25%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A008	53	Channel	Channel	309.6	705.21	701.04	1.35%	-	-	-	-	-	-	-	2.86	0.030	**1.8**
A008	54	Channel	Pipe	73.9	701.04	698.70	3.17%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A008	55	Channel	Channel	237.9	698.70	695.24	1.45%	-	-	-	-	-	-	-	2.89	0.023	**1.4**
A008	56	Channel	Pipe	34.1	695.24	694.82	1.23%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A008	57	Channel	Channel	618.6	694.82	685.74	1.47%	-	-	-	-	-	-	-	4.00	0.043	**2.6**
A008	58	Channel	Pipe	90.1	685.74	684.95	0.88%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A008	59	Channel	Channel	31.1	684.95	684.77	0.58%	-	-	-	-	-	-	-	6.00	0.001	**0.1**
A008	60	Channel	Pipe	38.5	684.77	691.99	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A009	61	Sheet	Short Grass Prairie	54.8	725.82	720.90	8.99%	0.15	0.052	**3.1**	-	-	-	-	-	-	-
A009	62	Channel	Pipe	72.7	701.66	700.89	1.06%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A009	63	Channel	Channel	77.0	700.89	699.55	1.74%	-	-	-	-	-	-	-	6.00	0.004	**0.2**
A009	64	Channel	Pipe	25.6	699.55	703.09	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A009	65	Channel	Swale	913.0	-	-	-	-	-	-	-	-	-	-	4.00	0.063	**3.8**
B001	66	Sheet	Short Grass Prairie	100.0	706.23	705.15	1.08%	0.15	0.196	**11.8**	-	-	-	-	-	-	-
B001	67	Shallow	Unpaved	420.8	705.15	688.87	3.87%	-	-	-	16.1345	3.17	0.037	**2.2**	-	-	-
B001	68	Channel	Swale	74.2	688.87	684.98	5.24%	-	-	-	-	-	-	-	4.00	0.005	**0.3**
B001	69	Channel	Pipe	74.2	684.98	682.99	2.68%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
B001	70	Channel	Swale	1,521.7	682.99	652.99	1.97%	-	-	-	-	-	-	-	4.00	0.106	**6.3**
B001	71	Channel	Pond	701.5	652.99	651.71	0.25%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
B001	72	Channel	Swale	594.5	651.71	643.12	1.44%	-	-	-	-	-	-	-	6.54	0.025	**1.5**
B001	73	Channel	Pond	743.8	643.12	636.35	0.91%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
B002	74	Sheet	Short Grass Prairie	100.0	714.23	711.79	2.44%	0.15	0.142	**8.5**	-	-	-	-	-	-	-

Basin Name	Sheet Flow Total Travel Time (min)	Shallow Flow Total Travel Time (min)	Channel Flow Total Travel Time (min)	Total Travel Time (min)	Lag Time (min)
A001	8.9	1.8	13.4	24.1	**14.5**
A002	8.8	0.0	13.1	22.0	**13.2**
A003	8.2	0.0	10.9	19.1	**11.5**
A004	14.4	0.6	14.2	29.3	**17.6**
A005	9.6	0.8	19.4	29.8	**17.9**
A006	3.7	0.0	4.2	7.9	**4.8**
A007	10.9	1.6	9.7	22.2	**13.3**
A008	11.6	6.1	9.1	26.8	**16.1**
A009	3.1	0.0	4.2	7.3	**4.4**
B001	11.8	2.2	8.3	22.3	**13.4**
B002	8.5	2.5	14.7	25.7	**15.4**
C001	7.4	1.8	5.6	14.7	**8.8**
C002	4.9	4.0	5.7	14.6	**8.8**

If the calculated TC is smaller than min. TC required by city ordinance, please use the min. TC

CARDINAL STRATEGIES

Time of Concentration Calculations

Post-Project Existing Conditions

Flow Path Parameters							Minimum Slope 0.25%	Sheet Flow Travel Time			Shallow Concentrated Flow Travel Time				Channel Flow Travel Time		
								$T_t = \frac{0.007\,(nL)0.8}{(P_2)^{0.5}\,s^{0.4}}$		Denton County iSWM $P_2 = 3.63$ (in)	$V = K\sqrt{s}$		$T_t = \frac{L}{3600V}$		$T_t = \frac{L}{3600V}$		
Basin Name	Flow Path ID	Flow Type	Flow Type Description	Length [L] (ft)	US Elevation (ft, NAVD88)	DS Elevation (ft, NAVD88)	Slope [s] (% ft/ft)	Mannings N-Value [n]	Sheet Flow Travel Time [T_t] (hr)	Sheet Flow Travel Time (min)	Shallow Flow K-Value [K]	Shallow Flow Velocity [V] (ft/s)	Shallow Flow Travel Time [T_t] (hr)	Shallow Flow Travel Time (min)	Channel Flow Velocity [V] (ft/s)	Channel Flow Travel Time [T_t] (hr)	Channel Flow Travel Time (min)
A001	1	Sheet	Short Grass Prairie	100.0	706.25	704.05	2.20%	0.15	0.148	**8.9**	-	-	-	-	-	-	-
A001	2	Shallow	Unpaved	424.5	704.05	679.57	5.77%	-	-	-	16.1345	3.87	0.030	**1.8**	-	-	-
A001	3	Channel	Channel	608.2	679.57	658.08	3.53%	-	-	-	-	-	-	-	6.41	0.026	**1.6**
A001	4	Channel	Pipe	80.8	658.08	655.20	3.56%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A001	5	Channel	Channel	329.2	655.20	643.51	3.55%	-	-	-	-	-	-	-	2.23	0.041	**2.5**
A001	6	Channel	Swale	268.6	643.51	635.49	2.99%	-	-	-	-	-	-	-	4.00	0.019	**1.1**
A001	7	Channel	Swale	664.2	635.49	633.01	0.37%	-	-	-	-	-	-	-	4.00	0.046	**2.8**
A001	8	Channel	Channel	1,017.3	633.01	627.66	0.53%	-	-	-	-	-	-	-	3.17	0.089	**5.3**
A002	9	Sheet	Short Grass Prairie	100.0	692.09	689.87	2.22%	0.15	0.147	**8.8**	-	-	-	-	-	-	-
A002	10	Channel	Swale	1,116.1	689.87	677.48	1.11%	-	-	-	-	-	-	-	4.00	0.078	**4.7**
A002	11	Channel	Channel	274.8	677.48	670.82	2.42%	-	-	-	-	-	-	-	6.00	0.013	**0.8**
A002	12	Channel	Pipe	784.5	670.82	656.27	1.85%	-	-	-	-	-	-	-	8.00	0.027	**1.6**
A002	13	Channel	Pond	66.6	656.27	651.69	6.88%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	14	Channel	Pond	42.5	651.69	650.97	1.69%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	15	Channel	Pond	11.8	650.92	649.95	8.24%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A002	16	Channel	Channel	490.8	650.10	645.35	0.97%	-	-	-	-	-	-	-	3.70	0.037	**2.2**
A002	17	Channel	Pipe	144.9	649.95	650.06	0.25%	-	-	-	-	-	-	-	8.00	0.005	**0.3**
A002	18	Channel	Channel	1,220.0	645.35	637.50	0.64%	-	-	-	-	-	-	-	5.69	0.060	**3.6**
A003	19	Sheet	Short Grass Prairie	100.0	685.27	682.63	2.64%	0.15	0.137	**8.2**	-	-	-	-	-	-	-
A003	20	Channel	Swale	450.2	682.63	678.45	0.93%	-	-	-	-	-	-	-	4.00	0.031	**1.9**
A003	21	Channel	Pipe	808.8	678.45	661.00	2.16%	-	-	-	-	-	-	-	3.71	0.061	**3.6**
A003	22	Channel	Swale	1,003.8	661.00	649.25	1.17%	-	-	-	-	-	-	-	4.79	0.058	**3.5**
A003	23	Channel	Channel	835.6	649.68	645.43	0.51%	-	-	-	-	-	-	-	5.64	0.041	**2.5**
A004	24	Sheet	Smooth Surfaces	100.0	711.44	710.44	1.00%	0.011	0.025	**1.5**	-	-	-	-	-	-	-
A004	25	Shallow	Paved	68.2	710.44	709.80	0.94%	-				1.97	0.010	**0.6**	-	-	-
A004	26	Channel	Pipe	165.3	709.80	676.25	20.30%	-							8.00	0.006	**0.3**
A004	27	Channel	Channel	1,298.3	707.75	671.16	2.82%	-							5.52	0.065	**3.9**
A004	28	Channel	Channel	1,547.8	671.16	665.79	0.35%	-							4.91	0.088	**5.3**
A004	29	Channel	Swale	1,548.8	665.81	653.38	0.80%	-							4.19	0.103	**6.2**
A005	30	Sheet	Short Grass Prairie	100.0	715.29	713.50	1.79%	0.15							-	-	-
A005	31	Shallow	Unpaved	171.6	713.50	704.67	5.15%	-				3.66	0.013	**0.8**	-	-	-
A005	32	Channel	Swale	1,214.3	704.67	696.71	0.66%	-	-	-	-	-	-	-	4.00	0.084	**5.1**
A005	33	Channel	Swale	2,607.7	696.71	671.75	0.96%	-	-	-	-	-	-	-	3.02	0.240	**14.4**
A006	34	Sheet	Short Grass Prairie	51.7	721.62	719.00	5.07%	0.15	0.062	**3.7**	-	-	-	-	-	-	-
A006	35	Channel	Swale	870.9	719.00	701.13	2.05%	-	-	-	-	-	-	-	4.00	0.060	**3.6**
A006	36	Channel	Pipe	193.1	701.13	690.88	5.31%	-	-	-	-	-	-	-	8.00	0.007	**0.4**
A006	37	Channel	Pond	64.3	690.88	690.63	0.39%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A006	38	Channel	Pipe	71.9	690.70	696.85	0.25%	-	-	-	-	-	-	-	8.00	0.002	**0.1**
A007	39	Sheet	Short Grass Prairie	100.0	734.09	732.77	1.32%	0.15	0.181	**10.9**	-	-	-	-	-	-	-
A007	40	Shallow	Unpaved	121.5	732.77	732.03	0.61%	-	-	-	16.1345	1.26	0.027	**1.6**	-	-	-
A007	41	Channel	Swale	205.6	732.03	728.40	1.77%	-	-	-	-	-	-	-	4.00	0.014	**0.9**
A007	42	Channel	Swale	710.2	728.40	701.42	3.80%	-	-	-	-	-	-	-	3.01	0.066	**3.9**
A007	43	Channel	Pipe	50.3	701.42	701.12	0.60%	-	-	-	-	-	-	-	8.00	0.002	**0.1**
A007	44	Channel	Channel	987.8	701.12	687.28	1.40%	-	-	-	-	-	-	-	3.89	0.071	**4.2**
A007	45	Channel	Pipe	93.6	687.28	686.84	0.47%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A007	46	Channel	Channel	116.6	686.84	685.07	1.52%	-	-	-	-	-	-	-	7.03	0.005	**0.3**
A007	47	Channel	Pipe	40.9	685.37	690.26	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A008	48	Sheet	Short Grass Prairie	100.0	734.23	733.11	1.12%	0.15	0.193	**11.6**	-	-	-	-	-	-	-
A008	49	Shallow	Unpaved	763.6	733.11	720.15	1.70%	-	-	-	16.1345	2.10	0.101	**6.1**	-	-	-
A008	50	Channel	Swale	284.7	720.15	714.19	2.09%	-	-	-	-	-	-	-	4.00	0.020	**1.2**
A008	51	Channel	Swale	385.5	714.41	705.21	2.39%	-	-	-	-	-	-	-	4.00	0.027	**1.6**
A008	52	Channel	Pond	161.0	714.19	714.41	0.25%	-	-	-	-	-	-	-	N/A	0.000	**0.0**
A008	53	Channel	Channel	309.6	705.21	701.04	1.35%	-	-	-	-	-	-	-	2.86	0.030	**1.8**
A008	54	Channel	Pipe	73.9	701.04	698.70	3.17%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A008	55	Channel	Channel	237.9	698.70	695.24	1.45%	-	-	-	-	-	-	-	2.89	0.023	**1.4**
A008	56	Channel	Pipe	34.1	695.24	694.82	1.23%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A008	57	Channel	Channel	618.6	694.82	685.74	1.47%	-	-	-	-	-	-	-	4.00	0.043	**2.6**
A008	58	Channel	Pipe	90.1	685.74	684.95	0.88%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A008	59	Channel	Channel	31.1	684.95	684.77	0.58%	-	-	-	-	-	-	-	6.00	0.001	**0.1**
A008	60	Channel	Pipe	38.5	684.77	691.99	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A009	61	Sheet	Short Grass Prairie	54.8	725.82	720.90	8.99%	0.15	0.052	**3.1**	-	-	-	-	-	-	-
A009	62	Channel	Pipe	72.7	701.68	700.90	1.07%	-	-	-	-	-	-	-	8.00	0.003	**0.2**
A009	63	Channel	Channel	77.0	700.90	699.06	2.39%	-	-	-	-	-	-	-	6.00	0.004	**0.2**
A009	64	Channel	Pipe	25.6	699.06	703.09	0.25%	-	-	-	-	-	-	-	8.00	0.001	**0.1**
A009	65	Channel	Swale	913.0	-	-	-	-	-	-	-	-	-	-	4.00	0.063	**3.8**
B001	66	Sheet	Short Grass Prairie	100.0	709.75	709.29	0.46%	0.15	0.276	**16.6**	-	-	-	-	-	-	-
B001	67	Shallow	Unpaved	364.8	709.29	701.21	2.21%	-	-	-	16.1345	2.40	0.042	**2.5**	-	-	-
B001	68	Channel	Swale	509.8	701.21	687.92	2.61%	-	-	-	-	-	-	-	4.00	0.035	**2.1**
B001	69	Channel	Channel	465.7	687.92	679.75	1.75%	-	-	-	-	-	-	-	6.00	0.022	**1.3**
B001	70	Channel	Pipe	1,058.3	679.75	665.25	1.37%	-	-	-	-	-	-	-	8.00	0.037	**2.2**
B001	71	Channel	Channel	129.6	665.25	664.04	0.93%	-	-	-	-	-	-	-	6.00	0.006	**0.4**
B001	72	Channel	Swale	183.6	664.04	661.60	1.33%	-	-	-	-	-	-	-	4.00	0.013	**0.8**
B001	73	Channel	Pipe	51.2	661.60	657.89	7.25%	-	-	-	-	-	-	-	8.00	0.002	**0.1**
B001	74	Channel	Pond	526.7	657.89	656.23	0.32%	-	-	-	-	-	-	-	N/A	0.000	**0.0**

This appears much higher than common pipe, especially for a proposed pipe in this case. Please clarify or revise.

It appears that the travel time increased from the sheet above. It is supposed to be independent of other phases. Please revise or clarify.

Basin Name	Sheet Flow Total Travel Time (min)	Shallow Flow Total Travel Time (min)	Channel Flow Total Travel Time (min)	Total Travel Time (min)	Lag Time (min)
A001	8.9	1.8	13.4	24.1	**14.5**
A002	8.8	0.0	13.1	22.0	**13.2**
A003	8.2	0.0	11.5	19.7	**11.8**
A004	1.5	0.6	15.7	17.8	**10.7**
A005	9.6	0.8	19.4	29.8	**17.9**
A006	3.7	0.0	4.2	7.9	**4.8**
A007	10.9	1.6	9.7	22.2	**13.3**
A008	11.6	6.1	9.1	26.8	**16.1**
A009	3.1	0.0	4.2	7.3	**4.4**
B001	16.6	2.5	8.6	27.7	**16.6**
B002	1.5	0.0	11.4	12.9	**7.8**
C001	7.4	1.8	5.6	14.7	**8.8**
C002	4.9	4.0	5.7	14.6	**8.8**

CARDINAL STRATEGIES