DRAINAGE CALCULATIONS

Pre-Developed Conditions

The 0.5 acre site has been covered with a aggregate surface to be used as a truck parking lot. Prior to the aggregate surface being placed, the lot was covered in poor, aged grass and volunteer vegetation with a fair amount of bare spots. The site slopes from the S.E. corner to an existing bee hive area drain at the N.W. corner at 1.03%.

The allowable runoff from a 10 year pre-developed condition assuming that the entire site was poor, aged grass and volunteer vegetation with a fair amount of bare spots is 0.41 cfs.

Proposed Developed Conditions

Since the area is within the Impacted Drainage Area along the north U.S. Highway 41 Industrial Corridor, the storm water detention will be based upon the 100 year storm event. The runoff from the 100 year storm event in the developed condition is 2.37 cfs. The volume of stormwater detention required for the 100 year storm is 2,850 cubic feet based upon Form 800.

Per the drainage plan for Arby's Hwy 41 North Minor Subdivision dated October 12, 1990 Arby's Restaurant on Lot #1 of the Minor Subdivision has already constructed Basins 1 and 2 as shown on said drainage plan with a total storage volume of 2,353 c.f. Also per the drainage plan, Arby's Restaurant was required to have 2,068 c.f, thus the amount of available storage in Basin 1 which could be utilized by Mr. Patel in developing Lot #2 is 285 c.f This equates to an area of 0.05 acres of parking lot surface which could drain into existing Basin 1 within the drainage easement between Lots #1 and #2, and is designated on the Grading & Drainage Plan as sub-drainage area B.

The two driveway entrances will drain off-site to the gutterlines of Elpers Road and Rusher Creek Drive undetained due to their grades. This equates to a storage volume of 57 c.f. which must be added to the required storage of Lot #2 since it leaves the site undetained and is designated on the Grading & Drainage Plan as sub-drainage areas A.

Thus, the total volume to be retained in the new stormwater detention basin at the northwest corner of Lot #2 for sub-drainage area C is:

	2,850 c.f	per Form 800
	- 285 c.f.	allowable to be discharged to existing Basin 1
	+ 57 c.f.	area leaving site undetained
TOTAL REQUIRED	= 2,622 c.f.	of on-site storage

New Detention Basin

The new detention basin in the northwest corner of Lot #2 will have a top berm at elevation 448.50 and bottom elevation of 447.25 at the bottom of the 4:1 side slopes for a total available storage of 2,624 c.f. which is greater than the required total storage of 2,622 c.f.

A 4" diameter outlet pipe from the detention basin with a depth of 1.25 feet at elevation 448.5 will discharge 0.47 cfs which closely corresponds to the allowable discharge rate of 0.41 cfs for the 10 year pre-developed condition. A 3" diameter outlet pipe trial was run, but a 3" diameter pipe only has a discharge rate of 0.27 cfs., which is considerably less that the allowable discharge rate of 0.41 cfs. Thus, a 4" diameter outlet pipe will be used to discharge the storm runoff from the detention basin into the existing underground stormwater drainage system.

file d:\4492\drainage report narrative

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CONSULTING ENGINEERS/LAND SURVEYORS/ARCHITECTS
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Project PATEL- LOT #2 ARBY'S HWY 41N MINOR Sheet 1 of
Project No. 4492 Date 12/23/99 By LAM

EXISTING CONDITIONS

EXISTING LOT (PRIOR TO PLACING AGGREGATE BASE)

TOTAL = 21,804 SF = .50 AC.

EXISTING BITUMINOUS SURFACE = 7' x 143' = 1,001 SF

CALCULATE $W_I C'$

$C = .15$ SLOPES < 2% W/TURF
$C = .92$ SLOPES < 2% W/IMP.

$$W_I C' = \frac{.15\,(21{,}804 - 1001) + (1001)(.92)}{21{,}804}$$ SURFACES

$W_I C' = .19$

TIME OF CONCENTRATION KIRBY'S FORMULA

$$t_c = K\left(\frac{LN}{\sqrt{S}}\right)^{.467}$$

WHERE $L = 231'$

$N = .40$

$S = \frac{452.77 - 449.69}{231} = \frac{4.08'}{231'} = .0177$

$K = .83$

$$t_c = .83\left(\frac{231 \times .40}{\sqrt{.0177}}\right)^{.467}$$

$= .83\,(21.23)$

$t_c = 17.62$ MIN.

RAINFALL INTENSITY - TABLE 807

i (10 YEAR)

15 MIN	4.515
17.62 MIN	4.290
30 MIN	3.226

i (10 YEAR) = 4.290 IN/HR

Q (10 YR) UNDEVELOPED = CiA RATIONAL METHOD
$= (.19)(4.290\ \text{IN/HR})(.50\ \text{AC})$

Q (10 YR) UNDEV. = .41 CFS

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Project _____

Sheet 2 of _____

Project No. _____ Date _____ By LAM

DEVELOPED CONDITION

AREA FROM RECORDED PLAT FOR SPECIAL DRAINAGE ESMT $\frac{1}{2}(50' \times 50') + 5' \times 220' = 2,350$ SF
$+ 10' \text{ P.U. ESMT} = 10' \times 100' = 1,000$ SF

TOTAL AREA = 21,804 SF

AREA 'GREEN' SPACE = 3,350 SF

AREA IMPERV. = 21,804 SF − 3,350 SF = 18,454 SF

CALC. Wt. 'C' $C = 0.15$ SLOPES < 2% W/ TURF
$C = 0.92$ SLOPES < 2% W/ IMPERV.

$$Wt'C' = \frac{(0.15)(3,350\text{ SF}) + (18,454\text{ SF})(0.92)}{21,840\text{ SF}}$$

$$Wt'C' = \frac{17,480}{21,840} = 0.80$$

TIME OF CONCENTRATION $T_C = 17.62$ MIN.

RAINFALL INTENSITY TABLE 807

$I_{(100\,YR)}$		
	15 MIN	6.194
	17.62 MIN	5.917 IN/HR
	30 MIN	4.608

$Q_{(100\,YR)}$ DEVELOPED $= CIA$ RATIONAL METHOD
$= (0.80)(5.917\text{ IN/HR})(0.50\text{ AC})$

$Q_{(100\,YR)}$ DEVELOPED = 2.37 CFS

TABLE 803

UNDEVELOPED RUNOFF COEFFICIENTS (C_u)

SURFACE TYPE:

WOODLAND, TURFED MEADOWS
ROUGH PASTURE, FALLOW BRUSH:

SLOPE:	
Less than 2%	C = 0.12
2% to 5%	C = 0.24
5+% to 10%	C = 0.36
Over 10%	C = 0.48

CULTIVATED FIELDS:

Less than 2%	C = 0.20
2% to 5%	C = 0.35
5+% to 10%	C = 0.50
Over 10%	C = 0.65

TABLE 804

DEVELOPED RUNOFF COEFFICIENTS (C_d)

SURFACE TYPE:

PAVEMENT, ROOFTOP
OTHER IMPERVIOUS SURFACES:

Less than 2%	C = 0.92
2% to 5%	C = 0.94
5+% to 10%	C = 0.96
Over 10%	C = 0.98

LAWNS WITH TURF:

Less than 2%	C = 0.15
2% to 5%	C = 0.25
5+% to 10%	C = 0.40
Over 10%	C = 0.55

ALL WATER SURFACES
BASINS, PONDS & LAKES:

C = 1.00

TABLE 807

RAINFALL INTENSITY-DURATION-FREQUENCY TABLE FOR EVANSVILLE

INTENSITY IN INCHES PER HOUR

STORM DURATION	STORM RETURN PERIOD IN YEARS				
	5	10	25	50	100
5 MIN	6.063	6.625	7.208	7.936	8.469
10 MIN	4.863	5.380	5.925	6.616	7.126
15 MIN	4.029	4.515	5.033	5.697	6.194
30 MIN	2.837	3.226	3.646	4.194	4.608
60 MIN	1.549	1.819	2.078	2.412	2.663
2.0 HRS	1.053	1.230	1.400	1.620	1.785
3.0 HRS	0.774	0.899	1.019	1.175	1.291
4.0 HRS	0.632	0.736	0.836	0.965	1.062
5.0 HRS	0.524	0.606	0.684	0.785	0.861
6.0 HRS	0.453	0.522	0.589	0.676	0.741
7.0 HRS	0.399	0.459	0.516	0.591	0.647
8.0 HRS	0.358	0.412	0.463	0.530	0.581
9.0 HRS	0.323	0.370	0.415	0.472	0.516
10 HRS	0.297	0.339	0.379	0.431	0.470
11 HRS	0.276	0.314	0.351	0.399	0.435
12 HRS	0.259	0.296	0.331	0.376	0.410
13 HRS	0.245	0.280	0.314	0.357	0.390
14 HRS	0.233	0.267	0.299	0.341	0.372
15 HRS	0.220	0.252	0.281	0.320	0.349
16 HRS	0.209	0.238	0.266	0.302	0.329
17 HRS	0.198	0.225	0.251	0.284	0.310

VANDERBURGH COUNTY DRAINAGE BOARD
FORM 800

PROJECT: DETENTION FACILITY DESIGN RETURN PERIOD 25 YRS

DESIGNER: MORLEY & ASSOC. RELEASE RATE RETURN PERIOD: 10 YRS

WATERSHED AREA:	0.5	ACRES
TIME OF CONCENTRATION (UNDEVELOPED WATERSHEI	17.62	MINUTES
RAINFALL INTENSITY (Iu):	4.29	INCHES/HR
UNDEVELOPED RUNOFF COEFFICIENT (Cu):	0.19	
UNDEVELOPED RUNOFF RATE (O = Cu*Iu*A):	0.41	CFS
DEVELOPED RUNOFF COEFFICIENT (Cd):	0.8	

STORM DURATION Td (HRS)	RAINFALL INTENSITY Id (INCH/HR)	INFLOW RATE I(Td) (Cd*Id*A) (CFS)	OUTFLOW RATE O (Cu*Iu*A) (CFS)	STORAGE RATE I(Td)-O (CFS)	REQUIRED STORAGE (Td)-O)*Td/12 (ACRE-FT)
0.08	7.208	2.88	0.41	2.48	0.017
0.17	5.925	2.37	0.41	1.96	0.027
0.25	5.033	2.01	0.41	1.61	0.033
0.33	4.571	1.83	0.41	1.42	0.039
0.42	4.108	1.64	0.41	1.24	0.043
0.50	3.646	1.46	0.41	1.05	0.044
0.58	3.385	1.35	0.41	0.95	0.046
0.67	3.123	1.25	0.41	0.84	0.047
0.75	2.862	1.14	0.41	0.74	0.046
0.83	2.601	1.04	0.41	0.63	0.044
0.92	2.339	0.94	0.41	0.53	0.040
1.00	2.078	0.83	0.41	0.42	0.035
1.25	1.909	0.76	0.41	0.36	0.037
1.50	1.739	0.70	0.41	0.29	0.036
1.75	1.570	0.63	0.41	0.22	0.032
2.00	1.400	0.56	0.41	0.15	0.025
2.50	1.210	0.48	0.41	0.08	0.016
3.00	1.019	0.41	0.41	0.00	0.000
4.00	0.836	0.33	0.41	-0.07	-0.024

PEAK STORAGE (ACRE/FT):	0.05
PEAK STORAGE (CUBIC FT):	2,037

THIS VOLUME IS NOT APPLICABLE AS SITE IS WITHIN U.S.41 DRAINAGE CORRIDOR ∴ MUST RETAIN 100 YEAR STORM EVENT.

SUB-AREA (C)

VANDERBURGH COUNTY DRAINAGE BOARD
FORM 800

PROJECT: **4492-4A** DETENTION FACILITY DESIGN RETURN PERIOD 100 YRS
David Patel
DESIGNER: MORLEY & ASSOC. RELEASE RATE RETURN PERIOD: 10 YRS

WATERSHED AREA:	0.5	ACRES
TIME OF CONCENTRATION (UNDEVELOPED WATERSHEI	17.62	MINUTES
RAINFALL INTENSITY (Iu):	4.29	INCHES/HR
UNDEVELOPED RUNOFF COEFFICIENT (Cu):	0.19	
UNDEVELOPED RUNOFF RATE (O = Cu*Iu*A):	0.41	CFS
DEVELOPED RUNOFF COEFFICIENT (Cd):	0.8	

STORM DURATION Td (HRS)	RAINFALL INTENSITY Id (INCH/HR)	INFLOW RATE I(Td) (Cd*Id*A) (CFS)	OUTFLOW RATE O (Cu*Iu*A) (CFS)	STORAGE RATE I(Td)-O (CFS)	REQUIRED STORAGE (Td)-O)*Td/12 (ACRE-FT)
0.08	8.469	3.39	0.41	2.98	0.021
0.17	7.126	2.85	0.41	2.44	0.034
0.25	6.194	2.48	0.41	2.07	0.043
0.33	5.665	2.27	0.41	1.86	0.052
0.42	5.137	2.05	0.41	1.65	0.057
0.50	4.608	1.84	0.41	1.44	0.060
0.58	4.284	1.71	0.41	1.31	0.063
0.67	3.960	1.58	0.41	1.18	0.065
0.75	3.636	1.45	0.41	1.05	0.065
0.83	3.311	1.32	0.41	0.92	0.064
0.92	2.987	1.19	0.41	0.79	0.060
1.00	2.663	1.07	0.41	0.66	0.055
1.25	2.444	0.98	0.41	0.57	0.059
1.50	2.224	0.89	0.41	0.48	0.060
1.75	2.005	0.80	0.41	0.39	0.057
2.00	1.785	0.71	0.41	0.31	0.051
2.50	1.538	0.62	0.41	0.21	0.043
3.00	1.291	0.52	0.41	0.11	0.027
4.00	1.062	0.42	0.41	0.02	0.006

PEAK STORAGE (ACRE/FT):	0.07
PEAK STORAGE (CUBIC FT):	2,850

ADDITIONAL STORAGE REQ'D FOR AREA OF DRIVE ENTRANCES LEAVING SITE UNRETAINED

SUB AREA (A)

VANDERBURGH COUNTY DRAINAGE BOARD
FORM 800

PROJECT: **4492-4A**
David Patel
DESIGNER: MORLEY & ASSOC.

DETENTION FACILITY DESIGN RETURN PERIOD 100 YRS
RELEASE RATE RETURN PERIOD: 10 YRS

WATERSHED AREA:	0.01	ACRES
TIME OF CONCENTRATION (UNDEVELOPED WATERSHEI	17.62	MINUTES
RAINFALL INTENSITY (Iu):	4.29	INCHES/HR
UNDEVELOPED RUNOFF COEFFICIENT (Cu):	0.19	
UNDEVELOPED RUNOFF RATE (O = Cu*Iu*A):	0.01	CFS
DEVELOPED RUNOFF COEFFICIENT (Cd):	0.8	

STORM DURATION Td (HRS)	RAINFALL INTENSITY Id (INCH/HR)	INFLOW RATE I(Td) (Cd*Id*A) (CFS)	OUTFLOW RATE O (Cu*Iu*A) (CFS)	STORAGE RATE I(Td)-O (CFS)	REQUIRED STORAGE (Td)-O)*Td/12 (ACRE-FT)
0.08	8.469	0.07	0.01	0.06	0.000
0.17	7.126	0.06	0.01	0.05	0.001
0.25	6.194	0.05	0.01	0.04	0.001
0.33	5.665	0.05	0.01	0.04	0.001
0.42	5.137	0.04	0.01	0.03	0.001
0.50	4.608	0.04	0.01	0.03	0.001
0.58	4.284	0.03	0.01	0.03	0.001
0.67	3.960	0.03	0.01	0.02	0.001
0.75	3.636	0.03	0.01	0.02	0.001
0.83	3.311	0.03	0.01	0.02	0.001
0.92	2.987	0.02	0.01	0.02	0.001
1.00	2.663	0.02	0.01	0.01	0.001
1.25	2.444	0.02	0.01	0.01	0.001
1.50	2.224	0.02	0.01	0.01	0.001
1.75	2.005	0.02	0.01	0.01	0.001
2.00	1.785	0.01	0.01	0.01	0.001
2.50	1.538	0.01	0.01	0.00	0.001
3.00	1.291	0.01	0.01	0.00	0.001
4.00	1.062	0.01	0.01	0.00	0.000

PEAK STORAGE (ACRE/FT):	0.00
PEAK STORAGE (CUBIC FT):	57

ALLOWABLE AREA TO DRAIN TO BASIN #1 FROM LOT #2

SUB-AREA (B)

VANDERBURGH COUNTY DRAINAGE BOARD
FORM 800

PROJECT: **4492-4A** **David Patel**
DESIGNER: MORLEY & ASSOC.

DETENTION FACILITY DESIGN RETURN PERIOD 100 YRS
RELEASE RATE RETURN PERIOD: 10 YRS

WATERSHED AREA:	0.05	ACRES
TIME OF CONCENTRATION (UNDEVELOPED WATERSHE	17.62	MINUTES
RAINFALL INTENSITY (Iu):	4.29	INCHES/HR
UNDEVELOPED RUNOFF COEFFICIENT (Cu):	0.19	
UNDEVELOPED RUNOFF RATE (O = Cu*Iu*A):	0.04	CFS
DEVELOPED RUNOFF COEFFICIENT (Cd):	0.8	

STORM DURATION Td (HRS)	RAINFALL INTENSITY Id (INCH/HR)	INFLOW RATE I(Td) (Cd*Id*A) (CFS)	OUTFLOW RATE O (Cu*Iu*A) (CFS)	STORAGE RATE I(Td)-O (CFS)	REQUIRED STORAGE (Td)-O)*Td/12 (ACRE-FT)
0.08	8.469	0.34	0.04	0.30	0.002
0.17	7.126	0.29	0.04	0.24	0.003
0.25	6.194	0.25	0.04	0.21	0.004
0.33	5.665	0.23	0.04	0.19	0.005
0.42	5.137	0.21	0.04	0.16	0.006
0.50	4.608	0.18	0.04	0.14	0.006
0.58	4.284	0.17	0.04	0.13	0.006
0.67	3.960	0.16	0.04	0.12	0.007
0.75	3.636	0.15	0.04	0.10	0.007
0.83	3.311	0.13	0.04	0.09	0.006
0.92	2.987	0.12	0.04	0.08	0.006
1.00	2.663	0.11	0.04	0.07	0.005
1.25	2.444	0.10	0.04	0.06	0.006
1.50	2.224	0.09	0.04	0.05	0.006
1.75	2.005	0.08	0.04	0.04	0.006
2.00	1.785	0.07	0.04	0.03	0.005
2.50	1.538	0.06	0.04	0.02	0.004
3.00	1.291	0.05	0.04	0.01	0.003
4.00	1.062	0.04	0.04	0.00	0.001

PEAK STORAGE (ACRE/FT):	0.01
PEAK STORAGE (CUBIC FT):	285

= 285 OK

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Project _____

Sheet 3 of _____

Project No. _____ Date _____ By LAM

ARBY'S RESTAURANT ON LOT #1

REQ'D STORAGE PER LOT #1 PER 10/12/90 = 2068 CF

AVAILABLE STORAGE PER 10/12/90

BASIN 1 = 1963 CF
BASIN 2 = 390 CF
2,353 CF

STORAGE IN BASIN 1 TO BE ALLOCATED TO LOT #2

2353 CF AVAILABLE
− 2068 CF REQ'D
285 CF SUB AREA B

FORM 800 PEAK STORAGE REQ'D = 2,850 CF
AVAILABLE STORAGE BASIN 1 = 285
STORAGE REQ'D ON LOT 2 = 2,565 CF

TOTAL STORAGE REQ'D = 2,565 CF
UNRETAINED DRIVEWAYS = SUB AREA A + 57 CF
2,622 CF

AREA @ ELEV. 448.50 = 2,383 SF
AREA @ ELEV 447.25 = 1,503 SF

$$\text{VOL. AVAILABLE} = \frac{2,383+1,503}{2} \times \frac{1.25+1.45}{2}$$

VOL. AVAILABLE = 2,624 CF
VOL AVAIL ≥ VOL REQ'D
2,624 CF > 2,622 CF OK

PIPE FLOW: For a pipe flowing full, but not under pressure, Manning's Equation (Equation 4.2.1) may be used to calculate the flowrate. As soon as a depth of water develops above the pipe the flowrate must be calculated using a modified form of the Manning equation and must include entrance and exit losses. Equation 6.3.5 is used to calculate the flowrate under these conditions,

$$Q = A_p \left[\frac{h_p}{\frac{K_e + K_o}{2g} + \frac{2.87 n^2 L}{D^{4/3}}} \right]^{1/2} \qquad (6.3.5)$$

where Q is the flowrate in cfs, A_p is the area of the pipe (ft^2), K_e is the entrance loss coefficient (given in Table 6.3.3), K_o is the outlet loss coefficient (usually taken as 1.0), D is the pipe diameter (ft), *n* is Manning's roughness coefficient (Table 4.2.1), L is the length of pipe (ft) (Equation assumes a free jet @ exit), and h_p is the height of water surface above center of pipe opening (ft).

All of the equations presented may be used to calculate the flowrate Q. Often the flowrate is known and the orifice opening, weir size or pipe diameter are the parameters actually required. In these cases the equations are rearranged to solve for the unknown variable. When the computed result does not correspond to a commercially available pipe size, the type of opening, discharge coefficient, or pipe roughness are varied to obtain a readily available pipe of proper size.

Table 6.3.3
Value of K_e (Entrance Losses)
(Bureau of Reclamation, 1987)

Entrance Condition	*K_e range*	*Average*
Square-edged inlets installed flush with vertical headwalls	0.43 to 0.70	0.50
Rounded Inlets installed flush with vertical headwalls, r/D ≤ 0.15	0.08 to 0.27	0.10
Grooved or socket-ended concrete pipe installed flush with vertical headwall	0.10 to 0.33	0.15
Projecting concrete pipe with grooved or socket ends	-	0.20
Projecting steel or corrugated metal pipes	0.5 to 0.9	0.85

4" ϕ SCH. 40 PVC
DETENTION BASIN OUTLET
STRUCTURE

99-4492

Friction Loss Calculations

Q= Flowrate (cfs)
Ke= Entrance Loss coefficient
Ko= Outlet Loss coefficient
g= Gravity (ft/sec2)
h= Height of water above the centerline of the pipe (ft)
d= Diameter of the pipe (ft)
A= Area of the pipe (ft2)
L= Length of pipe
n= Mannings roughness coefficient

$$Q = A \times [h((Ke+Ko)/2g) + ((2.87*n2*L)/d4/3)]1/2$$

Q=	0.474	cubic feet per second
Ke=	0.70	see table
Ko=	1.0	assumed
g=	32.20	ft^2 per second
h=	1.03	ft
d=	0.330	ft
A=	0.09	ft^2 (4-inch Dia. Pipe)
L=	7.0	ft
n=	0.009	(Sch. 40 PVC Pipe)

3" ϕ SCH. 40 PVC

99-4492

Friction Loss Calculations

Q= Flowrate (cfs)
Ke= Entrance Loss coefficient
Ko= Outlet Loss coefficient
g= Gravity (ft/sec2)
h= Height of water above the centerline of the pipe (ft)
d= Diameter of the pipe (ft)
A= Area of the pipe (ft2)
L= Length of pipe
n= Mannings roughness coefficient

$$Q = A \times [h((Ke+Ko)/2g) + ((2.87*n2*L)/d4/3)]1/2$$

Q= 0.265 cubic feet per second < ϕ.41 CFS

TOO SMALL

Ke=	0.70	see table
Ko=	1.0	assumed
g=	32.20	ft^2 per second
h=	1.07	ft
d=	0.250	ft
A=	0.05	ft^2 (4-inch Dia. Pipe)
L=	7.0	ft
n=	0.009	(Sch. 40 PVC Pipe)