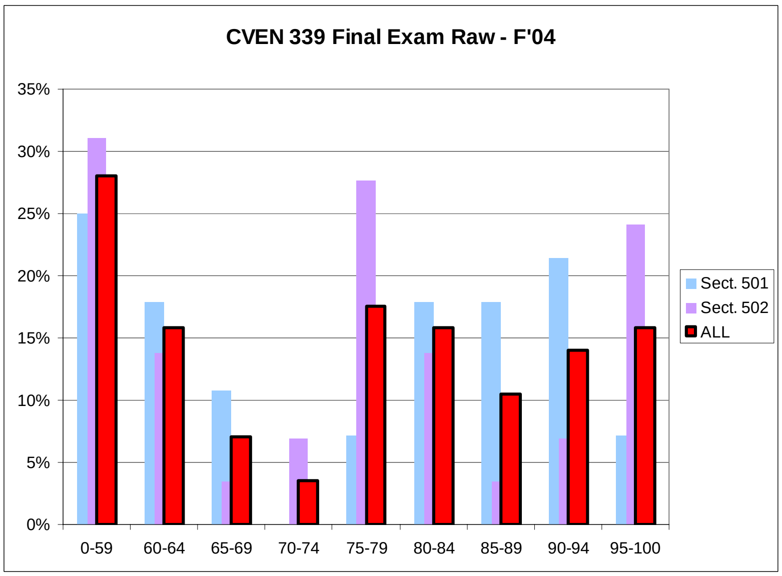
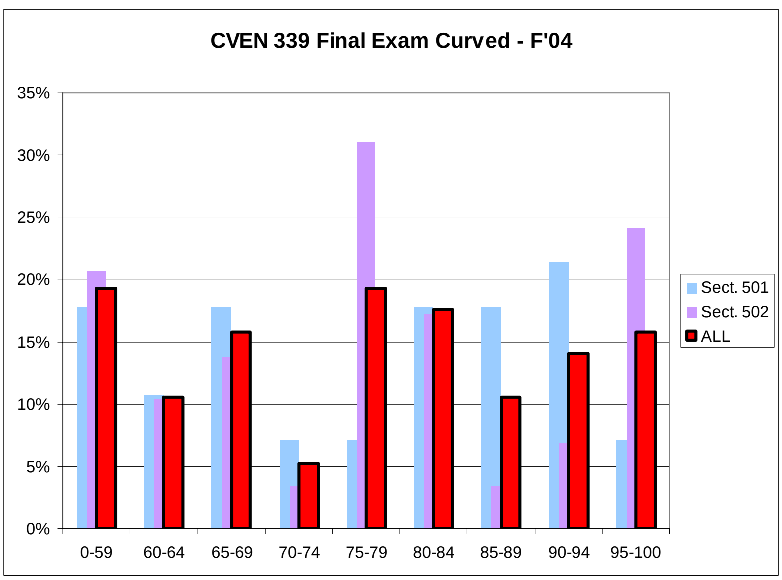
CVEN 339 – Final Exam – Fall 2004 (Separate exams for Sections 501 and 502)

	Section 501		Section 502		ALL	
	Raw	Curved	Raw	Curved	Raw	Curved
Median	81	81	75.5	77.3	77	77.6
Mean	74.8	76.6	72	76.5	73.3	76.6
Std. Dev.	16.5	14.1	19.7	14.5	18.1	14.2
High	96	96	98	98	98	98
Low	40	48.7	30	48.4	30	48.4





Name: ____

CVEN 339 – Water Resources Engineering
Fall Semester 2004 – Section 501
Dr. Kelly Brumbelow, Texas A&M University

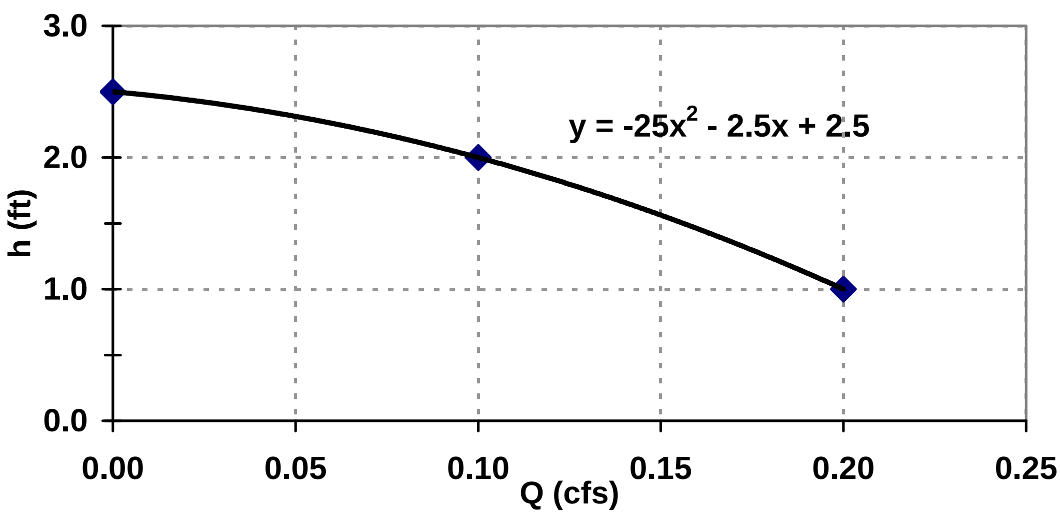
Final Exam

Open-book, Open-notes (10 pages, 4 questions)

1. A confined aquifer (see diagram on next page) has an undisturbed piezometric surface elevation of 764.3 ft above mean sea level (msl). A well is drilled into the aquifer from a point where ground elevation is 811.7 ft msl. Along the axis of the well the boundary between the aquifer and the upper confining layer is at elevation 684.2 ft msl, and the boundary between the aquifer and the lower confining layer is 497.0 ft msl. Saturated hydraulic conductivity for the aquifer is 29.2 ft/day. The well casing diameter is 30 inches.

A submersible well pump is installed in the well at an elevation of 640.0 ft msl. It is a multi-stage pump with 30 stacked modular impellers (like the one shown in class). The manufacturer supplies the pump characteristic curve shown below that applies to a single impeller only; thus, you will need to modify the curve for the multiple stages present. The well pump is connected to the surface by a 3 inch diameter galvanized iron pipe.

After well drawdown has fully developed, the aquifer and well will be in a steady state condition. However, you should remember that the amount of drawdown and the well flowrate are dependent on each other. Minor losses in the well pipe are negligible. You may assume the well's radius of influence to be 3,000 ft. *Once steady state is reached, what will be: (i) the drawdown of the piezometric surface at the well, and (ii) the flowrate leaving the well pipe at the ground surface?* (35 points)



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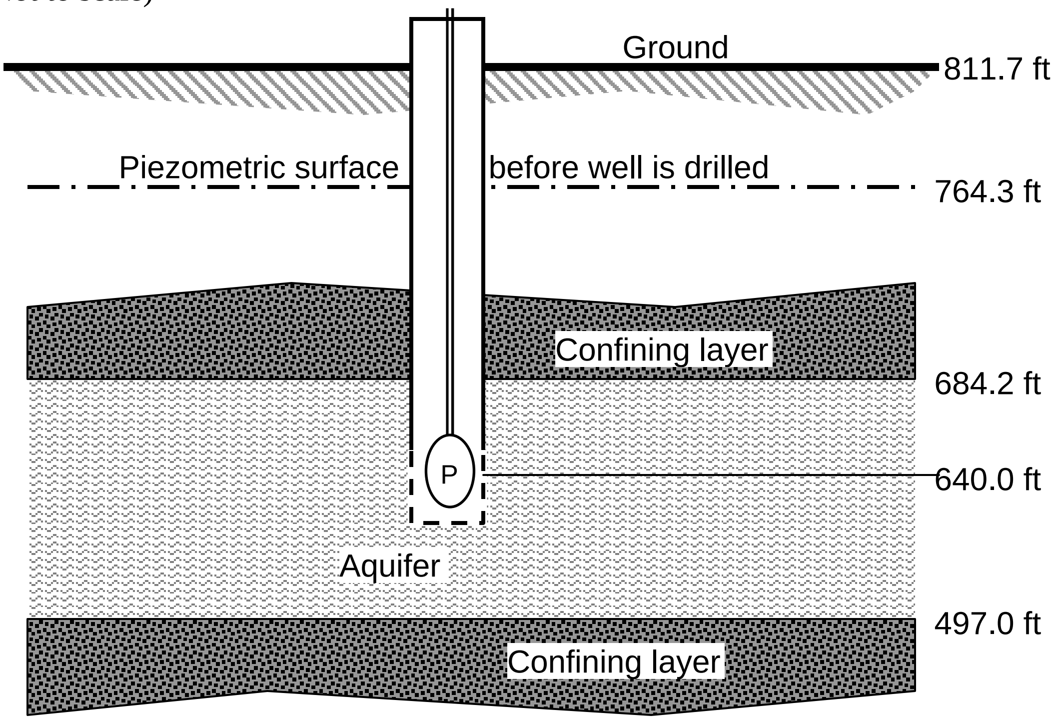
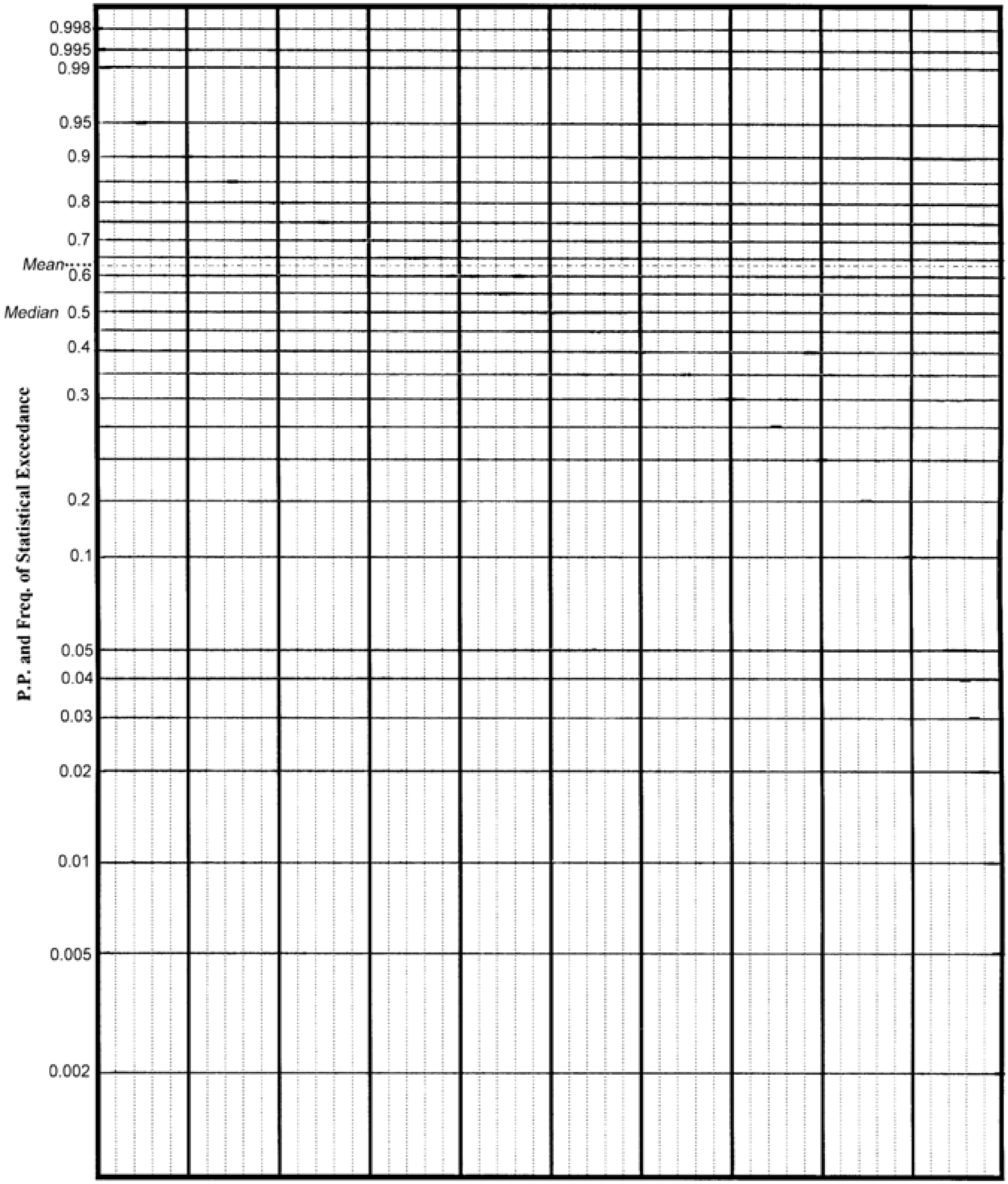

Ground
811.7 ft
Piezometric surface
before well is drilled
764.3 ft
Confining layer
684.2 ft
P
640.0 ft
Aquifer
497.0 ft
Confining layer

2. A water supply intake on a stream is to be built for a low flow magnitude of 5Q25. Given below are annual minima of 5-day averaged flows for several years. Using the Weibull probability paper on the next page, *determine the 5Q25 streamflow magnitude*. (15 points)

Year	**Minimum 5-day Averaged Flow (cfs)**
1971	460
1972	285
1973	340
1974	220
1975	235
1976	160
1977	125

Weibull Probability Paper



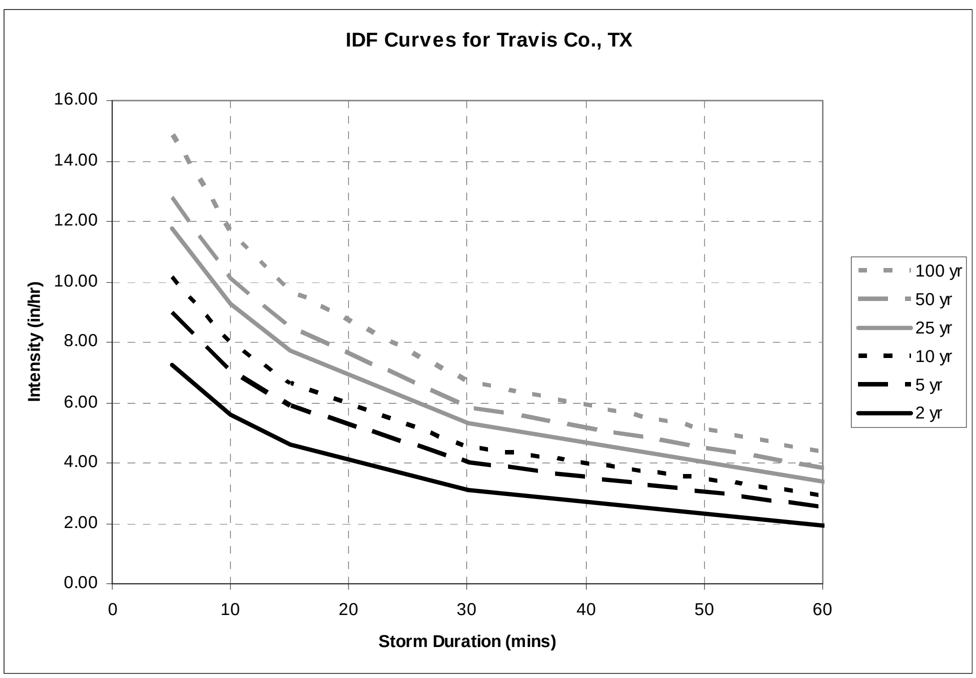
3. Given below are the IDF curves for Travis County, Texas, and the runoff coefficients included in stormwater design standards for the City of Austin, Texas, which is in Travis County. For a 100,000 ft^2 park with 90% grass coverage, average land slope of 1.5%, and time of concentration 12 minutes, *use the rational method to calculate the peak runoff rates from the park for the 5, 25, and 100 year storms.* (10 points)

TABLE 15.1.1
Runoff coefficients for use in the rational method

Character of surface	Return Period (years)						
	2	5	10	25	50	100	500
Developed							
Asphaltic	0.73	0.77	0.81	0.86	0.90	0.95	1.00
Concrete/roof	0.75	0.80	0.83	0.88	0.92	0.97	1.00
Grass areas (lawns, parks, etc.)							
Poor condition (grass cover less than 50% of the area)							
Flat, 0–2%	0.32	0.34	0.37	0.40	0.44	0.47	0.58
Average, 2–7%	0.37	0.40	0.43	0.46	0.49	0.53	0.61
Steep, over 7%	0.40	0.43	0.45	0.49	0.52	0.55	0.62
Fair condition (grass cover on 50% to 75% of the area)							
Flat, 0–2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2–7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Good condition (grass cover larger than 75% of the area)							
Flat, 0–2%	0.21	0.23	0.25	0.29	0.32	0.36	0.49
Average, 2–7%	0.29	0.32	0.35	0.39	0.42	0.46	0.56
Steep, over 7%	0.34	0.37	0.40	0.44	0.47	0.51	0.58
Undeveloped							
Cultivated Land							
Flat, 0–2%	0.31	0.34	0.36	0.40	0.43	0.47	0.57
Average, 2–7%	0.35	0.38	0.41	0.44	0.48	0.51	0.60
Steep, over 7%	0.39	0.42	0.44	0.48	0.51	0.54	0.61
Pasture/Range							
Flat, 0–2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2–7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Forest/Woodlands							
Flat, 0–2%	0.22	0.25	0.28	0.31	0.35	0.39	0.48
Average, 2–7%	0.31	0.34	0.36	0.40	0.43	0.47	0.56
Steep, over 7%	0.35	0.39	0.41	0.45	0.48	0.52	0.58

Note: The values in the table are the standards used by the City of Austin, Texas. Used with permission.

(From Chow, et al. 1988)



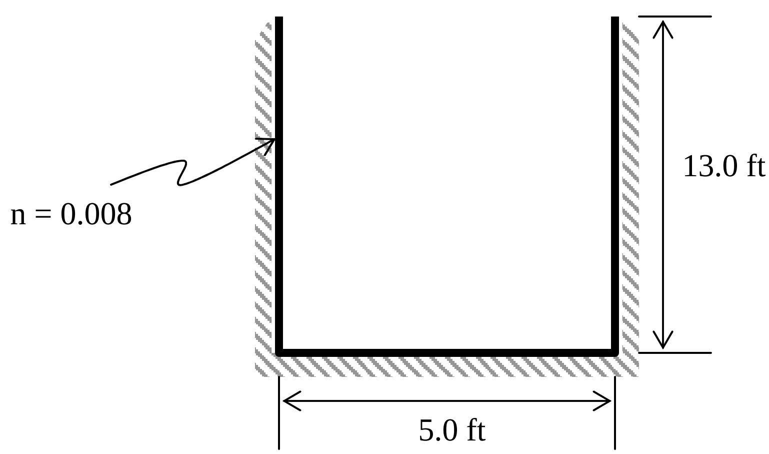
4. The town of Caldwell, Texas, has decided that it wants to become “New Braunfels near the Brazos” and build a tourist-attracting waterpark that cheesily exploits its local ethnic origins. “Kolachebahn” is currently in the design phase and promises thrills, spills, and overpriced concessions. The park’s premier attraction is the “Open Channel of Utter Devastation and Existential Horror” (sponsored by Slovacek Sausage). It will carry riders in inner tubes down near-fatal plunges and slam them into migraine-inducing walls of water. It was being designed by a glamorous young Water Resources Engineering professor at Texas A&M who recently passed away in a tragic exam-grading accident before he could finish the design. You, being his favorite and most promising student, have been brought in to finish the job.

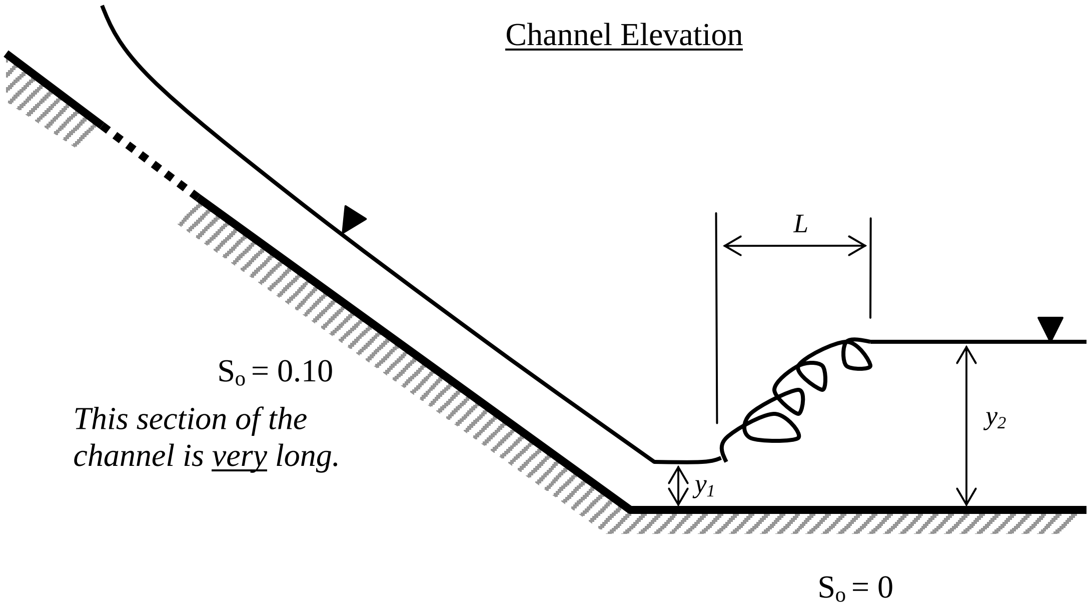
The ride’s centerpiece is a massive hydraulic jump called “Munch’s Scream” intended to swamp, flip, and launch riders. Drawings for this section of the channel are shown on this and the next page. The American Institute of Extreme and Extraneous Enterprises (AIEEE) has published a Thrill Scale for hydraulic jumps based upon the ratio of the change in depth across the jump to the jump’s length, $(y_2 - y_1)/L$. This scale is given below.

The design flowrate in the channel is 350.0 cfs. *(i) What will be the Thrill Score for the hydraulic jump? (ii) Name one design change that could increase the Thrill Score and provide mathematical justification for this answer.* (40 points)

$(y_2 - y_1)/L$	**AIEEE Thrill Score**
< 0.130	Cool.
0.131 – 0.136	OK. All right. OK.
0.137 – 0.143	Sweet.
0.144 – 0.155	Righteous!
0.156 – 0.167	Dude, where’s my glass eye?
0.168 – 0.180	Uh, that is definitely going to leave a mark.
> 0.181	Hey, watch while I do this…

Channel Cross-section




Channel Elevation
L
$S_o = 0.10$
This section of the channel is very long.
y_1
y_2
$S_o = 0$

Name: ____

CVEN 339 – Water Resources Engineering
Fall Semester 2004 – Section 502
Dr. Kelly Brumbelow, Texas A&M University

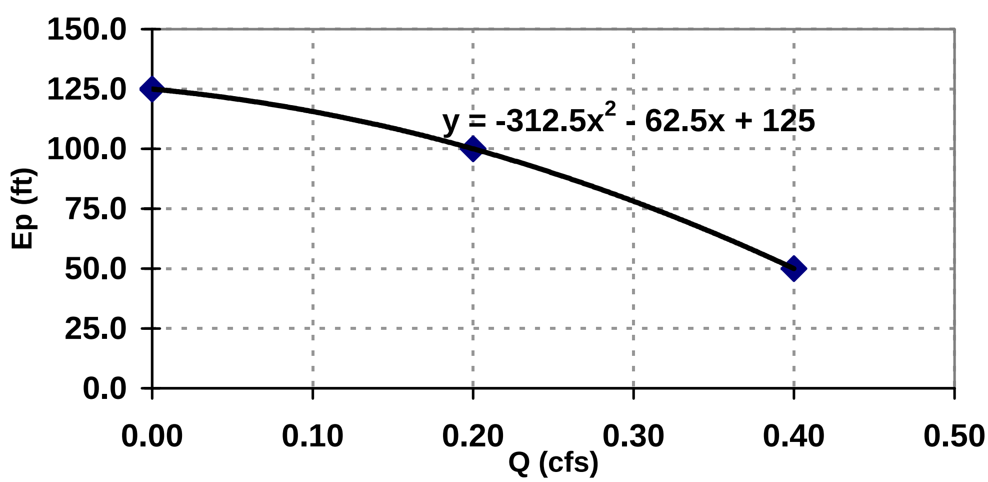
Final Exam

Open-book, Open-notes (8 pages, 4 questions)

1. A confined aquifer (see diagram on next page) has an undisturbed piezometric surface elevation of 849.3 ft above mean sea level (msl). A well is drilled into the aquifer from a point where ground elevation is 952.7 ft msl. Along the axis of the well the boundary between the aquifer and the upper confining layer is at elevation 694.1 ft msl, and the boundary between the aquifer and the lower confining layer is 324.1 ft msl. Saturated hydraulic conductivity for the aquifer is 13.3 ft/day, and the aquifer storage coefficient is 0.0005. The well casing diameter is 30 inches.

A submersible well pump is installed in the well at an elevation of 630.0 ft msl. The manufacturer supplied pump characteristic curve is shown below. The well pump is connected to the surface by a 4 inch diameter galvanized iron pipe.

As the well begins operation, the aquifer is in an unsteady condition while drawdown develops. During this period, well flowrate changes as drawdown increases, but the flowrate and drawdown are mutually dependent throughout the process. Thus, they must be solved simultaneously for any given time. In this problem, you should assume that at any instant in time, the pump-pipeline equation and the unsteady drawdown equation (Theis equation) can be solved simultaneously. Minor losses in the well pipe are negligible. You may assume the well's radius of influence to be 5,000 ft. *At times after start of well pumping 0, 15, and 900 days, what will be: (i) the drawdown of the piezometric surface at the well, and (ii) the flowrate leaving the well pipe at the ground surface?* (40 points)



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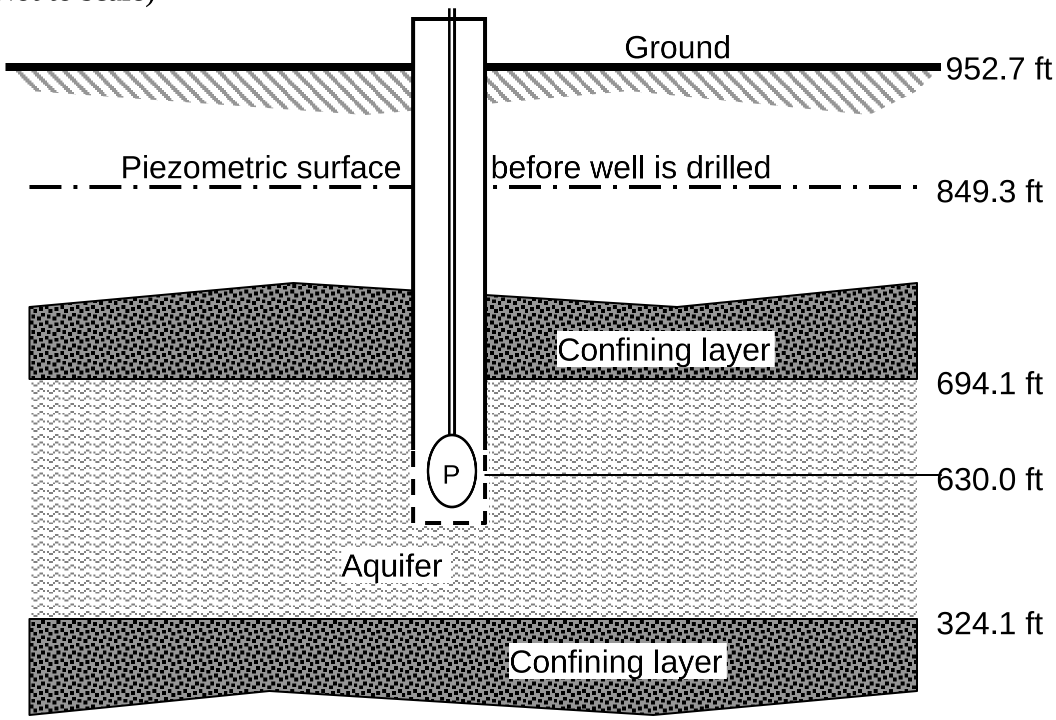
Ground
952.7 ft
Piezometric surface before well is drilled
849.3 ft
Confining layer
694.1 ft
P
630.0 ft
Aquifer
324.1 ft
Confining layer

2. As part of a large flood control project a stream will be channelized into a constructed trapezoidal channel. The channel bottom width will be 40.0 ft; sideslopes will be 2.5; longitudinal slope will be 0.0045; and the channel will be lined with smooth-finished concrete. Frequency analysis for the runoff entering the channel has been performed with the results shown in the table below. A roadway bridge is to be constructed across the channel, and there is a question of what design standard should be used for flow passage under the bridge. If the estimated cost of the bridge is $27,000 per foot of bridge span length, *what will be the estimated costs for design for the 50 year return period?* (25 points)

F(Q)	Q (cfs)
0.01	594
0.02	859
0.04	1,254
0.05	1,421
0.10	2,127
0.15	2,733
0.20	3,298
0.25	3,845
0.30	4,389
0.35	4,940
0.40	5,506
0.45	6,094
0.50	6,713
0.55	7,374
0.60	8,089
0.65	8,875
0.70	9,757
0.75	10,771
0.80	11,977
0.85	13,490
0.90	15,559
0.95	18,975
0.96	20,051
0.97	21,424
0.98	23,336
0.99	26,553

3. Given below are the IDF curves for Travis County, Texas, and the runoff coefficients included in stormwater design standards for the City of Austin, Texas, which is in Travis County. A 60,000 ft^2 asphalt parking lot and a 125,000 ft^2 asphalt parking lot are adjacent to one another and function as separate watersheds but drain to a common outlet point. Because of slope differences both basins have time of concentration equal to 9 minutes. *Use the rational method to calculate the peak runoff rate at the common outlet point for the 50 year storm.* (10 points)

TABLE 15.1.1
Runoff coefficients for use in the rational method

Character of surface	Return Period (years) 2	5	10	25	50	100	500
Developed							
Asphaltic	0.73	0.77	0.81	0.86	0.90	0.95	1.00
Concrete/roof	0.75	0.80	0.83	0.88	0.92	0.97	1.00
Grass areas (lawns, parks, etc.)							
Poor condition (grass cover less than 50% of the area)							
Flat, 0–2%	0.32	0.34	0.37	0.40	0.44	0.47	0.58
Average, 2–7%	0.37	0.40	0.43	0.46	0.49	0.53	0.61
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Fair condition (grass cover on 50% to 75% of the area)							
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Average, 2–7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
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Pasture/Range							
Flat, 0–2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2–7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Forest/Woodlands							
Flat, 0–2%	0.22	0.25	0.28	0.31	0.35	0.39	0.48
Average, 2–7%	0.31	0.34	0.36	0.40	0.43	0.47	0.56
Steep, over 7%	0.35	0.39	0.41	0.45	0.48	0.52	0.58

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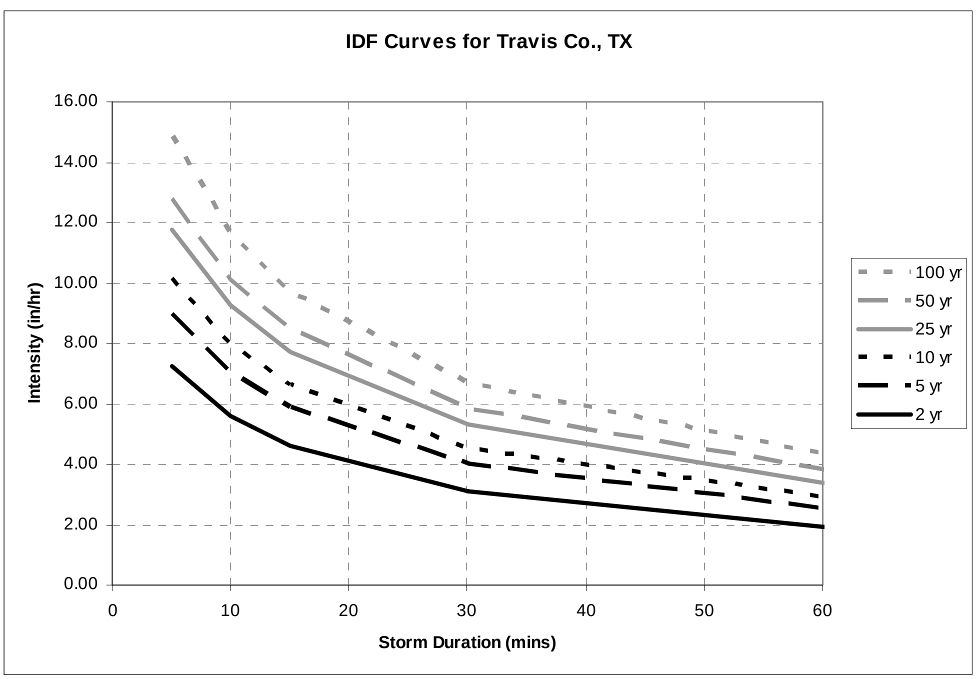


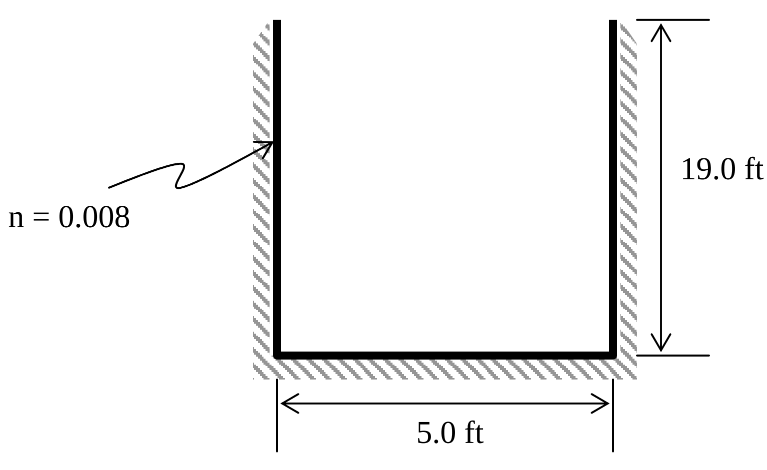
4. The town of Caldwell, Texas, has decided that it wants to become "New Braunfels near the Brazos" and build a tourist-attracting waterpark that cheesily exploits its local ethnic origins. "Kolachebahn" is currently in the design phase and promises thrills, spills, and overpriced concessions. The park's premier attraction is the "Open Channel of Utter Devastation and Existential Horror" (sponsored by Slovacek Sausage). It will carry riders in inner tubes down near-fatal plunges and slam them into migraine-inducing walls of water. It was being designed by a glamorous young Water Resources Engineering professor at Texas A&M who recently passed away in a tragic exam-grading accident before he could finish the design. You, being his favorite and most promising student, have been brought in to finish the job.

The ride's centerpiece is a massive hydraulic jump called "Munch's Scream" intended to swamp, flip, and launch riders. Drawings for this section of the channel are shown on this and the next page. The American Institute of Extreme and Extraneous Enterprises (AIEEE) has published a Thrill Scale for hydraulic jumps based upon the deceleration across the jump, $V_2 - V_1$. This scale is given below.

The design flowrate in the channel is 350.0 cfs. *What will be the Thrill Score for the hydraulic jump?* (25 points)

$V_2 - V_1$ (miles/hr)	**AIEEE Thrill Score**
> -7.0	Cool.
-7.1 to -15.0	OK. All right. OK.
-15.1 to -24.0	Sweet.
-24.1 to -35.0	Righteous!
-35.1 to -43.0	Dude, where's my glass eye?
-43.1 to -50.0	Uh, that is definitely going to leave a mark.
< -50.1	Hey, watch while I do this…

<u>Channel Cross-section</u>



Channel Elevation