**CE 3372 Water Systems Design Exam 1**
**Fall 2017**

Instructions:

1. Write your name on each sheet.
2. Read the entire exam before you begin – use this initial scan to determine how to allocate your time on the exam.
3. Answer each problem – if the problem is multiple choice **circle** the answer you think is correct.
4. For questions that ask you to identify items on a graphic, make your markings obvious and distinctive. Use labels as necessary to guide the reader to your answer.
5. For questions that require analysis and calculations, show your work for full credit – an answer alone, whether or not correct is insufficient demonstration of ability to solve the problem.
6. If you need to make an assumption, clearly state the assumption to receive partial credit.
7. If you do work on additional sheets, hand in those sheets with this exam, and put your name on each additional sheet.
8. If you delete an answer, clearly circle the entire deleted portion, then draw a diagonal line through the deleted portion, and write the word **delete** next to the diagonal line.

Useful Equations and Material Properties:

| | | |
|---|---|---|
| Hazen-Williams (SI) | $Q = 0.849\ A\ C_h\ R^{0.63}\ S^{0.54}$ | (1) |
| Reynolds number | $Re = \frac{VD}{\nu}$ | (2) |
| Friction factor (Jain) | $f = \frac{0.25}{[log(\frac{k_s}{3.7D}+\frac{5.74}{Re^{0.9}})]^2}$ | (3) |
| Darcy-Weisbach Loss Model | $h_{loss} = f\frac{L}{D}\frac{V^2}{2g} = \frac{8fLQ^2}{\pi^2 gD^5}$ | (4) |
| Discharge (Jain) | $Q = -2.22D^{5/2} \times \sqrt{gh_f/L} \times [log_{10}(\frac{k_s}{3.7D} + \frac{1.78\nu}{D^{3/2}\sqrt{gh_f/L}})]$ | (5) |
| NPSH Available | $NPSH_A = H_{abs.} + H_s - H_f - H_{vp}$ | (6) |
| Vapor Pressure $(H_2O)$@25C | $3.170\ kPa$ | (7) |
| $\text{P}_{abs.}$@1000 meters | $87.586\ kPa$ | (8) |
| Sp. Weight $(H_2O)$@25C | $9781\ N/m^3$ | (9) |

1. “Application of water on lands to assist in growing of crops and pasture; maintain vegetative growth in recreational lands; maintain vegetative growth in ornamental displays” describes which use category below?
   a) Commercial Use
   b) Domestic Use
   c) Navigation (Inland) Use
   d) Irrigation Use
   e) Industrial Use
2. “Water for fabrication, processing, washing, and cooling in the production of manufactured items” describes which use category below?
   a) Commercial Use
   b) Domestic Use
   c) Navigation (Inland) Use
   d) Irrigation Use
   e) Industrial Use
3. “Water used as part of navigational systems to provide sufficient pool elevations for commercial waterborne cargo shipment” describes which use category below?
   a) Commercial Use
   b) Domestic Use
   c) Navigation (Inland) Use
   d) Irrigation Use
   e) Industrial Use
4. The Los Angeles aqueduct system is best described as which kind of system?
   (a) Water use system
   (b) Water control system
   (c) Environmental restoration system
   (d) Strategic withdrawl system

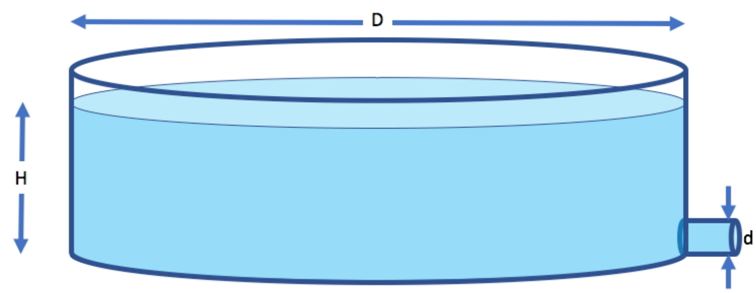


Figure 1: Circular Tank

5. Figure 1 is a circular (plan view) detention pond. The tank diameter, $D$, is 30 meters. The outlet diameter, $d$, is 127 millimeters. The initial depth in the pond is 2 meters. Assume the discharge velocity is $V(t) = \sqrt{2gH(t)}$

   (I) What is the outflow rate in Liters-per-second, if there is a supply of water that maintains the tank depth at 2 meters?

   (II) What is the time, in hours, for the tank to drain if there is no external supply and the discharge coefficient is unity ($c_d = 1$)?

6. The questions below page refer to Figure 2 on the following page .

   (I) Is the design flow in the drawing from left-to-right, or right-to-left?

   (II) What object is depicted at station STA 54+05.00 in the plan view portion of the drawing?

   (III) The elevation view drawing depicts a drop at a junction box. What is the bottom elevation of the junction box indicated on the drawing?

   (IV) What is the diameter of the conduits indicated on the drawing?

   (V) What is the slope (in percent) of the storm sewer conduits?

   (VI) Relative to the drop structure, what is the flow-line (invert) elevation of the left-most sewer pipe?

   (VII) Relative to the drop structure, what is the flow-line (invert) elevation of the right-most sewer pipe?

   (VIII) Relative to the drop, structure what is the soffit (crown) elevation of the left-most sewer pipe?

   (IX) Relative to the drop structure, what is the soffit (crown) elevation of the right-most sewer pipe?

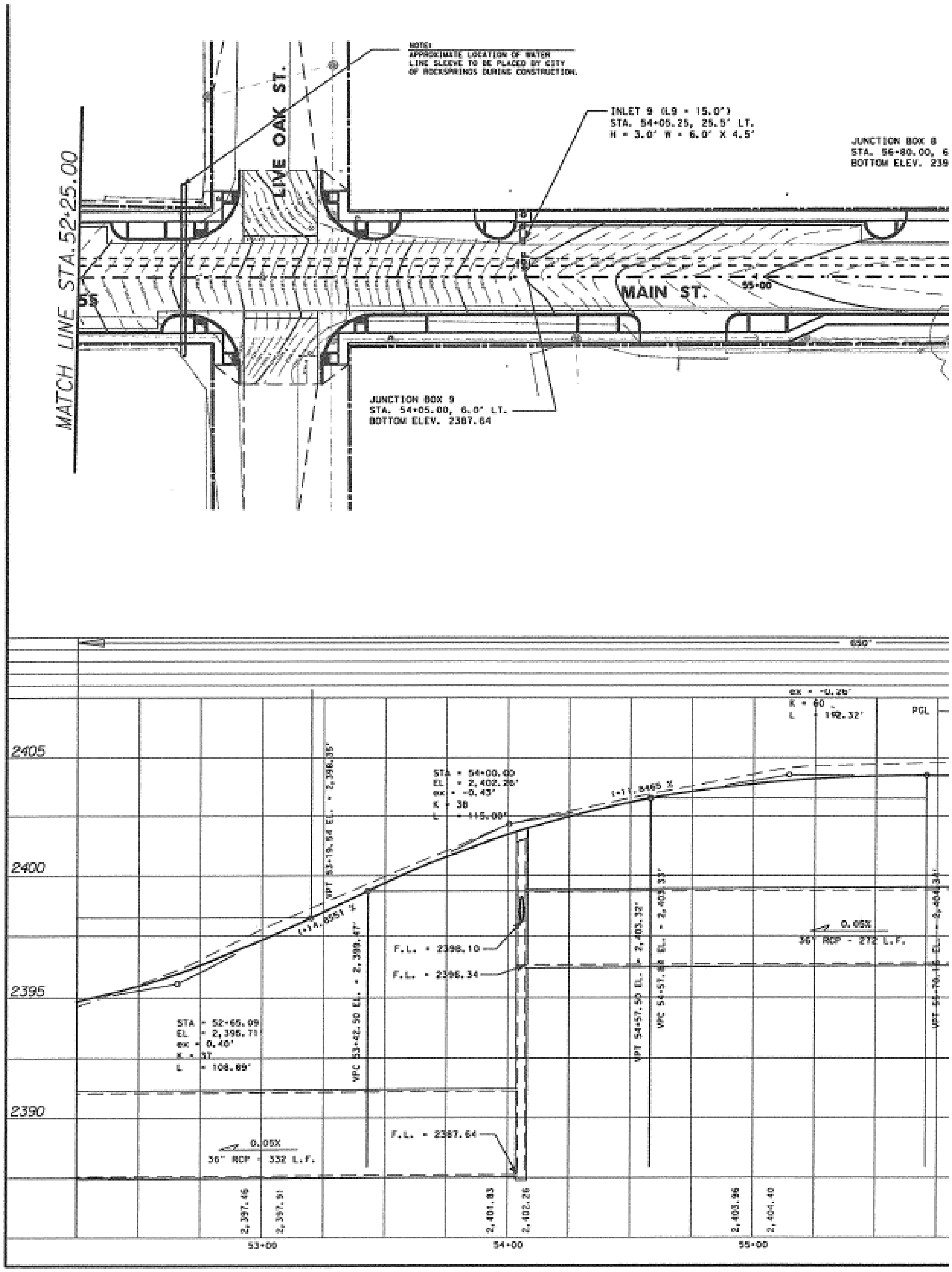

Figure 2: Plan and profile of a storm sewer system

7. Figure 3 is an aerial image of a pipeline system with preliminary engineering sketches of the system (lower left panel) and a detail sketch of the terminal small storage tank (upper right panel). The 3,200 meter long pipeline lifts 25C water ($\rho = 997\ kg/m^3$, $\nu = 8.94 \times 10^{-7}\ m^2/s$) from a treatment plant on the downstream face of Gulameta Dam through a 127 millimeter high-density polyethylene (HDPE) pipe ($k_s = 0.0015\ mm$) to a large diameter at-grade cylindrical storage tank. A secondary, 800 meter long pipeline carries water from the large diameter storage tank to a small, cylindrical ($D = 1\ meter$), elevated storage tank at the village school. Both storage tanks have float valves to prevent overflow and maintain the indicated water pool elevations.

   (I) What is the pool elevation, in meters, of the supply reservoir (Lake Gulameta)?

      a) 965 meters

      b) 975 meters

      c) 3165.2 feet

      d) 3198 feet

   (II) What is the pump centerline elevation, in meters, that supplies water to the HDPE pipeline?

      a) 965 meters

      b) 975 meters

      c) 3165.2 feet

      d) 3198 feet

   (III) What is the length of HDPE pipeline, in meters, from the pump station to the large diameter storage tank?

      a) 800 meters

      b) 3200 meters

      c) 2624 feet

      d) 10,496 feet

   (IV) What is the pool elevation, in meters, in the large diameter storage tank, assuming the float valve is correctly operating?

      a) 1000.3 meters

      b) 1000.6 meters

      c) 1003.6 meters

      d) 1006.3 meters

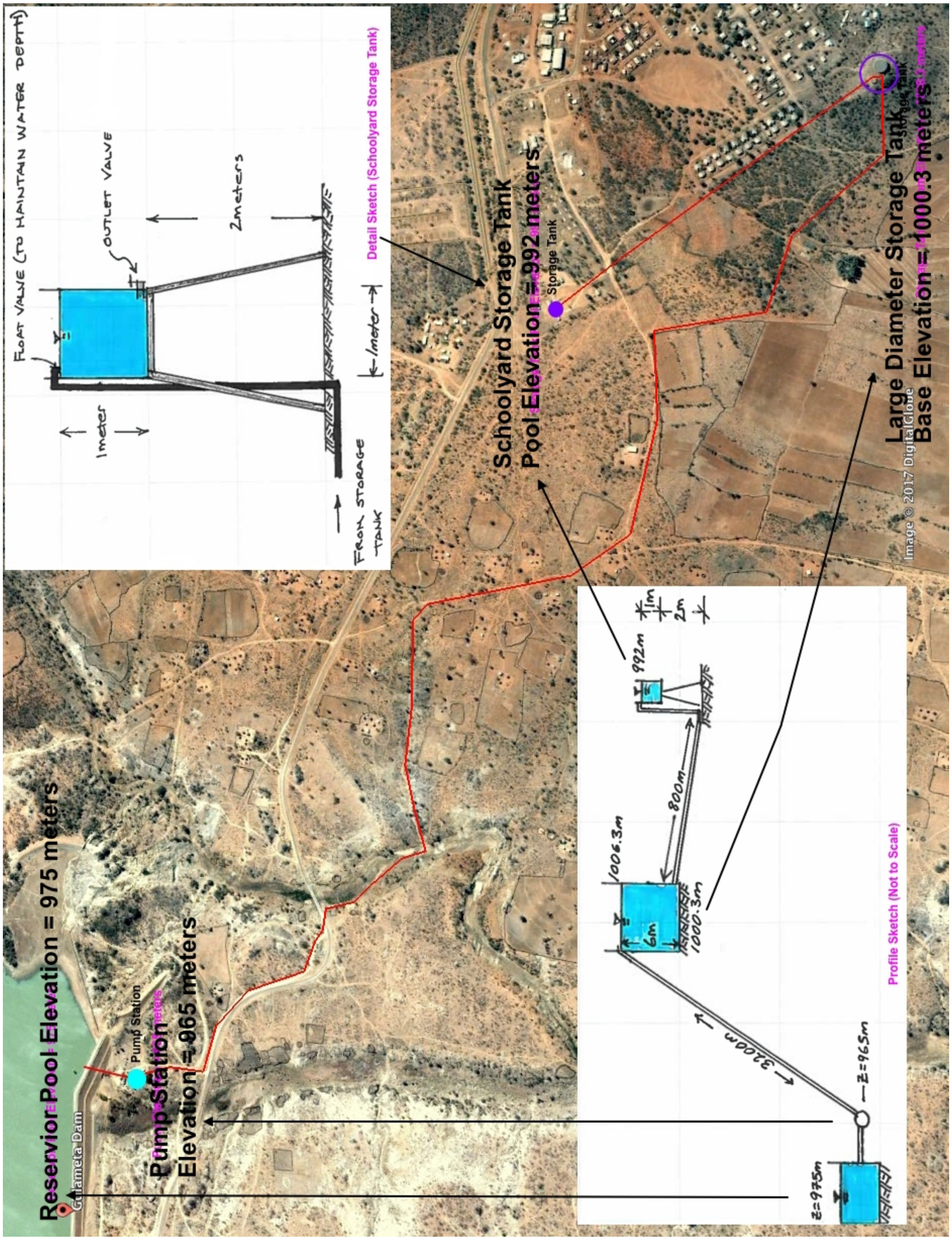


Figure 3: Water Supply System in Re-Developing Nation

(V) What is the length of HDPE pipeline, in meters, from the large diameter storage tank to the schoolyard storage tank?

a) 800 meters

b) 3200 meters

c) 2624 feet

d) 10,496 feet

(VI) What is the pool elevation, in meters, in the schoolyard storage tank, assuming the float valve is correctly operating?

a) 989 meters

b) 990 meters

c) 991 meters

d) 992 meters

(VII) What is the ground surface elevation, in meters, at the schoolyard storage tank?

a) 989 meters

b) 990 meters

c) 991 meters

d) 992 meters

(VIII) Write the Modified Bernoulli (Energy) Equation for the portion of the system from the water supply reservoir (Lake Gulameta) to the large diameter storage tank.

(IX) Write the Modified Bernoulli (Energy) Equation for the portion of the system from the large diameter storage tank to the schoolyard storage tank.

(X) Assume the float valve at the schoolyard fails in the open position, and the schoolyard tank overflows. Using the Modified Bernoulli (Energy) Equation for the portion of the system from the large diameter storage tank to the schoolyard storage tank, and neglecting minor loss terms (but not the pipeline loss), determine the flow rate in the system in Liters-per-second.

(XI) Using the flow rate just computed, and the Modified Bernoulli (Energy) Equation for the portion of the system from from the water supply reservoir (Lake Gulameta) to the large diameter storage tank, and neglecting minor loss terms (but not the pipeline loss), determine the required pump head (added head).

(XII) Assume the float valve at the schoolyard is operating normally, but someone accidentally leaves the outlet valve (nominal diameter = 75 mm) from the tank open. Estimate the required flow rate in the system in Liters-per-second to sustain the indicated pool elevations.

(XIII) Figure 4 is a set of pump curves for a pump at different impeller speeds. Circle the portion of the graphic that contains information about the Net Positive Suction Head (NPSH) required by the pump.

(XIV) Assuming the schoolyard overflow condition is the most flow the pump will have to deliver, select a pump speed from one of the five on Figure 4 below. Indicate which curve you selected, show the operating point. Indicate if you need two pumps in series to supply the necessary head.

(XV) Estimate the NPSH required for the pump at your operating point.

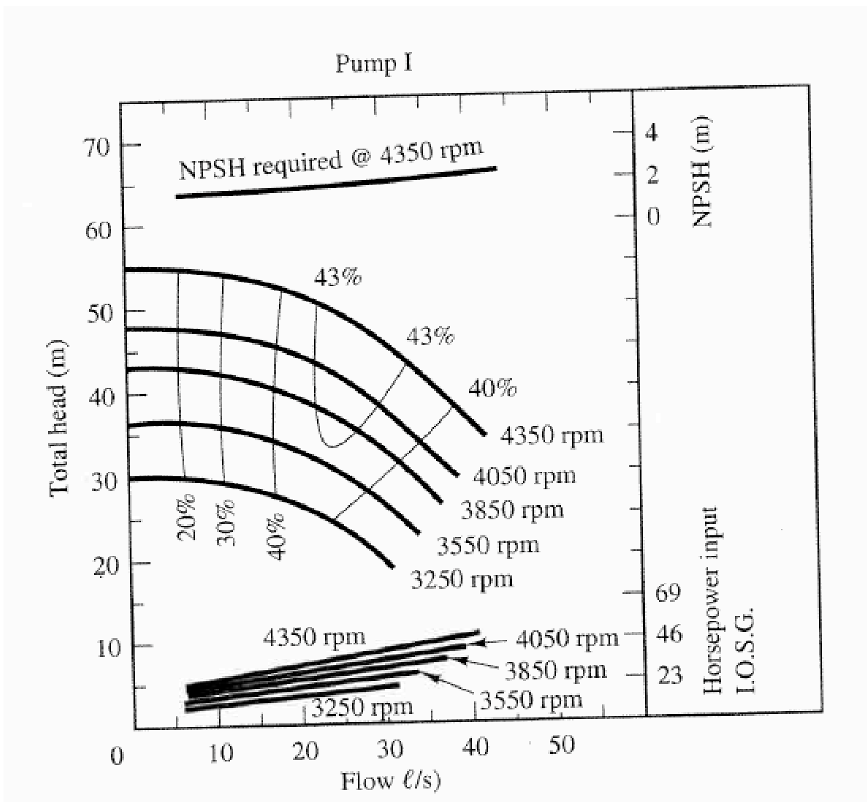


Figure 4: Pump curves for 5 different impeller speeds.

(XVI) Estimate the NPSH available for the system, you can neglect inlet piping and minor losses. Assume the water is at 25 degrees Celsius.

(XVII) Is there sufficient NPSH available for the system to function at the design flow rate without cavitation?

8. Figure 5 is a pipe network with the following properties:

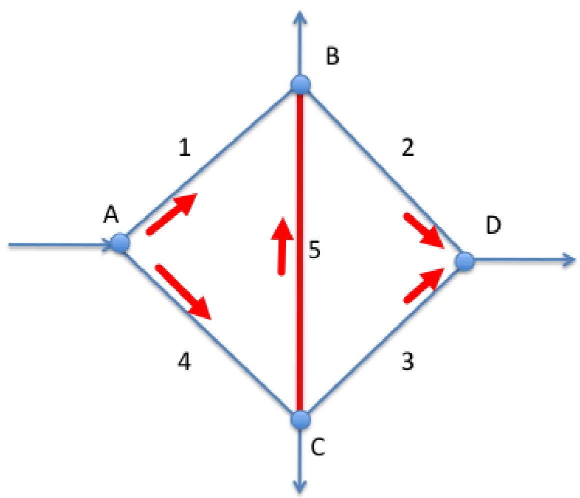


Figure 5: Pipe network

Table 1: Network properties for Figure 5

| Node | Demand (lps) | Elevation(m) |
|---|---|---|
| A | -0.60 | 0.00 |
| B | 0.15 | 0.00 |
| C | 0.15 | 0.00 |
| D | 0.30 | 0.00 |
| **Pipe** | **Length (m)** | **Diameter (mm)** |
| 1 | 10,000 | 77.0 |
| 2 | 10,000 | 77.0 |
| 3 | 10,000 | 77.0 |
| 4 | 10,000 | 77.0 |
| 5 | 14,000 | 77.0 |

Referring to Figure 5, and Table 1 the flow distribution is:

(A) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,-0.15,-0.15,0.30,-0.60] LPS

(B) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.30,0.30] LPS

(C) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.00,0.50] LPS

(D) $[Q_1,\ Q_2,\ Q_3,\ Q_4,\ Q_5\ ]$ =[0.30,0.15,0.15,0.30,0.00] LPS