1. Work text problems 13.4 and 13.7.

2. At the Farm Lane / Mt. Hope location, your plan for landscaping the apartment complex calls for landscaping as shown on the attached map. For the trees, in areas A and B, develop a scale drawing showing the plantings, irrigation release points (emitter locations) and waterlines connecting the emitters to the water supply (city water, pressure =65 psi, at the apartment building). For areas A and B, complete and hand-in the appropriate Atm Excel sheets, answer the following questions and provide a sketch showing emitters, pipe lengths, and diameters.

   a) What species of do you recommend be planted?
   b) What make and model emitter do you recommend be used?
   c) What is the run time for each irrigation?
   d) Assuming rain does not occur between irrigations and you begin irrigating when the available water has been reduced by 50%, how many days can you wait between irrigation during the time period the trees are using water at peak ET rates?
   e) What is the total water volume the trees require for the growing season, in gallons?
   f) If, during a dry year, rainfall is 50% of average rainfall, how much water in gallons will need to be provided by your micro-irrigation system?
   g) If you use Hardie 16-mm PE pipe between emitters, and PVC pipe elsewhere, determine pipe diameters needed to supply water to the system.

3. Use Atm_pump xls to size main, and manifold waterlines to the Mt. Hope office complex to irrigate turfgrass in Area C. For Area C the water supply is the top 3-ft of water from the pond. Area C will be irrigated by Toro Super 700 Series heads in a square pattern at a rate of 0.30 inches per hour using 25-degree standard angle heads.

   a) Determine the appropriate spacing for the sprinkler heads.
   b) Show on the drawing the main, manifolds, lateral lines and sprinkler heads
   c) Sketch the main and manifold lines showing design pressure, flow rate, pipe sizes and
   d) Determine the pipe diameters needed for lateral line with the maximum run of sprinkler heads.
   e) Hand in printouts of your final Atm_irrigation and Atm_pump sheets used to arrive at your answers. Make notations on the sheets so that the instructor can easily follow what the sheets pertain to and how you used the results.
   f) Determine the size motor (hp) needed to provide the irrigation water for area C.
   g) Show that the office complex pond is or is not large enough to provide the irrigation water needed for Area C for a growing season. Note: for this analysis, neglect evaporation from the surface of the pond and assume a dry year which provides monthly rainfall volumes equal to 50% of the average rain for each month.

Note: For problems 2 and 3 above, assume the area has been leveled except within the pond area.
Problem 13.4

TDH: \( \text{max.} \Delta \text{Elev} + \text{headloss} + \text{operating pressure} \)

\[ \text{max.} \Delta \text{Elev} = 8 + 15 = 23 \text{ ft} \]

operating pressure = 45 psi = \((45 \times 0.147) = 10.40 \text{ ft} \)

headloss:

\[
\text{flowmeter, 500} \text{ gal/100 ft} \times \text{ 14.9 gpm} \\
= 4.47 \text{ psi/100 ft} \times \text{ Appendix C3} \\
= 4.47 \times 500 \times 0.01 = 51.4 \text{ ft} \\
\]

\[
\text{gate valve, 0.6 steel pipe, length } \text{ Table 9.3} \\
= 0.6 \times 2.31 = 1.32 \text{ PVC pipe length} \\
= 4.47 \times 1.32 \times 0.01 = 0.1 \text{ ft} \\
\]

\[
\text{in line screen (30 mesh), 1.7 psi, Table 9.6} \\
= 1.7 \times 2.31 = 3.9 \text{ ft} \\
\]

Total headloss = 51.4 + 0.1 + 3.9 = 55.4 ft

TDH = 23 + 28.9 + 10 + 0 = 185.1 ft of water

Problem 13.7

Lift = BP - VP - PL - NPSH

\[
\text{max NPSH} = \text{BP} - \text{VP} - \text{PL} - \text{Lift} \\
\]

1 lb/ft\(^2\) VP = 14.0 ft

for maximum NPSH, PL = 0 ft

@ sea level, BP = 33.9 ft

Lift = 10 ft

\[
\text{max NPSH} : 33.9 - 10 - 0 - 10 = 22.9 \text{ ft} \\
\]
Problem 2-1

- **Recommended Species:** Colorado Blue Spruce
- **Recommended Emitter:** Rainbird XR-20
- **Run Time:** 220 hours/irrigation
- **IRR Interval:** 3.0 days

**c) Total Volume of Water Req’d**

0.33 gpm/plant \times 13 plants \times 22 hrs \times 60 \text{ min/hr} = 5662.8 \text{ gallon/irrigation}

Assume growing season is 90 days

\text{no. of irrigations} = \frac{90}{3} = 30

\text{total water required} = \frac{5662.8 \text{ gallon/irrigation} \times 30 \text{ irrigations}}{12 \text{ months}} = 169,884 \text{ gallons}

Assuming maximum ET for full 90 days

**Alternate Calculation**

From tables, Table 1

Total Season H2O Use = 25 inches (curing rains)

Area Irrigated = 1068.1 \text{ ft}^2/\text{plant}

\text{Total Volume of Water} = 1068.1 \text{ ft}^2/\text{plant} \times 13 \text{ plants} \times 25 \text{ inches} \times \frac{1 \text{ in.}}{12 \text{ in.}} = 28,928 \text{ ft}^3 \times 7.48 \text{ gal/ft}^3 = 216,381 \text{ gallons}

\text{1) dry year rain (Ref: Climate of Michigan)}

<table>
<thead>
<tr>
<th>Month</th>
<th>Avg. Rain</th>
<th>50% Avg. Rain</th>
</tr>
</thead>
<tbody>
<tr>
<td>June</td>
<td>2.1&quot;</td>
<td>4.1&quot;</td>
</tr>
<tr>
<td>July</td>
<td>1.4&quot;</td>
<td>0.7&quot;</td>
</tr>
<tr>
<td>Aug</td>
<td>1.2&quot;</td>
<td>0.6&quot;</td>
</tr>
</tbody>
</table>

\text{Sum} = 24"  

\text{Dry Year Water Needed} = 216,381 \text{ gal} - \left( \frac{24}{12} \times 1068.1 \times 13 \times 25 \text{ in.} \right) = 212,000 \text{ gal}
# MICRO IRRIGATION SYSTEM ANALYSIS

### BASIC DATA
- base plant: trees
- predominate soil type: P
- type of micro-irrigation (P or L): P
- peak consumptive use or ET (in/day): 0.2
- canopy diameter, feet: 40
- canopy width, feet: XXXXXXXXXXX
- plant spacing, feet: XXXXXXXXXXX
- wetted area reduction ratio: 0.85
- wetted area, ft²: 1088.1
- irrigation efficiency: 0.9
- plant water usage, gal/day: 148.0
- emitter flow rate (0.5, 1.0 or 2.0 gph): 2.00
- effective root depth, inches: 36
- calculated number of emitters per plant: 3.08
- planned number of emitters per plant: 10
- allowed % depletion after irrigation: 50

### AVAILABLE WATER CAPACITY

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness, in</th>
<th>AW, in/in</th>
<th>AWC, in</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9</td>
<td>0.10</td>
<td>1.7</td>
</tr>
<tr>
<td>2</td>
<td>23</td>
<td>0.16</td>
<td>3.7</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0.15</td>
<td>0.8</td>
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<tr>
<td>4</td>
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<td></td>
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<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>33</td>
<td></td>
<td>6.0</td>
</tr>
</tbody>
</table>

- Irrigation interval, days: 15.0
- volume to apply, inches per irrigation interval: 3.33
- volume to apply, gal per irrigation interval: 2215.7
- irrigation run time per irrigation interval, hours: 110.8
- planned irrigation run time per application, hours: 22.0
- required applications per irrigation interval: 5
- application rate per plant, inch/hour: 0.03
- application rate per plant, gpm: 0.33
- application rate per plant, gph: 20

### SUMMARY
- emitter brand, series, model: Rainbird X
- base plant: trees
- emitters per plant: 10
- emitter flow rate, gph: 2
- irrigation run time, hours: 22.0
- irrigation interval, days: 3.0
### Irrigation Waterline and Pump Station Evaluation

**Instructions:**

This spreadsheet assumes that the pipe is at the water supply source and the pump is at the water outlet. Enter pump efficiency and motor efficiency. Results are in the table, the pipeline data starting at water source and continuing to outlet.

<table>
<thead>
<tr>
<th>Pressure Reqd at Source (psi)</th>
<th>21.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Pipe Pressure (psi)</td>
<td>21.6</td>
</tr>
<tr>
<td>HP Required (hp)</td>
<td>3.1</td>
</tr>
<tr>
<td>Electric Reqd (kWh)</td>
<td>3.0</td>
</tr>
<tr>
<td>Diesel Fuel Reqd (gallons)</td>
<td>0.0</td>
</tr>
<tr>
<td>Gasoline Reqd (gallons)</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Pipe Sizes Needed (PVC, Schedule 40):**

- 3/4" PVC, Sch. 40
- Hardic, 16 mm

**Diagram:**

- Hardic, 16 mm
- 3/4" PVC, Sch. 40
Problem 3-1

b) AREA C
Sprinkler Head Layout

Yellow Area
Spacing
40.0' x 33.3'

Green Area
Spacing
40.6' x 32.5'

Pond

Scale in Feet
# Rectangular Area Sprinkler Irrigation Head Analysis

**Reference**: Landscape Irrigation Design by E. W. Rochester

<table>
<thead>
<tr>
<th>Area To Be Irrigated:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>length, ft.</td>
<td>400</td>
</tr>
<tr>
<td>width, ft.</td>
<td>100</td>
</tr>
</tbody>
</table>

**Sprinkler Head Specifications (from manufacturer):**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>toro super 700</th>
<th>toro super 700</th>
<th>toro super 700</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td></td>
<td>25 deg</td>
<td></td>
</tr>
<tr>
<td>Nozzle</td>
<td>25 deg</td>
<td>25 deg</td>
<td>25 deg</td>
</tr>
<tr>
<td>Type</td>
<td>4.5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Pattern, degrees</td>
<td>360</td>
<td>180</td>
<td>90</td>
</tr>
<tr>
<td>Flow Rate, gpm</td>
<td>4.23</td>
<td>2.11</td>
<td>1.16</td>
</tr>
<tr>
<td>Pressure, psi</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Throw Radius, ft.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Throw Radius, ft.</td>
<td>37</td>
<td>use minimum</td>
<td></td>
</tr>
</tbody>
</table>

**Sprinkler Head Layout**: 5

**Design Wind Speed, mph**: 0-3

\( k_s \): 0.55

<table>
<thead>
<tr>
<th>Calculated Spacing, ( S_{\text{calc}} )</th>
<th>40.7 feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculated ( L ) for triangular</td>
<td></td>
</tr>
</tbody>
</table>

**Recommended Spacing, length**: 40.0 feet

**Recommended Spacing, width**: 33.3 feet

<table>
<thead>
<tr>
<th>Pattern, degrees</th>
<th>360 degrees</th>
<th>180 degrees</th>
<th>90 degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Sprinkler Heads</td>
<td>18</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>Area Irrigated / Sprinkler Head</td>
<td>1333 ft(^2)</td>
<td>667 ft(^2)</td>
<td>333 ft(^2)</td>
</tr>
<tr>
<td>Precipitation Rate</td>
<td>0.31 inches/hour</td>
<td>0.30 inches/hour</td>
<td>0.34 inches/hour</td>
</tr>
</tbody>
</table>

**Total Irrigated Area, ft\(^2\)**: 40000

**Total Flow to Irrigated Area, gpm**: 127
### RECTANGULAR AREA SPRINKLER IRRIGATION HEAD ANALYSIS

*reference: Landscape Irrigation Design by E. W. Rochester*

**Area To Be Irrigated:**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>length, ft.</td>
<td>325</td>
<td></td>
</tr>
<tr>
<td>width, ft.</td>
<td>130</td>
<td></td>
</tr>
</tbody>
</table>

**Sprinkler Head Specifications (from manufacturer):**

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>toro</th>
<th>toro</th>
<th>toro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Series</td>
<td>super700</td>
<td>super700</td>
<td>super700</td>
</tr>
<tr>
<td>Nozzle</td>
<td>25 deg</td>
<td>25 deg</td>
<td>25 deg</td>
</tr>
<tr>
<td>Type</td>
<td>4.5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Pattern, degrees</td>
<td>360</td>
<td>180</td>
<td>90</td>
</tr>
<tr>
<td>Flow Rate, gpm</td>
<td>4.23</td>
<td>2.11</td>
<td>1.16</td>
</tr>
<tr>
<td>Pressure, psi</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Throw Radius, ft.</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design Throw Radius, ft.</td>
<td>37</td>
<td>use minimum</td>
<td></td>
</tr>
</tbody>
</table>

**Sprinkler Head Layout**

s for square or t for triangular

- 0-3 mph, 4-7 mph, 8-12 mph
- From Table 1, this sheet

**Design Wind Speed, mph**

| k_s         | 0.55 |

**Calculated Spacing, S_{calc}**

| feet       | 40.7 |

**Calculated L for triangular**

| feet       |      |

**Recommended Spacing, length**

| feet       | 40.6 |

**Recommended Spacing, width**

| feet       | 32.5 |

**Pattern, degrees**

| degrees | 360 | 180 | 90 |

**Number of Sprinkler Heads**

| 21 | 20 | 4 |

**Area Irrigated / Sprinkler Head**

| ft^2 | 1320 | 660 | 330 |

**Precipitation Rate**

| inches/hour | 0.31 | 0.31 | 0.34 |

**Total Irrigated Area, ft^2**

| 42250 |

**Total Flow to Irrigated Area, gpm**

| 136 |
### Problem 3-4

#### Area C Pipeline Layout

![Diagram of pipeline layout]

<table>
<thead>
<tr>
<th>pipe</th>
<th>360's</th>
<th>180's</th>
<th>90's</th>
<th>Q</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>L10</td>
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<td>1.18</td>
<td>2.83</td>
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<td>L9</td>
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<td>1.1</td>
<td>1.18</td>
<td>0.25</td>
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</tbody>
</table>

### Table 1

<table>
<thead>
<tr>
<th>pipe</th>
<th>350's</th>
<th>180's</th>
<th>90's</th>
<th>Q</th>
<th>Cum Q</th>
<th>Length</th>
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</thead>
<tbody>
<tr>
<td>S3E</td>
<td>9</td>
<td>2</td>
<td>2</td>
<td>21</td>
<td>21</td>
<td>33.3</td>
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<td>S2E</td>
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<td>2</td>
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<td>2</td>
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<td>2</td>
<td>26</td>
<td>297</td>
<td>140</td>
</tr>
</tbody>
</table>

### Notes
- The pipeline layout includes key points labeled as L1 through L10.
- The table provides flow rates and cumulative flow for each segment of the pipeline.
- The lengths are measured in feet for each segment.
# Irrigation Waterline and Pump Station Evaluation

**Instructions:**

This spreadsheet assumes the pump is at the water supply source and the pipe distribution is to cover more outlets. Enter pump efficiency and motor efficiency. Read data in table for pipeline data starting at source and continuing to outlet. 

**Pressure Needed at Ductal or Emitter (psi): 50 (see press_values)**

<table>
<thead>
<tr>
<th>Pipe</th>
<th>Design Capacity (gpm)</th>
<th>Inside Diameter (inch)</th>
<th>Length (ft)</th>
<th>Upstream Elev (ft)</th>
<th>Downstream Elev (ft)</th>
<th>Hazen</th>
<th>Sum of V (functions)</th>
<th>Flow (gpm)</th>
<th>Friction Loss (ft)</th>
<th>Minor Loss (ft)</th>
<th>Total Loss (ft)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>100.0</td>
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<td>40</td>
<td>100.0</td>
<td>100.0</td>
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</tr>
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<td>8</td>
<td>11.00</td>
<td>1.04</td>
<td>40</td>
<td>150.0</td>
<td>100.0</td>
<td>150</td>
<td>2.2</td>
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- **MAX. DISCHARGE (gpm):** 50
- **MAX. FLOW (CPS):** 20
- **TOTAL FRICTION LOSS (ft):** 21.0
- **TOTAL MINOR LOSSES (ft):** 2.0
- **TOTAL DISCHARGE LOSS (ml):** 12.5
- **PRESSURE REQD AT SOURCE (gpm):** 35.2
- **MAXIMUM PIPE PRESSURE (psi):** 152

**Notes:**

- **Nominal Pipe Size:**
  - L1 2"
  - L2 2.5"
  - L3 1.5"
  - L4 1.5"
  - L5 1.5"
  - L6 1.5"
  - L7 1.5"
  - L8 1.5"
  - L9 1.5"
  - L10 1.5"

**Pipe Sizes for Lateral Pipes:**

- Schedule 40 pipe

---

*Problem 3-5*
### Irrigation Waterline and Pump Station Evaluation

**Instructions:**
- This spreadsheet assumes pump is at the water supply source and the pipe distribution is in series to crown more outlets.
- Enter pump efficiency and motor efficiency. Next enter in table the pipeline data starting at water source and continuing to outlet farthest from the pump.

**Pressure Needed at Nock On Intake (psig):**
- See press. values

**Pump Efficiency (%):**
- 70

**Motor Efficiency (%):**
- 60

### Table

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**Max. Discharge (gpm):**
- 700

**Max. Elevation (ft):**
- 20

**Total Friction Losses (ft):**
- 3.2

**Total Minor Losses (ft):**
- 2.3

**Total Discharge (gpm):**
- 340.0

**Pressure Reqd. at Source (psig):**
- 60.4

**Maximum Pipe Pressure (psig):**
- 80.4

**Gas Pump:**
- 9.0

**Electric Reqd. (kW/hr):**
- 1.0

**Diesel Fuel Reqd. (gph):**
- 5.4

**Gasoline Reqd. (gph):**
- 3.5

---

**Pipe Sizes for East Submain:**
- Class 160 Pipe
**Problem 3-7**

**IRRIGATION WATERLINE AND PUMP STATION EVALUATION**

**INSTRUCTIONS:**

This spreadsheet assumes the pump is at the water supply source and the pipe distribution is in series to one or more outlets. Enter pump efficiency and water efficiency. Next enter in table the pipe sizes starting at water source and continuing to outlet. Farthest from the pump.

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<th>total</th>
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**Max. Discharge (gpm):** 115

**Max. Elev. Diff. (ft):** 3.0

**Total Friction Losses (ft):** 4.2

**Total Minor Losses (ft):** 3.3

**Total Discharge Loss (ft):** 16.9

**Pressure Req'd at Source (psi):** 62.3

**Maximum Pipe Pressure (psi):** 62.3

**Cost of Pump:** 4,000

**Pump Efficiency:** 0.5

**Elect. Reqd (kWhr):** 0.4

**Diesel Fuel Reqd (gall):** 0.4

**Gasoline Reqd (gall):** 0.5

**Pipe sizes for West Submain**

*Class 160 pipe*
Problem 3-8 (continued)

IRRIGATION WATERLINE AND PUMP STATION EVALUATION

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MAX. DISCHARGE (gpm): 140
MAX. PUMP CAP. (hp): 3.0
TOTAL FRICTION LOSSES (in): 4.3
TOTAL MINOR LOSSES (in): 0.0
TOTAL DISCHARGES (gpm): 140.0
PRESSURE RECD. AT SOURCE (psi): 68.2
MAXIMUM PIPE PRESSURE (psi): 68.2

PUMP:
HP REC'D (hp): 7.9
ELECT. REC'D (KW/HR): 7.0
DESEL FUEL REC'D (gph): 0.05
GASOIN REC'D (gph): 0.7

clouds: 97 because we can drawdown pond 3 ft.
Nominal Pipe Size
M1 3"

( f ) pump hp req'd = 7.9

Pipe size for main, class 160 pipe
9) Volume of Pond

Surface Area

31 squares

25 squares = 100 ft x 100 ft
= 10,000 ft²

Surface Area
= \frac{3}{25} (10,000) = 12,000 ft²

Pond volume in 100
3' = 12,000 x 3 = 37,000 ft³

Volume Needed

Season water use for turf = 25" season rain/irrig. dry year = 2.4" (Reference Problem 2 9)

Area Irrigated
Yellow: 100 x 100 = 10,000 ft²
Green: 325 x 130 = 42,250 ft²

\frac{82,250 ft²}{62,250 ft²}

Vol. Needed = 82,250 ft² x (25 - 2.4) \text{ inches} \times \frac{1 \text{ ft}}{12 \text{ inches}}
= 154,900 ft³

Vol. Available (37,000 ft³) < Vol. Needed (154,900)

\therefore Pond is not large enough to provide irrig. water to turf area.