

# Assignment #4 Solutions

due Friday, February 19th, 2021

1

- (a) Let  $x_1$  = number of salespeople assigned to south.  
 $x_2$  = number of salespeople assigned to east.  
 $x_3$  = number of salespeople assigned to midwest.  
Then the model is as follows:

$$\max z = 600x_1 + 540x_2 + 375x_3$$

$$s.t. \quad x_1 \leq 5$$

$$80x_1 + 70x_2 + 50x_3 \leq 750$$

$$x_1 + x_2 + x_3 = 12$$

$$x_i \geq 0, i = 1, 2, 3 \text{ and integer.}$$

- (b) The results are shown below. The maximum profit is \$5715 with optimal solution = (1, 6, 5).

|    |                  |         |       |         |        |            |           |
|----|------------------|---------|-------|---------|--------|------------|-----------|
| 3  | Items:           | south   | east  | midwest |        |            |           |
| 4  | Profit per unit: | 600     | 540   | 375     |        |            |           |
| 5  | Conditions:      |         |       |         | Usage  | Constraint | Available |
| 6  | constrain1       | 1.00    | 0.00  | 0.00    | 1.00   | <=         | 5.00      |
| 7  | constrain2       | 80.00   | 70.00 | 50.00   | 750.00 | <=         | 750.00    |
| 8  | constrain3       | 1.00    | 1.00  | 1.00    | 12.00  | =          | 12.00     |
| 9  |                  |         |       |         |        |            |           |
| 10 | Production:      |         |       |         |        |            |           |
| 11 | south=           | 1.00    |       |         |        |            |           |
| 12 | east=            | 6.00    |       |         |        |            |           |
| 13 | midwest=         | 5.00    |       |         |        |            |           |
| 14 | Return =         | 5715.00 |       |         |        |            |           |

2

- (a) Let  $x_1$  = number of bracelets produce.  
 $x_2$  = number of necklaces produce.  
 $x_3$  = number of pins produce.  
Then the model is as follows:

$$\max z = 1650x_1 + 850x_2 + 790x_3$$

$$s.t. \quad 6.3x_1 + 3.9x_2 + 3.1x_3 \leq 125$$

$$17x_1 + 10x_2 + 7x_3 \leq 320$$

$$x_i \geq 0, i = 1, 2, 3 \text{ and integer}$$

- (b) From Fig. 1 and Fig. 2 , we can see that these two optimal solutions are different. The rounded-down solution of the model with the integer restrictions relaxed is (13, 0, 12) with profit \$30,930, which is not optimal.

|    |                  |           |           |      |        |            |           |
|----|------------------|-----------|-----------|------|--------|------------|-----------|
| 3  | Items:           | bracelets | necklaces | pins |        |            |           |
| 4  | Profit per unit: | 1650      | 850       | 790  |        |            |           |
| 5  | Conditions:      |           |           |      | Usage  | Constraint | Available |
| 6  | constrain1       | 6.30      | 3.90      | 3.10 | 125.00 | <=         | 125.00    |
| 7  | constrain2       | 17.00     | 10.00     | 7.00 | 320.00 | <=         | 320.00    |
| 8  |                  |           |           |      |        |            |           |
| 9  | Production:      |           |           |      |        |            |           |
| 10 | bracelets=       | 13.60     |           |      |        |            |           |
| 11 | necklaces=       | 0.00      |           |      |        |            |           |
| 12 | pins=            | 12.67     |           |      |        |            |           |
| 13 | Return =         | 32460.47  |           |      |        |            |           |

Figure 1: Excel with the integer restrictions relaxed

|    |                  |           |           |      |        |            |           |
|----|------------------|-----------|-----------|------|--------|------------|-----------|
| 3  | Items:           | bracelets | necklaces | pins |        |            |           |
| 4  | Profit per unit: | 1650      | 850       | 790  |        |            |           |
| 5  | Conditions:      |           |           |      | Usage  | Constraint | Available |
| 6  | constrain1       | 6.30      | 3.90      | 3.10 | 125.00 | <=         | 125.00    |
| 7  | constrain2       | 17.00     | 10.00     | 7.00 | 310.00 | <=         | 320.00    |
| 8  |                  |           |           |      |        |            |           |
| 9  | Production:      |           |           |      |        |            |           |
| 10 | bracelets=       | 10.00     |           |      |        |            |           |
| 11 | necklaces=       | 0.00      |           |      |        |            |           |
| 12 | pins=            | 20.00     |           |      |        |            |           |
| 13 | Return =         | 32300.00  |           |      |        |            |           |

Figure 2: Excel with integer restrictions

**3**

- (a) We can split 24 hour into six 4-hour periods. Assume the time period is 1, 2, 3, 4, 5, and 6. Then we assume the average fare made by the driver in period  $i$ ,  $i = 1, \dots, 6$ , is  $c_i$ . Based on the question, we know:

$$\begin{aligned}c_1 &= 80 \\c_2 + c_3 &= 500 \\c_3 + c_4 &= 420 \\c_4 + c_5 &= 300 \\c_5 + c_6 &= 270 \\c_6 + c_1 &= 210\end{aligned}$$

Then we can get

$$\begin{aligned}c_1 &= 80 \\c_2 &= 240 \\c_3 &= 260 \\c_4 &= 160 \\c_5 &= 140 \\c_6 &= 130\end{aligned}$$

So, the average fare made by drivers who start their 8-hour shift at midnight is  $c_1 + c_2 = 320$ .

Assume the time period is 1, 2, 3, 4, 5, and 6. Define  $x_i$  as the number of people beginning to work in period  $i$ ,  $i = 1, \dots, 6$ .

Then the model is as follows:

$$\begin{aligned}\max z &= 320x_1 + 500x_2 + 420x_3 + 300x_4 + 270x_5 + 210x_6 \\s.t. \quad x_1 + x_6 &\geq 10 \\x_1 + x_2 &\geq 12 \\x_2 + x_3 &\geq 20 \\x_3 + x_4 &\geq 25 \\x_4 + x_5 &\geq 32 \\x_5 + x_6 &\geq 18 \\x_1 + x_2 + x_3 + x_4 + x_5 + x_6 &= 70 \\x_i &\geq 0, i = 1, \dots, 6 \text{ and integer}\end{aligned}$$

The maximum revenue is \$25380 with optimal solution = (10, 17, 11, 14, 18, 0).

|    |             |          |         |         |         |         |         |       |            |           |
|----|-------------|----------|---------|---------|---------|---------|---------|-------|------------|-----------|
| 3  | Items:      | period1  | period2 | period3 | period4 | period5 | period6 |       |            |           |
| 4  |             | 320.00   | 500.00  | 420.00  | 300.00  | 270.00  | 210.00  |       |            |           |
| 5  | Conditions: |          |         |         |         |         |         | Usage | Constraint | Available |
| 6  | constrain1  | 1.00     | 0.00    | 0.00    | 0.00    | 0.00    | 1.00    | 10.00 | >=         | 10.00     |
| 7  | constrain2  | 1.00     | 1.00    | 0.00    | 0.00    | 0.00    | 0.00    | 27.00 | >=         | 12.00     |
| 8  | constrain3  | 0.00     | 1.00    | 1.00    | 0.00    | 0.00    | 0.00    | 28.00 | >=         | 20.00     |
| 9  | constrain4  | 0.00     | 0.00    | 1.00    | 1.00    | 0.00    | 0.00    | 25.00 | >=         | 25.00     |
| 10 | constrain5  | 0.00     | 0.00    | 0.00    | 1.00    | 1.00    | 0.00    | 32.00 | >=         | 32.00     |
| 11 | constrain6  | 0.00     | 0.00    | 0.00    | 0.00    | 1.00    | 1.00    | 18.00 | >=         | 18.00     |
| 12 | constrain7  | 1.00     | 1.00    | 1.00    | 1.00    | 1.00    | 1.00    | 70.00 | =          | 70.00     |
| 13 |             |          |         |         |         |         |         |       |            |           |
| 14 | Production: |          |         |         |         |         |         |       |            |           |
| 15 | period1     | 10.00    |         |         |         |         |         |       |            |           |
| 16 | period2     | 17.00    |         |         |         |         |         |       |            |           |
| 17 | period3     | 11.00    |         |         |         |         |         |       |            |           |
| 18 | period4     | 14.00    |         |         |         |         |         |       |            |           |
| 19 | period5     | 18.00    |         |         |         |         |         |       |            |           |
| 20 | period6     | 0.00     |         |         |         |         |         |       |            |           |
| 21 | revenue=    | 25380.00 |         |         |         |         |         |       |            |           |

(b) Add constraint  $x_1 \leq 15$ . The model is as follows:

$$\max z = 320x_1 + 500x_2 + 420x_3 + 300x_4 + 270x_5 + 210x_6$$

$$s.t. \quad x_1 + x_6 \geq 10$$

$$x_1 + x_2 \geq 12$$

$$x_2 + x_3 \geq 20$$

$$x_3 + x_4 \geq 25$$

$$x_4 + x_5 \geq 32$$

$$x_5 + x_6 \geq 18$$

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 = 70$$

$$x_1 \leq 15$$

$$x_i \geq 0, i = 1, \dots, 6 \text{ and integer}$$

The maximum revenue is \$25380 with optimal solution = (10, 17, 11, 14, 18, 0).

|    |             |          |         |         |         |         |         |       |            |           |
|----|-------------|----------|---------|---------|---------|---------|---------|-------|------------|-----------|
| 3  | Items:      | period1  | period2 | period3 | period4 | period5 | period6 |       |            |           |
| 4  |             | 320.00   | 500.00  | 420.00  | 300.00  | 270.00  | 210.00  |       |            |           |
| 5  | Conditions: |          |         |         |         |         |         | Usage | Constraint | Available |
| 6  | constrain1  | 1.00     | 0.00    | 0.00    | 0.00    | 0.00    | 1.00    | 10.00 | >=         | 10.00     |
| 7  | constrain2  | 1.00     | 1.00    | 0.00    | 0.00    | 0.00    | 0.00    | 27.00 | >=         | 12.00     |
| 8  | constrain3  | 0.00     | 1.00    | 1.00    | 0.00    | 0.00    | 0.00    | 28.00 | >=         | 20.00     |
| 9  | constrain4  | 0.00     | 0.00    | 1.00    | 1.00    | 0.00    | 0.00    | 25.00 | >=         | 25.00     |
| 10 | constrain5  | 0.00     | 0.00    | 0.00    | 1.00    | 1.00    | 0.00    | 32.00 | >=         | 32.00     |
| 11 | constrain6  | 0.00     | 0.00    | 0.00    | 0.00    | 1.00    | 1.00    | 18.00 | >=         | 18.00     |
| 12 | constrain7  | 1.00     | 1.00    | 1.00    | 1.00    | 1.00    | 1.00    | 70.00 | =          | 70.00     |
| 13 | constrain8  | 1.00     | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 10.00 | <=         | 15.00     |
| 14 |             |          |         |         |         |         |         |       |            |           |
| 15 | Production: |          |         |         |         |         |         |       |            |           |
| 16 | period1     | 10.00    |         |         |         |         |         |       |            |           |
| 17 | period2     | 17.00    |         |         |         |         |         |       |            |           |
| 18 | period3     | 11.00    |         |         |         |         |         |       |            |           |
| 19 | period4     | 14.00    |         |         |         |         |         |       |            |           |
| 20 | period5     | 18.00    |         |         |         |         |         |       |            |           |
| 21 | period6     | 0.00     |         |         |         |         |         |       |            |           |
| 22 | revenue=    | 25380.00 |         |         |         |         |         |       |            |           |

(c) Add constraint  $x_3 \leq 20$ . The model is as follows:

$$\begin{aligned}
 \max z &= 320x_1 + 500x_2 + 420x_3 + 300x_4 + 270x_5 + 210x_6 \\
 \text{s.t. } &x_1 + x_6 \geq 10 \\
 &x_1 + x_2 \geq 12 \\
 &x_2 + x_3 \geq 20 \\
 &x_3 + x_4 \geq 25 \\
 &x_4 + x_5 \geq 32 \\
 &x_5 + x_6 \geq 18 \\
 &x_1 + x_2 + x_3 + x_4 + x_5 + x_6 = 70 \\
 &x_1 \leq 15 \\
 &x_3 \leq 20 \\
 &x_i \geq 0, i = 1, \dots, 6 \text{ and integer}
 \end{aligned}$$

The maximum revenue is \$25380 with optimal solution = (10, 17, 11, 14, 18, 0).

| 3  | Items:      | period1  | period2 | period3 | period4 | period5 | period6 |       |            |           |
|----|-------------|----------|---------|---------|---------|---------|---------|-------|------------|-----------|
| 4  |             | 320.00   | 500.00  | 420.00  | 300.00  | 270.00  | 210.00  |       |            |           |
| 5  | Conditions: |          |         |         |         |         |         | Usage | Constraint | Available |
| 6  | constrain1  | 1.00     | 0.00    | 0.00    | 0.00    | 0.00    | 1.00    | 10.00 | >=         | 10.00     |
| 7  | constrain2  | 1.00     | 1.00    | 0.00    | 0.00    | 0.00    | 0.00    | 27.00 | >=         | 12.00     |
| 8  | constrain3  | 0.00     | 1.00    | 1.00    | 0.00    | 0.00    | 0.00    | 28.00 | >=         | 20.00     |
| 9  | constrain4  | 0.00     | 0.00    | 1.00    | 1.00    | 0.00    | 0.00    | 25.00 | >=         | 25.00     |
| 10 | constrain5  | 0.00     | 0.00    | 0.00    | 1.00    | 1.00    | 0.00    | 32.00 | >=         | 32.00     |
| 11 | constrain6  | 0.00     | 0.00    | 0.00    | 0.00    | 1.00    | 1.00    | 18.00 | >=         | 18.00     |
| 12 | constrain7  | 1.00     | 1.00    | 1.00    | 1.00    | 1.00    | 1.00    | 70.00 | =          | 70.00     |
| 13 | constrain8  | 1.00     | 0.00    | 0.00    | 0.00    | 0.00    | 0.00    | 10.00 | <=         | 15.00     |
| 14 | constrain9  | 0.00     | 0.00    | 1.00    | 0.00    | 0.00    | 0.00    | 11.00 | <=         | 20.00     |
| 15 |             |          |         |         |         |         |         |       |            |           |
| 16 | Production: |          |         |         |         |         |         |       |            |           |
| 17 | period1     | 10.00    |         |         |         |         |         |       |            |           |
| 18 | period2     | 17.00    |         |         |         |         |         |       |            |           |
| 19 | period3     | 11.00    |         |         |         |         |         |       |            |           |
| 20 | period4     | 14.00    |         |         |         |         |         |       |            |           |
| 21 | period5     | 18.00    |         |         |         |         |         |       |            |           |
| 22 | period6     | 0.00     |         |         |         |         |         |       |            |           |
| 23 | revenue =   | 25380.00 |         |         |         |         |         |       |            |           |

4

(a) Let Rugby fields, Football fields, Soccer fields, Dog park, Playground, Walking/running trails, Softball fields and Baseball fields are ith ( $i = 1, \dots, 8$ ) project.

Assume

$$x_i = \begin{cases} 1 & \text{if ith project is constructed, } i = 1, \dots, 8 \\ 0 & \text{otherwise} \end{cases}$$

Then the model is as follows:

$$\begin{aligned}
 \max z &= 4700x_1 + 12500x_2 + 32000x_3 + 7500x_4 + 41000x_5 + 47000x_6 + 23000x_7 + 16000x_8 \\
 \text{s.t. } &7x_1 + 12x_2 + 20x_3 + 6x_4 + 3x_5 + 25x_6 + 5x_7 + 8x_8 \leq 55 \\
 &75000x_1 + 180000x_2 + 350000x_3 + 45000x_4 + 120000x_5 + 80000x_6 + 115000x_7 + 210000x_8 \leq 550000 \\
 &3x_1 + 2x_2 + x_3 + 3x_4 + 2x_5 + x_6 + 2x_7 + 3x_8 \leq 1.75(x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + x_8) \\
 &0 \leq x_i \leq 1, i = 1, \dots, 8, \text{ integer}
 \end{aligned}$$

After simplification, the model becomes:

$$\begin{aligned}
 \max z &= 4700x_1 + 12500x_2 + 32000x_3 + 7500x_4 + 41000x_5 + 47000x_6 + 23000x_7 + 16000x_8 \\
 \text{s.t. } &7x_1 + 12x_2 + 20x_3 + 6x_4 + 3x_5 + 25x_6 + 5x_7 + 8x_8 \leq 55 \\
 &75000x_1 + 180000x_2 + 350000x_3 + 45000x_4 + 120000x_5 + 80000x_6 + 115000x_7 + 210000x_8 \leq 550000 \\
 &1.25x_1 + 0.25x_2 - 0.75x_3 + 1.25x_4 + 0.25x_5 - 0.75x_6 + 0.25x_7 + 1.25x_8 \leq 0 \\
 &0 \leq x_i \leq 1, i = 1, \dots, 8, \text{ integer}
 \end{aligned}$$

|    |             |           |           |           |          |           |          |           |           |           |            |           |
|----|-------------|-----------|-----------|-----------|----------|-----------|----------|-----------|-----------|-----------|------------|-----------|
| 3  | Items:      | project1  | project2  | project3  | project4 | project5  | project6 | project7  | project8  |           |            |           |
| 4  |             | 4700.00   | 12500.00  | 32000.00  | 7500.00  | 41000.00  | 47000.00 | 23000.00  | 16000.00  |           |            |           |
| 5  | Conditions: |           |           |           |          |           |          |           |           | Usage     | Constraint | Available |
| 6  | constrain1  | 7.00      | 12.00     | 20.00     | 6.00     | 3.00      | 25.00    | 5.00      | 8.00      | 53.00     | <=         | 55.00     |
| 7  | constrain2  | 75000.00  | 180000.00 | 350000.00 | 45000.00 | 120000.00 | 80000.00 | 115000.00 | 210000.00 | 495000.00 | <=         | 550000.00 |
| 8  | constrain3  | 1.25      | 0.25      | -0.75     | 1.25     | 0.25      | -0.75    | 0.25      | 1.25      | 0.00      | <=         | 0.00      |
| 9  |             |           |           |           |          |           |          |           |           |           |            |           |
| 10 |             |           |           |           |          |           |          |           |           |           |            |           |
| 11 | Production: |           |           |           |          |           |          |           |           |           |            |           |
| 12 | project1    | 0.00      |           |           |          |           |          |           |           |           |            |           |
| 13 | project2    | 1.00      |           |           |          |           |          |           |           |           |            |           |
| 14 | project3    | 0.00      |           |           |          |           |          |           |           |           |            |           |
| 15 | project4    | 0.00      |           |           |          |           |          |           |           |           |            |           |
| 16 | project5    | 1.00      |           |           |          |           |          |           |           |           |            |           |
| 17 | project6    | 1.00      |           |           |          |           |          |           |           |           |            |           |
| 18 | project7    | 1.00      |           |           |          |           |          |           |           |           |            |           |
| 19 | project8    | 0.00      |           |           |          |           |          |           |           |           |            |           |
| 20 | usage=      | 123500.00 |           |           |          |           |          |           |           |           |            |           |

The maximum annual usage is 123500 with  $(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8) = (0, 1, 0, 0, 1, 1, 1, 0)$ .

(b) In this case, the model is as follows:

$$\max z = 3x_1 + 2x_2 + x_3 + 3x_4 + 2x_5 + x_6 + 2x_7 + 3x_8$$

$$s.t. \quad 7x_1 + 12x_2 + 20x_3 + 6x_4 + 3x_5 + 25x_6 + 5x_7 + 8x_8 \leq 55$$

$$75000x_1 + 180000x_2 + 350000x_3 + 45000x_4 + 120000x_5 + 80000x_6 + 115000x_7 + 210000x_8 \leq 550000$$

$$4700x_1 + 12500x_2 + 32000x_3 + 7500x_4 + 41000x_5 + 47000x_6 + 23000x_7 + 16000x_8 \geq 120000$$

$$0 \leq x_i \leq 1, i = 1, \dots, 8, \text{ integer}$$

|    |                  |          |           |           |          |           |          |           |           |           |            |           |
|----|------------------|----------|-----------|-----------|----------|-----------|----------|-----------|-----------|-----------|------------|-----------|
| 3  | Items:           | project1 | project2  | project3  | project4 | project5  | project6 | project7  | project8  |           |            |           |
| 4  |                  | 3.00     | 2.00      |           | 1.00     | 3.00      | 2.00     | 1.00      | 2.00      | 3.00      |            |           |
| 5  | Conditions:      |          |           |           |          |           |          |           |           | Usage     | Constraint | Available |
| 6  | constrain1       | 7.00     | 12.00     | 20.00     | 6.00     | 3.00      | 25.00    | 5.00      | 8.00      | 48.00     | <=         | 55.00     |
| 7  | constrain2       | 75000.00 | 180000.00 | 350000.00 | 45000.00 | 120000.00 | 80000.00 | 115000.00 | 210000.00 | 550000.00 | <=         | 550000.00 |
| 8  | constrain3       | 4700.00  | 12500.00  | 32000.00  | 7500.00  | 41000.00  | 47000.00 | 23000.00  | 16000.00  | 120000.00 | >=         | 120000.00 |
| 9  |                  |          |           |           |          |           |          |           |           |           |            |           |
| 10 |                  |          |           |           |          |           |          |           |           |           |            |           |
| 11 | Production:      |          |           |           |          |           |          |           |           |           |            |           |
| 12 | project1         | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 13 | project2         | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 14 | project3         | 1.00     |           |           |          |           |          |           |           |           |            |           |
| 15 | project4         | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 16 | project5         | 1.00     |           |           |          |           |          |           |           |           |            |           |
| 17 | project6         | 1.00     |           |           |          |           |          |           |           |           |            |           |
| 18 | project7         | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 19 | project8         | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 20 | averagepriority= | 4.00     |           |           |          |           |          |           |           |           |            |           |

The minimum sum of priority is 4 with  $(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8) = (0, 0, 1, 0, 1, 1, 0, 0)$ .

(c) In this case, the model is as follows:

$$\max z = 7x_1 + 12x_2 + 20x_3 + 6x_4 + 3x_5 + 25x_6 + 5x_7 + 8x_8$$

$$s.t. \quad 7x_1 + 12x_2 + 20x_3 + 6x_4 + 3x_5 + 25x_6 + 5x_7 + 8x_8 \leq 55$$

$$75000x_1 + 180000x_2 + 350000x_3 + 45000x_4 + 120000x_5 + 80000x_6 + 115000x_7 + 210000x_8 \leq 550000$$

$$1.25x_1 + 0.25x_2 - 0.75x_3 + 1.25x_4 + 0.25x_5 - 0.75x_6 + 0.25x_7 + 1.25x_8 \leq 0$$

$$0 \leq x_i \leq 1, i = 1, \dots, 8, \text{ integer}$$

|    |                     |          |           |           |          |           |          |           |           |           |            |           |
|----|---------------------|----------|-----------|-----------|----------|-----------|----------|-----------|-----------|-----------|------------|-----------|
| 3  | Items:              | project1 | project2  | project3  | project4 | project5  | project6 | project7  | project8  |           |            |           |
| 4  | acreage per project | 7.00     | 12.00     | 20.00     | 6.00     | 3.00      | 25.00    | 5.00      | 8.00      |           |            |           |
| 5  | usage per project   | 4700.00  | 12500.00  | 32000.00  | 7500.00  | 41000.00  | 47000.00 | 23000.00  | 16000.00  |           |            |           |
| 6  | Conditions:         |          |           |           |          |           |          |           |           | Usage     | Constraint | Available |
| 7  | constrain1          | 7.00     | 12.00     | 20.00     | 6.00     | 3.00      | 25.00    | 5.00      | 8.00      | 52.00     | <=         | 55.00     |
| 8  | constrain2          | 75000.00 | 180000.00 | 350000.00 | 45000.00 | 120000.00 | 80000.00 | 115000.00 | 210000.00 | 505000.00 | <=         | 550000.00 |
| 9  | constrain3          | 1.25     | 0.25      | -0.75     | 1.25     | 0.25      | -0.75    | 0.25      | 1.25      | -0.25     | <=         | 0.00      |
| 10 |                     |          |           |           |          |           |          |           |           |           |            |           |
| 11 |                     |          |           |           |          |           |          |           |           |           |            |           |
| 12 | Production:         |          |           |           |          |           |          |           |           |           |            |           |
| 13 | project1            | 1.00     |           |           |          |           |          |           |           |           |            |           |
| 14 | project2            | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 15 | project3            | 1.00     |           |           |          |           |          |           |           |           |            |           |
| 16 | project4            | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 17 | project5            | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 18 | project6            | 1.00     |           |           |          |           |          |           |           |           |            |           |
| 19 | project7            | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 20 | project8            | 0.00     |           |           |          |           |          |           |           |           |            |           |
| 21 | acreage=            | 52.00    |           |           |          |           |          |           |           |           |            |           |
| 22 | usage=              | 83700.00 |           |           |          |           |          |           |           |           |            |           |

The maximum acreage used is 52 with  $(x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8) = (1, 0, 1, 0, 0, 1, 0, 0)$ . The annual usage with these facilities is  $4,700 + 32,000 + 47,000 = 83,700$ .