Problem a: Find the location of the fire station for Monroe County to serve its four towns, given their location and average no of fires per year

Solution: Build a non-linear optimization model to find the location of the fire station that minimizes the average distance travelled by the fire engine to each town

- 'Multistart' option was used in Solver for the 'GRG Nonlinear' optimization method
- This is because a nonlinear model can have local optima in addition to global optima, so Solver solution depends on starting solution
- Multistart option provides multiple starting solutions automatically

Inputs: In blue in spreadsheet,

- X, Y coordinates of location for each town
- Average no of fires in each town
- Distance calculation uses sum of absolute of difference of coordinates between the towns and the fire station

Objective function: Min (**Avg distance travelled**) = $\min_{i} \sum(|\boldsymbol{TXi} - \boldsymbol{X}| + |\boldsymbol{TYi} - \boldsymbol{Y}|) * \boldsymbol{Fi}$

- **TX_i** – X coordinate of location of Town i
- **TY_i** – Y coordinate of location of Town i
- **X** – X coordinate of location of the fire station
- **Y** – Y coordinate of location of the fire station
- **F_i** – Average no of fires per year at town i
- **i** ∈ **(1…4)** for the 4 towns

Decision variables:

- **X, Y** – X and Y coordinates of the location of the fire station

Constraints:

- **X, Y >= 0, Lower Bound**
- **X, Y <= 100, Upper Bound**, could be any large number
  - But given optimal location of (40,20), safer to use a value larger than both
  - Lower than 40 gives sub-optimal results
- Upper and Lower Bound constraints have been specified on the decision variables as 'Multistart' option was used along with 'Require bound on variables' option in Solver for the 'GRG Nonlinear' optimization method
- Solver's help states that Multistart option works better if there are bounds on variables
- This gives a more optimal solution than without any constraints
- Without any constraints Optimal location is (42.95, 20.00) with minimum average distance of 4,314.76 miles

Result:

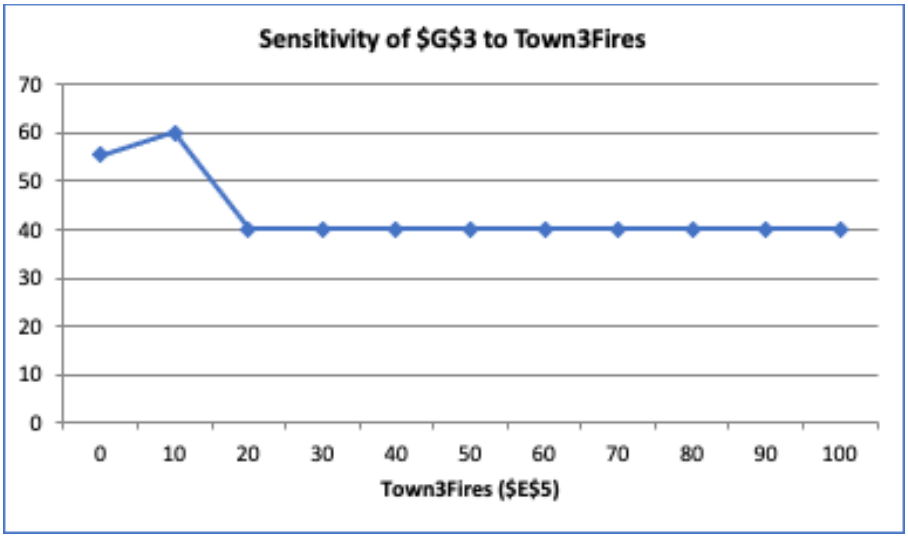
- The **optimal location** of the fire station is **(40.00, 20.00)** which **minimizes the average distance travelled** by the fire engine to each town to **4,300.00 miles**

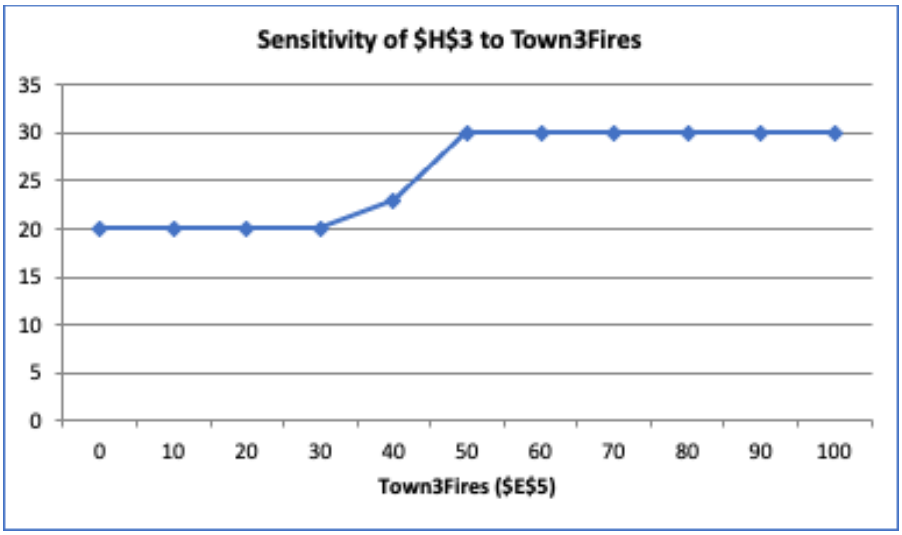
Problem b: Use SolverTable to see how the optimal location of the fire station changes as the number of fires at town 3 changes

Solution: Use SolverTable on the model built in part a by using a range of values for no of fires for town 3 (actual value given is 20) and observing the output cells of location of fire station

Result:

- We run SolverTable for town 3 fires from 0 to 100 fires in increments of 10
- Looking at the output of SolverTable we can see that
- As the no of fires increase from 0 to 100 the X,Y coordinates of the location of the fire station initially change and then become constant
- The X coordinate initially increases and then reduces to a constant value
- The Y coordinate increases and then settles at a constant value
- This is probably due to the optimal minimum distance travelled by the fire engine to each town being reached, after a lower threshold of no of fires at town 3 is crossed
- The results are given in the STS sheet




Sensitivity of H3 to Town3Fires
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Town3Fires (E5)