

# **A Risk-Based Approach to Protecting Accessibility, Mobility, and Safety Options for Transportation Corridors**

Training Manual Version 4.5

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We are training Virginia localities on a GIS-based methodology for assessing the potential for land-development of half-mile primary road sections. The methodology measures and combines real estate, employment, population, and conservation/easement databases as described in the steps below.

We generated the following statewide base layers, for each half-mile, primary-road section throughout the Commonwealth:

- Population within one-, two-, and five-mile buffers
- Employment within one-, two-, and five-mile buffers
- Number of intersecting roads within a half-mile buffer
- Percentage of land area within a half-mile buffer designated as conservation lands
- Percentage of land area within a half-mile buffer designated as agricultural and forest districts adjacent to each section
- Weighted average of real estate parcel land-value assessments and improvement-value assessments

Our assessment of the relative development potential of a half-mile section of primary road is as follows-

*“Development potential” is proportional to:*  
*(population in a (1, 2, 5) mile radius) •*  
*(employment in a (1, 2, 5) mile radius) •*  
*(number of road intersections in a half-mile radius) •*  
*(percentage of land that is not conserved or designated*  
*agricultural/forestal within a half-mile radius) •*  
*(area-weighted average of the ratio of the land improvement to land*  
*value)*

## Summary of Approach:

*Note:* Between steps, it is recommended that the user clear the layer of extraneous information. The new layer should have the same name *Layername*, or *LayerName2*, *LayerName3*, *LayerName4*, etc.

1. Load layer *VARoadsIndicators* in ArcMap. Perform a “Select by attributes” operation on *VARoadsIndicators* to select the relevant areas for the analysis. Create a new layer from the selection. The reference name for this layer is *Region\_sections*.
  - *Purpose:* *VARoadsIndicators* contains half-mile points throughout the state which will be used throughout the methodology.
2. Load layers *TwoMileEmploy* and *TwoMilePop*. Spatially join *TwoMile Employ* to *Regions\_sections* using the “if falls inside option.” The reference name for this intermediate file is *ind\_emp*. Next, spatially join *TwoMilePop* to *ind\_emp* in the same way. The reference name for the new layer is *ind\_emp\_pop*. This file should contain the following data – FID, Shape, Name, Sum\_Num\_Emp, Sum\_Pop200.  
NOTE: The layers may take a minute to load on the screen; be patient and let them fully load before performing the operations or the product layers may contain an empty.
  - *Purpose:* *TwoMileEmploy* is a set of two-mile buffers that contain the sum of employees in the area.. *TwoMilePop* is a set of two-mile buffers that contain the sum of population in the area. The one and five-mile buffer files can also be used in this approach. Joining these data layers to *Region\_sections* allows for the characterization of the half-mile sections using two indicators, population and employment.
3. Load the layer *VAIIntersectionCount*. Join *VAIIntersectionCount* to *ind\_emp\_pop* using a “Spatial Join” and choosing the option to join the point closest to the corresponding point. The reference name for the new layer is *ind\_emp\_pop2*.
  - *Purpose:* *VAIIntersectionCount* contains the number of half-mile primary-road sections within a two-mile buffer thus indicating how close sections are to intersections with other primary roads.
4. Join any other layers to *ind\_emp\_pop2* that have variables that may be considered as indicators for the risk of land development.
5. Multiply all indicators together (Sum\_NumEmp, Sum\_Pop, and Join\_count) to create a “score” field. For population or employment of zero, we enter instead a minimum “1”. Note: When creating a new field, the field type should **always be “double.”**
  - Code for filtering out 0’s below in screenshot section
  - *Purpose:* To start to create a score for the risk of land development by *multiplying* indicators
6. Create a new layer by buffering a quarter-mile around *ind\_emp\_pop2*. The reference name for the new layer is *ind\_bufferQuarterM*.

- *Purpose:* The buffer will be used to incorporate the land indicators around the road sections
7. Load layers *VDCR\_LND* and *VDOF\_AG\_FOREST\_DIST*. “Union” together layers. The reference name for the new layers is ***cons\_land1***.
    - *Purpose:* Join together conserved land layers
  8. “Intersect” *ind\_bufferQuarterM* and *cons\_land1*. The reference name for the new layer is ***cons\_buffer\_intersect***.
    - *Purpose:* Get the area in which the buffers intersect the conserved land
  9. Use the “Erase” tool to erase the areas of *cons\_buffer\_intersect* from *ind\_bufferQuarterM*. The reference name for the new layer is ***ind\_cons\_bufferQuarterM***.
    - *Purpose:* To remove overlap between *ind\_bufferQuarterM* and *cons\_buffer\_intersect*.
  10. Calculate area of polygons in *ind\_cons\_bufferQuarterM* “calculate areas” tool. The reference name for the new layer is ***ind\_cons\_bufferQuarterM2***.
    - Arc Toolbox->Spatial Statistics Tools->Utilities -> Calculate Areas, it will insert a field called “F\_AREA”
    - *Purpose:* To calculate how much of each buffer is conserved and thus part of the risk of development.
  11. Create a new field in *ind\_cons\_bufferQuarterM2* called “area\_fact”. The field is a ‘double’ and calculated by dividing the area of each shape by the total area of the circle.
    - The total area of each buffer should be the area of the circle, which is  $\pi * radius^2 = \pi * 0.25miles^2 = \pi * 402.4meters^2 \sim 508450$  meters.
    - *Purpose:* The calculation yields the percentage of area in each buffer that is usable and thus will be able to weight the score of each buffer.
  12. In *ind\_cons\_bufferQuarterM2*, multiply “score” field by “area\_fact” to create “area\_score” field.
    - *Purpose:* As stated above, to weight the score of the buffer
  13. “Spatially Join” *ind\_cons\_bufferQuarterM2* to *Region\_sections* (right-click *Regions\_sections* using “Join Data” with the “if falls inside” option. The reference name for the new layer is ***road\_section\_scores***.
    - *Purpose:* To map the area scores back to the quarter-mile sections

**If not using Parcels:**

14. Load layer *VA\_major\_roads*. Select the appropriate areas using “Select by Attributes” for County\_Cod field and RRstcc.pdf (in “starting files” folder) as a key. To convert the codes in the RRstcc.pdf file the county codes in the GIS layer, match

the rightmost two or three digits from the PDF file to the rightmost digits for the codes in the layer. The reference name for the new layer is *region\_roads*.

- *Purpose:* Prepare roads for join with quarter-mile sections

15. “Spatially Join” *road\_section\_scores* to *region\_roads* using the option of having the line given points that are “intersected by it” and the attributes of the points being averaged. The reference name for the new layer is *overall\_road\_scores*.

- *Purpose:* Provide risk of development scores for roads based on quarter-mile road sections. The road scores are calculated using

### **If using Parcels:**

1. Get Parcel data for area; if there is more than one parcel file, a Union operation can be performed to combine the parcels together and then cleansed of unnecessary data. A recommended approach is to have a ‘total land value’ and ‘total improved land’ field that sums the previous value fields of the now-unioned parcels.

NOTE: The field storing land improvement will not be called [IMPRV] in all parcels. The field name should be similar to this however.

- Code the land\_value as a 1 if it is a 0
  - If [IMPRV]=0 Then
  - [IMPRV]=1
  - End If
- For TOTLD field:
  - If [TOTLD]=0 Then
  - [TOTLD]=1
  - End If
- *Purpose:* Prepare the parcel layer to yield a ratio that indicates the potential for land development.

2. Create a field called “*TotRat*” showing the ratio of land improvement value to land value (land improvement value/ land value)

- *Purpose:* Creates a ratio of land improvement value to land value. This ratio is an indicator value for the methodology

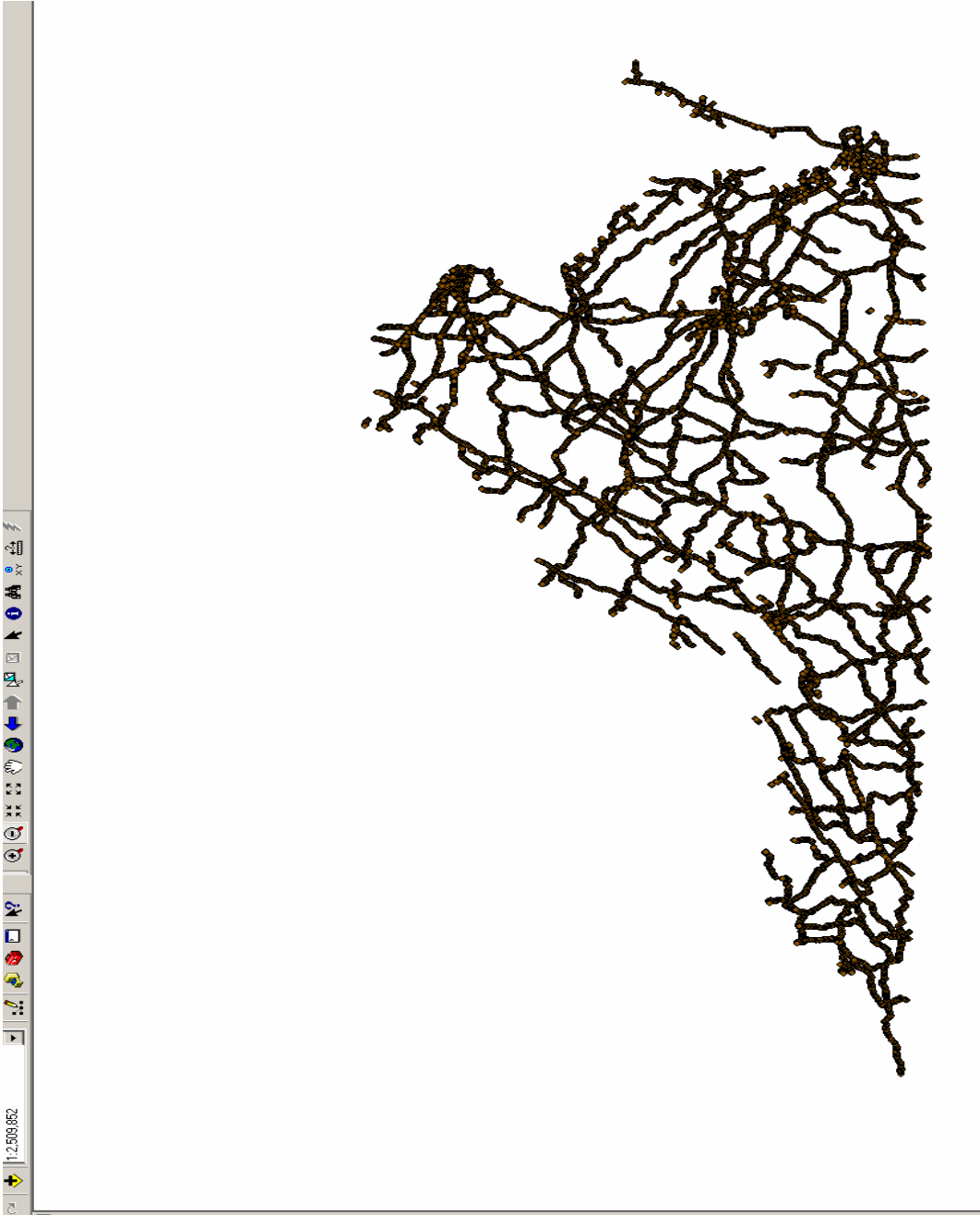
3. Create a multiplier field called “*multi*”. This field is based on the ratio score of land improvement value to land value (*TotRat*) and can be given various values. See step 2 in screenshots for sample code.

- *Purpose:* Multiplier will increase the risk of land development score. If the ratio is lower the multiplier should be higher since a low score indicates that the land has not been improved on much.

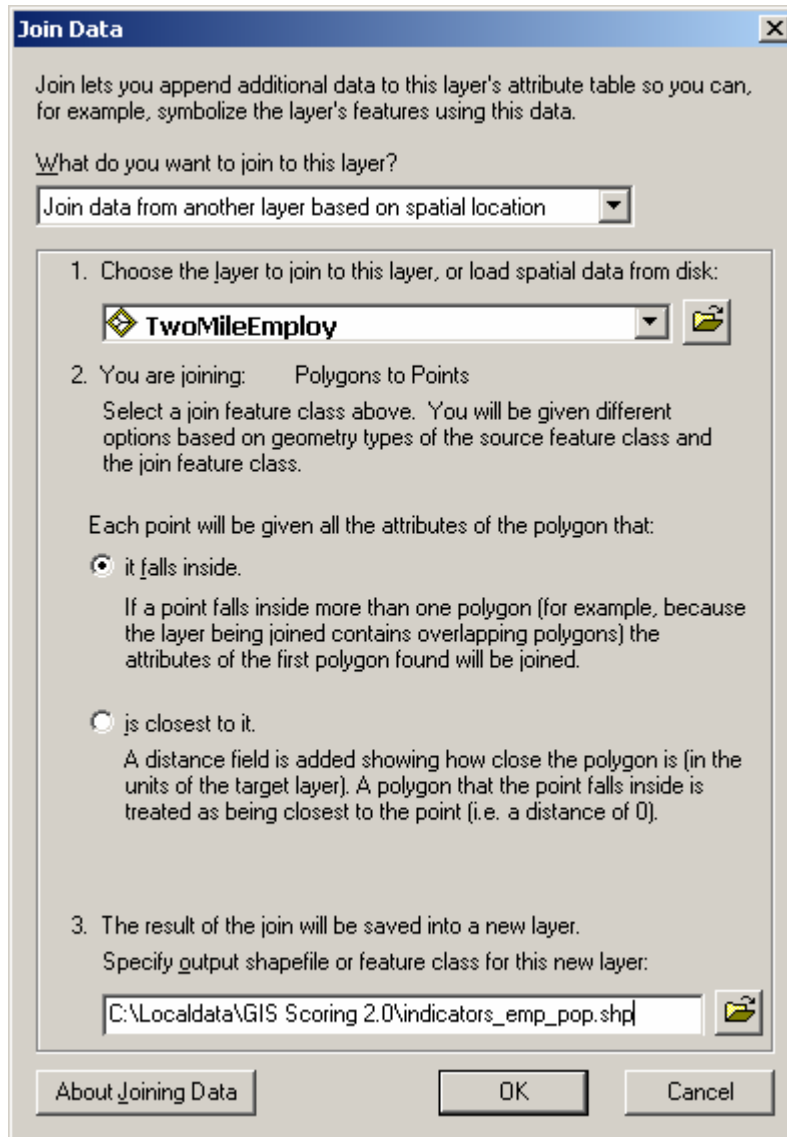
4. If necessary, do a “select attributes” on the *road\_section\_scores* to correspond to the parcels. Create a quarter mile buffer around *road\_section\_scores*. The reference name of the new layer is *road\_scores\_buffer1*.

- *Purpose:* The buffer reaches a quarter-mile out to get the parcel indicator around the road sections.
5. Perform an Intersect operation with *road\_scores\_buffer1* and the unioned parcel files. The reference name of the new layer is ***scoreBufInter***.
    - *Purpose:* Combine the parcel indicator ratio and the buffers around *road\_section\_scores*.
  6. Before proceeding, make sure to do a “select by attributes” on *region\_roads* so that only the regions of the corresponding parcels are included. Spatially join *scoreBufInter* to *region\_roads* using the “Average” option for the lines intersection multiple polygons. The reference name of the new layer is ***overall\_road\_score\_p***. Multiply the land improvement ratio multiplier by the score to get the overall score.
    - *Purpose:* Generate overall scores for the roads. The multipliers for the parcels within the buffers that the roads pass through are averaged.
- 

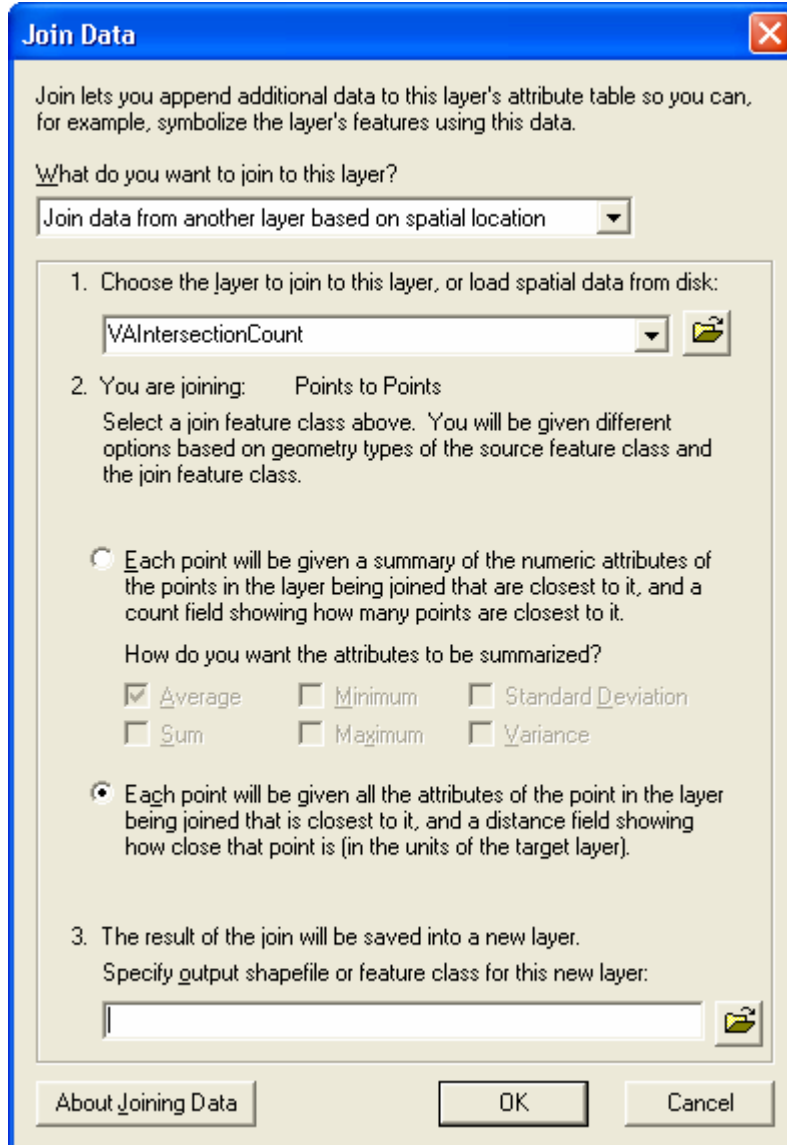
The following pages document the steps



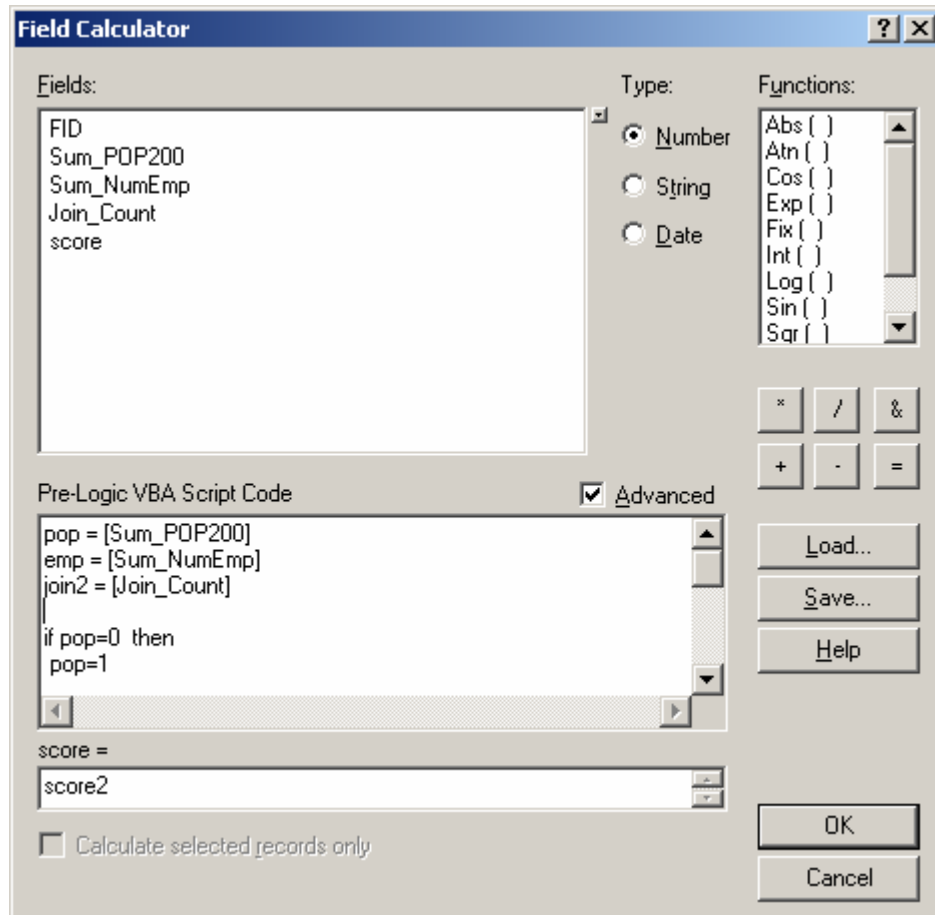
Step 1 – Half mile sections layer loaded



## Step 2 – joining employment to the road points



### Step 3 – Joining intersection count



### Step 5– creating the “score” field

#### CODE[

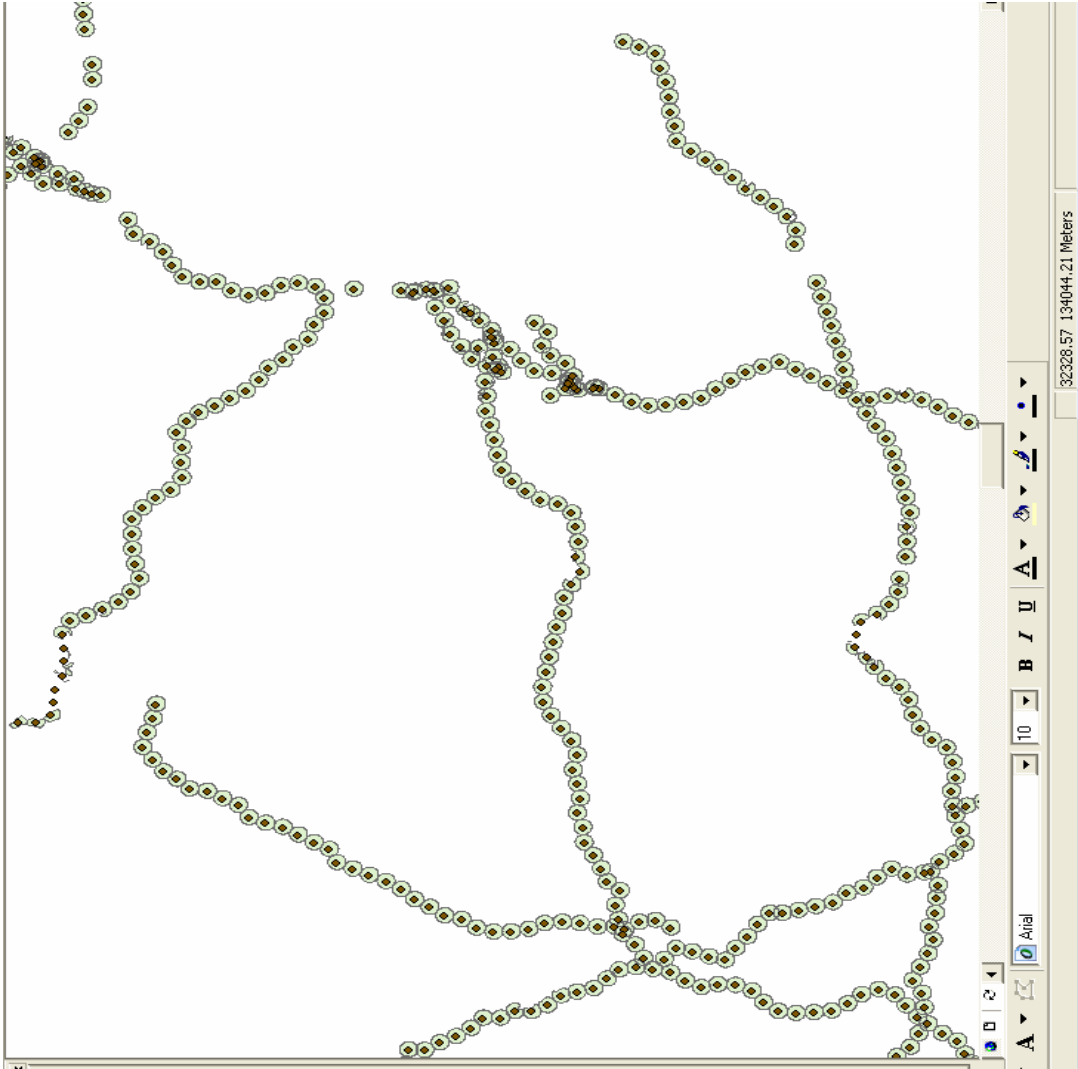
```
pop = [Sum_POP200]
emp = [Sum_NumEmp]
join2 = [Join_Count]
```

```
If pop=0 Then
  pop=1
End If
```

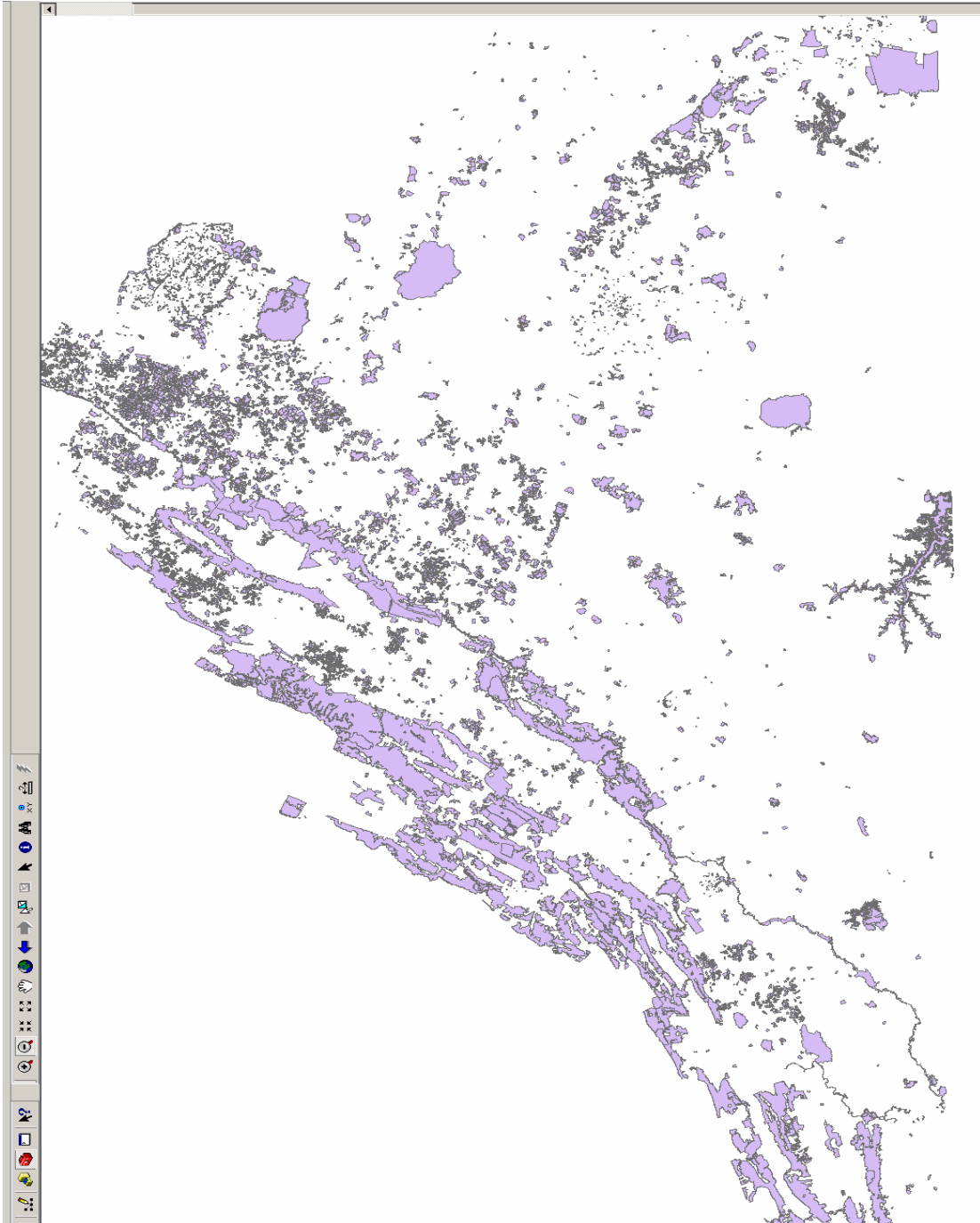
```
If emp=0 Then
  emp=1
End If
```

```
If join2=0 Then
  join2=1
End If
```

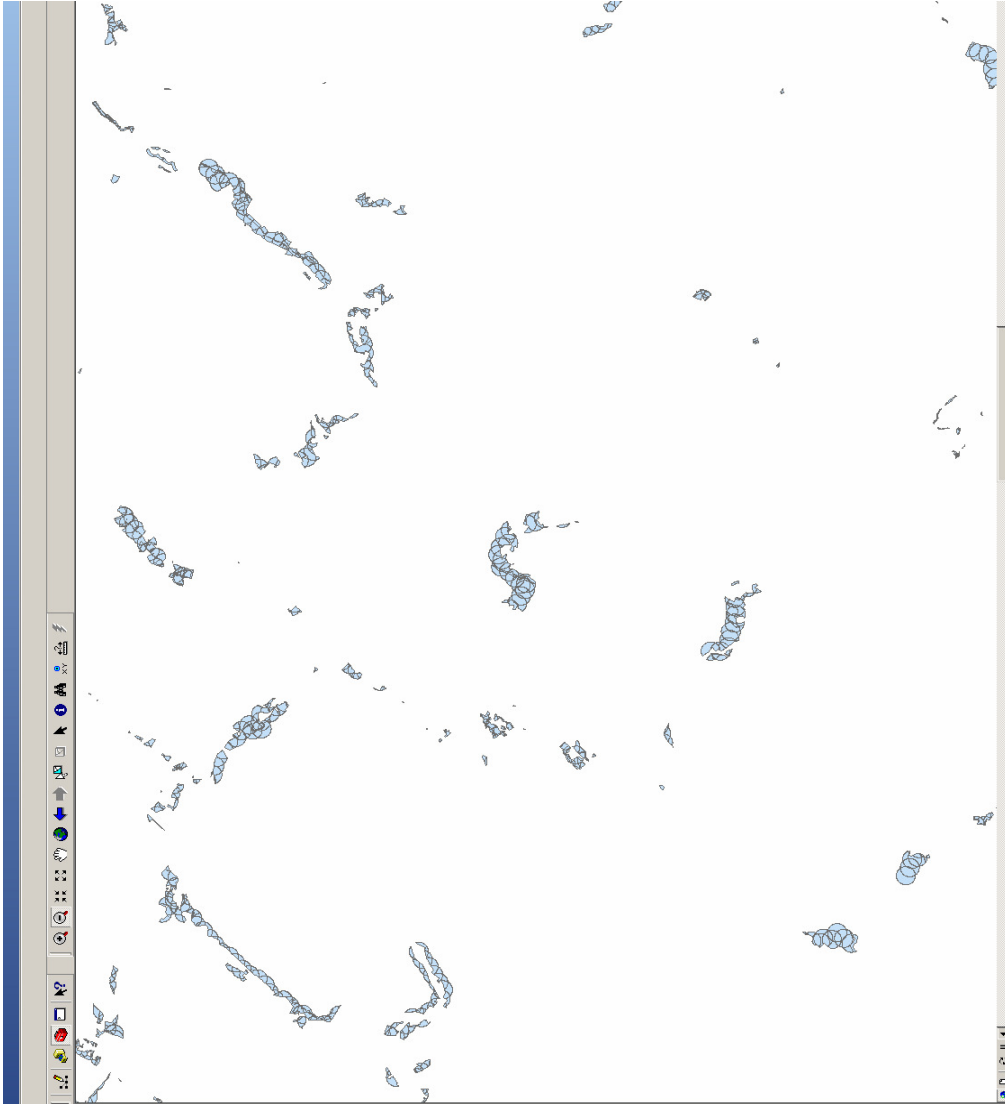
```
score2 = join2*emp*pop ]
```



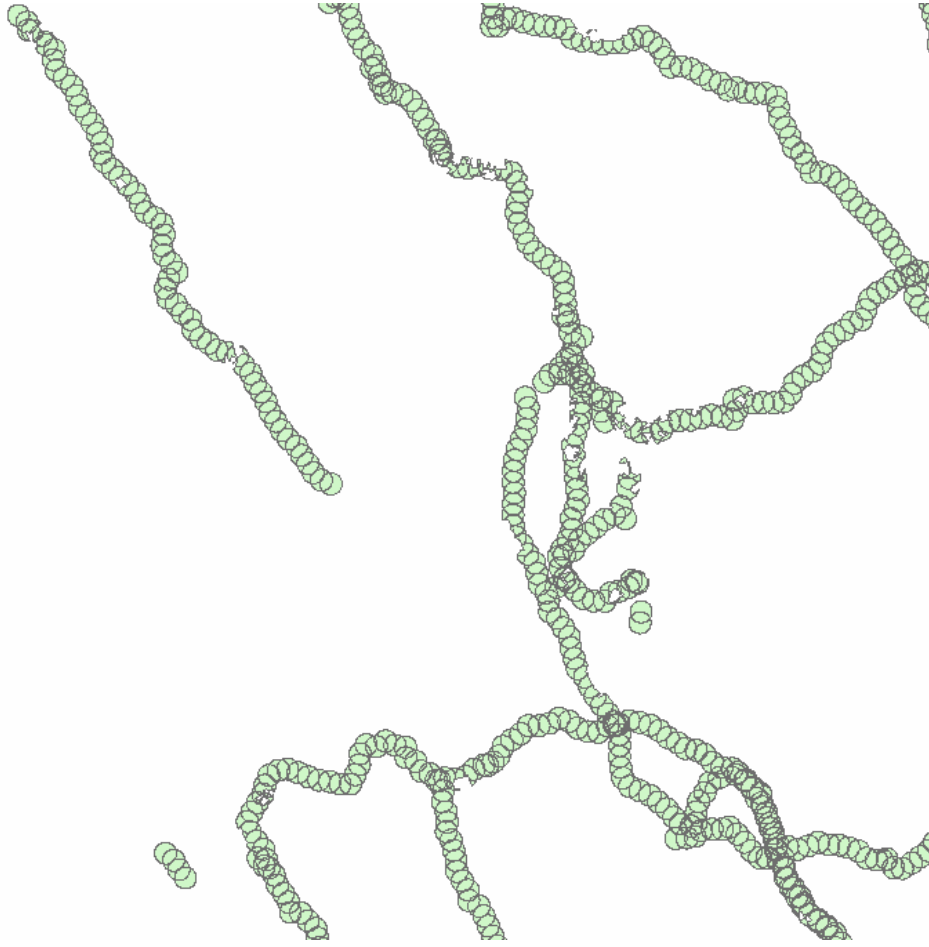
Step 6 – Quarter-mile buffers



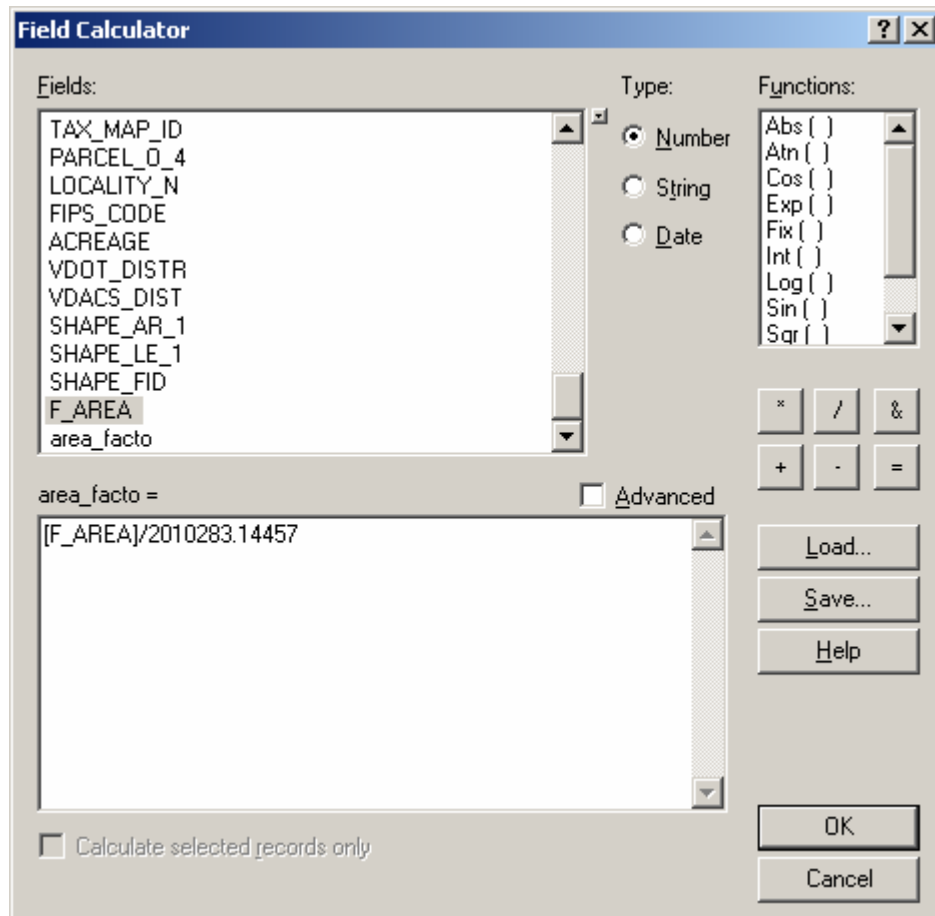
**Step 7: Conserved land shape files joined with “union” tool**



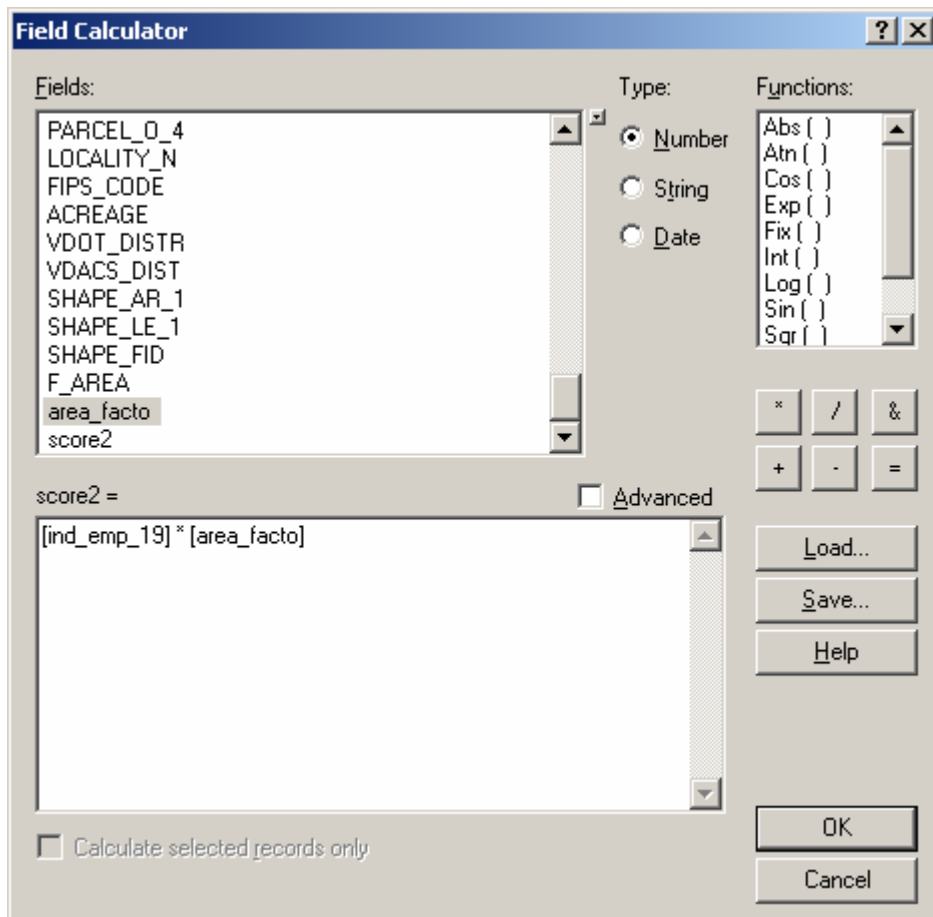
**Step 8: intersection of conserved land and buffers**



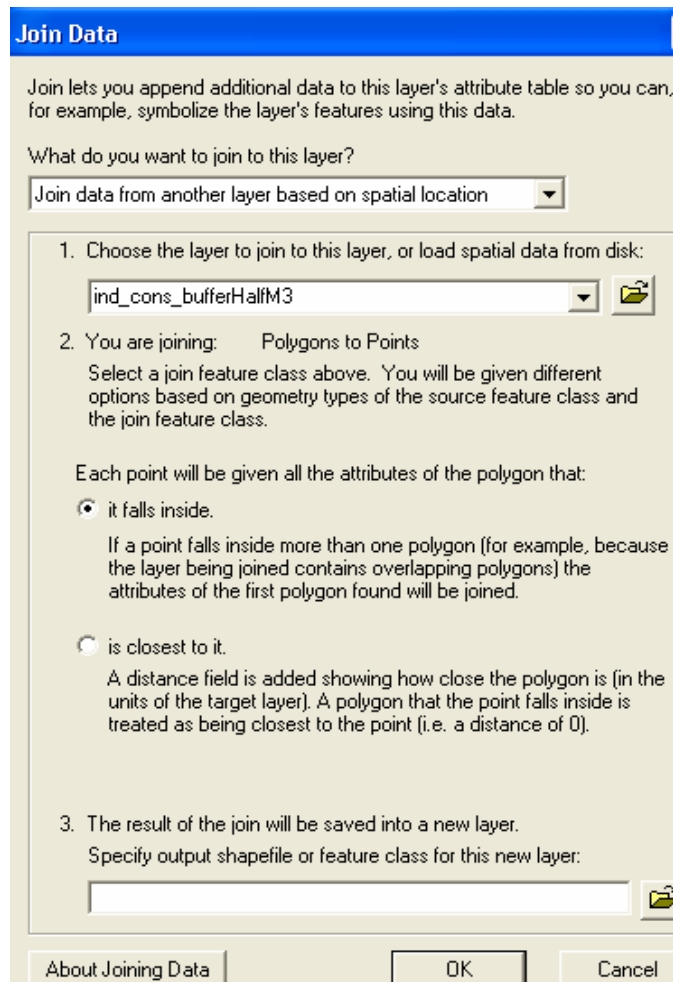
**Step 9: Result of “symmetrical difference” tool**



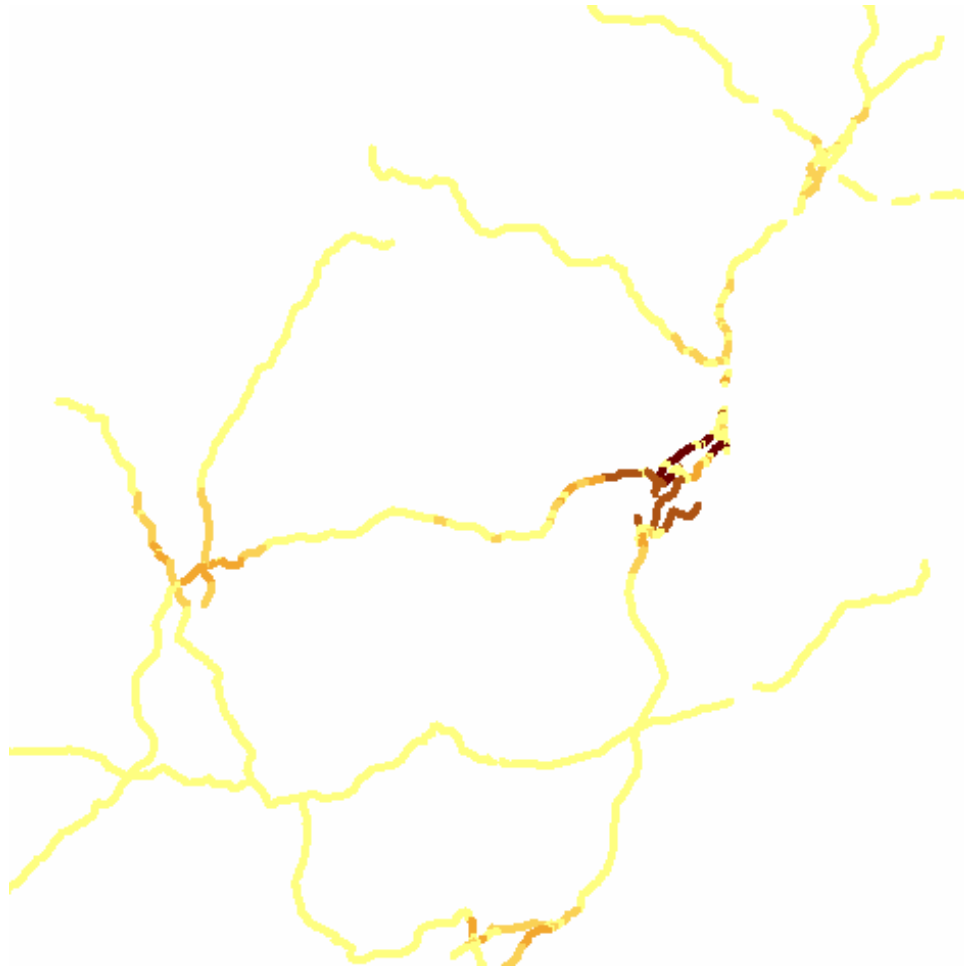
**Step 11: getting an area factor by dividing the area of the polygon by the total buffer area (numerical value is for half-mile buffer)**



**Step 12 – calculating buffer score**

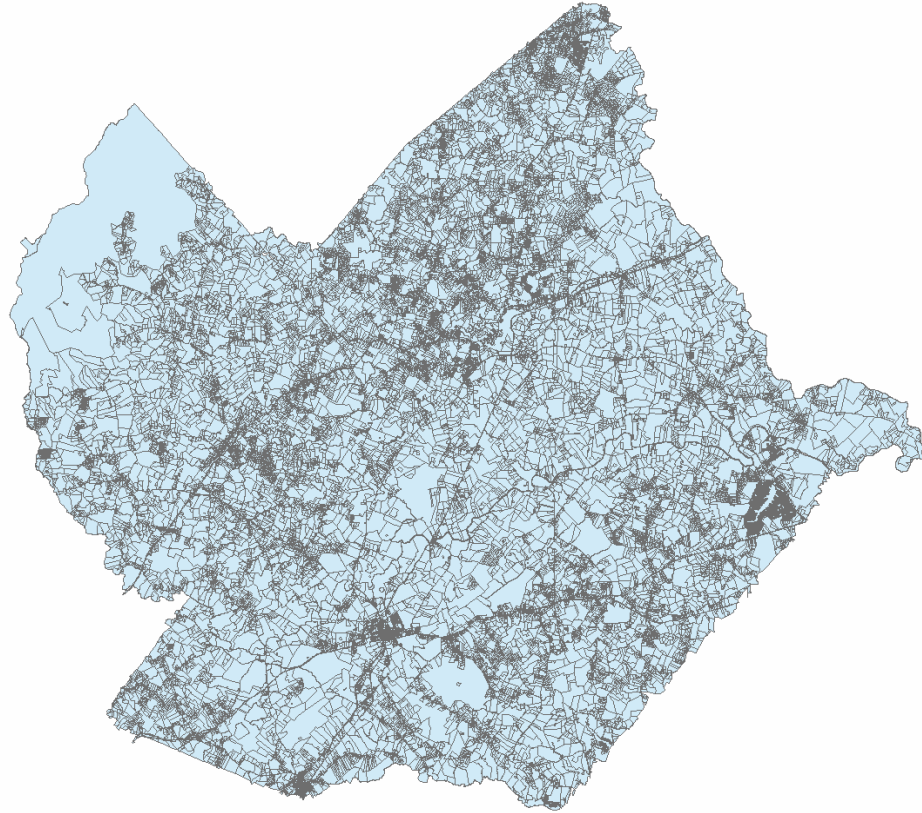


### Step 13: Join points with buffers to roads

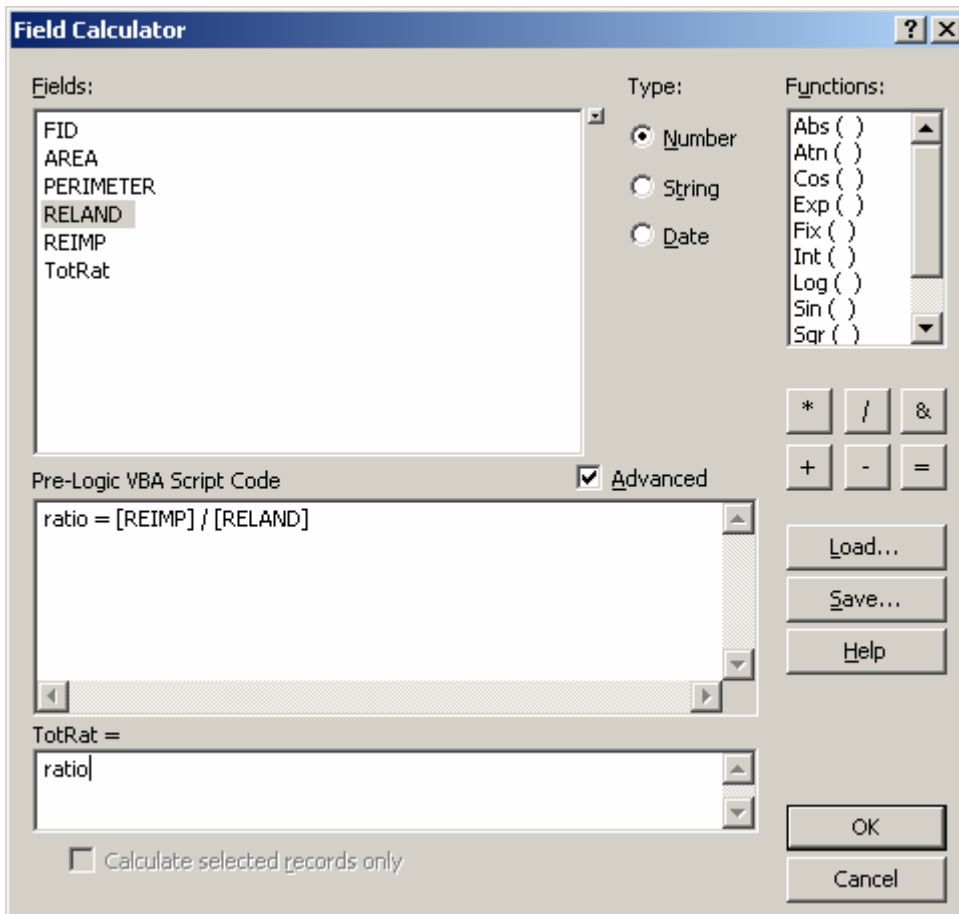


**Step 15: Example of the result of join with the layer symbology options and three quantiles**

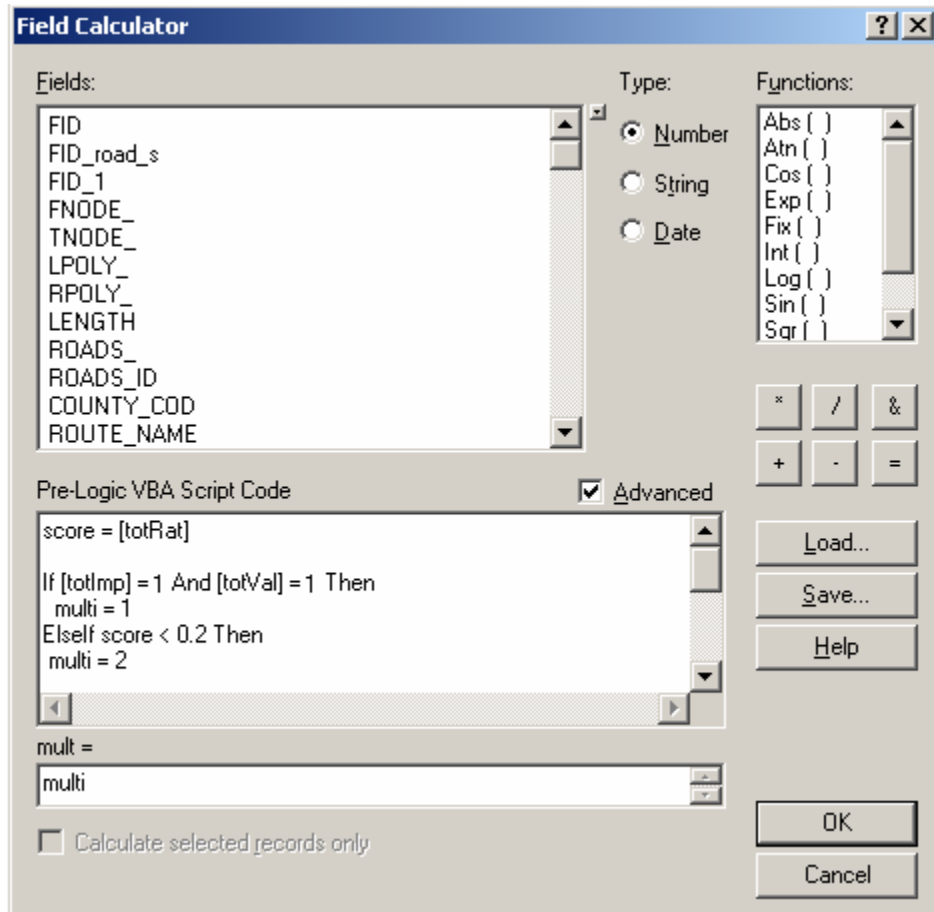
The scores were log normalized to better capture the scale of scores. (Right click on layer -> properties -> symbology tab-> click 'quantities' under 'show' -> choose overall score field and "<log" for normalization -> customize colors as desired



**Step 1 (*if using parcels*): Union of parcels**



**Step 2 (if using parcels): Ratio of Land Improvement Value to Land Value (note: REIMP = land improvement value, RELAND = Total Land Value)**

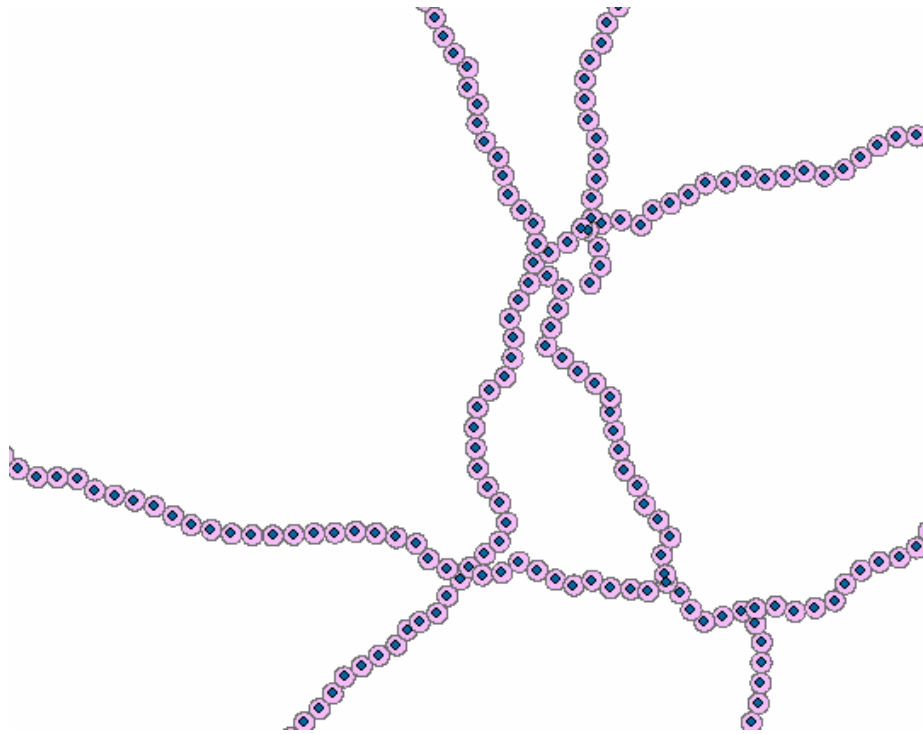


*CODE*

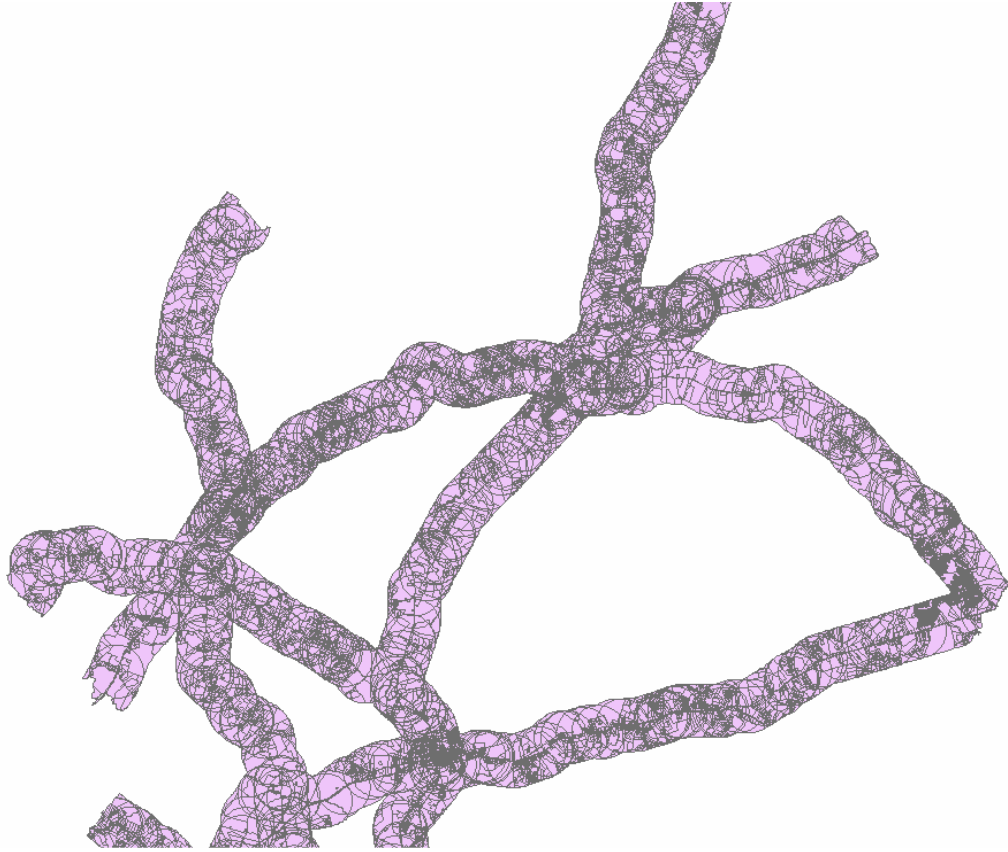
```
score = [totRat]
```

```
If [IMPRV] = 1 And [TOTLD] = 1 Then
    multi = 1
ElseIf score < 0.2 Then
    multi = 2
ElseIf score >= 0.2 And score < 0.9 Then
    multi = 1.5
ElseIf score >= 0.9 And score < 2 Then
    multi = 0.8
ElseIf score >= 2 And score < 3 Then
    multi = 0.6
ElseIf score >= 3 Then
    multi = 0.4
End If ]
```

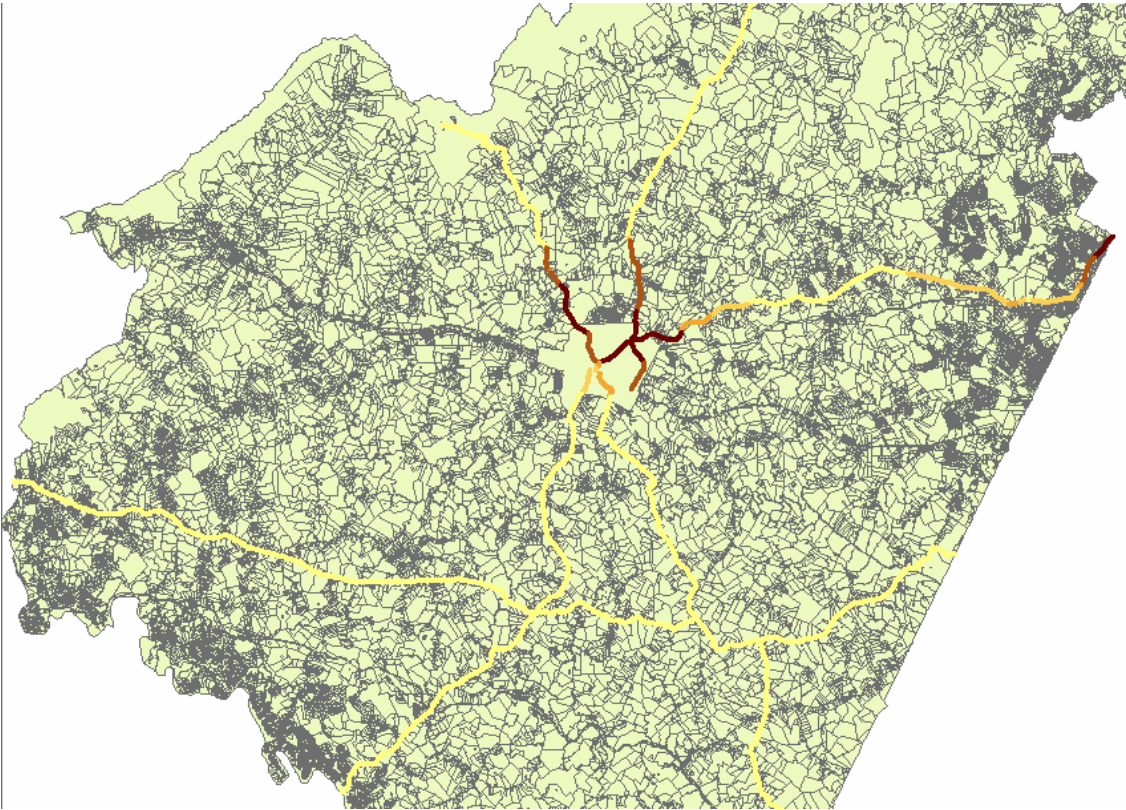
**Step 3 (if using parcels): Multiplier Fields**



**Step 3 (if using parcels): Buffer around road sections**



**Step 4 (if using parcels): Intersection of parcels and buffers**



**Step 5: Development risk indicated by the shade of red, the darkest shade indicating the highest development risks**

The scores were log normalized to better capture the scale of scores. (Right click on layer -> properties -> symbology tab-> click 'quantities' under 'show' -> choose overall score field and "<log" for normalization -> customize colors as desired