Using Indicator-Based Measures and Dispersion Modelling to Assess Air Pollution Risks from an Incinerator

Scenario:

It has been hypothesised that a new waste incinerator in the Kerrier area of Cornwall, UK is responsible for respiratory disease among neighbouring residents. The stack gas output from the incinerator is believed to contain carcinogenic pollutants such as arsenic, cadmium, dioxin, and PCBs. These pollutants have been linked to both lung cancer and larynx cancer. A recent study of a similar incinerator in Germany found that schoolchildren living within 25km of the incinerator had dioxin levels 1.7 times greater than the national average. Within 10km of the German incinerator, dioxin levels in the children's blood were 3 times the national average.

The potential risks from the new incinerator have received widespread media coverage. As a GIS analyst within the local borough council, you have been asked to evaluate the possible risks to residents, but so far no data have been forthcoming from the company that runs the incinerator, nor are atmospheric levels of any of the suspected carcinogens routinely monitored.

Data:

Incinerator: a Shape file that shows the location of the waste incinerator

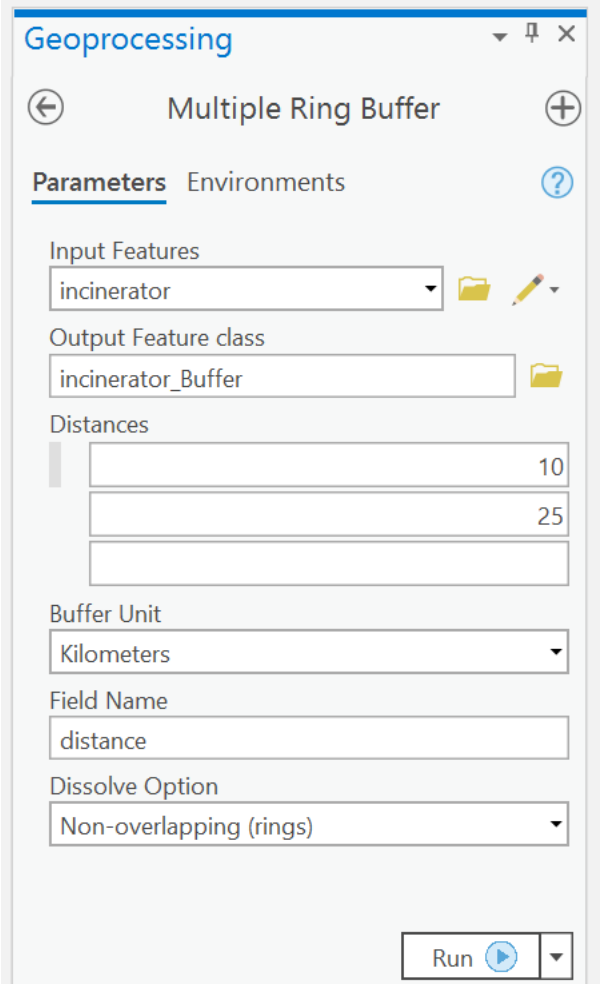
CornwallLSOApop: This contains mid-year estimates of the population in 2019, both for the total population (in the field **allages**) and for children under 16 years old (**childu16**). The file was created by downloading the Lower-level Super Output Area boundaries for the 2011 census from the Office for National Statistics' Open Geography Portal here: https://geoportal.statistics.gov.uk/datasets/lower-layer-super-output-areas-december-2011-boundaries-generalised-clipped-bgc-ew-v3?geometry=-16.049%2C50.522%2C11.703%2C55.161 . These boundaries were linked to the Office for National Statistics' population projections for each LSOA for 2019: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/lowersuperoutputareamidyearpopulationestimates

Note 1: Although the location of the incinerator and the air filter failure are fictitious, the overall background to the scenario is based on a real-life study in the Ribble Valley, UK (Diggle and Rowlinson, 1994).

Produce an indicator-based map of dioxin exposure

Task: Using the information provided above about potential risks to children, produce an indicator-based map of exposure to dioxins (e.g. using the *multiple ring buffer* command within *analysis tools* of the geoprocessing panel).

You should be able to produce such a buffer as shown below:



Calculate the total population at risk - overview

Now we need to calculate the total population at risk in our study area. This is slightly more complicated. If you look at the map that you just produced, you can see that the buffer zones around the incinerator dissect several of the census tracts. Within these tracts, some of the population live within the zone exposed to dioxins and the remainder

live outside the exposure zone. We are going to need to work out how many people live in the exposed sub-section of each census tract. Take a few moments to think about how you might do this, then look at a possible solution over the page.

The solution: how to find the population at risk

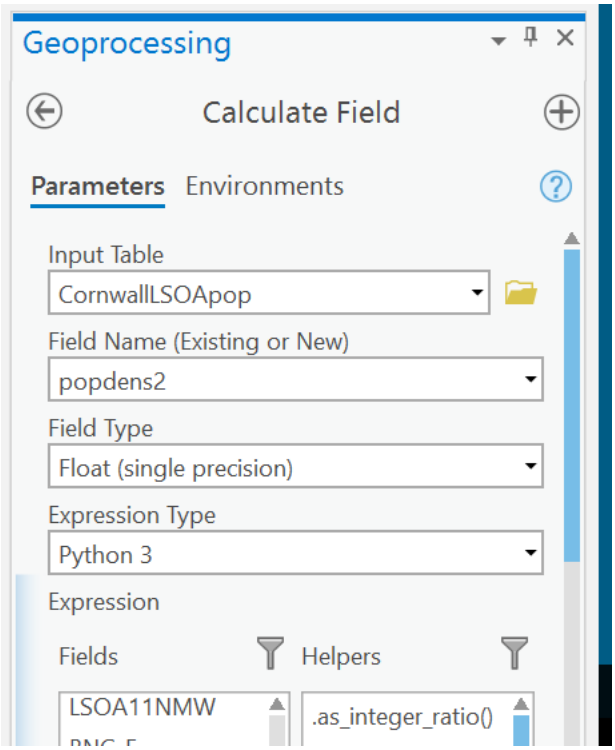
One way of solving this problem is to assume that the population density is the same everywhere in each census tract. Using this assumption, we can figure out the population at risk as follows:

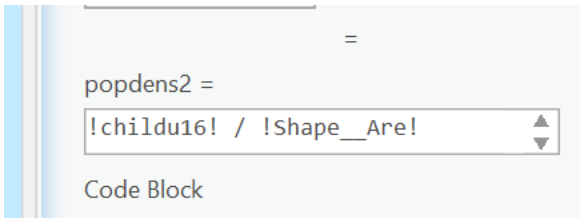
1. work out the population density for each tract
2. overlay the dioxin exposure zone map layer and the census tracts
3. Using population density, work out the total population in the exposed parts of the census tracts.
4. Add up the total population in the exposed zone

Working with population density

We can figure out the population density of each tract as follows:

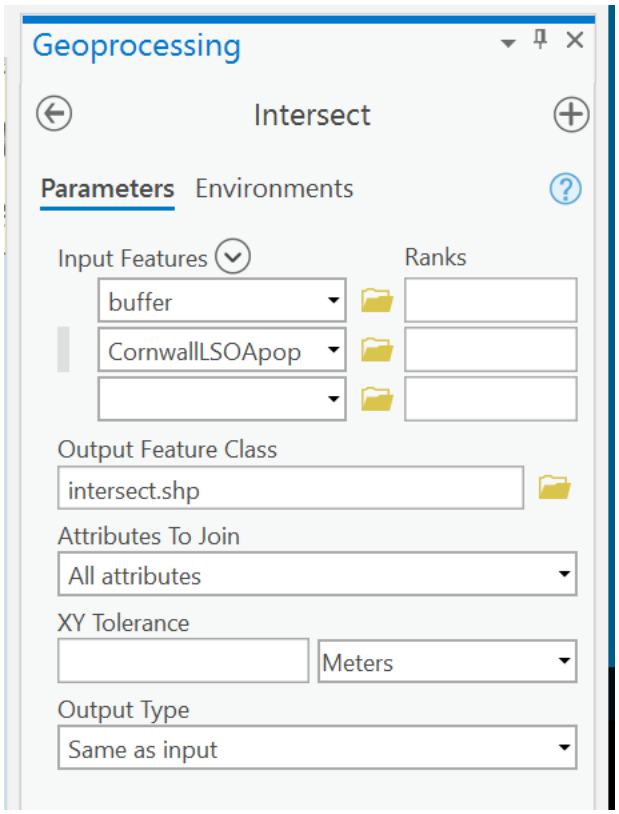
- Within ArcGIS Pro, head for the *Analysis* menu, then *tools,* then in the geoprocessing panel, search for *calculate field*.
- Use this tool to create a new field of type *float*, which contains the number of children under 16 years (in the field **childu16**) divided by the area of each LSOA (in **shape_are**). This is the density of children per m^2:





Overlay the exposure zone and census tracts

Using *intersect* in the *analysis tools* within *overlay,* combine your census tracts map layer with the map layer depicting dioxin exposure.:

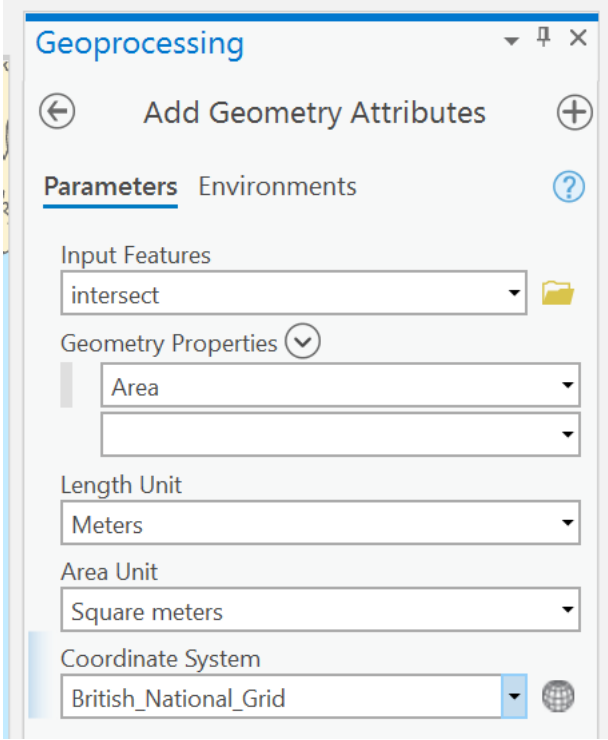


To finish the calculation:

- Add two new fields to your resultant map layer. In the first field, calculate the area of each new polygon that you have created. In the second field, work out the population in the polygon. You can do this by multiplying its area by its population density.
- Using the *Statistics* command (accessible by right-clicking on the field name at the top of your new population column of figures), you should be able to work out the

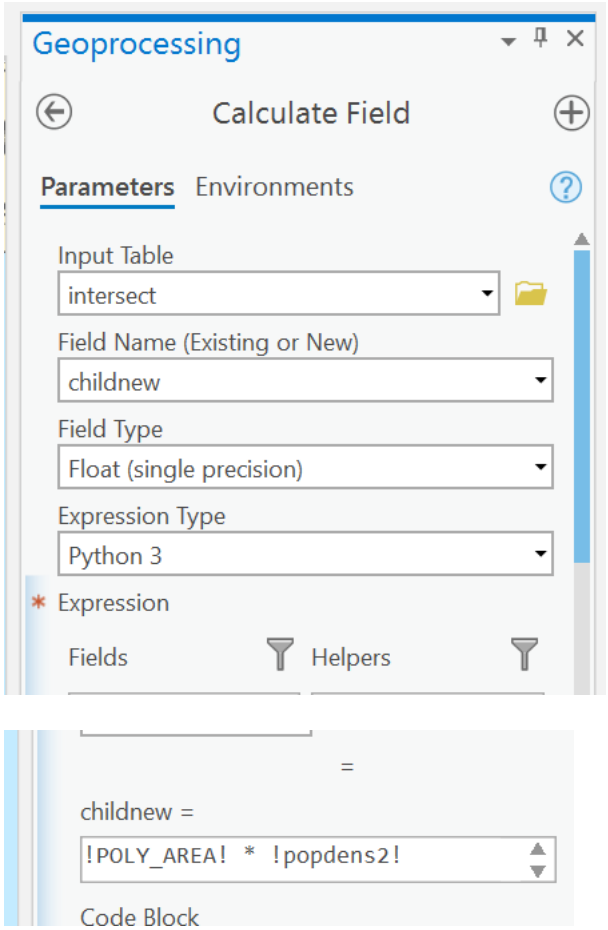
total number of people living in the exposed zone. The total population at risk will appear next to *sum* in the output from the *statistics* command.

If you created a new polygon feature layer within a geodatabase, then when that layer was created, there should automatically be updated areas for each polygon stored in a field called **shape_area**. However, if you created a shape file, you will first need to calculate the area of each new polygon created via *intersect* by running the *add geometry attributes* tool as follows:

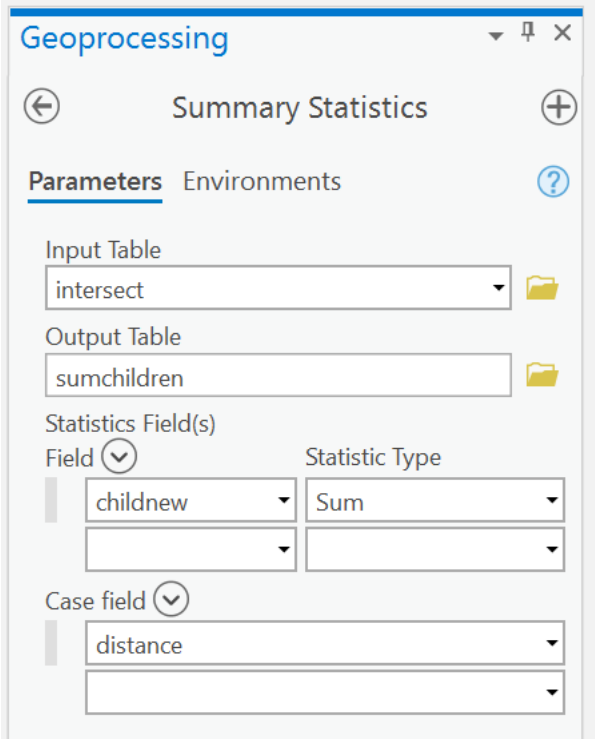


This will create a new field that contains the area of each intersected polygon in square metres. This step should only be necessary if you created a shape file with the intersect tool: it should not be necessary if you created a new layer within a geodatabase with intersect.

Finally, you should now be in a position to run the *calculate field* tool again to generate a new field of type *float* containing the number of children in each intersected polygon. You can estimate this number of children by multiplying the child density that you calculated earlier by each intersected polygon's area:



Finally, by drawing on this new field (I called it **childnew** in the screenshot above) the *summary statistics* tool can be used to create a new table that shows the total number of children living within each of the buffer zones:



All being well, your answer should look like this:

OBJECTID	distance	FREQUENCY	SUM_childnew
1	10	19	4934.304214
2	25	110	26630.90599