

Southeast Coast Network

National Park Service
Inventory and Monitoring Division



Standard Operating Procedure 1.2.01

Park-wide Assessment Spatially-Balanced Sampling Location Generation Using ArcGIS 10—Version 2.0

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Summary

This standard operating procedure (SOP) outlines the procedure used to generate spatially-balanced sampling points using ArcGIS 10. The ArcGIS tool uses a Reversed Randomized Quadrant-Recursive Raster (RRQRR) algorithm to generate sampling locations (Theobald et al. 2007), when the incorporation of pre-existing sampling locations is not necessary. This method produces sets of sampling locations that are compatible with those used by the EPA Coastal Assessment Program (Virginia Engle, EPA, pers. comm.). This SOP assumes the user has an intermediate skill level with ArcGIS.

Revision Log

Revision Date	Author	Changes Made	Reason for Change	New Version #
1/17/2013		Citation updated	Protocol publication	1.0
04/22/2021	C. S. Cooper	Revised to reflect the most recent version of Arc GIS. Updated procedures so sample points fall within intended sample frame. Updated GIS share drive pathways.	Changes to GIS software version, and SECN GIS share drive pathways. Original SOP did not place sample points within the intended sample frame (i.e., water).	2.0

Contents

	Page
Parkwide Assessment Activities and Workflow Summary	3
Required Software	4
Procedure	4
Setting Geoprocessing Environment	4
Create a Half Hectare Raster	5
Create a Half Hectare Shapefile	7
Create Land-masked half hectare shapefile.....	8
Create an Inclusion Probability Raster	11
Create Sampling Locations.....	13
Assigning Attributes to Point Features	14
Populating Location Attribute Fields	15
Populating Text Attribute Fields	16
Exporting the Attribute Table to Microsoft Excel.....	17
Cleanup Temporary Workspace	18
Literature Cited	18
Appendix A. Example Python Script for Text Attribute Fields.....	19

Parkwide Assessment Activities and Workflow Summary

An overview of parkwide assessment activities and workflow are presented in Figure 1. SOPs are presented left to right in the general order of operations for each activity. This SOP (1.2.01) pertains to the Pre-Departure activity.

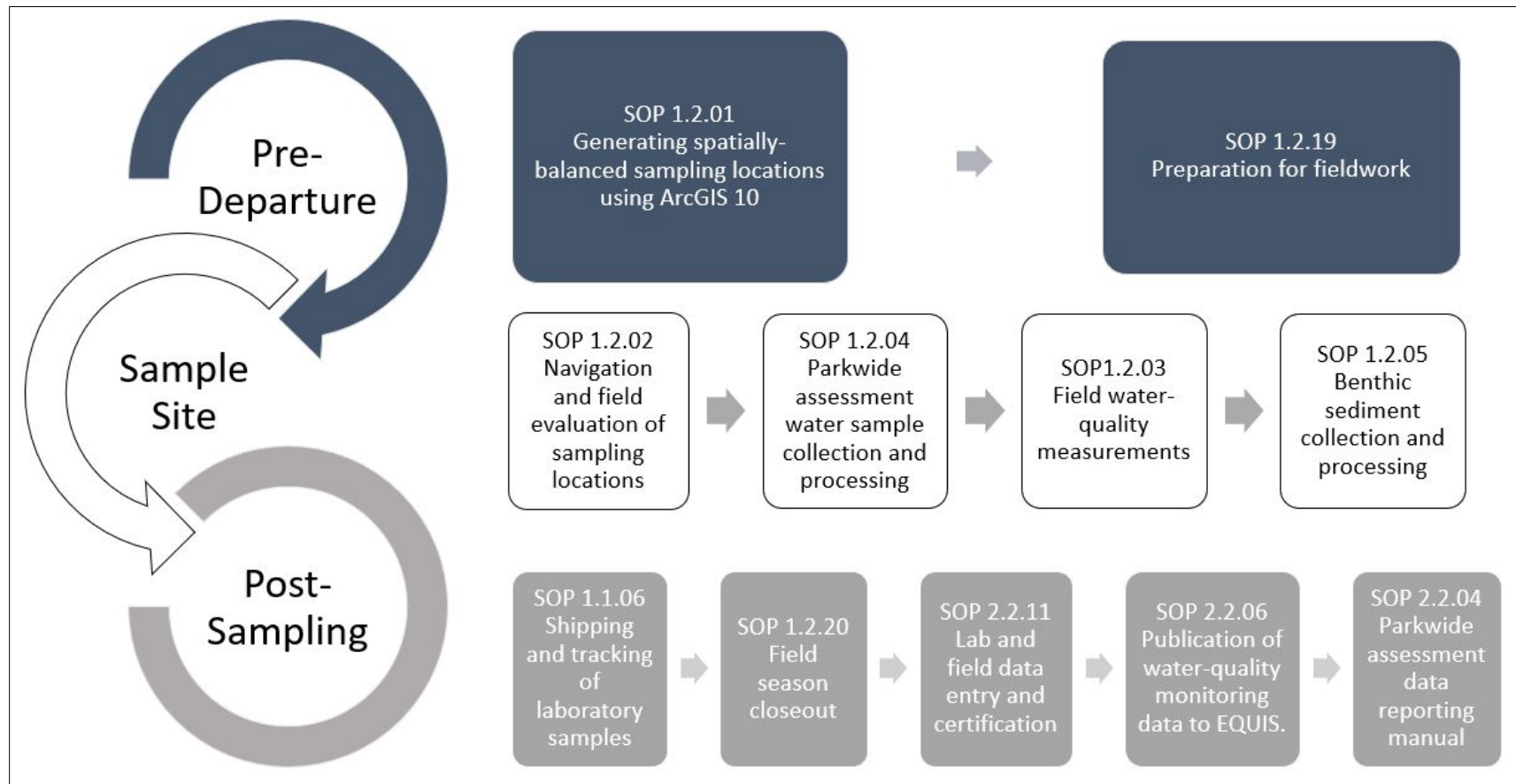


Figure 1. Parkwide assessment activities and workflow. SOPs are presented left to right in the general order of operations for each activity.

Required Software

- Code editor such as Notebook, Notebook++, or PythonWin
- Microsoft Excel
- ArcGIS 10.7 or above
 - Spatial Analyst License
 - Geostatistical Analyst License

Procedure

****NOTE:** Ensure all files used in this process are projected in the appropriate NAD 83 UTM Zone for the park (Figure 2).

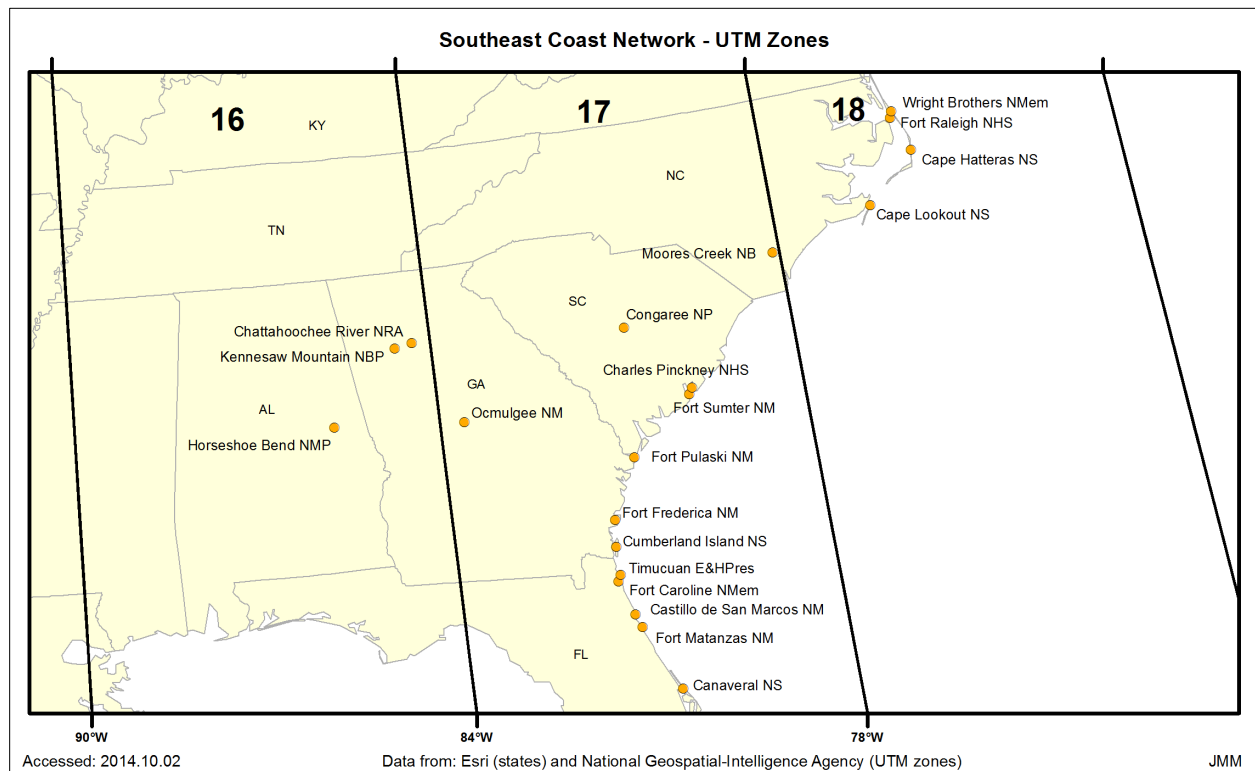


Figure 2. Map depicting locations of SECN park units within NAD 83 UTM Zones.

Setting Geoprocessing Environment

1. Open File Explorer and navigate to:
L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\EPA_design.

Where “PARK” is the four letter NPS unit code.

2. Create a new folder called “_temp”.
3. Open ArcMAP.
4. Adjust the Geoprocessing environment with the “Geoprocessing” dropdown menu > Environments (Figure 3). Set the workspace and scratch workspace to:
L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\EPA_design_temp.

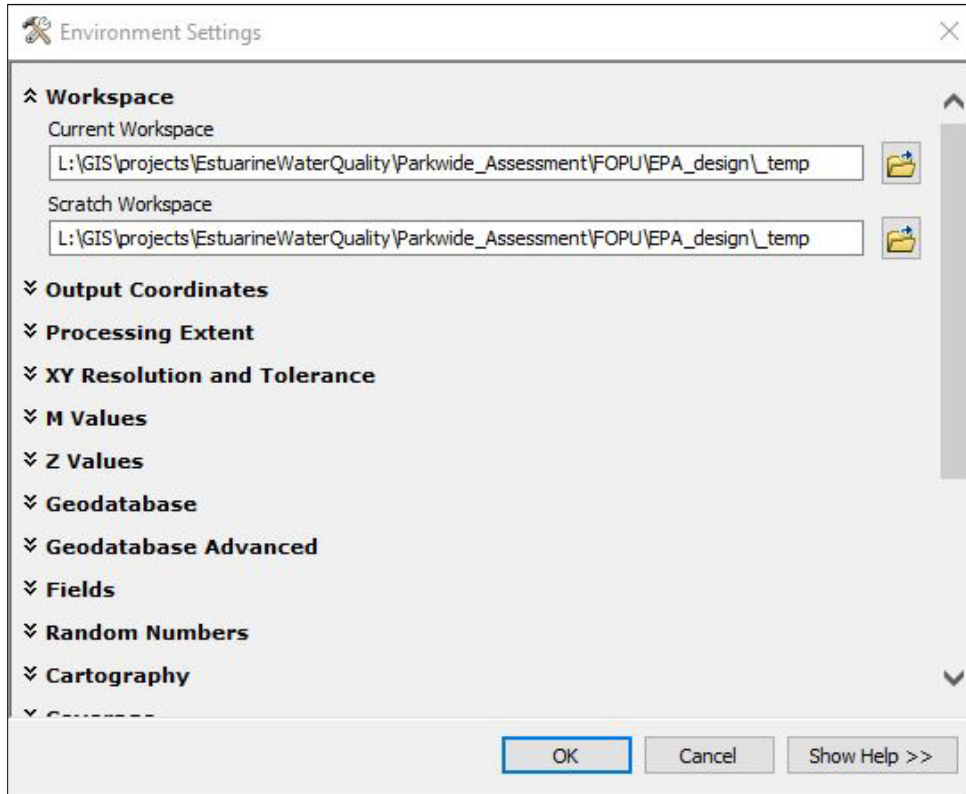


Figure 3. Geoprocessing environment options (workspace pathway uses “PARK” as FOPU for example).

Create a Half Hectare Raster

The following section provides the necessary procedures for creating a 0.5-hectare (1.2 acres) grid which encompasses the entirety of the park unit.

1. Using the Catalog window in ArcMap, navigate to the EPA sample frame boundary and add PARK_Poly.shp to the Table of Contents. Appropriate boundary files can be found at:
L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\EPA_design\PARK_Poly.shp.
2. Ensure that the boundary shapefile is projected to the appropriate NAD 83 UTM Zone (Figure 2).
3. Right click the park boundary layer and click “Zoom to Layer.”

4. Check to make sure the “Spatial Analyst” extension is enabled (Customize> Extensions> Spatial Analyst).
5. Open the “Create Random Raster” Tool (ArcToolbox > Spatial Analyst Tools > Raster Creation > Create Random Raster).
6. Populate the tool fields as follows (Figure 4):
 - a. Output raster: Name your file PARKras_05ha (will automatically be saved to the Workspace folder specified in geoprocessing environments).
 - b. Output cell size: 70.7106781 (cell size for a half hectare).
 - c. Output extent: Leave as the default.

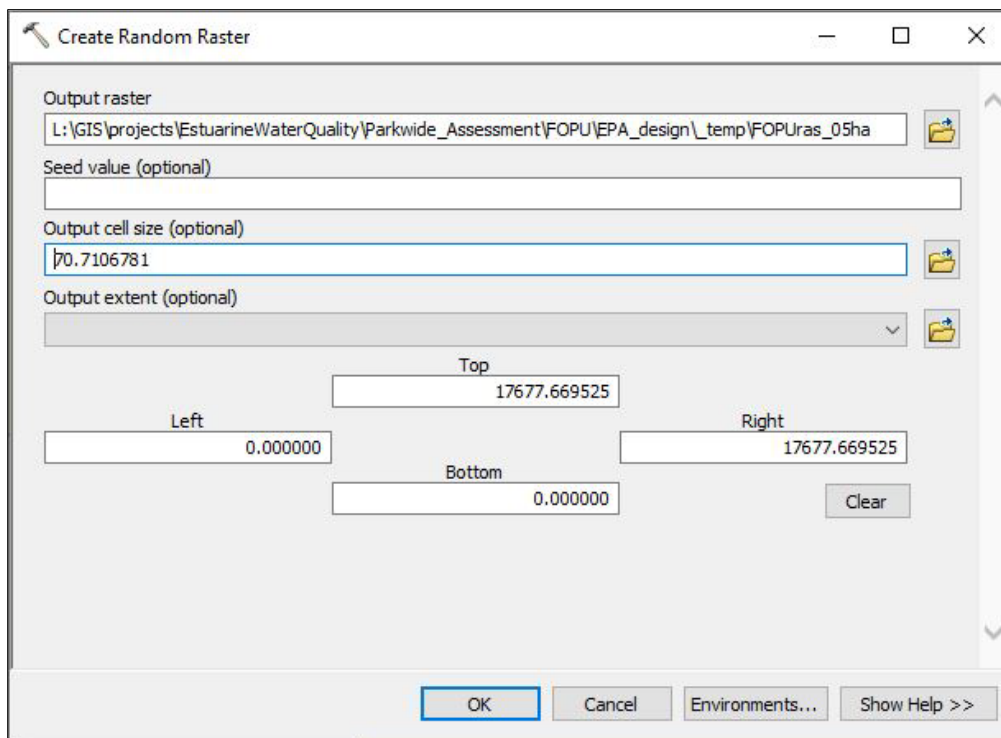


Figure 4. Create Random Raster options.

7. Click “Environments”
 - a. In the “Output Coordinates” drop down, change “Output Coordinate System” to “Same as Layer PARK_Poly”.
 - b. In the “Processing Extent” drop down, change “Extent” to “Same as Display”.
 - c. Leave “Snap Raster” blank.
8. Click “OK” in both the “Environment Settings” and “Create Random Raster” windows.

Create a Half Hectare Shapefile

1. Add the PARKras05ha raster created in the previous section and the PARK_Poly boundary shapefile, if not already in the project from the previous section.
2. Adjust Geoprocessing environment with the “Geoprocessing” dropdown menu > Environments. In the “Processing Extent” menu change the “Extent” to “Same as layer PARKras_05ha”.
3. Open the “Create Fishnet” Tool (ArcToolbox > Data Management Tools > Sampling > Create Fishnet).
4. Populate the tool fields as follows (Figure 5):
 - a. Output feature class: grid_temp (this file can be discarded at the end)
 - b. Template extent: PARK_Poly.shp
 - c. Cell Size Width: 70.7106781
 - d. Cell Size Height: 70.7106781
 - e. Number of Rows: 0
 - f. Number of Columns: 0
 - g. Uncheck the “Create Label Points” box
 - h. Geometry Type: Polygon

Create Fishnet

Output Feature Class
 L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\FOPU\EPA_design_temp\grid_temp.shp

Template Extent (optional)
 L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\FOPU\EPA_design\FOPU_Poly.shp

Left: 498579.569092 Top: 3550392.408032 Right: 512359.449739
 Bottom: 3538085.661884 Clear

Fishnet Origin Coordinate
 X Coordinate: 497890.5750592672 Y Coordinate: 3536189.963497586

Y-Axis Coordinate
 X Coordinate: 497890.5750592672 Y Coordinate: 3536199.963497586

Cell Size Width: 70.7106781
 Cell Size Height: 70.7106781

Number of Rows: 0
 Number of Columns: 0

Opposite corner of Fishnet (optional)
 X Coordinate: 513022.6601726671 Y Coordinate: 3552311.998104386

☐ Create Label Points (optional)

Geometry Type (optional): POLYGON

OK Cancel Environments... Show Help >>

Figure 5. Create Fishnet options.

5. Click “OK”
6. The resulting polygon is added to the project and should align with the PARKras_05ha raster.

Create Land-masked half hectare shapefile

1. This section provides instructions to isolate water bodies within the PARK_Poly.shp boundary feature. Doing so will greatly reduce the number of points generated that are located within mixed or land pixels. Add the PARK_Poly.shp boundary feature to the “Table of Contents” (if it is not already there).
2. In the “Catalog” window, navigate to the PARK_waters.shp shapefile located at:
 L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\EPA_design\PARK_waters.shp and add it to the “Table of Contents.”

3. Make sure that PARK_waters.shp is projected in the appropriate NAD83 UTM Zone.
4. Open the “Union” Tool (ArcToolbox > Analysis Tools > Overlay > Union).
5. Populate the tool fields as follows: (Figure 6).
 - a. Input Features: from the dropdown menu add layers PARK_Poly and PARK_waters
 - b. Output Feature Class: Navigate to your _temp folder and name the output PARK_union
 - c. Join Attributes: leave as default (ALL)
 - d. XY Tolerance: leave as default (blank)
 - e. Gaps Allowed: leave checked

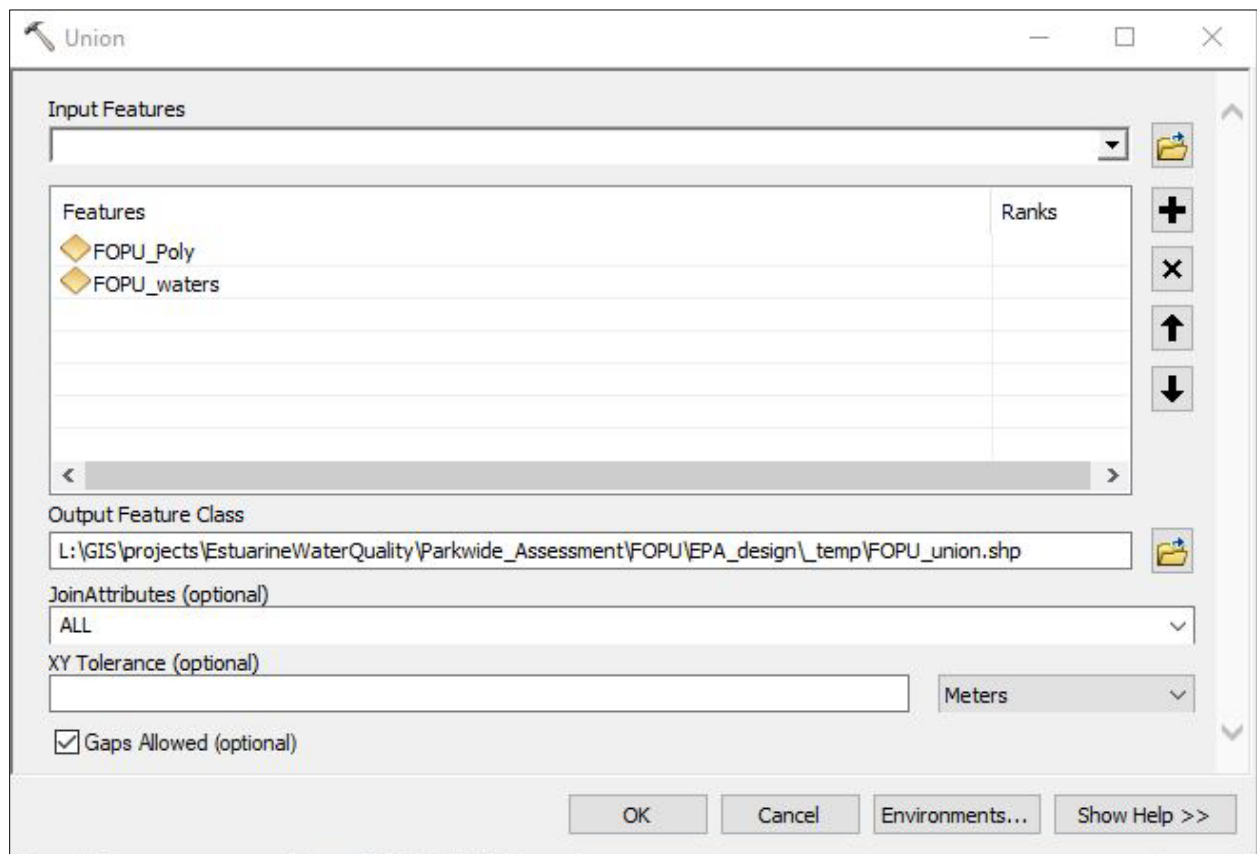


Figure 6. Union options window

6. Click “OK”
7. In the “Table of Contents”, right-click on the PARK_Poly layer and click “Zoom to Layer”. You should now be focused on the PARK_union layer, but in the vicinity of the PARK_Poly layer.

8. In the “Table of Contents” turn off all layers except for the newly created PARK_union layer.
9. In the toolbar click on the “Select Features” icon 
10. Click on a polygon that represents a body of water within the PARK_union layer, which falls inside the PARK_Poly boundary (e.g. an estuary, not the open ocean). Only water bodies that fall within the boundary of the PARK_Poly layer should be highlighted.
11. In the “Table of Contents”, right click on the PARK_union layer and choose “Data”, then “Export Data”
12. Populate the tool fields as follows (Figure 7):
 - a. Export: Selected Features
 - b. Use the same coordinate system as: default (this layer’s source data)
 - c. Output feature class: navigate to your _temp folder and name the file grid_clip.shp
 - d. Click “OK” and add the layer to the “Table of Contents”
 - e. You should now have a shapefile of polygons that ONLY represent waterbodies within the extent of the PARK_Poly layer

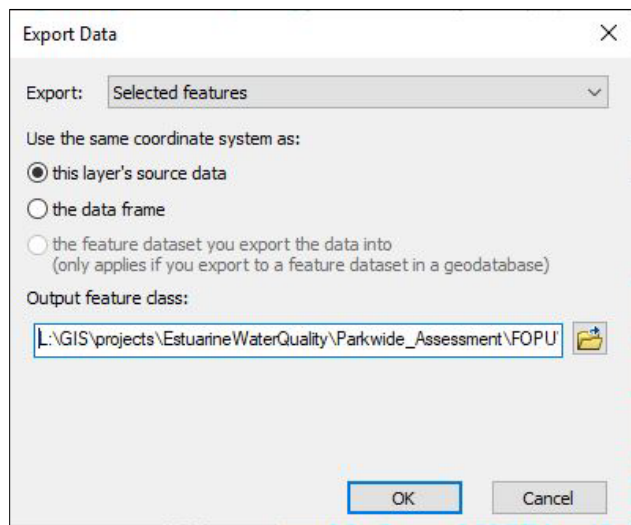


Figure 7. Export Data options

13. Open the “Clip” Tool (ArcToolbox > Analysis Tools > Extract > Clip)
14. Populate the tool fields as follows (Figure 8):
 - a. Input Features: grid_temp
 - b. Clip Features: grid_clip.shp

- c. Output Feature Class: PARKgrid_05ha.shp
- d. Click OK.

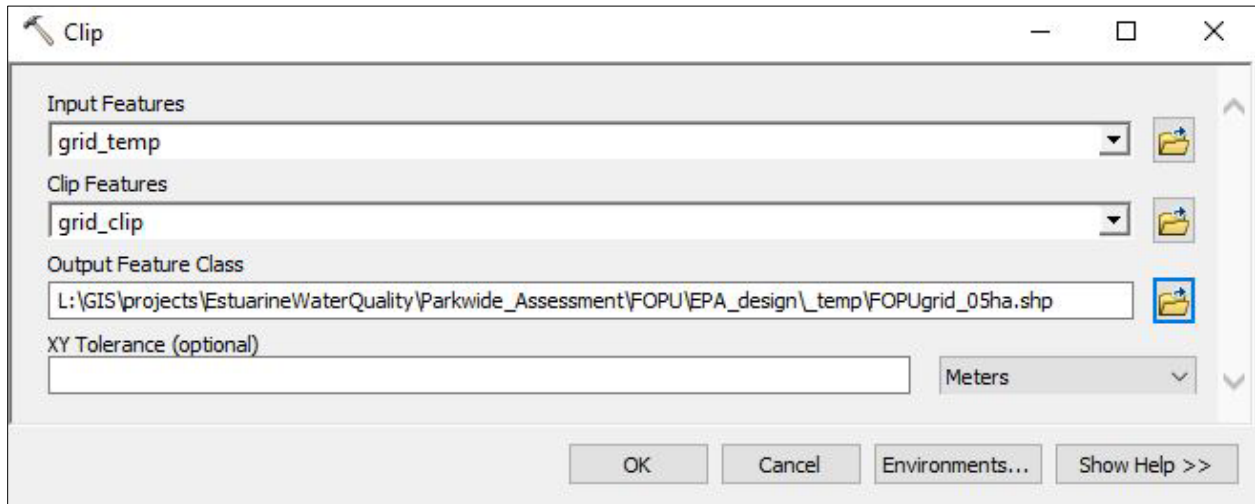


Figure 8. Clip options.

Create an Inclusion Probability Raster

1. Add PARKgrid_05ha.shp and the raster file PARKKras_05ha, created in the previous sections, to the project. These files delineate the sampling frame.
2. Convert PARKgrid_05ha.shp to a raster (ArcToolbox > Conversion Tools > To Raster>Polygon to Raster).
3. Populate the tool fields as follows (Figure 9):
 - a. Input field: choose PARKgrid_05ha from dropdown menu
 - b. Value Field: leave as default (FID)
 - c. Output raster dataset: navigate to _temp folder and name file temp_ras
 - d. Cell Center Assignment Type: leave as default (CELL_CENTER)
 - e. Priority Field: leave as default (NONE)
 - f. Cell size: 70.7106781 (same as PARKKras_05ha raster)

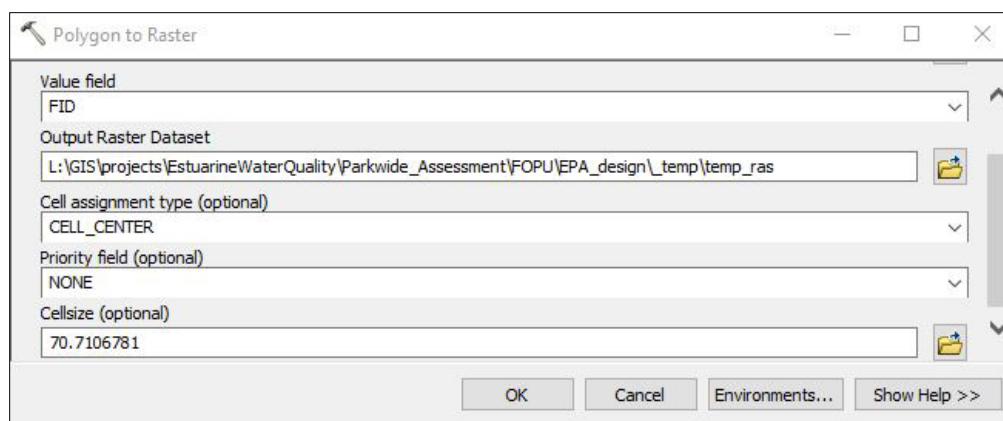


Figure 9. Feature to Raster options.

- g. Click “Environments” (Figure 3).
- i. In the “Processing Extent” dropdown identify PARKras_05ha as the Output Extent, and PARKras_05ha as the Snap raster (Figure 10).

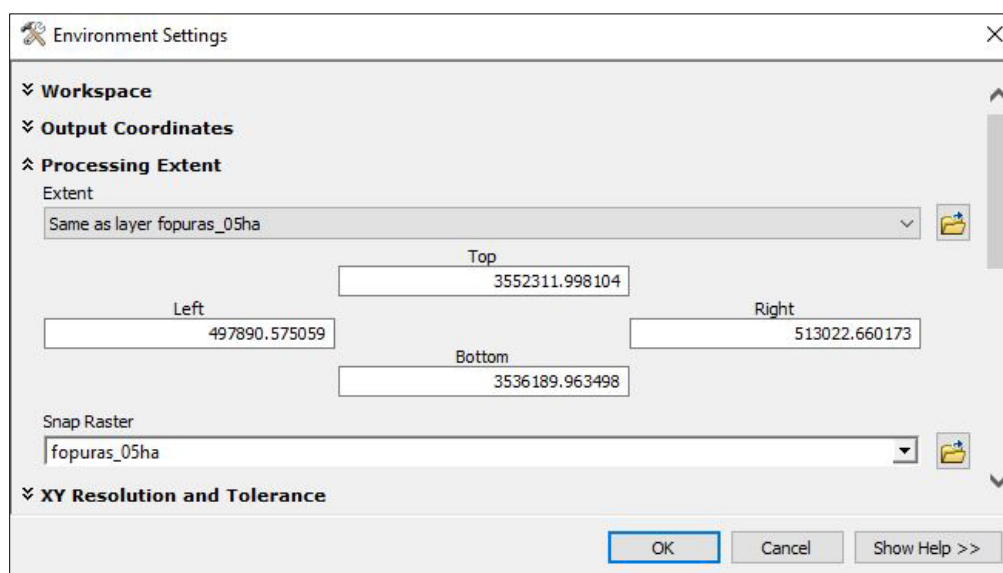


Figure 10. Environment Settings in Feature to Raster options.

4. Click “OK” in both the “Environment Setting” and “Polygon to Raster” windows.
5. The new raster file is added to the project view automatically. In this new raster file, the cell values must be edited to the target inclusion probability used for the sampling design (i.e., inclusion probability = 1).
6. Check to make sure that the “Spatial Analyst” extension is enabled (Customize> Extensions> Spatial Analyst).

- Open the Raster Calculator (ArcToolbox > Spatial Analyst Tools > Map Algebra > Raster Calculator). Enter the expression: “**temp_ras**”*0+1 into the calculator (including quotes; see Figure 11). Note: “temp_ras” is the raster dataset created in step 4 and names are case sensitive. Change the output raster name to incprob1_PARK (e.g., incprob1_FOPU), press OK (Figure 11).
- The raster is automatically added to the project view. Ensure all values of this file are equal to one (i.e., inclusion probability of 100%). Because the inclusion probability of all of the raster cells is equal, the attribute table will only consist of one row. Right click on ‘incprob1_PARK’ in the table of contents > Open Attribute Table.

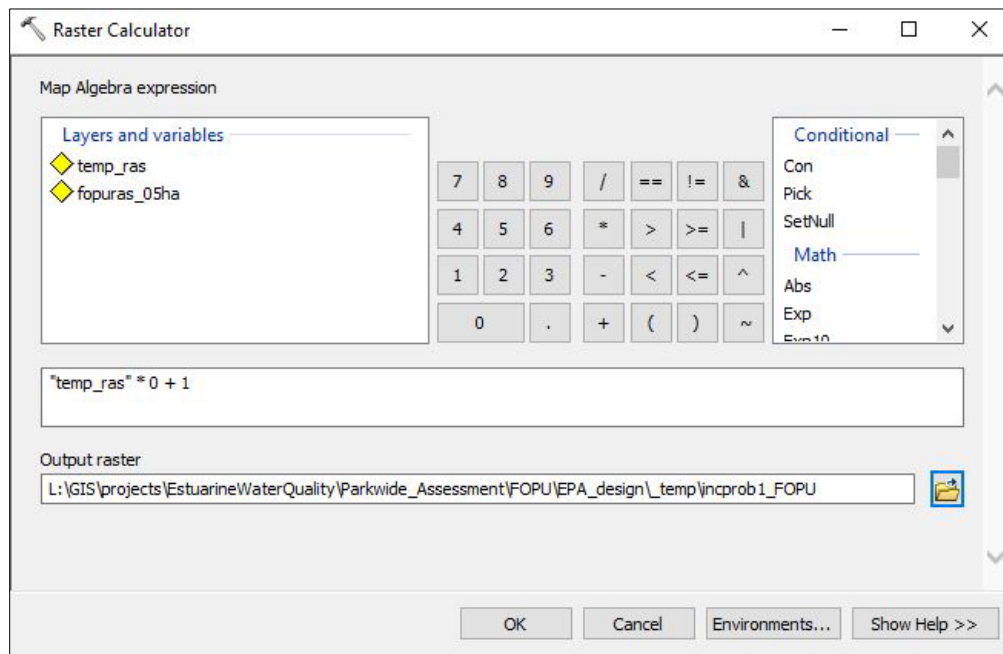


Figure 11. Raster Calculator settings.

Create Sampling Locations

- Ensure that the “Geostatistical Analyst” extension is enabled (Customize> Extensions> Geostatistical Analyst).
- Open the “Create Spatially Balance Points” Tool (ArcToolbox > Geostatistical Analyst Tools > Sampling Network Design > Create Spatially Balanced Points; Figure 12).
- Select the incprob1_PARK raster (created in the previous section) for the “Input inclusion probability raster.”
- Identify how many sites to select. For SECN Park-wide Assessments, this will be 60.
- Navigate to the appropriate output file at
\\INPSECNS01\GIS\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\EPA_design\cycleX_psd_points_YEAR, where PARK is the appropriate park acronym, X is the

appropriate EPA cycle number and YEAR is the year of the planned Parkwide Assessment. See the SECN share drive L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment

6. Name the file PARK_allpts_YEAR.shp, where YEAR is the year of the planned Parkwide Assessment.
7. Click “OK.”
8. The new points (i.e., sampling locations) are automatically added to the project view.
9. Remove all shapefiles from the table of contents except for PARK_allpts_YEAR.shp.

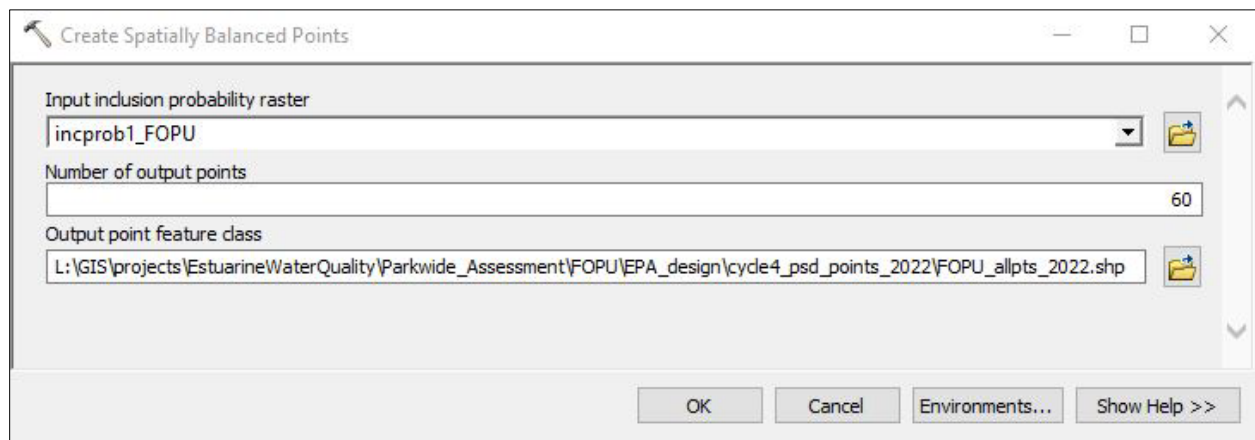


Figure 12. Create Spatially Balanced Points options.

Assigning Attributes to Point Features

1. Right-click on PARK_allpts_YEAR.shp and choose “Open Attribute Table”.
2. Click on the Table Options Icon  and choose “Add Field. . .” (“Add Field” will be used to add each of the below attributes).
3. Name: SITEID; Type: Text; Length: 18
4. Name: XCOORD; Type: Double; Precision: 18; Scale:11
5. Name: YCOORD; Type: Double; Precision: 18; Scale:11
6. Name: SITE_TYPE; Type: Text; Length:12
7. Name: LONGDD; Type: Double; Precision: 18; Scale: 8
8. Name: LATDD; Type: Double; Precision: 18; Scale: 8
9. Name: Name; Type: Text; Length: 6

- Right-click on the “InclProb” field header and choose “Delete Field.” This will prompt a warning, click “OK”. You should now see an attribute table containing each field that was added, but only the fields “FID” and “Shape*” should be populated (Figure 13).

FID	Shape *	SITEID	XCOORD	YCOORD	SITE_TYPE	LONGDD	LATDD	Name
0	Point		0	0		0	0	
1	Point		0	0		0	0	
2	Point		0	0		0	0	
3	Point		0	0		0	0	
4	Point		0	0		0	0	
5	Point		0	0		0	0	
6	Point		0	0		0	0	
7	Point		0	0		0	0	
8	Point		0	0		0	0	
9	Point		0	0		0	0	
10	Point		0	0		0	0	
11	Point		0	0		0	0	
12	Point		0	0		0	0	
13	Point		0	0		0	0	
14	Point		0	0		0	0	
15	Point		0	0		0	0	
16	Point		0	0		0	0	
17	Point		0	0		0	0	
18	Point		0	0		0	0	
19	Point		0	0		0	0	
20	Point		0	0		0	0	

Figure 13. Example of unpopulated attribute table.

Populating Location Attribute Fields

- Right-click on the XCOORD field header and choose “Calculate Geometry. . .” (Figure 14).
- Property: X Coordinate of Point
- Coordinate System: Choose “Use coordinate system of the data source” (should be PCS: NAD 1983 UTM Zone XXN where “XX” is the appropriate UTM Zone number)
- Units: Meters [m]
- Repeat steps one through four for the YCOORD field, but change “Property” to “Y Coordinate of Point.”
- Repeat steps one through four for the LONGDD field, but change “Property” to “X Coordinate of Point” and “Units” to Decimal Degrees.
- Repeat steps one through four for the LATDD field, but change “Property” to “Y Coordinate of Point” and “Units” to Decimal Degrees.

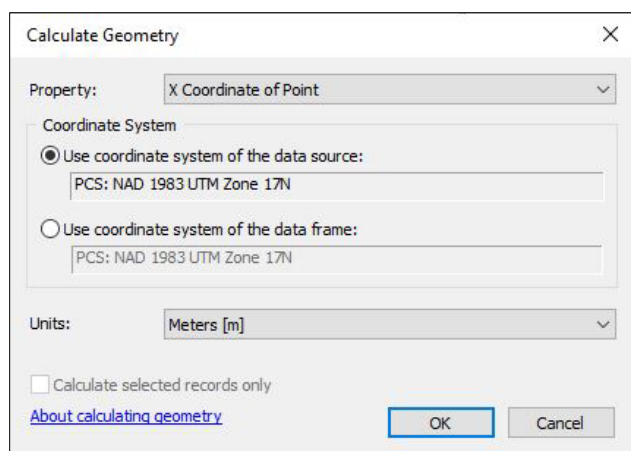


Figure 14. Calculate Geometry options.

Populating Text Attribute Fields

1. In your file explorer navigate to
`\\INPSECNS01\GIS\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\Archive_EP
A_probable_sample_draw_scripts` and right click on `Parkwide_Assessment.py` and open the
file with an appropriate code editor (e.g. Notepad, Notepad++, Pythonwin). See example in
Appendix A. The three blocks of code will be used to populate the remaining text fields.
2. In the attribute table, right-click on the SITEID field header and select “Field Calculator”
(Figure 15).
3. Set “Parser” to Python and check the “Show Codeblock” box.
4. Copy and paste the first block of code (lines 5-13) into the “Pre-Logic Script Code” box.
5. Be sure to change any instance of “PARK” to the proper four-letter park unit code.
6. Copy and paste the expression: `Reclass(!SITEID!, !FID!)` from line 3 into the “SITEID=”
box.
7. Click “OK.”
8. In the attribute table, right-click on the SITE_TYPE field header and select “Field
Calculator.”
9. Press “Clear” to remove the previous code-block.
10. Repeat steps 4 through 7 using the second block of code and expression provided in
`Parkwide_Assessment.py` (use line 17 of code in place of line 3 in step 6) making sure that
“Parser” is still set to Python (it will change without being prompted from time to time).
11. In the attribute table, right-click on the Name field header and select “Field Calculator.”

12. Press “Clear” to remove the previous code-block.
13. Repeat steps 4 through 7 using the third block of code and expression provided in Parkwide_Assessment.py
14. Check your completed attribute table for any possible mistakes before proceeding.

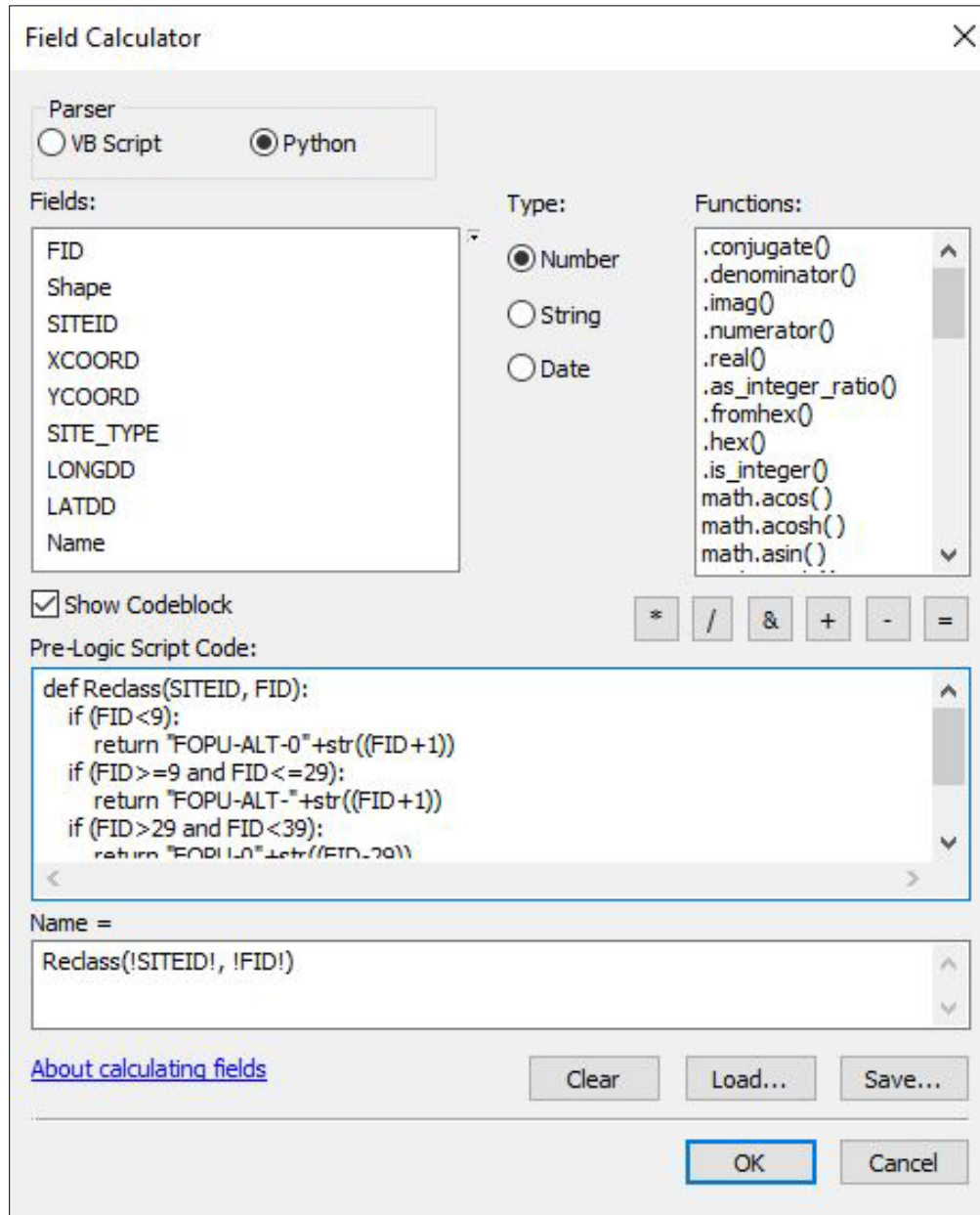


Figure 15. Field Calculator properly set to execute SITEID reclass.

Exporting the Attribute Table to Microsoft Excel

1. Click on the Table Options Icon  and choose “Export. . .”

2. Set “Export” to “All Records” and save the output table to
\\INPSECNS01\GIS\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\YEAR\data\
3. Name the table PARK_allPts_year.dbf. You can save as .dbf by simply typing that onto the end of the file name, or by selecting type “dBASE Table” from the “Save as Type” dropdown menu.
4. Close ArcMAP and open Microsoft Excel.
5. In Excel, choose File> Open and navigate to the location of the newly created .dbf table.
(\\INPSECNS01\GIS\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\YEAR\data\PARK_allSites_YEAR.dbf)
6. Open the PARK_allPts_YEAR.dbf keeping in mind that you may have to change the file type to “All Files (*.*)” or “dBASE Files (*.dbf)” in order for it to be visible.
7. Once the dBASE table is open, choose File> Save As and navigate to the same folder that the dBASE Table is placed in.
(L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\YEAR\data\)
8. Delete “.dbf” out of the file name and be sure to save as type .xlsx. The file should be named PARK_allPts_YEAR.xlsx

Cleanup Temporary Workspace

Remove the _temp folder created as a temporary workspace. The files in this folder are no longer needed.

(i.e., L:\GIS\projects\EstuarineWaterQuality\Parkwide_Assessment\PARK\EPA_design_temp)

Literature Cited

Theobald, D. M., D. Stevens, D. White, N. Urquhart, A. Olsen, J. Norman. 2007. Using GIS to generate spatially-balanced random survey designs for natural resource applications. Environmental Management 40(1):134-146.

Appendix A. Example Python Script for Text Attribute Fields

```
1  #The below script is designed to populate the "SITEID" field based on "FID" for SECN Parkwide Assessments.
2  #"PARK" in the below code represents the four-letter park code for a given SECN park unit.
3  #Copy and paste into expression window: Reclass(!SITEID!, !FID!)
4
5  def Reclass(SITEID, FID):
6      if (FID<9):
7          return "PARK-ALT-0"+str((FID+1))
8      if (FID>=9 and FID<=29):
9          return "PARK-ALT-"+str((FID+1))
10     if (FID>29 and FID<39):
11         return "PARK-0"+str((FID-29))
12     else:
13         return "PARK-"+str((FID-29))
14
15
16  #This python script is designed to populate the "SITE_TYPE" field based on for SECN Parkwide Assessments.
17  #Copy and paste into expression window: Reclass(!SITE_TYPE!, !FID!)
18
19  def Reclass(SITE_TYPE, FID):
20      if (FID<=29):
21          return "Alternate"
22      else:
23          return "Base"
24
25
26  #The below script is designed to populate the "Name" field based on "FID" for SECN Parkwide Assessments.
27  #Copy and paste into expression window: Reclass(!Name!, !FID!)
28
29  def Reclass(Name, FID):
30      if (FID<9):
31          return "p00"+str((FID+1))
32      else:
33          return "p0"+str((FID+1))
```