Developing a Subdivision Build-Out Study and Site Suitability Tool; Enabling Access Through a Web GIS Application

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Project Outline

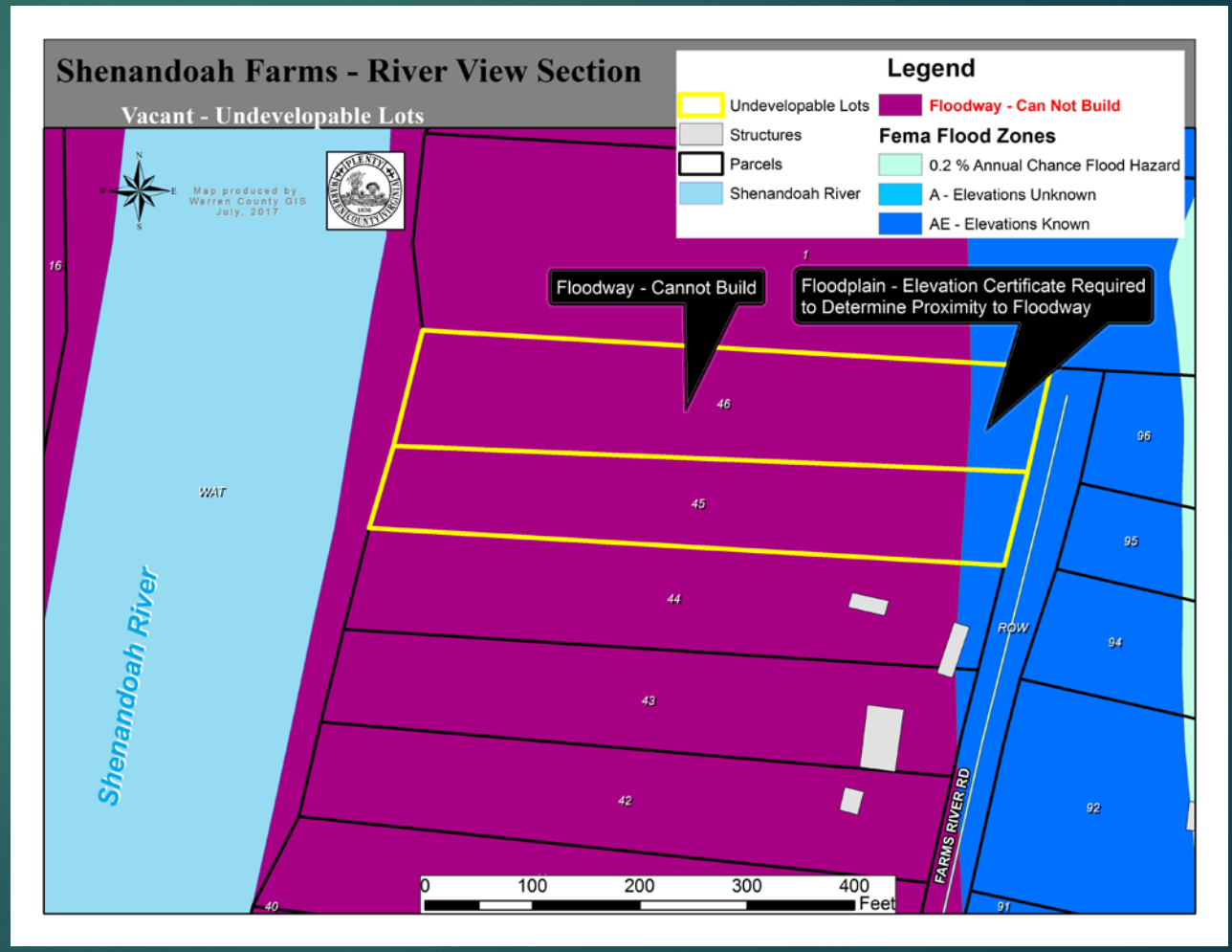
- Introduction
- Project Overview
- Goals
  - Objectives
- Research
- Project Scope
- Limitations / Anticipated Results

Introduction – *Build-Out Analysis*

- *What is it*? Inventory of all existing subdivisions in Warren County, VA that provides access to the following information:
  - Total Number of Developed Lots
  - Total Number of Vacant Lots that **Can Be Developed** (Developable)
  - Total Number of Vacant Lots that **Can Not Be Developed** (Undevelopable)

What is an Undevelopable Lot?

- Regulatory restrictions prevent these lots from being developed
- To develop a lot, the structure must be placed in accordance with zoning setbacks
- Floodways, Water bodies, Conservation easements, Perk rejections, Steep slopes, Insufficient lot acreage can all contribute to undevelopable conditions



Need for Build-Out and Site Suitability Analysis in Local Government

- How long can existing subdivisions accommodate current growth rates?
- Where is development possible, and how much is yet to occur?
  - Impact on resource oriented districts: schools, emergency services
  - Impact on infrastructure: road improvements, waste generation, utilities
- Forecast potential tax revenues, including sanitary district taxes
- Designate / redefine future growth areas
- Provide access to current / future property owners of land potential & restraints

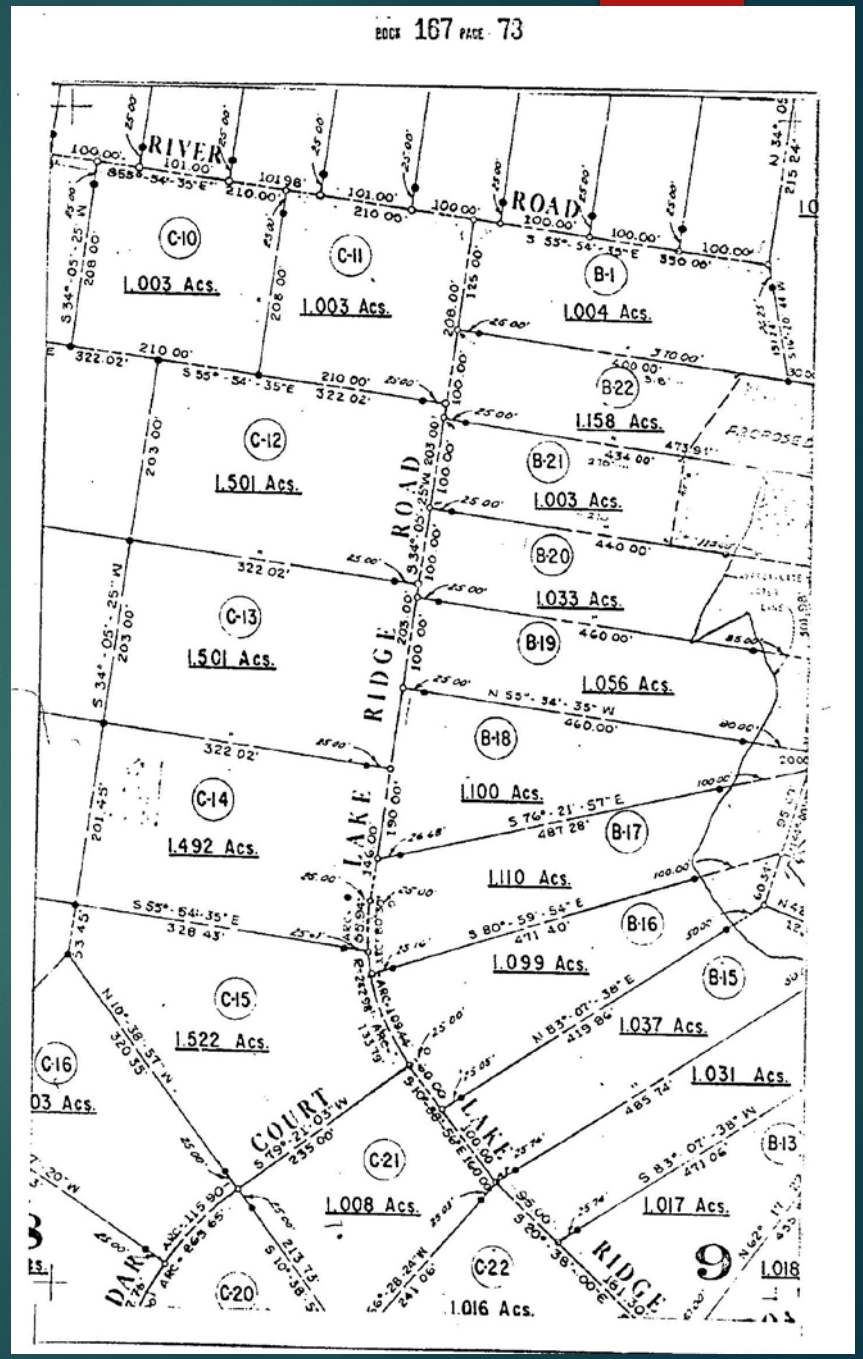
Overview - How to accomplish this ?

- Gather relevant data
- Assess completeness and accuracy of data, specifically GIS parcels
- Correct discrepancies
- Identify existing subdivisions to apply analysis
- Develop methodology to utilize tabular and spatial data in the analysis
- Automate procedure to be repeatable
- Provide interactive access to results through Web GIS application(s)

Land Records Management

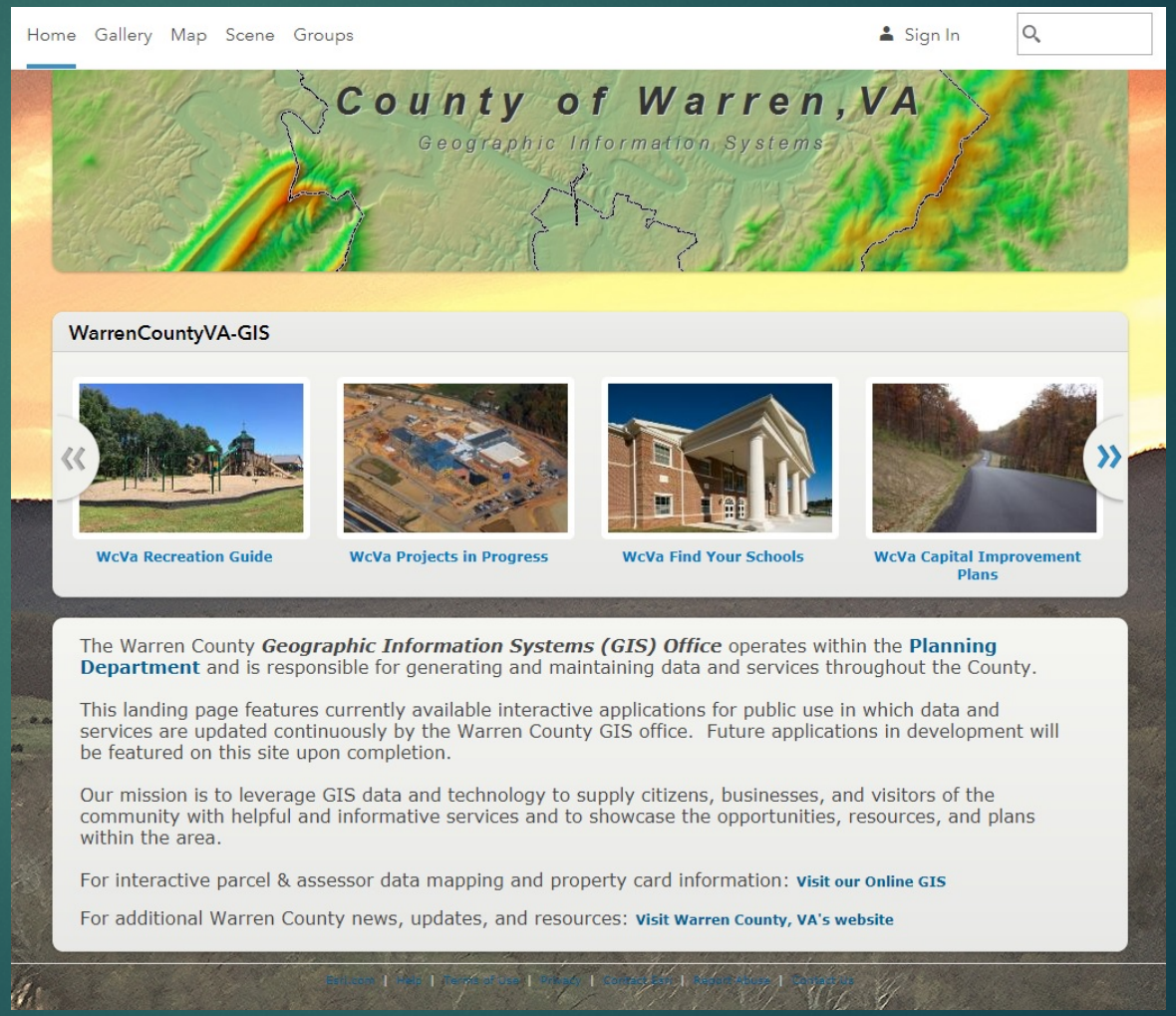
"Parcel data (also known as cadastral data) Constitute the most appropriate level of geographic detail for a host of decisions and actions relating to the development of land, business activities, regulatory compliance, emergency response, law enforcement, and logistical support" (Committee on Land Parcel Databases, 2007, Ch.1,Pg.1)

- The role of parcels in local government
- Need for high level of data integrity
- Commissioner of Revenue assessor data
- Role of automation and scripting



Accessibility - Web GIS Application

- Reporting mechanism for statistics
- Interactively query by subdivision of interest
- Visualize development
- Site-Suitability
  - Distinction undevelopable v. unsuitable
  - Need to supply access to unsuitable factors at the individual parcel level
  - Citizen better informed of a parcels development potential
  - Planners equipped with a tool that takes the guess work out



Goals

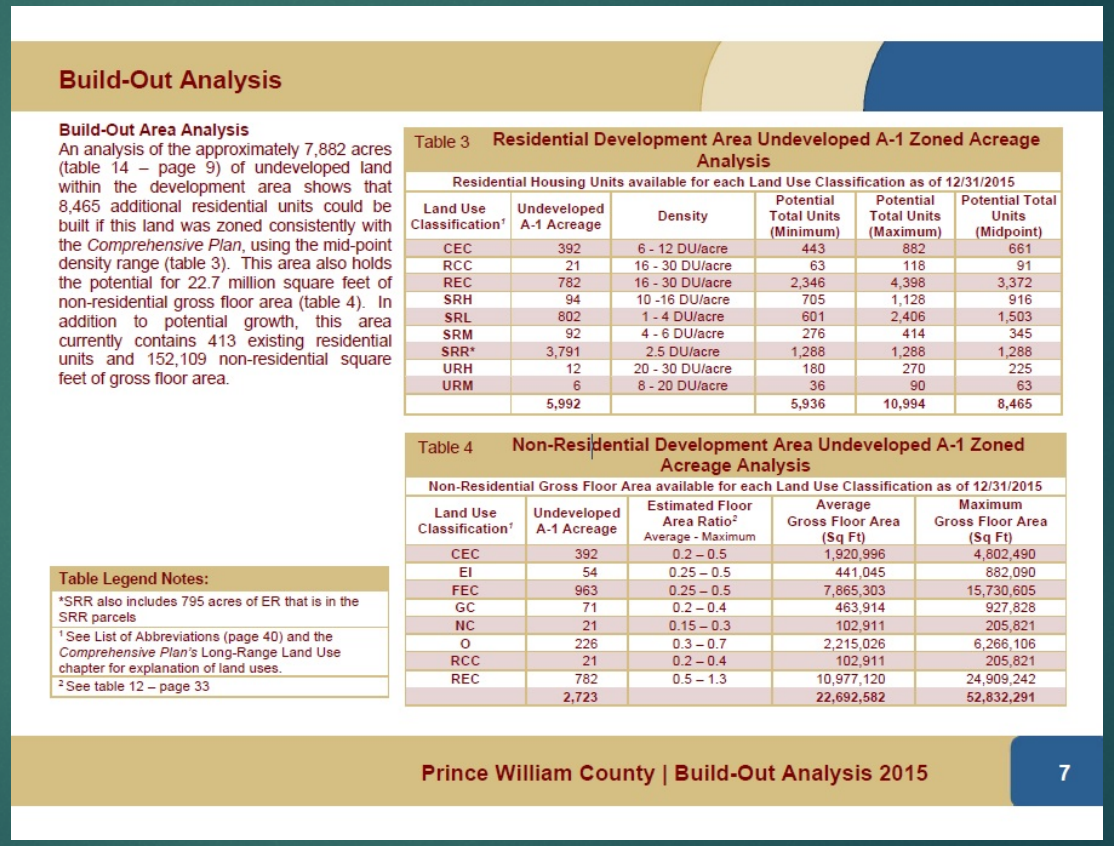
- Develop a system for determining the maximum potential Build-Out for existing subdivisions within The County of Warren, VA that contains the following characteristics:
  - Inclusion of development constraining factors such as regulatory boundaries and unsuitable build characteristics such as steep slopes in the lot classification process
  - Can be automated so that Build-Out status reflects the most current information available
  - Results are highly accessible and can be dynamically generated
- Provide a way for a user to visualize developable area at the parcel level and check to see if the location of a building will meet setbacks

Objectives

- Develop a method for identifying GIS parcel and CAMA database discrepancies that can be *automated* via Python scripting
- Correct GIS parcel errors in all subdivisions that will impact results of the analysis
- Devise a Build-Out methodology for classifying the status of vacant lots as developable or undevelopable that can be *automated* and *updated* via Python scripting
- Develop a model to determine and display developable area at the parcel level that can be called through a geoprocessing service within a Web GIS application
- Develop a tool to check to see if the location of a building will meet setbacks
- Develop a Web GIS application that interactively provides access to Build-Out results and enables a user to run suitability analysis tools on a selected parcel

Research: Build-Out Studies

- Density computation models
- Includes larger undeveloped (typically agricultural) land that has yet to be subdivided or rezoned to a particular use
- Determines maximum developable potential of all lands within a defined area



Build-Out Analysis

Build-Out Area Analysis

An analysis of the approximately 7,882 acres (table 14 – page 9) of undeveloped land within the development area shows that 8,465 additional residential units could be built if this land was zoned consistently with the *Comprehensive Plan*, using the mid-point density range (table 3). This area also holds the potential for 22.7 million square feet of non-residential gross floor area (table 4). In addition to potential growth, this area currently contains 413 existing residential units and 152,109 non-residential square feet of gross floor area.

Table 3 **Residential Development Area Undeveloped A-1 Zoned Acreage Analysis**

Residential Housing Units available for each Land Use Classification as of 12/31/2015

Land Use Classification[1]	Undeveloped A-1 Acreage	Density	Potential Total Units (Minimum)	Potential Total Units (Maximum)	Potential Total Units (Midpoint)
CEC	392	6 - 12 DU/acre	443	882	661
RCC	21	16 - 30 DU/acre	63	118	91
REC	782	16 - 30 DU/acre	2,346	4,398	3,372
SRH	94	10 -16 DU/acre	705	1,128	916
SRL	802	1 - 4 DU/acre	601	2,406	1,503
SRM	92	4 - 6 DU/acre	276	414	345
SRR*	3,791	2.5 DU/acre	1,288	1,288	1,288
URH	12	20 - 30 DU/acre	180	270	225
URM	6	8 - 20 DU/acre	36	90	63
	5,992		5,936	10,994	8,465

Table 4 **Non-Residential Development Area Undeveloped A-1 Zoned Acreage Analysis**

Non-Residential Gross Floor Area available for each Land Use Classification as of 12/31/2015

Land Use Classification[1]	Undeveloped A-1 Acreage	Estimated Floor Area Ratio[2] Average - Maximum	Average Gross Floor Area (Sq Ft)	Maximum Gross Floor Area (Sq Ft)
CEC	392	0.2 – 0.5	1,920,996	4,802,490
EI	54	0.25 – 0.5	441,045	882,090
FEC	963	0.25 – 0.5	7,865,303	15,730,605
GC	71	0.2 – 0.4	463,914	927,828
NC	21	0.15 – 0.3	102,911	205,821
O	226	0.3 – 0.7	2,215,026	6,266,106
RCC	21	0.2 – 0.4	102,911	205,821
REC	782	0.5 – 1.3	10,977,120	24,909,242
	2,723		22,692,582	52,832,291

Table Legend Notes:

*SRR also includes 795 acres of ER that is in the SRR parcels

[1] See List of Abbreviations (page 40) and the *Comprehensive Plan's* Long-Range Land Use chapter for explanation of land uses.

[2] See table 12 – page 33

Prince William County | Build-Out Analysis 2015 7

(Prince William County Planning Office, 2016, Build-Out Analysis, Pg.7)

PWC Build-Out Methodology: Limitations and Benefits

Pros

- Comprehensive approach to estimate ranges for total growth capacity of *all* lands within county
- Enables window into assessing implications of future land use zoning as outlined in the Comprehensive Plan
- Supplements a residential inventory analysis

Cons

- Does not accommodate instances that require more precise totals - ie: traffic flow, waste production, tax projections
- Undevelopable conditions such as steep slope are not factored in as constraints
- Variance in lot sizes within a subdivision, and setback implications are masked by using dwelling unit per acre formulas

Town of Amherst, Massachusetts Build-Out Analysis and Future Growth Study

- Density computation model
- Density algorithm factors in minimum road frontage setbacks
- Steep slopes are added as development constraint
- Includes partial constraints - ie. wetlands, farmland conservation districts

Appendix F: AMHERST BUILD-OUT SUMMARY TOTALS

The following table describes calculated summary totals for the Amherst build-out. The numbers contained in this table represent totals derived for the presentation build-out. AGI/Herr delivered the Amherst build-out with full tools and data to actively tune and modify build-out results to satisfy changing conditions, assumptions or varying scenarios.

BUILD-OUT IMPACTS SUMMARY

Total area (acres)	17,050		
Buildable Land (acres)	4,053		24%
No constraints		1,966	12%
Single partial constraints		1,706	10%
Multiple partial constraints		380	2%
Non-Buildable Land, Water (acres)	12,997		76%
New Residential Lots	3,031		
New Dwelling Units	3,395		
New Residential Subdivision Roads (miles) [1]	34		
New Commercial/Industrial Floor Area (sq. feet)	3,896,815		
Additional Residential Water Use (gallons/day) [2]	662,025		
Additional Commercial/Industrial Water Use (gallons/day) [3]	292,261		
Additional Municipal Solid Waste, Recycled (tons) [4]	2,030		
Additional Municipal Solid Waste, Non-Recycled (tons) [5]	7,591		
Additional Residents [6]	8,827		
Additional Students [7]	1,222		

Notes:

1. Based on the assumption that 40% of the new residential lots will have frontage on new subdivision roads.
2. Based on 75 gallons per day per person.
3. Based on 75 gallons per 1,000 square feet of floor space.
4. Based on 460 lbs per person per year. All waste estimates are for residential uses only.
5. Based on 1720 lbs per person per year.
6. Based on 2.6 persons per household (1990 US Census).
7. Based on 0.36 students per household (1990 US Census).

(Applied Geographics, Inc. Philip B. Herr & Associates, 2002, Appendix F, Pg. 46)

Town of Amherst Build-Out Methodology Limitations and Benefits

Pros

- Multi-faceted algorithm contains more constraint variables & factors, includes slopes, and uses setbacks in density computation
- Designed to accommodate variety of scenarios and models
- Highly accurate parcel dataset
- Raster analysis procedure for developing constraints
- Growth forecasting under various conditions

Cons

- Seems to combine developable area into one polygon. Subdivision rights & restrictions ignored?
- Projects number of new residential lots based on density computation under hypothetical scenarios - inapplicable to Warren County project concerned with what exists now
- Partial constraints, conservancy factor weighting, are subjective and conditional. Results widely vary from scenario to scenario

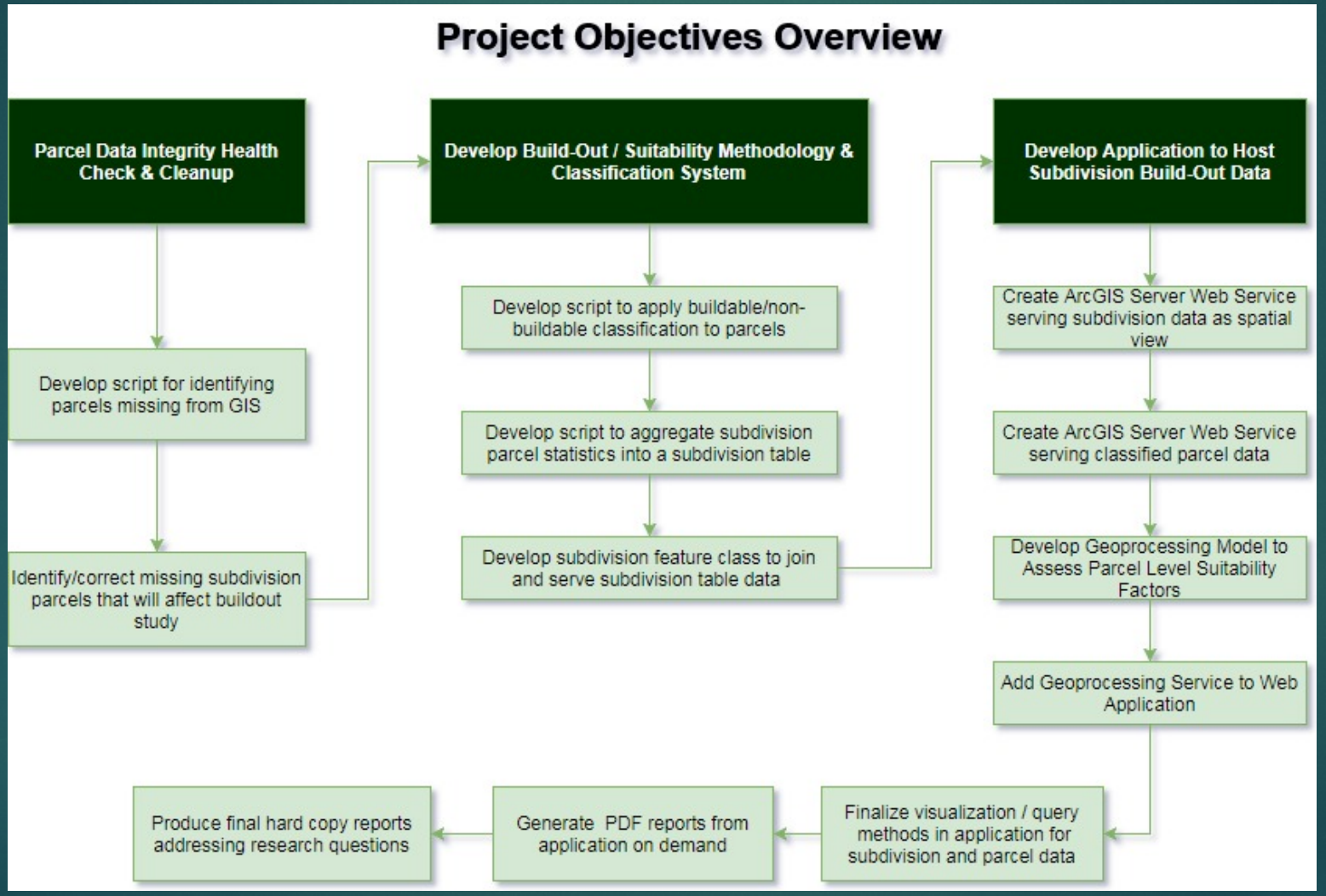
Project Purpose - Research Questions

- Determine precise totals for current and potential development within existing subdivisions that can help answer the following research questions:
  - When will existing subdivisions within Warren County, VA reach Build-Out?
  - What are these totals, and what locational impacts will this have when achieved?
  - How does this compare to current development within existing subdivisions?

What do these answers provide?

- In answering these research questions we can:
  - Project a timeline for when new subdivisions may be required by applying recent growth trends to the availability of vacant-developable lots within existing subdivisions
  - Provide locational awareness for the designation or redefining of future growth areas
  - Understand current and potential impacts of development to the balance of resource oriented districts such as school & emergency zones
  - Understand current and potential impacts of development to infrastructure such as road improvements necessitated by traffic volume, waste disposal volume, and utility usage

Project Scope Flow Diagram



Parcel Data Integrity Health Check & Cleanup

- Automate via Python script utilizing list comprehensions
  - Can be used to make new lists where each element can be the result of an operation or certain condition applied to each member of another iterable (Python Documentation, Ch.5, Sec.1.3)
- Compare assessed parcels CAMA table to GIS parcels table and identify all CAMA records not present in GIS using *not in* operator

mySet = set(s)

result = [x for x in t if x not in mySet] (Stack Exchange, 2013)

Parcel Data Integrity Health Check & Cleanup

- **Pseudocode**
  - Create variables for GIS table location and GIS Tax Map Unique ID column
  - Create variables for CAMA table location and CAMA Tax Map Unique ID column
  - Use search cursor to append all rows in GIS Tax Map Unique ID column into GIS list
  - Use search cursor to append all rows in CAMA Tax Map Unique ID column into CAMA list
  - Set GIS list
  - Create list comprehension that includes all CAMA elements that are not in the GIS list
  - Print each tax map attribute to query against CAMA database and obtain legal record index numbers for plat research

Parcel Data Integrity Health Check & Cleanup

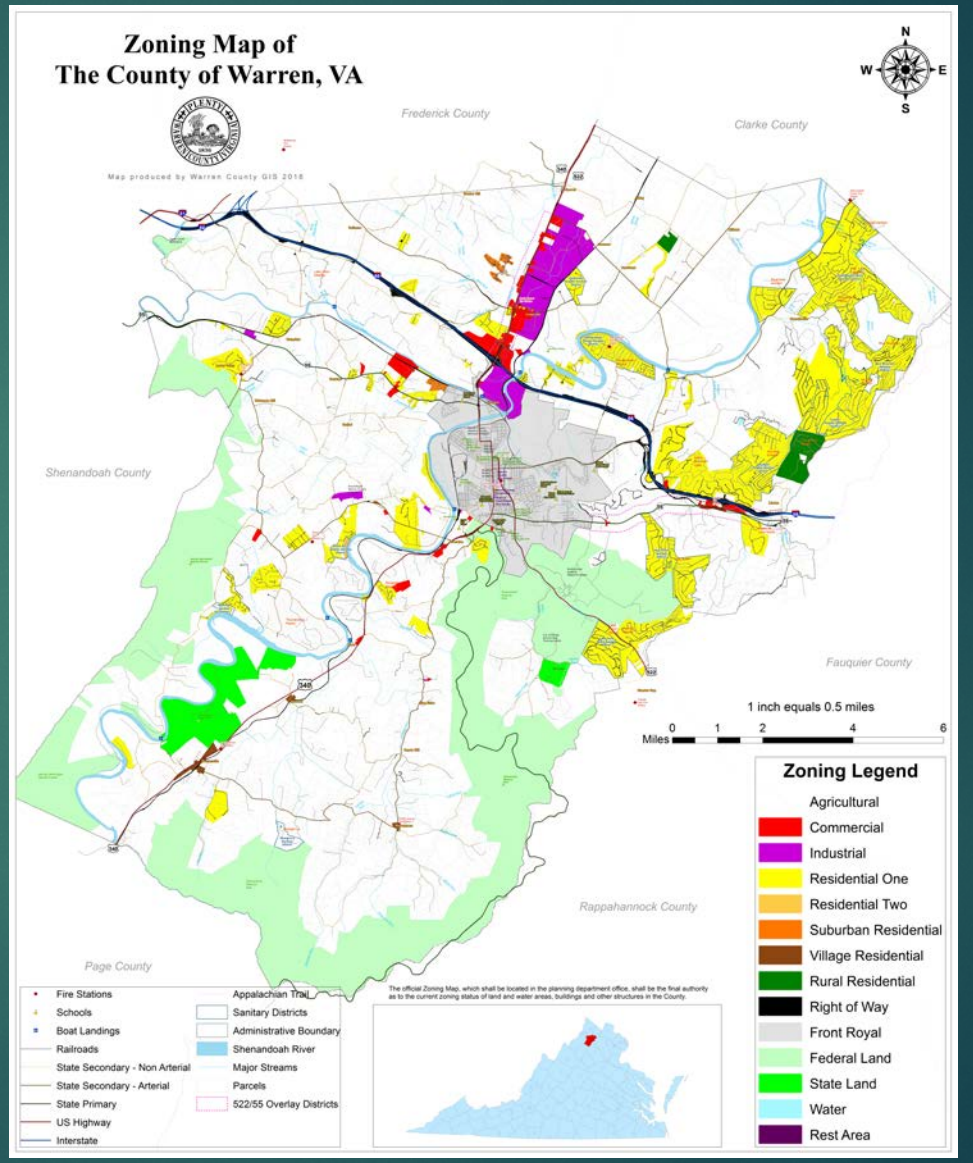
table_compare.py

```
'''Utilize this script to determine the parcels in the assessors database that are not in the GIS'''

import arcpy
#missing values table
mTable = ##GIS Table
mField = ##GIS Tax Map Unique ID Attribute
mList = []

#full table
fTable = ##CAMA Table
fField = ##CAMA Tax Map Unique ID Attribute
fList = []
fMissing = []

with arcpy.da.SearchCursor(mTable,(mField,)) as cursor:
    for row in cursor:
        mList.append(row[0])

with arcpy.da.SearchCursor(fTable,(fField,)) as cursor:
    for row in cursor:
        fList.append(row[0])

s = set(mList) ##use this to find the difference
difference = [x for x in fList if x not in s]
print "There are " + str(len(difference)) + " values in Full Table that are not in Missing Table"
#print each missing record on a separate line
for dif in difference:
    print dif


query = " OR MMAP ="
for rec in mList:
    print "'" + rec + "'" + query
##strip = ##add the printed results here""
##print strip.replace("u","")
```

Python script to compare GIS parcel & CAMA assessor tables, returning CAMA records not found in GIS table.
Produced by Doug Sexton, Warren County GIS 2016.

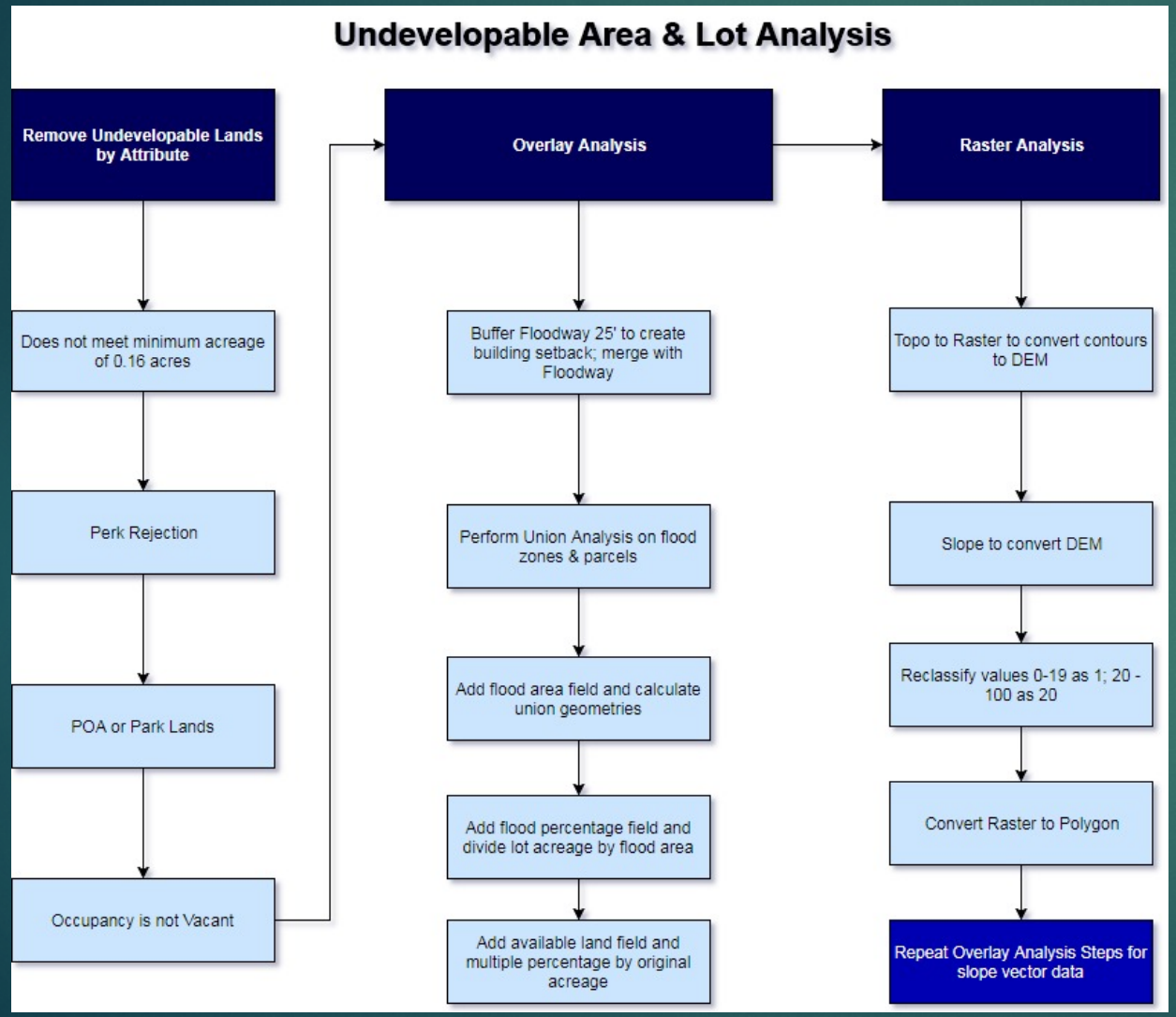
Develop Build-Out / Suitability Methodology

- Project Area:
  - Subdivision list contains 327 subdivisions comprised of various zoning and lot counts
- Data Collection
- Required Data:
  - Parcels
  - Assessor Tables
  - FEMA Flood Zones
  - Conservation Lands
  - 4ft Contours
  - DEM



County of Warren, VA. Zoning Map. Produced by Doug Sexton, Warren County GIS 2016.

Build-Out Scope Flow Diagram



- Obtain percentage of land that is developable, and apply to acreage of parcel in order to determine the acreage of developable land on a parcel
- Process to calculate overlap percentage (Stack Exchange, 2016)

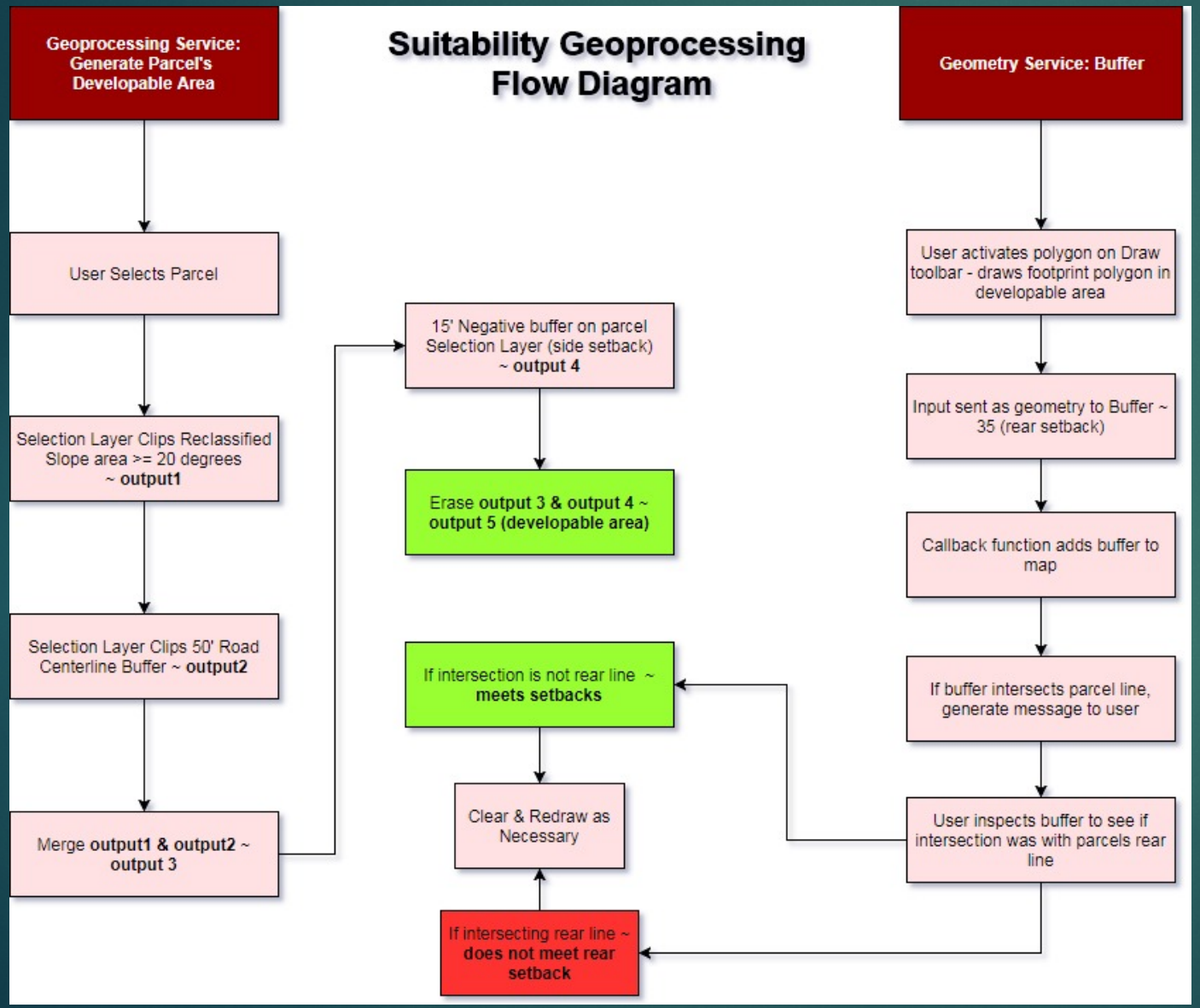
Develop Application to Host Build-Out Data & Suitability Geoprocessing Service

- On premise: ArcGIS Server; IIS Web Server; SQL Server 2012
- Subdivision table & subdivision feature class as Spatial View in feature service
- Update process will be a python script that populates table for each subdivision and can be run in batch

Subdivision	Primary Zoned Lots	Secondary Zoned Lots	Total Lots	Percent Developed	Percent Vacant	Vacant Developable	Vacant Undevelopable	Potential Build-Out	Total Acreage	Average Acreage	Average Land Value	Average Improvements	Average Total Value

- Parcel feature class w/ feature access accessible to Geoprocessing & Geometry Service
- Suitability Model will be a Python script published as Geoprocessing Service
- Geometry Service buffer using user generated graphic created from Draw toolbar
- Javascript API or Web Appbuilder w/ desired Geoprocessing Widgets
- GeoEnrichment Service to create PDF Reports In Application / Google Chart API or Dojo Charts

Suitability Geoprocessing Service



Tool to help a user understand potential difficulties in developing a property

- Geoprocessing service will *display* developable area of property
  - Area 15' from sides ; 50' from road centerline ; slope < 20 degrees
- Geometry service to buffer footprint *drawn* within developable area
  - Buffer will generate 35' to accommodate rear setback
  - If buffer intersects rear parcel line ~ setback not met

Limitations

- Gaps in methodology - other factors could be at play (potential perk rejections, utility gas & electric lines, easements); willingness of contractor or owner to build in undevelopable conditions
- Lack of floodway delineation; flood zone layer inaccuracy
- Geometry errors in parcel dataset (lines drawn on houses)
- Learning curve for developing application
- Too cumbersome for one application?

Anticipated Results

- 14703 GIS Parcels w/ Subdivision Attributes; 7448 Address Points ~ 50% existing subdivisions “developed”
- Duplicate & missing parcels; address points not indicative of developed lots (ie. demo, error, non-residential structure); undevelopable lots yet to be excluded anticipate a higher developed percentage
- Suitability tool to provide valuable resource to planners consistently dealing with setback & “developable status” questions from public; should aid in uncovering more parcel boundary discrepancies with use adoption

Project Timeline

- Complete parcel dataset analysis & corrections by mid August 2017
- Complete Build-Out methodology, suitability model, and update scripts by mid September 2017
- Develop application by October 2017
- QA/QC through October 2017
- Desire to present in Fall 2, 2017 or Spring 1, 2018 if necessary
  - ESRI Dev. Summit Europe October 24-26, 2017
  - GIS-Pro 2017: URISA's 55th Annual Conference October 23-26, 2017
  - 22nd Annual GIS/CAMA Technologies Conference March 19-22, 2018

End of Presentation – Discussion & Review

References

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2) Prince William County Planning Office, Price, Christopher M. (2016). *Build-Out Analysis As of December 31, 2015.* Retrieved July 22, 2017 from http://eservice.pwcgov.org/planning/documents/BuildOutAnalysis/2015_Publication.pdf.

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4) Python Documentation 3.6.2 (2001-2017). *Data Structures - 5.1.3 List Comprehensions*. Python Software Foundation. Retrieved June 26, 2017 from https://docs.python.org/3/tutorial/datastructures.html#tut-listcomps.

5) MangoHands (Oct. 22, 2013). *Python List Comprehension and 'not in'* #19507759. Stack Exchange forum post. RE-Retrieved June 26, 2017 from https://stackoverflow.com/questions/19507714/python-list-comprehension-and-not-in.

6) Jbalk (Aug. 5, 2016). *Calculating percentage of overlap between two different layers #205890.* Stack Exchange forum post. Retrieved July 27, 2017 from https://gis.stackexchange.com/questions/205884/calculating-percentage-of-overlap-between-two-different-layers