An ArcView tool for simulating Land Subdivision for Build Out Analysis

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(Abstract)

The objective of this paper is to develop a tool in ArcView for simulating the land subdivision process in order to simplify the process of build out analysis.

Build out analysis is a valuable tool for evaluating the effectiveness of land regulations and performing impact analysis of development on the environment and other natural resources. The process involved in carrying out build out analysis involves dealing with various layers of spatial information, maps and tabular data. Geographical information systems (GIS) are very effective in handling spatial and tabular data. Analysis of various layers of information at the city level can be done simultaneously using GIS. However, GIS does not possess necessary tools to model future development on buildable land. Hence modeling of development is done using AutoCAD or similar drafting software. In addition, the modeling of development has to be done at a single parcel level, as parcel characteristics like size, shape, terrain, land use and zone greatly influence the probable pattern of subdivision of land parcel.

This paper looks at the process of developing a subdivision layout in AutoCAD at a single parcel level. Based on the understanding of this process, a tool has been developed in ArcView, which enables a user to draw different arrangements of lots in gridiron pattern of development. This tool has been developed using Avenue. The layout developed using ArcView program is not as precise as the AutoCAD generated layout, however it is sufficient to simulate a probable subdivision layout pattern for a land parcel in less time.

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Chapter 1: Introduction

Community planning is an ongoing process. Plans for the future have to be periodically updated and corrected in the context of present. The planning decisions are mainly shaped by prevailing trends, availability of resources, forecasting of growth and the vision and desire of the community for their future. In this process, many unknown factors are estimated to arrive at a master plan for the community.

Implementation of the master plan is primarily achieved through use of zoning regulations. Traditionally, the tools used in guiding development mainly consist of density controls and land use controls. Planners apply various combinations of density controls and land use restrictions to different zones in the planning region. These controls then define the pattern of the built form. However, positive or negative impacts of proposed development in the master plan and the associated planning regulations are apparent only after some development takes place. Therefore, from time to time, the master plan and the planning regulations are altered, to guide development in the desired direction.

Over time, communities have developed various innovative regulations from density and land use controls. Some examples of such regulations are conditional zoning, performance zoning and sliding scale zoning. These regulations are successful at some places, whereas at other places, they are not so successful. Each community's planning issues are location specific. Therefore, the regulations that are successful in one community may not prove to be equally effective in another community.

Build out Analysis is one of the tools used by planners to understand the effects of planning regulations at the planning stage itself. This paper aims at developing an ArcView tool for subdividing the land in order to simplify the build out analysis process.

1.1 Build Out Analysis

Build out analysis is a visualization of a scenario in which all the developable land is built. Modeling of the build out analysis is based on the following assumptions.

1. It is assumed that entire development takes place according to the current regulations and that there are no changes in the regulations.

2. It is also assumed that the supporting infrastructure will be built at a required pace to accommodate growth.

3.While constructing a build out scenario, it is presumed that the existing trends of development will continue.

Thus the 'build out scenario' demonstrates the nature of development, if all the land in the community is built as per current regulations. Such an analysis gives the decision makers like the community administrators and the planners, a better idea of the impacts of development on the community land. They can visually compare the patterns of development with the vision portrayed in the master plan. They can obtain estimates for the population growth, housing, adequacy of the public utilities, investments in the infrastructure and energy and quantify the impacts on the natural resources and the environment. Build out analysis is a very useful technique for assessing the extent of impacts of development on the community. It is also useful for demonstrating the results of the regulations in a dramatic way to the people of the community.

By definition, build out analysis is a worst-case scenario modeled with the prevailing regulations only, without any concern for environmentally sensitive lands or other constraints like pollution. However, one can simulate several such build out scenarios to select the best possible alternative for the community. An image of a build out analysis map of the Thomas Jefferson Planning district is attached in the Appendix 4 for reference.

1.2 The process of developing a build out analysis

The entire process of developing a build out analysis can be categorized into 5 phases.

1. Inventory analysis (Collection of various maps and related information)

2. Identification of undeveloped and semi developed land

3. Incorporating constraints based on the land regulations into the model

4. Modeling of the development as per the constraints, on each land parcel

5. Quantitative analysis of impacts based on the modeled development

The first phase of the build out analysis involves doing an inventory analysis for that area. Inventory analysis consists of collection of information and maps for land use, zoning, existing development, terrain, streams and water bodies, roads and other relevant matters.

Based on this information, one can delineate areas that cannot be developed due to the public ownership, easements, and other restrictions or due to the presence of natural constraints like wetlands or steep slopes.

In the second phase, information of the undeveloped, semi developed and totally developed land is extracted from the inventory analysis.

Once the inventory analysis is complete and information of the buildable land is available, next phase involves identification of constraints on development imposed by the prevailing land regulations. This stage requires examination of the applicable development standards and regulations according to the different zone categories. For e.g. in case of a residential zone, one has to look at the minimum lot sizes, frontage requirements, and permissible densities for identifying constraints.

The fourth phase, involves actual modeling of development on the land. Modeling of development has to be done separately for every land parcel, as each land parcel is unique in terms of shape, size, terrain, road access and other location features. This phase is tedious and time consuming. Once modeling of undeveloped lands is complete, modeling of semi developed land is carried out in a similar manner.

The next phase involves quantitative and qualitative analysis of the impacts of modeled development on the community. The factors considered for such an analysis may vary depending on the community's concerns. These may include changes in the population, number of schools, number of housing units, traffic, tax revenues, acreage farmed or percentage of impermeable surfaces.

1.3 Tools (software) used for performing build out analysis

Two types of software tools are useful in carrying out the build out analysis, Geographical Information Systems (GIS) software and drafting software.

One of the main tools used in the build out analysis is the GIS software. The GIS software has capability of analyzing spatial as well as tabular data. In the GIS software, one can overlay various maps and create new maps by performing operations such as union, clip, add, subtract. It is also possible to deal with different types of data in the spatial analysis like raster and vector data, aerial photographs and satellite imagery.

Various companies such as ESRI, Intergraph, and ERDAS have developed the GIS software, for commercial use. The ESRI suite of GIS software is quite popular. ArcView, developed by ESRI is widely used for performing spatial analysis.

ArcView can successfully handle the spatial analysis requirements of the build out analysis. Therefore, in further discussions, ArcView has been considered as typical GIS software that would be used for performing the build out analysis.

The first phase of the build out analysis consists of inventory analysis. In order to use any GIS software, in the build out analysis, it is necessary to have a digital database of maps, and associated tables. Much of the commonly required data such as census data, terrain related data, elevation information, soil types information, streams and physical features information is available on the internet. (Posted by various departments of US government for public use). This data can be downloaded for use in the build out analysis.

The location specific data pertaining to land use, zoning and land parcel information needs to be obtained from the community government and if not in digital format, requires to be converted into the digital format.

ArcView can be very useful in the phase 2, 3 and 5 of the build out analysis. All these phases require spatial analysis of maps and use of overlay functions on the entire community land.

The fourth phase of the build out analysis, which requires modeling of development on each land parcel. This phase cannot be addressed very well with the existing version of ArcView (3.2). ArcView does not have many advanced drafting utilities, and that makes the task of drafting subdivision layouts in each parcel much more difficult and time consuming. Since the fifth phase of the build out analysis can be carried out very effectively in ArcView, it becomes necessary to perform the fourth phase in some other way and import the output into ArcView for further analysis.

The subdivision layout for a land parcel can be drafted manually and converted into the digital format for use in ArcView. Alternatively one can choose from a variety of drafting software, such as AutoCAD, or Micro station, or ArcCad and use that software to draft the subdivision layout. These subdivision layout files can be imported into ArcView.

In summary, a combination of GIS software and drafting software such as ArcView and AutoCAD is required to develop the build out analysis for a selected area. The build out analysis process is very time consuming, particularly in the phase 4, which consists of modeling of development for each land parcel.

If ArcView is strengthened with drafting capabilities required for performing the land subdivision, then the whole process of build out analysis can be completed within ArcView. This additional capability if developed in ArcView will be very useful in streamlining the build out analysis process.

1.4 Objective

The objective of this paper is to develop a tool in ArcView for simulating land subdivision process in order to simplify the process of build out analysis.

1.5 Methodology

This paper focuses on development of a land subdivision tool in ArcView. Since the ArcView application itself does not provide direct tools for drafting, development of the appropriate tool requires programming in ArcView. The ArcView version 3.2 supports 'Avenue' language for programming. Therefore, primary work in this paper involves programming in Avenue to facilitate subdivision of a land parcel in ArcView.

The methodology outlined for the development of an ArcView tool for simulating land subdivision is described below.

1. Identify the functionality required in the ArcView tool

This study aims at developing an ArcView tool for facilitating subdivision process in ArcView. In this step, the functional capability desired from the ArcView tool for drawing subdivision process will be identified.

2. Develop the ArcView tool programmatically and explain its working

An Avenue program will be developed in this step, satisfying the functionality criteria identified in the first step. Also, the working of the Avenue program will be explained.

3. Selection of a land parcel and design of the subdivision layout

In this step, a suitable land parcel will be identified for demonstrating the land subdivision process. With applicable zoning regulations as constraints, a subdivision layout will be designed for the selected land parcel.

4. Compare the results

In this step, subdivision layouts designed in the previous step will be drafted using ArcView tool and AutoCAD. Then, the results obtained from use of both the methods will be compared. Advantages and disadvantages of using both the methods will be described.

5. Suggest enhancements to the program

In this step, further enhancements to the ArcView program will be suggested. Also comments will be made on the limitations of the ArcView program.

Chapter 2: ArcView program for creating subdivision layout

In the first part of this chapter, conceptual development of the ArcView tool, designed for programmatically drawing the subdivision layout patterns, is explained. In the later parts, working of the ArcView program is explained.

2.1 Development of the ArcView program for drawing subdivision layout

ArcView application offers the user, capability of drawing a polygon or a rectangle. However, it does not allow the user to precisely draw a polygon based on line angles and distances. Also, the copy and paste functions in ArcView are not very easy to use. Therefore, drawing of multiple polygons as subdivided lots is not easy in ArcView. Moreover, the build out analysis process requires preparation of subdivision layouts for multiple land parcels. Therefore, ArcView is not used for performing modeling of development.

However, it is possible to program the ArcView application in Avenue, to enhance its functionality. Objective of this study is to develop a program in ArcView, which will enable processing of entire build out analysis process in ArcView. Therefore, only functions necessary for drawing a subdivision layout will be incorporated in the program. Basic functionality required in the program is defined by examining the subdivision process and the resulting layout patterns in detail.

2.1.1 The subdivision process

Preparation of a subdivision layout for a land parcel essentially involves breaking of a land parcel into smaller chunks to allow development of separate units. A single subdivided unit is referred as a lot. The subdivision layout displays arrangement of lots and roads within the land parcel.

Subdivision of a land parcel is governed by two sets of rules, the zoning regulations and the development standards. The zoning regulations define rules related to the minimum lot size, lot coverage, open space requirements and density. These rules vary in different zones. They are designed according to the desired nature of development expected in each zone. The development standards define rules related to the arrangement of lots in a subdivision layout. They define minimum values for various subdivision parameters such as the width of different types of roads, parking lots, or the length of a block. The development rules are applicable for all the zones.

The rules of the subdivision, generally establish minimum standards necessary for creating livable development. Based on these rules, various types of subdivision layouts can be drawn. A layout may consist of lots having bigger sizes and less density than the specified standard. Such type of development however does not violate the standards, and therefore is not a concern. The build out analysis is carried out to examine the effectiveness of rules in regulating unwanted development.

Therefore, subdivision layouts prepared under the build out analysis are designed as the worst case scenarios developed without violating the rules. For example, a layout is prepared with the minimum possible lot size, maximum possible block width, maximum permissible density and the minimum road width. Such an arrangement of lots in a layout portrays a visual picture of most intense development possible within the framework of rules. The build out scenario developed in this process is used to analyze if the simulated nature of development is acceptable and if the rules can satisfactorily maintain the desired standard of development.

2.1.2 Subdivision layout pattern

As mentioned earlier, a subdivision layout can consist of different arrangements of lots. A lot itself can be of different shapes such as triangle or rectangle or many-sided polygon. The roads in the subdivision layout can be laid out along curves and winding patterns or they can be laid out in straight lines meeting each other at right angles. Shown below are some images, which indicate existing development patterns in the Town of Blacksburg. These are obtained from the maps available at the website of the Town of Blacksburg.

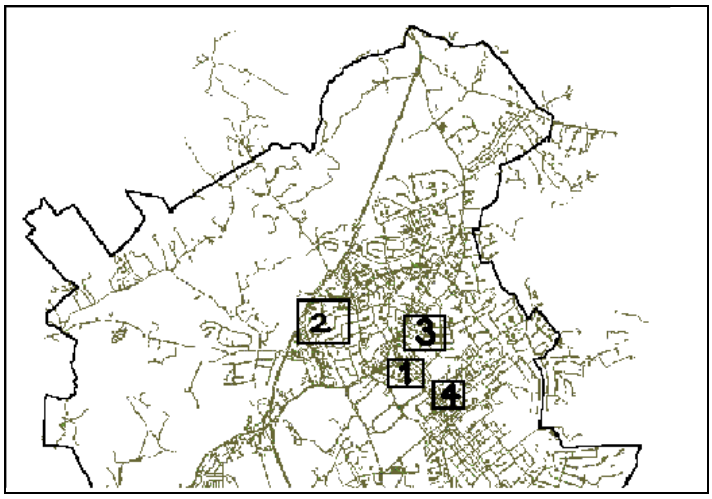

Figure 1: Key to Layout patterns

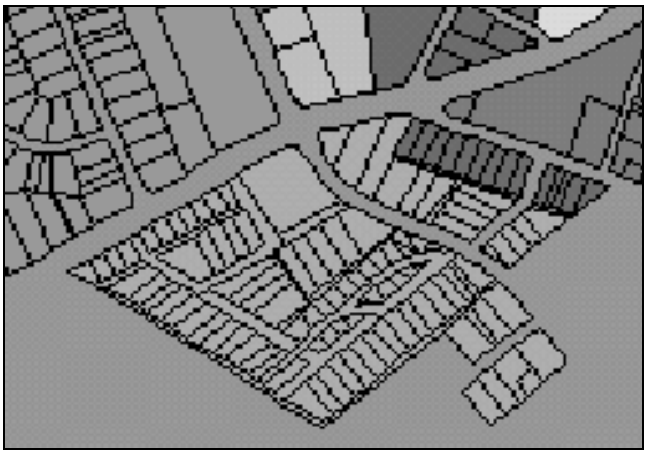

Figure 2: Layout pattern 1

Figure 3: Layout pattern 2

Figure 4: Layout pattern 3

Note that the subdivision layout pattern shown in figure 2 consists of curved roads and irregular lot shapes, whereas all the other layouts display more or less regular rectilinear patterns.

Figure 5: Layout pattern 4

Development of a subdivision layout is a creative, subjective process, which can be addressed in multiple ways. However, in this study, gridiron pattern of layout is chosen as the preferred type of subdivision layout. The gridiron pattern of development as the name suggests implies a layout in which lots are arranged in blocks and rows and roads are laid out in a grid. This pattern creates a development pattern that is repetitive, and very regular and is not really a pattern of development, which evolves organically. Looking at the layout, one feels that there is no consideration for natural features, water bodies, terrain, and gradient of the surface, all of which may obliterate some of the regularly arrangement of lots.

The reason for choosing the gridiron pattern lies in its purpose. These layouts are being prepared for understanding the intensity of development possible in the selected area. Modeled development is further analyzed with other relevant environmental maps and information to complete the build out analysis. Therefore, it is more important to model all the possible development on the plan, and get an idea of the spread of development, requirement of infrastructure and the total number of lots. It is not necessary to generate a map that will closely resemble actual development. Besides, in build out analysis we model development that is yet to come, and therefore the exact nature of the probable development cannot be predicted. Also, the gridiron pattern of development is quite efficient in terms of area consumed by the roads and lots. More importantly, it is easier to program drawing of rectilinear arrangement instead of curvilinear or other types of arrangements.

2.1.3 Programming gridiron pattern of development in ArcView

Ideally, it would have been most beneficial if a program could have generated a gridiron pattern of layout given a land parcel boundary. However, it is evident from different examples that even though the gridiron pattern of layout displays a very regular pattern, the layout in each parcel may be different due to the difference in boundaries and sizes of the parcel.

To make efficient use of the land available for development, most of the times it is necessary to align the gridiron pattern along the edges of the parcel on all the sides if possible.

However, depending on the width and the length of the parcel, the user has to make an intelligent decision about orientation of the grid, and alignment of the grid to some of the edges of the parcel. Because of these difficulties, idea of automating drawing of a gridiron pattern of layout based on parcel boundaries had to be dropped. Also, it would have been quite a difficult task to program such intelligent choices.

A close observation of a layout with (Figure 1, 4 and 5) the gridiron pattern shows that three types of arrangements of lots and roads are repeated in the layout to fill all the available developable space in a land parcel. These three arrangements are described below.

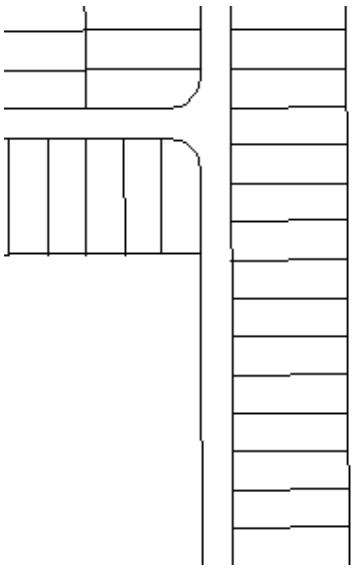

Figure 6: Lots arranged in a row

1. Lots arranged in a single row

This arrangement shows lots arranged along a road in a single row. Generally it is efficient to have lots on both the sides of a road. However space constraints in a narrow strip of land may require laying out the lots in a single row with a road.

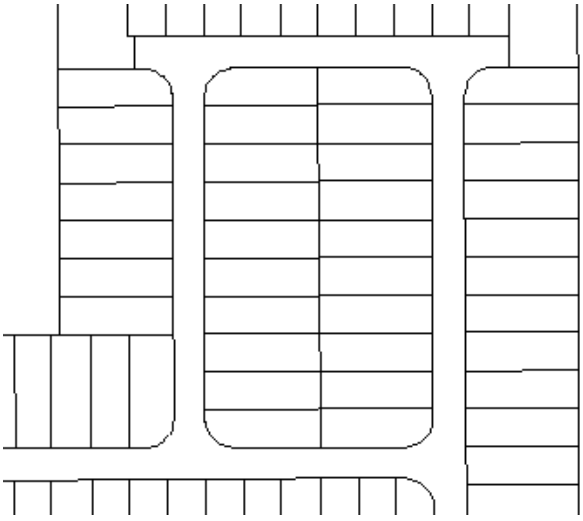

Figure 7: Lots arranged in a block

2. Lots arranged in a block

This arrangements shows lots arranged in a block, surrounded by roads on all the sides. In this arrangement typically lots are laid out in two rows forming a rectangular block and the roads are laid out along the block to service all the lots. Depending on the space available around the block, it may be either possible to lay out another block adjacent to this block or to lay out another set of lots arranged in a row.

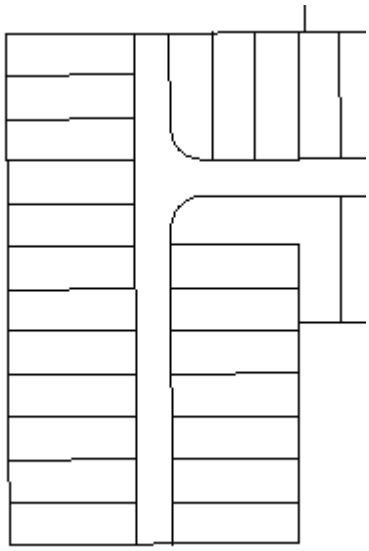

Figure 8: Lots arranged on both the sides of the road

3. Lots arranged in two rows on both sides of a road

The third arrangement comprises of two rows of lots placed along opposite edges of the road. This kind of an arrangement can be efficient, if there is a narrow strip of land, which can just accommodate two rows of lots and one road in between.

Various combinations of these three types of arrangements can be used to form a gridiron layout for any shape and size of a land parcel. If a user is provided with the capability of drawing these three kinds of arrangements in ArcView, the need for use of an external drafting program will be eliminated. Therefore, an ArcView program is developed to draw these three types of arrangements with user input on the location and values of variables. Moreover, extra functionality of drawing rectangular footprint of the building is also incorporated into the program. The building footprint however can only be drawn at the center of the lot. Adding buildings to the layout is incorporated as an optional feature.

The variables required by the program are defined from the examination of these three arrangements mentioned before. A description of these variables is provided below.

- **Lot dimensions, Block width, Road width**

Lot is a basic unit of subdivision, and the lot size can vary for different subdivision assignments. Also, the user may want to use different sizes of a lot in a single subdivision layout. Besides, the map in which a subdivision layout is drawn can have different units such as meters or feet. Therefore, it is necessary that the user enter these values. Similarly, values for the block width and the road width need to be entered by the user. Some guideline for specifying these values will be present in the zoning regulations. For e.g. the minimum lot area will be specified in the regulations, from which the user can define lot dimensions. Also, the range for permissible block width will be specified in the development standards.

- **Start line**

The program requires user to input a line in the map. From the starting point of this line, the program can retrieve information about the location of the first lot to be drawn. The angle of the input line tells the program about the orientation of the grid.

- **Building width, Building length**

The building footprint size in a lot is affected by many factors such as setbacks, permissible lot coverage on the ground and the floor area ratio. These values are also variable in different locations. Therefore they need to be specified by the user.

2.2 Working of the ArcView program

This part of the chapter explains the working of the program step by step. The layout drawn with this program is based on the gridiron pattern of development. Types of layout drawn with the program have been derived from the examination of subdivision layouts developed with AutoCAD.

This program renders added functionality to the ArcView 'View' menu bar. It has been assumed that the users of the program are well acquainted with the ArcView interface and commands.

This program can be accessed through the 'Build out' menu option added to the 'View' menu bar, which also means that the view window in ArcView has to be active for the 'Build out' menu to be visible on the menu bar.

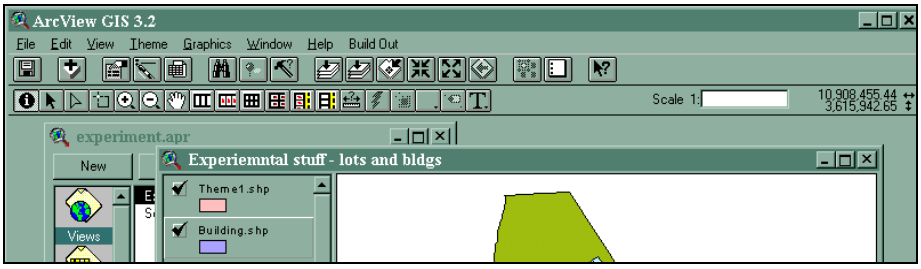

Figure 9: ArcView 'View' menubar with 'Build Out' menu

2.2.1 Set parameters

'Set parameters' is the first item listed under the 'Build Out' menu. At this step, the users set basic parameters for drawing lots. Clicking on the 'Set parameter' item in the 'Build out' menu causes a dialog box titled 'Set parameters for drawing lots' to open. An image of the dialog box is shown below and each option in the dialog box is discussed.

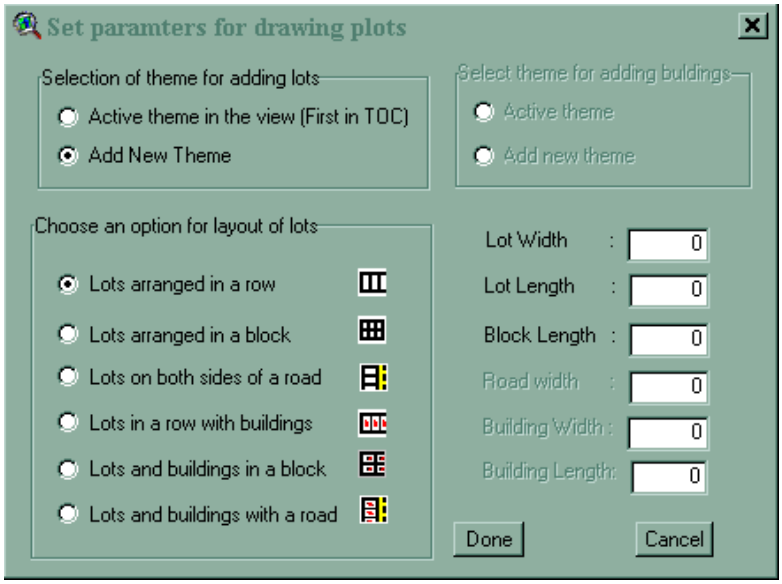

Figure 10: Set parameters dialog box

2.2.2 Selection of a theme for adding lots

In this step, the users are required to specify a theme in which lots will be drawn. Two options are available for selecting a theme.

1. Active theme in the view (First in TOC)
2. Add a new theme

The users might want to use a theme that has already been added to the view. In this case, they can select the option 'Active theme in the view (First in TOC)'. As the option suggests, the program searches for a list of active themes in the 'Table of Contents' (TOC) of the current view.

An ArcView project can have more than one view. Therefore, specification of the current view is important. As per the program, the 'Current view' implies the view that was active prior to the selection of the 'Build out' menu. In order for a theme to be selected from the current view it is necessary that the current view has at least one active theme. ArcView allows for more than one theme to be active in a view. If more than one theme is active in the current view, then the program chooses a theme that is placed higher in order amongst the active themes in the 'Table of Contents' (TOC) area of that view.

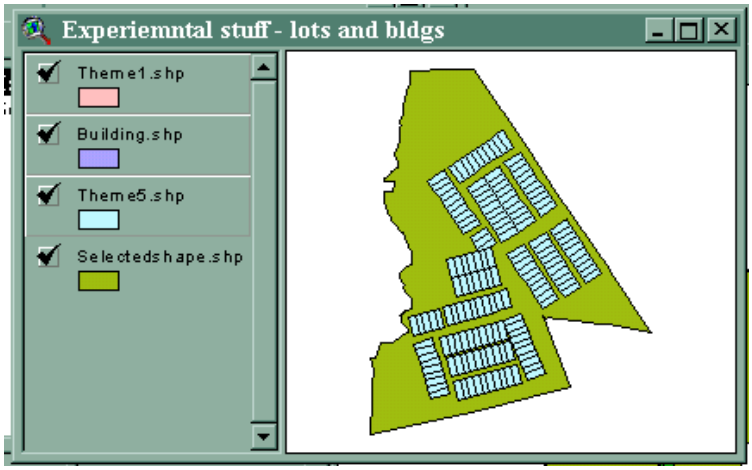

Figure 11: TOC of view with 3 active themes

The second option under the 'Selection of theme for adding lots' frame, allows the user to add a new theme to the view. Selection of this option displays an 'Add theme' dialog box, through which the users can select a theme that is not already added to the ArcView project. This dialog box works the same way in which we add a new theme to an ArcView view. Therefore the users will already be familiar with this option.

After the user has chosen a theme by clicking on either of the two options, a message box is displayed which lists the name of the theme selected for drawing lots.

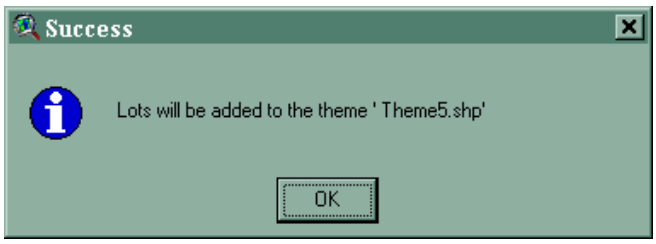

Figure 12: Message about selection of theme for drawing lots

If the chosen theme is not the one in which the user wishes to add lots, then he can again click on the required option buttons to reselect the desired theme. Sometimes, the user may want to use a theme that has already been added in the view. However that theme may not be selected for drawing lots if it is not active or if it is not the first active theme in the table of contents for that view.

In that case, the user can switch to the view window by clicking on it and make the required theme active and place it higher in order than all the other active themes in the table of contents for that view. Then the user can reactivate the dialog window and reselect that theme by clicking on the appropriate option button.

A message box will then be displayed, informing the user of the theme selected for drawing lots. The user can go through this process till he is satisfied with the theme selection for drawing lots.

2.2.3 Choose a pattern of lots for drawing

This is the second choice that the user is expected to make, after selection of a theme for drawing lots. In this frame there are six option buttons offering six choices for the user to choose from. Each choice is described in detail below.

Lots arranged in a row

Choice of this option leads to drawing of lots in a row along the line input by the user in the view window. This choice requires setting of three parameters; namely the Lot length, Lot width and the Block length. These parameters and the resulting layout pattern are shown below graphically. The ‘Block length’ variable defines the number of lots drawn in a row. It is possible to draw a single lot by defining the block length larger than the lot width and smaller than twice the lot width.

In all of the six choices, the program does not allow the user to set the block length lesser than the lot width, as that will result in addition of zero lots. The program draws lot width parallel to the user input line and lot length perpendicular to the user input line.

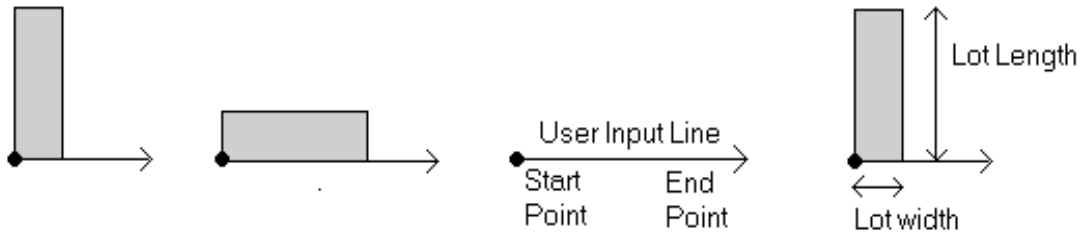

Figure 13: Orientation of lots as per lot parameters

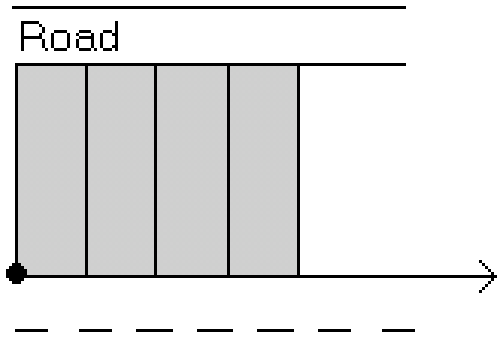

Figure 14: Lots arranged in a row

In terms of a layout, drawing of lots in a row implies that there is a road facing the row of lots on one of the sides.

Lots arranged in a block

Choice of this option leads to drawing of lots in two rows along the line input by the user in the view window. This choice also requires setting of three parameters namely, the Lot length, Lot width and the Block length. These parameters and the resulting layout pattern are shown below graphically. The 'Block length' variable defines the number of lots drawn in a row. It is not possible to draw a single lot by defining the block length larger than the lot width and smaller than twice the lot width by exercising this choice. The settings mentioned in this case will result in drawing of two lots placed in two adjacent rows.

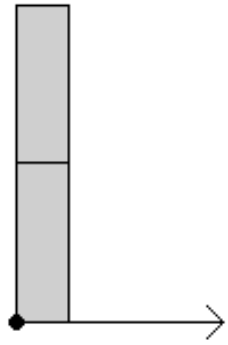

*Figure 15: Drawing if Block length <(Lot width * 2)*

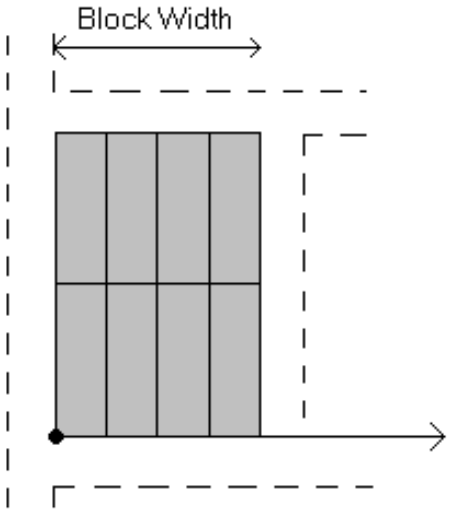

Figure 16: Lots arranged in a Block

In terms of a layout, drawing of lots in a block implies that there are at least two roads along the length of block located on opposite sides of the block. It may be possible that the block is surrounded by a road on all sides.

Lots on both sides of the road

Choice of this option leads to drawing of lots in two rows along the line input by the user in the view window, with rows separated by a road. This choice requires setting of four parameters namely, the Lot length, Lot width, Block length and the Road width. The resulting layout pattern is shown below graphically.

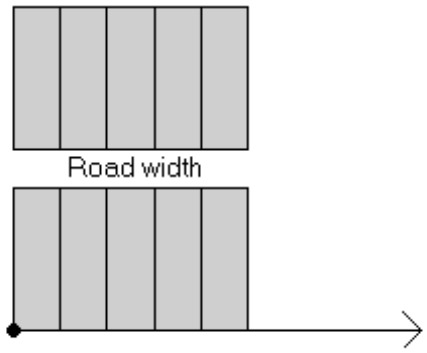

Figure 17: Lots facing a road

The 'Road width' variable defines the width of the road space, which separates the two rows of lots drawn. The 'Block length' variable defines number of lots drawn in a row.

It is not possible to draw a single lot by defining the block length larger than the lot width and smaller than twice the lot width using this choice. The settings mentioned in this case will result in drawing of two lots placed in two adjacent rows separated by the road width. In terms of a layout, drawing of lots facing a road implies that, these two rows of lots are serviced by a road in between them.

The remaining three choices are similar to the first three choices explained above, except for the fact that they also draw buildings along with lots. For this reason, it is necessary to define a theme in which buildings are added. Hence that part is explained before describing the other three choices. However while executing the program, the user has to select a layout choice with provision of buildings, to make the frame for selecting the building theme visible.

2.2.4 Selection of a theme for adding buildings

The theme for adding buildings is defined by selecting an appropriate theme using one of the two choices in the 'Select theme for adding the buildings' frame. The two available choices are as follows.

1. Active theme
2. Add new theme

Exercising the above choices involves a similar process that has been explained earlier under the section for 'Selection of theme for adding lots'.

The program however does not allow selection of the same theme for drawing buildings as well as lots, by displaying a message stating that the user has selected the same theme for adding both buildings and lots. In such a case the user can either go to the view window and make another theme active or add a new theme to the view.

Lots in a row with buildings

Choice of this option leads to drawing of lots in a row along the line input by the user in the view window. This choice requires setting of five parameters, namely the Lot length, Lot width, Block length, Building length and the Building width. These parameters and the resulting layout pattern are shown below graphically. As mentioned earlier, the 'Block length' variable defines the number of lots drawn in a row. It is possible to draw a single lot along with a single building by defining the block length larger than the lot width and smaller than twice the lot width.

Drawing of a building within a lot is governed by the building length and width parameters. The building length is drawn perpendicular to the user input line, while the building width is drawn parallel to the user input line. The user can set the building length and width parameters according to the desired orientation of the longer dimension of the building within a lot. The Building is always centered within the lot i.e. the center point of the lot polygon coincides with the center point of the building polygon.

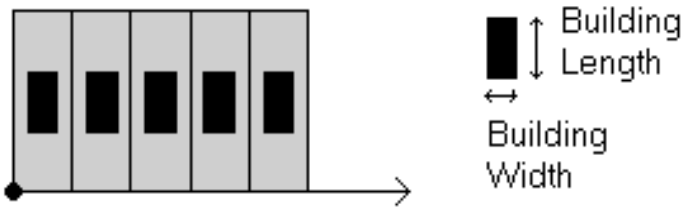

Figure 18: Lots with Buildings arranged in a row

In terms of a layout, location of a building on the lot is also affected by other parameters like setbacks from the lot boundary. The front, rear and side setbacks define the buildable area on the lot. Besides the minimum lot coverage is also dependant on the lot coverage percentage stipulated in the regulations. These parameters are not considered here, as it is presumed that the users will take these factors into consideration and then set the building dimensions.

Moreover a building is always centered within the lot, so as to avoid any violation of the setback regulations. In reality however building may not be centered in the lot. Build out

scenario for a place requires modeling the entire development in that area to get an idea of the intensity and pattern of development. In this context it is not necessary to have the exact locations of buildings on the lot as long as at least one building per lot is shown.

Lots and buildings arranged in a block

Choice of this option leads to drawing of lots and buildings in two rows along the line input by the user in the view window. This choice also requires setting of five parameters namely, the Lot length, Lot width, Block length, Building length and the Building width. These parameters and the resulting layout pattern are shown below graphically. The 'Block length' variable defines the number of lots drawn in a row. It is not possible to draw a single lot by defining the block length larger than the lot width and smaller than twice the lot width using this choice. The settings mentioned in this case will result in drawing of two lots with buildings placed in two adjacent rows.

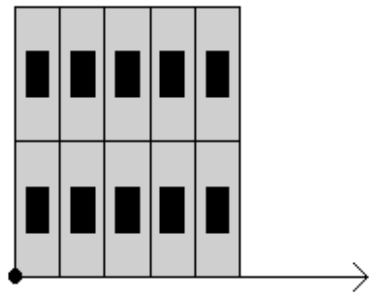

Figure 19: Lots and Buildings in a Block

Lots on both sides of the road

Choice of this option leads to drawing of lots and buildings in two rows along the line input by the user in the view window, with rows separated by a road width in between. This choice requires setting of all the six parameters, namely the Lot length, Lot width, Block length, Building length, building width and the Road width. These parameters and the resulting layout pattern are shown below graphically. The 'Road width' variable defines the width of the road space, which separates the two rows of lots drawn. The 'Block length' variable defines the number of lots drawn in a row. It is not possible to draw a single lot by defining the block length larger than the lot width and smaller than twice the lot width with this choice. The settings mentioned in this case will result in drawing of two lots with buildings placed in two adjacent rows separated by the road width.

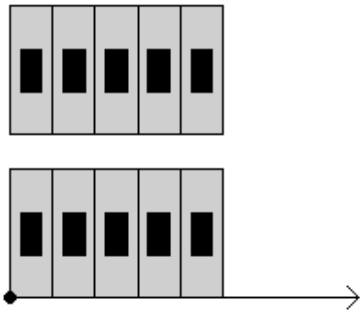

Figure 20: Lots and Buildings on both sides of a road

2.2.5 'Done' button

After all the parameters required for drawing lots and/or buildings are set, the user is expected to click the 'Done' command button. Clicking on this button causes a message box to open. In this message box information about all the parameters set by the user are given. If at this step, the user wants to change some parameters again, he can do so by closing the message box and clicking on the required parameter choices. If some parameters contradict any of the assumptions of the program, the user may get an error message after clicking the 'Done' button.

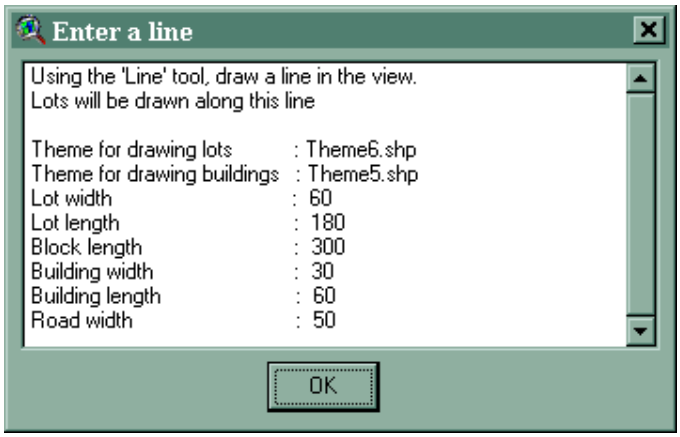

Figure 21: Messagebox that shows up after clicking on 'done' button

The message box displayed above also informs the user about the activation of the line tool available on the dialog box for drawing a line on the view.

2.2.6 Units

In the discussion above regarding setting of lot and building parameters, there has been no mention of units. The map in which the user would be drawing the lots and the buildings can be having units of measurement as feet or meters or decimal degrees. Whatever units the map is using, the user can enter values for parameters in those units. The program does not take into consideration any conversion of units, and just draws the lots according to the values entered.

Hence any measurements in degrees will not work correctly for drawing of lots and buildings. Feet and meters should work fine, as long as the user enters values that correlate with the units specified.

2.2.7 'Line' tool

Clicking on the Line tool results in two things, closure of the dialog box and return of the control back to the current view, which is the view that was active prior to opening the 'Set parameters' dialog box. Also the shape of the cursor changes from the normal arrow shape to the crosshair. As mentioned in the message box displayed prior to activation of the line tool, the user is expected to enter a line in the view so that lots can be drawn along that line.

The line input in the view is done in the same manner that the user would normally do under ArcView. (Left click and input the start point and then drag the cursor to the end point and click again.) The line input in the view is necessary for drawing of lots. It specifies the location at which lots are to be added to the map.

Specifying a line on the map in different ways can result in drawing of lots in different directions. All the possibilities regarding the line input and drawing of maps are shown below.

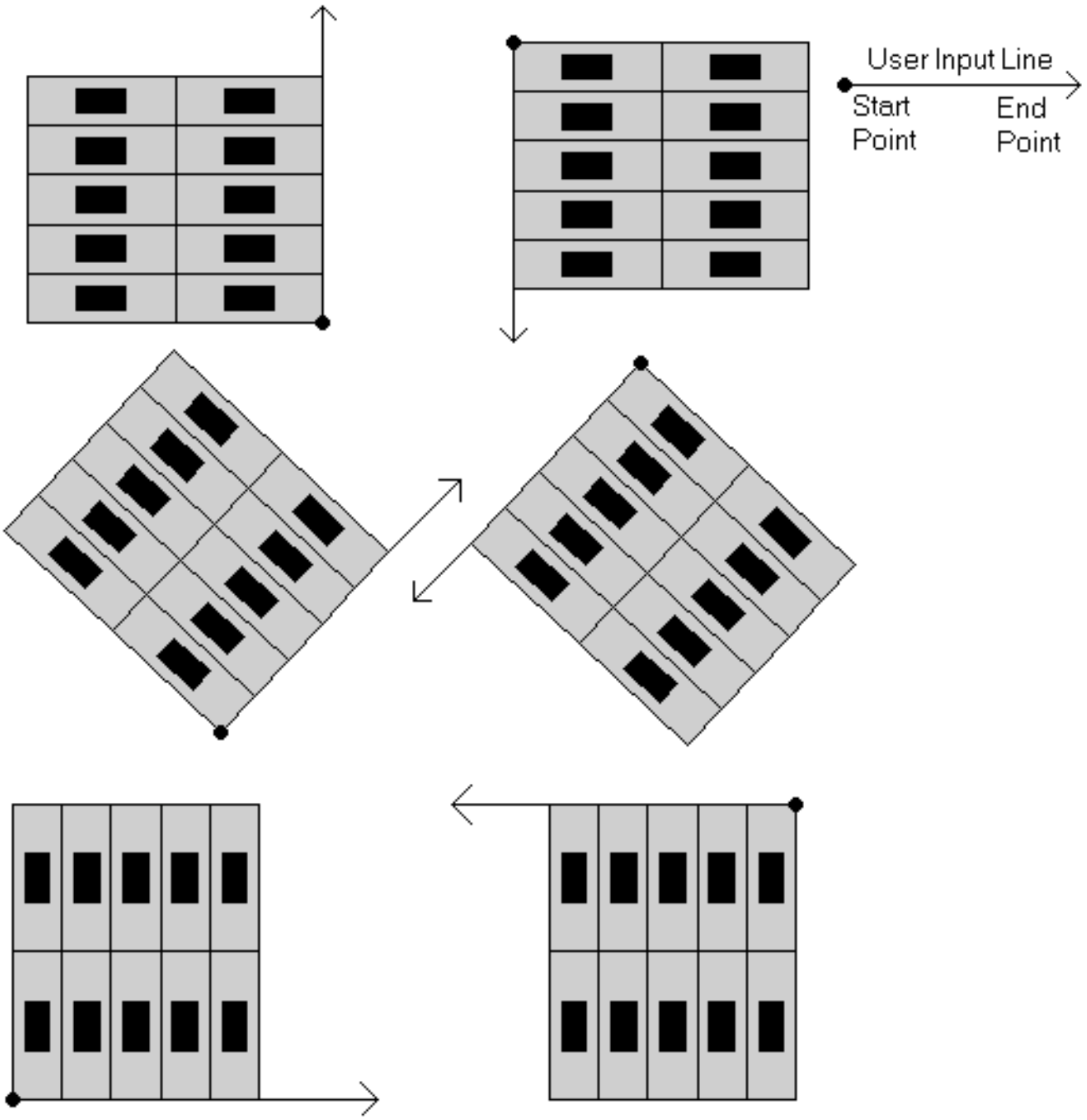

Figure 22: Change in drawing pattern with different ways of entering the input line

The line tool stays activated even after drawing of lots. This is evident from the shape of the cursor, a cross hair shape.

This is so, because the line tool is like any other tool in ArcView, (zoom or pan) and stays activated unless some other tool is activated. Therefore to deactivate the line tool, the user needs to activate select tool or some other tool.

2.2.8 'Cancel' button

On the 'Set parameters' dialog box there is a cancel button, which allows the user to close the dialog box and cancel the setting of parameters operation.

2.3 Execution of the program

When the user enters a line in the active view, the program is executes in the following manner:

1. Start point coordinates of the line drawn in the view are selected as the coordinates of the starting point for drawing lots.

2. Slope of the line drawn in the view is selected as the slope for the row of lots in the direction of the width of lots.

3. Number of lots to be drawn is computed based on the values of 'Block width' and 'Lot width'. (Number of lots in a single row = Block width / Lot width) Accordingly, lots are drawn in the view.

4. Along with addition of each lot to the view, theme attribute table is also updated. A row representing each lot is added to the table and the id value for the lot is obtained by incrementing the previous maximum value for the id.

5. All the changes to the theme and attribute table are saved.

6. The line tool still stays activated. The user can restart the process of drawing lots with same parameters by drawing another line in the view. Alternatively to stop drawing of lots the user can deactivate the line tool by activating another tool like 'Select' tool or 'zoom' tool.

2.4 Deleting the lots

As mentioned in the section about execution of the program, all the changes made to the theme and theme attribute table are saved during execution of the program. Therefore the user can delete the lots in two ways:

1. The user can start editing the theme in which lots are drawn, select lots for deletion and delete them by using the delete key.

2. The user can open the theme attribute table for the theme in which lots are drawn. Then the user can start editing that table, select rows, which represent lots to be deleted and choose 'delete rows' option from the edit menu. The user can also select the lots for deletion using this query.

2.5 'Grid' tool

The build out menu also has a feature called 'Grid', which allows the user to draw a grid in the current view. While working towards development of the subdivision layouts with the ArcView program, the need for a grid as a reference was felt. Other drafting software like AutoCAD has grid facility. Users can turn on the grid option in such software. The grid tool designed in the ArcView program is incorporated as a separate tool on the toolbar. In the figure shown below, the grid tool is indicated by the grid symbol. Other layout options are also built into the ArcView view toolbar, for ease of use. Some of those tools can also be seen in the toolbar figure shown below.

Figure 23: Build out tools added to the ArcView toolbar

In ArcView, the users do not get a sense for distance while drawing, because ArcView only gives information about exact coordinates at the location of the cursor. With the use of the 'Measure' tool information about distance between two points can be obtained in ArcView, but this tool is not available for use if another tool is active. Therefore, when the 'Line' tool for drawing lots is being used with the ArcView program, the user cannot avail of the functionality of the 'Measure' tool. If the user has created a grid theme, then grid can be used as a reference, to precisely specify the starting point of the reference line entered in the view for drawing of lots. Also presence of a grid is helpful in aligning groups of lots drawn in different operations, with each other.

The grid tool allows the user to draw grid lines in one direction or in two directions. The parameters required for drawing of the grid are gridline spacing and grid line length. Grid lines can also be drawn at an angle. However information about the angle of the gridline as well the starting point of the grid is obtained from a line input by user in the view. If user specifies a bi-directional grid, then one set of lines is drawn parallel to the direction of the input line, and another set of lines is drawn in the direction perpendicular to the input line. In the grid parameters, the dimensions specified in the x direction refer to the direction of the input line, whereas the dimensions specified in the y direction refer to the direction perpendicular to the input line.

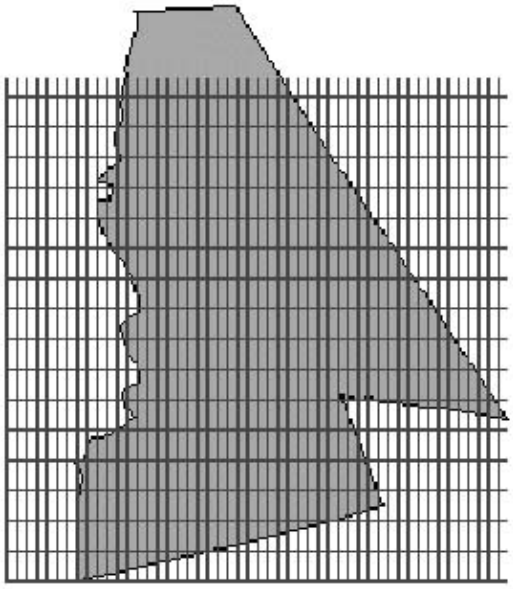

Figure 24: Grid theme added to the view

Grid can be used in a variety of ways. A grid can be drawn using the extent of the land parcel with X spacing and Y spacing set according to the lot dimensions. This kind of a grid can give user an idea of space and possible arrangement of lots in it. If x spacing and y spacing is set according to the road width and lot width, then the user can get an idea of the space to be left for roads in between the lots. Similarly on a bigger scale, one can set the x spacing and y spacing to define blocks, and again get an idea of the possible layout at a block level.

It is possible to add multiple grids as a reference to the view for use in the drawing process. Each grid is added as a theme, and therefore it is possible to turn a required grid theme on or off as per convenience.

Chapter 3: Land parcel selection and subdivision

This chapter explains the process of subdivision of the selected parcel. The first part of the chapter describes selection of the suitable land parcel for demonstrating subdivision process. The second part of the chapter describes process involved in designing the subdivision layouts for the selected parcel as per the applicable zoning regulations.

3.1 Selection of a suitable land parcel

Focus of this study is on identifying a way in which modeling of development can be done within ArcView. Therefore size of the study area as well as the type of the zoning category to be studied has been kept simple and manageable.

3.1.1 Location

To use GIS software, for any sort of spatial analysis, it is necessary that a place has required information in the digital format. The Town of Blacksburg has a digital database comprising of various maps like land use, zoning, road network, creek etc. For this reason, a suitable land parcel was chosen from the town of Blacksburg. Following figures show maps of the town with the road network and the creek area.

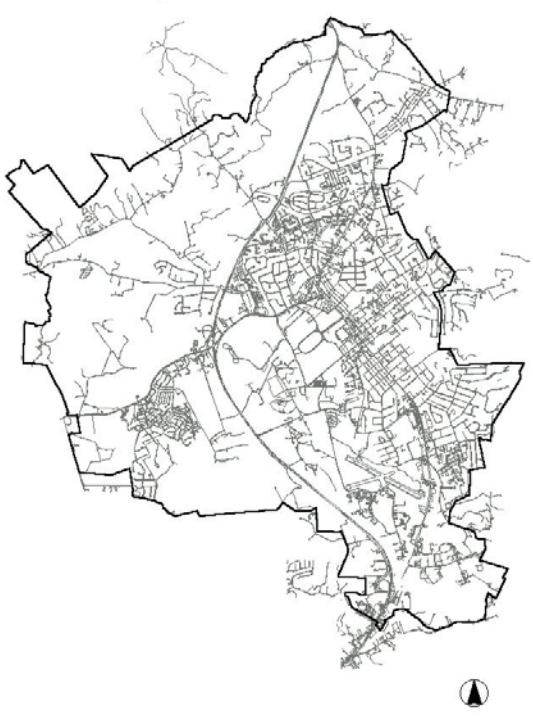

Figure 25: Road network in Blacksburg

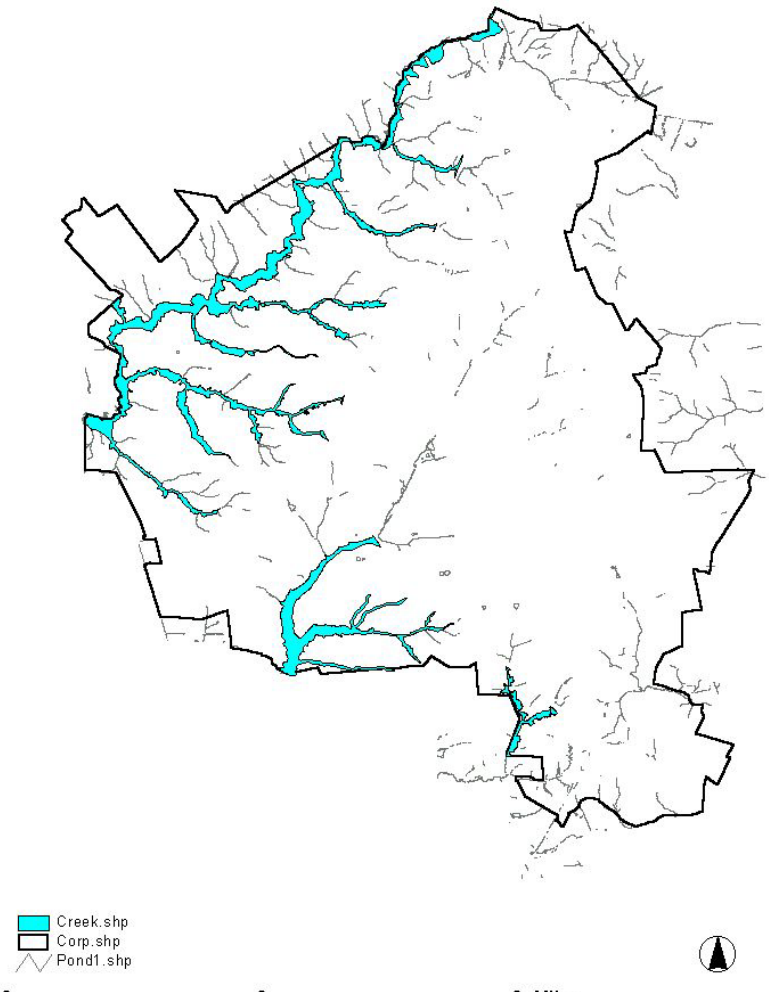

Figure 26: Creek overlay district in Blacksburg

To keep the scale of the subdivision plan manageable, a parcel of 100 acres area was decided as an appropriate sized parcel to do the analysis. Also it was decided to choose an undeveloped parcel in order to simplify the subdivision process. Town of Blacksburg has developed quite densely along its core due to the presence of Virginia Tech University at its center. Lot of residential development has taken place around the university and along the major roads. Therefore finding an undeveloped land parcel of 100-acre size in the central area of the town was not possible. However on the outskirts, the town has large areas, which have their land use as agriculture or farmland.

The Tom's creek area, located along the northwestern boundary of the town has many undeveloped lands. Quite a few lands in this area have agricultural land use. Therefore, most of the lands within the Tom's creek area are zoned as 'Rural Residential zone' – (RR1).

Considering availability of large land parcels, it was decided to choose a suitable land parcel from the Tom's creek area. Also, zoning category of the Tom's creek area was in accordance with the preferred zoning category of the land parcel. The zoning category selection is explained in the next section.

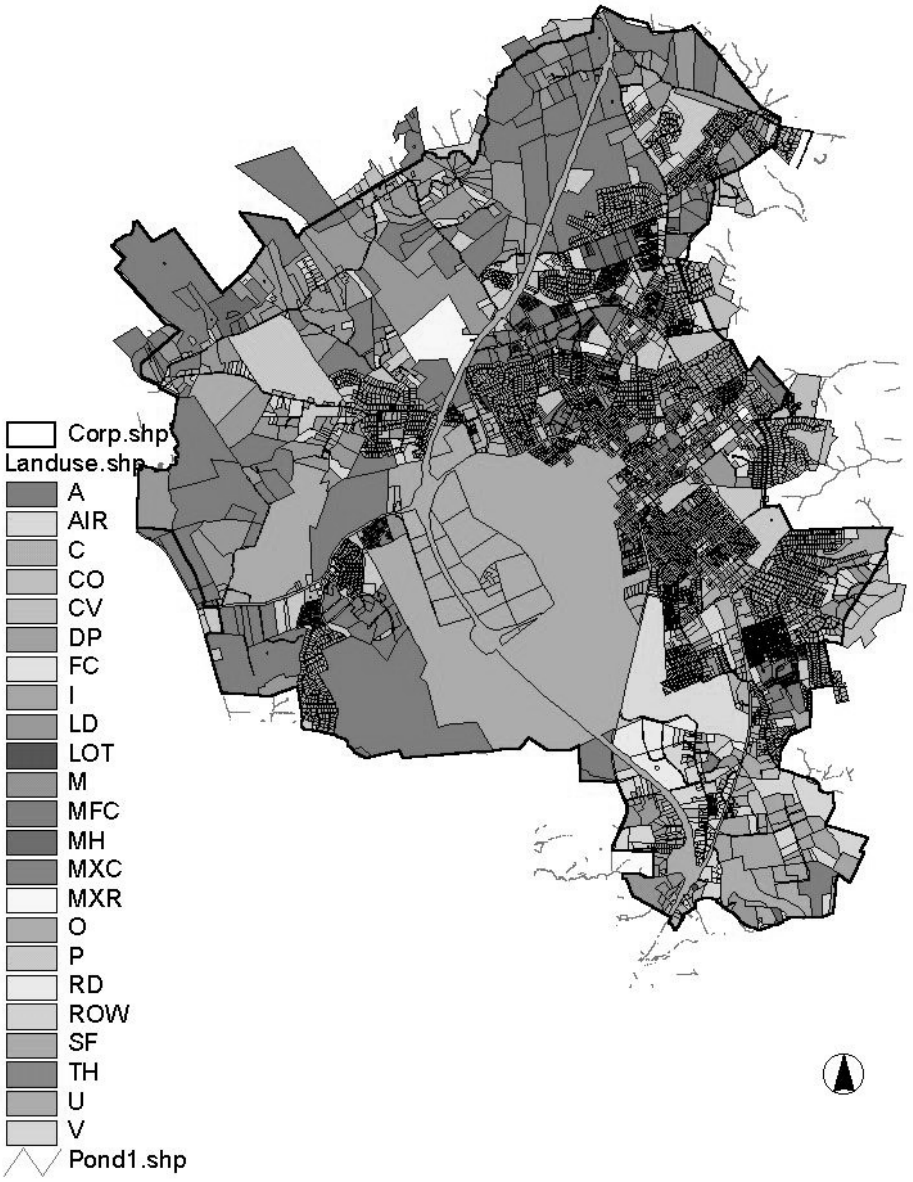

Figure 27: Land use in Blacksburg

(Detailed legend is provided in the Appendix A)

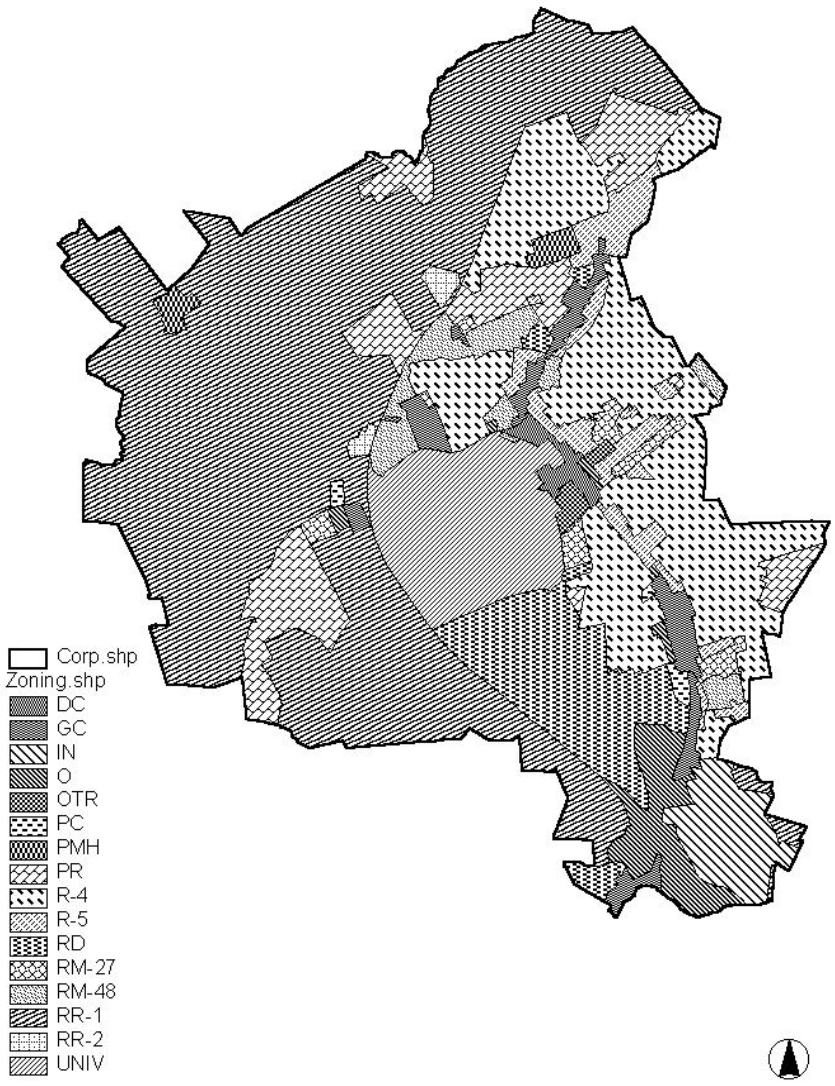

Figure 28: Blacksburg Zoning categories

(Detailed legend is provided in the Appendix A)

3.1.2 Zoning category selection

The zoning map for the town shows prevalent zoning categories within the town. The town has used many different zoning categories for its lands. In the Town of Blacksburg, proffering or conditional zoning is also allowed in some of the areas.

In the lands with conditional zoning, the developers, in exchange for compliance with certain conditions specified in the zoning ordinance, can get increased density; and build higher number of units than are normally allowed. These kinds of zoning conditions can greatly affect the subdivision layout.

To keep the zoning regulations clear and simple, it was decided to choose a parcel from residential zones without provision of conditional zoning. The town of Blacksburg has four such residential zoning categories namely, Rural Residential zone (RR1), Low Residential zone (R4), Multiunit Residential zone and Old Area Residential zone (R5).

From these zoning categories, zones allowing single-family dwelling unit type of development were given preference as they resulted in simpler subdivision layouts. RR1 zone as well as R4 zone, allow single-family dwelling unit type of development.

While RR1 zone aims to protect the rural character of the area, R4 zone allows for complete development of a land parcel with no provision of the open space. Considering the contrasting nature of the restrictions present in these two zoning categories, both the categories were selected for preparation of subdivision layouts. Tom's creek area of the town is primarily zoned as RR1 zone. Therefore it was decided to choose a suitable parcel, from the Tom's creek area and develop subdivision layouts for that parcel according to RR1 and R4 zone regulations.

3.1.3 Selection of a suitable parcel

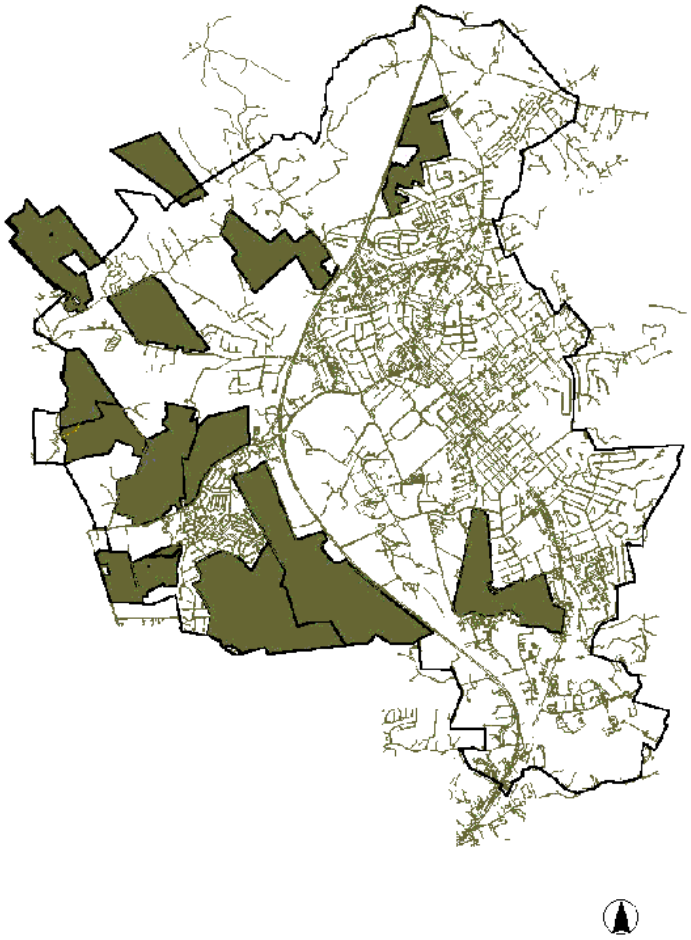

Figure 29: Land parcels with area more than 100 acres

This figure shows all the candidate parcels (with area higher than 100 acres) in the Tom's creek area. While looking for an appropriate land parcel within the Tom's creek area, it was realized that most of the undeveloped parcels are smaller in size than the predefined size of the study parcel; about 100 acres. Moreover, candidate parcels with area higher than 100 acres are all classified under agricultural and forestal districts. A parcel in the agricultural and forestal district gets reduction in the property tax against a promise to retain the agricultural or forestal use of land.

Obviously, these parcels will not be developed primarily for the residential land use in near future. Hence in reality, for the build out analysis, modeling of total residential development will not be done for these land parcels.

However, considering hypothetical nature of the study as well as the unavailability of other suitable parcels of the required size, a parcel from the agricultural and forestal district is chosen. This parcel has some land in the creek overlay zone. Tom's creek area is affected by floodplain of the creek. The town of Blacksburg has identified a creek overlay zone, which prohibits any development in the floodplain of the creek. Therefore, the land affected by creek in the selected land parcel cannot be developed upon.

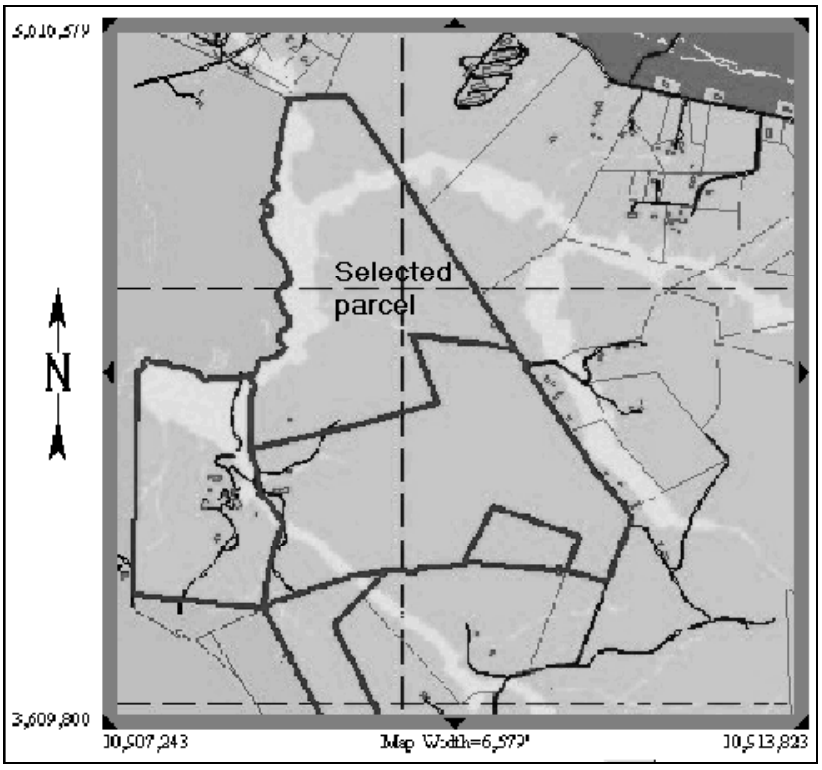

Figure 30: Land parcel selected

3.1.4 Details of the selected land parcel

This information is obtained from the website of the town titled as, 'Town of Blacksburg - WebGIS'. It seems that one person owns the selected parcel as well as some adjacent parcels and therefore more than one parcel boundaries have been highlighted in the image obtained in the query.

The area of the land owned by owner confirms this.

Tax Record: 012263

Owner: McDonald James L et al, 2070 Walnut Springs Rd, Blacksburg, VA 24060

D.B. 362 Pg. 354 Toms Creek,

Map No.: 252- A 1;253(A)*, Transfer year: 0, Acres 339.4

Land Value: $831,900, Building Value: $148,700, Total Value: $980

3.2 Designing subdivision layouts

In this part of the chapter, the process involved in designing of the subdivision layouts for the selected land parcel is explained.

Zoning ordinances specify requirements of subdivision for a particular zone. Depending on the zone type and restrictions, the subdivision parameters can range from detailed level specifications like lot area, lot dimensions, lot coverage to a very broad specification like the gross density of lots within the land parcel. The two zoning categories used for subdivision of the selected parcel have both the extremes as far as zoning regulations are concerned. In the subdivision regulations, the R4 zone has detailed specifications for creation of a subdivision layout, whereas the RR1 zone has general guidelines for the creation of a subdivision layout.

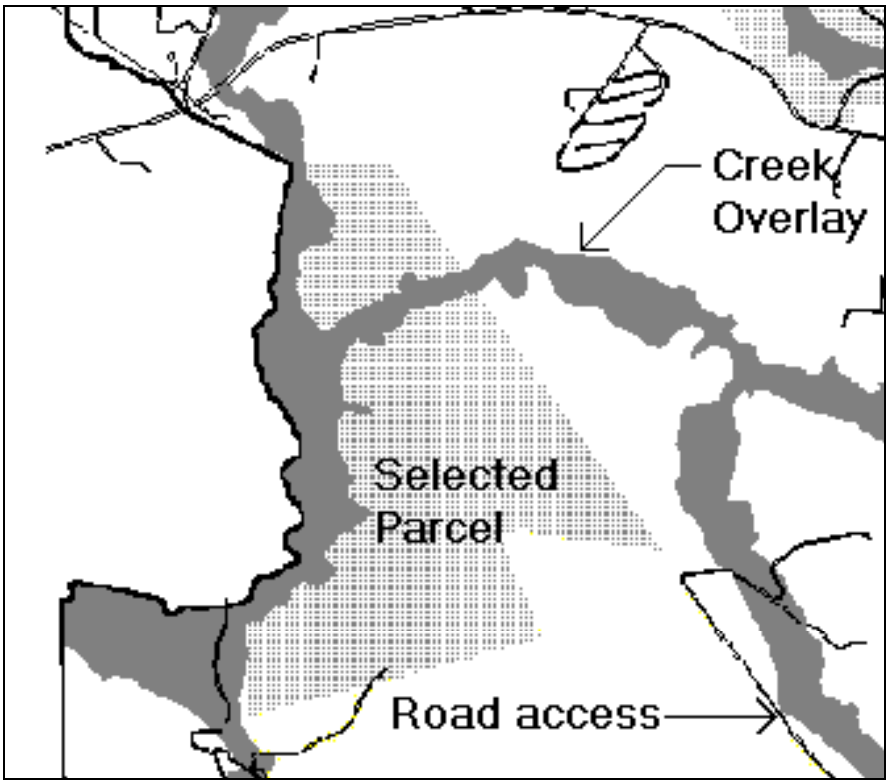

Figure 31: Selected Land parcel, creek overlay and road access

As mentioned earlier, the selected land parcel is located in the RR1 zone in the Town of Blacksburg. Two subdivision layouts are prepared for this parcel in AutoCAD. The first layout is prepared according to the subdivision rules specified in the RR1 zone, while the second layout is prepared according to the subdivision rules for the R4 zone. The selected parcel is also affected by the 'Creek Overlay District'.

The area statement for the selected land parcel is given below.

Table 1: Area of the selected land parcel

Area of the land parcel	4817579.25	sqft
Total area of the creek overlay	1022761.18	sqft
Remaining usable area of the land parcel	3794818.07	sqft

Before presenting the subdivision rules under each zone, definitions of subdivision parameters are given below for reference. These have been obtained from the town code given at the website of the Town of Blacksburg.

3.2.1 Definitions of some terms related to subdivision

LOT--A parcel of land intended to be separately owned, developed, or otherwise used as a unit, established by plat, subdivisions or as otherwise permitted by law.

LOT COVERAGE--That portion of a lot, which when viewed from directly above, would be covered by any building or structure, parking and loading areas and other surface which is impermeable or substantially impervious to storm water. Gravel parking areas shall be considered impervious. For the purposes of this definition, lot shall include contiguous lots of the same ownership within a single zoning district, which are to be used, developed or built upon as a unit.

LOT FRONTAGE--The horizontal distance between the side lot lines measured at the point where the side lot lines intersect the street right-of-way of an improved and publicly maintained street. All sides of a lot, which abut a street, shall be considered frontage. On curvilinear streets the arc between the side lot lines shall be considered the lot frontage. (Ord. No. 1166, adopted 9-9-97)

SETBACK--The minimum distance by which any building or structure must be separated from a street right-of-way or lot line.

FLOOR AREA RATIO--The ratio of gross floor area of all structures on a lot to total lot area.

OPEN SPACE--A cohesive body of land designated for agriculture, horticulture, forestry, or open space use, as those terms are defined by Virginia Code 58.1-3230.

This definition also includes land in which the Town has an interest of not less than five years' duration, which the Town has designated to be retained and used for the preservation and provision of open-space land.

FLOOR AREA, GROSS--The sum of the horizontal areas of the several stories of a building, measured from the exterior faces of exterior walls, or in the case of a common wall separating two buildings, from the centerline of such common wall. Gross floor area shall exclude basements and attics. The surface area of tennis courts, swimming pools, driveways, surface parking spaces, decks, patios, and porches, is not included in the total gross floor area.

3.2.2 Relevant Development standards

(Other relevant development standards can be referenced from the Appendix 3.)

- In general, residential blocks should be between five hundred feet (500') and twelve hundred feet (1200') in length.

- The minimum right-of-way width of proposed streets shall be fifty (50') feet except for permanent cul-de-sacs in which case the minimum width of the linear part of the cul-de-sac shall be forty (40) feet.

- Alley length shall not exceed 1,000 feet without an intersecting street.

3.2.3 The R4 Low Density Residential District

This district allows for low-density residential development for single-family dwellings. The selected parcel does not fall in this district. In order to contrast the results of subdivision layout with RR1 district, subdivision layout with R4 district is also prepared. In the town code, area under each zone is identified as district. The zoning regulations for that district are termed as the district standards.

The district standards for development in this district are shown in the table 2. (Detailed information about the R4 district is given in appendix 2.) There is no restriction on the density in this district. Selected land parcel is also affected by creek overlay district and hence the available area for developable area is reduced.

The maximum number of lots possible in the selected land parcel is about 380, obtained by dividing the developable area by minimum lot size of 10000 sqft. With a floor area ratio of 0.25 for a lot size of 60 ft by 180 ft, the owner can construct a dwelling unit of area 2700 sqft.

With the prevailing setbacks requirements for this district it is possible to construct a single story house. The constraint on the maximum height allows for a three-floor construction.

Table 2: Subdivision Requirements for R4 zone

Parameters	Values	
Minimum Lot Size	10000	Sqft
Lot Frontage	40	ft
Min Setback		
Front Yard	30	ft
Side Yard	10	ft
Rear Yard	25	ft
Max Height	30 - 40 ft	
Lot Coverage	45	%
FAR	0.25	
Gross Density		
Mandatory open space	0	%

The minimum lot frontage allowed in this district is 40ft. However while doing the subdivision layout, the lot width has been kept at 60 ft, to allow for a greater degree of flexibility in the design of a dwelling unit as also for larger side setbacks for corner lots. If a lot is just 40 ft wide, then with 10 ft setbacks on each side, only 20 ft of width is available for the dwelling unit construction. However, if the selected land parcel is subdivided with lots having width of 40 ft, it might be possible to fit in more number of lots than the total number of lots in this layout.

As can be seen in the table 3, out of the developable area, the lots have occupied 84% of the area and the roads occupy about 16% of the area. Lots arranged along the periphery of the land parcel are located about 5 ft away from the parcel boundary in order to allow for utility lines and other such services.

However this additional space of 5 ft space for these edge lots has been calculated in their area, so these lots have area larger than 10800 ft. Some of the lots located at the corners or at awkward junctions are of larger area. Therefore average lot area has increased to 12357 ft.

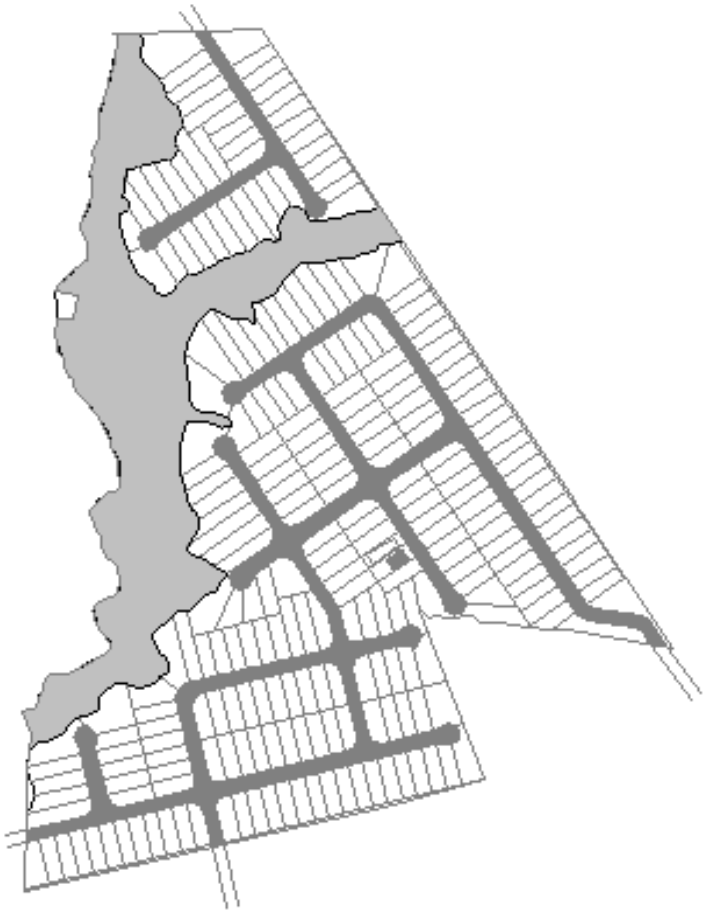

Figure 32: Subdivision layout as per R4 zone

Table 3: Summary of subdivision layout for R4 zone

Maximum possible lots	481.76		
Maximum possible lots - with Creek area subtracted	379.48		
Area of a single lot (60*180)	10800.00	sqft	
Building area (Based on FAR 0.25)	2700.00	sqft	
Max possible area on the ground (Based on setbacks 68 * 40)	2720.00	sqft	
Total area used for development	3794818.07	sqft	100.00 %
Number of lots	258.00		
Area of lots	3188238.05	sqft	84.02 %
Road area	606580.01	sqft	15.98 %
Open space	0.00	sqft	
Average area of a lot	12357.51	sqft	

3.2.4 The RR1 Rural Residential District 1

The rural residential districts have been designed in the town to maintain the rural character of the district. This district aims to protect the conservation areas like agricultural and forestall lands, farm fields and pastures, environmentally sensitive areas like flood plains or steep slopes. The district standards in this district allow lesser development and also require mandatory provision for the open space. The standards are given in the table 4. (Detailed information about the RR1 district is given in appendix B).

In this district, the development standards are not stringent and there is a gross density specification of 1 dwelling per acre. Therefore the maximum number of lots possible in this district for the developable area of selected land parcel is 88. This district is designed for conservation of rural character. The gross density specification along with mandatory requirement of 50% open space encourages clustered development. For the subdivision layout as per requirements of this district, a lot size of 60 ft by 180 ft is chosen. This lot size equals a quarter acre lot and creates quite a dense development.

Table 4: Subdivision Requirements for the RR1 zone

Parameters	
Minimum Lot Size	No minimum size
Lot Frontage	20 ft minimum
Min Setback	
Front Yard	35 ft from a road 50 ft wide
Side Yard	10 ft, corner plot 20 ft
Rear Yard	20 ft for main structures
Max Height	35 ft
Lot Coverage	
FAR	0.30, Townhouse 0.50
Gross Density	1 dwelling per acre
Mandatory open space	50 %

The subdivision of the land parcel with 88 lots of 60ft by 180 ft size, has accounted for 31 % of the developable area.

The lots located at corners and awkward junctions are of much larger size, also the lots located along the edge of the land parcel are about 5 feet longer in order to accommodate the utility services if any along the boundary.

Hence the average lot area is 11297 sqft. The road area is about 15.32% of the developable area. Total open space provided in this layout occupies 69% of the total area of the selected land parcel. However, this area also includes area unavailable for development due to the creek overlay district.

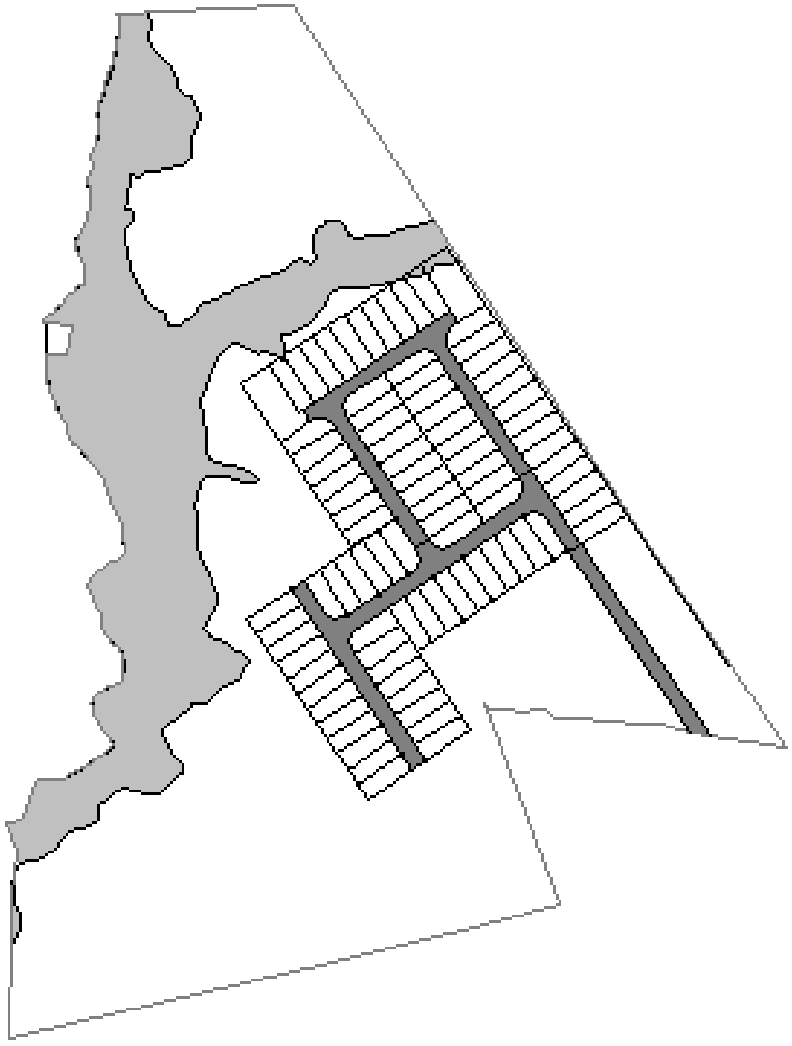

Figure 33: Subdivision layout as per RR1 zone

Table 5: Summary of subdivision layout for the RR1 zone

Maximum possible lots	110.60			
Maximum possible lots - with Creek area subtracted	87.12			
Area of a single lot (60*180)	10800.00	sqft		
Building area (Based on FAR)		sqft		
Max possible area on the ground (Based on setbacks)		sqft		
Total area used for development	1174107.57	sqft	(100.00)	30.93 %
Number of lots	88.00			
Area of lots	994143.36	sqft	(84.67)	%
Road area	179964.21	sqft	(15.32)	%
Open space	2620710.49	sqft	69.06	%
Average area of a lot	11297.08	sqft		

Comparison of two layouts prepared above is given in the table below.

Table 6: Comparison of subdivision layouts for RR1 and R4 zone

	Layout for the RR1 zone		**Layout for the R4 zone**	
Total area used for Development (sqft)	1174107.57	(100.00) 30.93 %	3794818.07	100.00 %
Number of lots	88.00		258.00	
Area of lots (sqft)	994143.36	(84.67) %	3188238.05	84.02 %
Road area (sqft)	179964.21	(15.32) %	606580.01	15.98 %
Open space (sqft)	2620710.49	69.06 %	0.00	
Average area of a lot (sqft)	11297.08		12357.51	

Difference in the intensity of possible development with application of the different district standards is evident from the total number of lots possible in each layout. The R4 zone allows about 258 lots whereas the RR1 zone allows for 88 lots, thus reducing the number of dwelling units by two thirds. Moreover the RR1 zone also has a lot of open space, compared to the R4 zone.

Chapter 4: Comparison of layouts

The process involved in drawing of the subdivision layouts using the build out program in ArcView has already been explained before. In this chapter, the process involved in preparing a subdivision layout in AutoCAD and importing it into ArcView, is explained. A comparative analysis of both these methods is presented.

4.1 Integration of AutoCAD layouts into ArcView

ArcView has been used in this study as GIS software, primarily because it is commonly used for this kind of spatial analysis. It provides various tools for analysis of maps such as creation of new maps using overlay operations and other specialized functions like derivation of surfaces. However, it is not very easy to draft in ArcView. It has basic tools for drawing of a point, line and shapes, most of which suffice drawing needs during digitizing operations. Therefore, if one has to draw a number of rectangles of the same size, aligned together, and having same slope, it is quite tedious to do so using this software. ArcView has compatibility with file formats of other sophisticated drafting software like AutoCAD or Micro station. It allows for exportation of shape files into DXF files (Drawing exchange format) and importation of DXF files. Hence, it is possible to use external drafting software for developing subdivision layouts.

AutoCAD is widely used for drafting as well as 2d and 3d modeling. It supports precision drawing and provides variety of drawing tools to make the process highly efficient and user friendly. AutoCAD was used as external drafting software for preparing the subdivision layouts for the selected land parcel. The layout drawing files were imported into ArcView in DXF format.

AutoCAD drawing in both, DXF or DWG format can be directly added to a theme in ArcView, by keeping the 'Cad Reader' extension on. There are four types in which a drawing can be read in ArcView, namely Line, Point, Polygon and Annotation. For drawing of subdivided lots in a parcel, the polygon type is needed. The polygon type requires that each lot polygon be closed. A normal AutoCAD drawing, composed of lines cannot be successfully imported in a polygon type into ArcView.

However, if each lot in AutoCAD is made into a 'Polygon' entity using the 'Boundary' command then all the lots, roads and other polygons can be successfully incorporated in an ArcView map as different polygons. However, in the theme attribute table the imported lot polygons do not have unique ids, but are identified by a unique row. This is evident in the figure 38, depicting the theme attribute table of a DXF file.

To match the format of the DXF file, with other theme files, the user needs to convert it to a shape file format by choosing the 'Convert to a shape file' menu item from the 'Theme' menu. In this theme then the user can manually define ids for each lot and enter those values in the theme attribute table.

The imported DXF files need to be inserted carefully into the ArcView at correct coordinate locations, to match with other themes. Otherwise there may be errors. AutoCAD being precise drafting software, offers a variety of tools and options for drawing.

Even then, creating a simple layout in AutoCAD takes a lot of time. To draft multiple subdivision layouts in AutoCAD, it is necessary to have a skilled AutoCAD user.

4.2 Comparison of output generated by AutoCAD and ArcView program

Subdivision layouts prepared for R4 and RR1 zones, with use of AutoCAD and ArcView program are shown below for comparison.

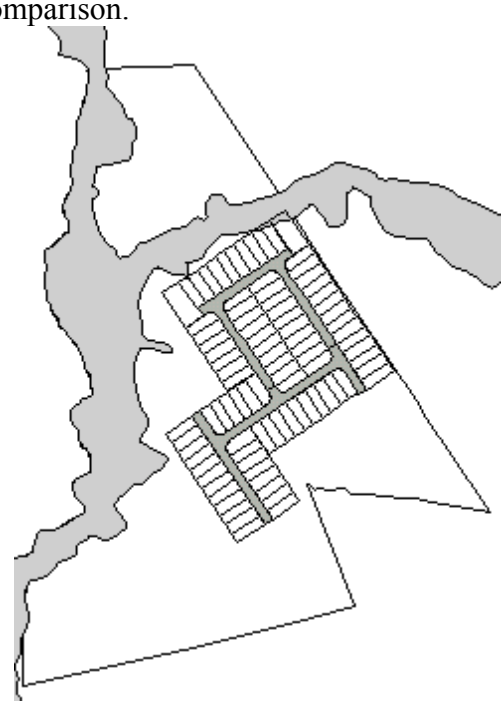

Figure 34: Layout for RR1 zone with use of AutoCAD

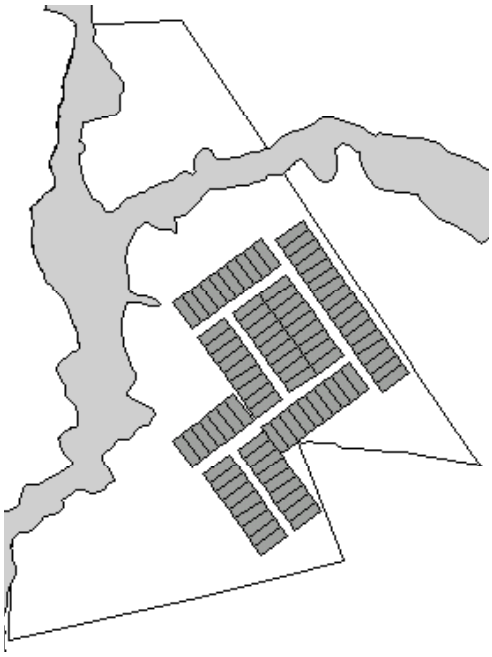

Figure 35: Layout for RR1 zone with use of program

Note that the layouts drafted in ArcView with the program, have been drawn without the aid of the grid tool. If the user resorts to the use of grid, then the lot arrangements will be well aligned in the resulting layout.

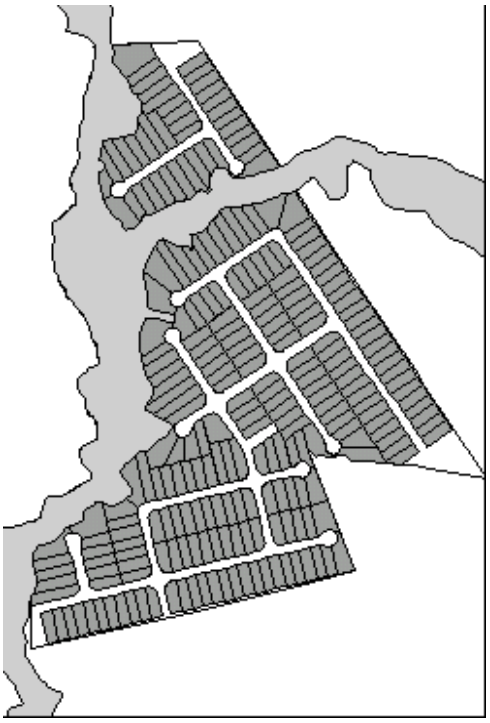

Figure 36: Layout for R4 zone with use of AutoCAD

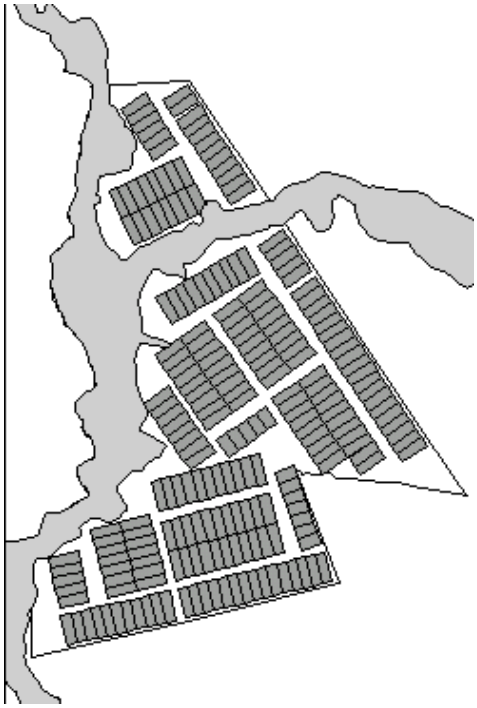

Figure 37: Layout for R4 zone with use of program

Theme attribute tables generated by both these methods are shown below.

Attributes of Pgons.dxf

Shape	Entity	Layer	Elevation	Thickness	Colo
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	0	0.00000	0.00000	50
Polygon	Polyline	ROADS	0.00000	0.00000	253
Polygon	Polyline	ROADS	0.00000	0.00000	253

Figure 38: Theme attribute table for the AutoCAD dxf theme

Note that a unique id field representing each lot polygon is absent in the attribute table of the imported DXF theme.

Attrib...

Shape	ID
Polygon	214
Polygon	215
Polygon	216
Polygon	217
Polygon	218
Polygon	219
Polygon	220
Polygon	221
Polygon	222
Polygon	223

Figure 39: Theme attribute table for the ArcView Program theme

Table 7: Comparison of methods

Criteria	AutoCAD/ Similar drafting software	ArcView
1. Level of Detailing	Very precise and detailed	No detailing, rough work
2. Theme attribute table	Editing required	No editing required
3. Skill	Knowledge of a drafting software necessary	ArcView knowledge is sufficient
4. Time	Time consuming	Fast
5. Drawing process	Availability of variety of tools like grid, copy, move, rotate, align etc.	No tools, Can move but not very precise.
6. Efficient use of land Area	In AutoCAD land can be used more efficiently and it may be possible to fit more number of lots.	In ArcView program, there is some loss of land space due to incorrect alignment of lots against road areas etc.
7. Roads	Can be drawn and imported as polygons	Roads are implied by drawing of lots, they aren't drawn as polygons, difficult to estimate road areas
8. Polygon theme	To bring in a drawing as polygon theme, line drawing has to be converted into polygons	Program makes a polygon theme

4.2.1 Level of Detailing

It can be seen from the output, that layouts generated with AutoCAD are precise. They are more detailed, with features like curved edges for roads and cul-de-sac at the end of a road. Also road widths are consistent everywhere and lots are well aligned within blocks. In case of a layout generated by ArcView program, it is not possible to get exact and precise output like AutoCAD work. This can be attributed to various factors like unavailability of precise tools for drafting and difficulty involved in programming for drawing of detailed features like curvature of lots. Also, it is difficult to get a feel for distance initially when one starts drawing lots. The Reason for this is, in ArcView user can get information about the coordinates at the cursor location, but user cannot get information about the relative movement of cursor unless 'Measure' tool can be used, or grid theme is used as a reference. While entering a line in the view for drawing of lots, only 'Line' tool can be active, and therefore simultaneous use of 'Measure' tool is not possible.

4.2.2 Theme attribute table

Theme attribute table generated by each method is quite different. The ArcView method gives a unique id to every lot polygon created whereas the AutoCAD method gives attribute information pertaining to the AutoCAD drawing.

In the AutoCAD generated layout, lot polygons are not identified with a unique id, though there is a unique row for each lot polygon. Hence, in the AutoCAD generated layout, it is necessary to input id information manually in the theme attribute table.

4.2.3 Skill

Drawing of subdivision layouts in AutoCAD or similar drafting software, requires working knowledge of that software. However, for layout generation with the use of the program in ArcView, additional knowledge of drafting software is not necessary. As mentioned earlier, ArcView or similar GIS software is used for doing most of the work in build out analysis. Therefore generally, a user working on a build out analysis project has necessary skills in GIS software.

4.2.4 Time

Time wise ArcView program is much faster because some time is saved in export, import operations. Besides ArcView work does not involve detailing of lots and precise drafting hence it consumes less time. In AutoCAD even after the drafting process is complete, it is necessary to spend additional time in creating a polygon boundary for every lot. Moreover as mentioned above ArcView generated layout does not require any editing on the theme attribute table.

4.2.5 Drawing process

In ArcView, tools for operations like move, copy, rotate, align are not available. It is possible to move a group of lots but the method is unwieldy, and does not allow precise movement. Besides aligning groups of lots in one line is very difficult especially if they are not drawn along a horizontal line, or if the grid is not used.

4.2.6 Efficient use of land area

In an AutoCAD generated layout, because of the availability of efficient drafting tools, it is possible to use the entire land economically and fit more number of lots. This can also be done in ArcView, however drawing of single lots with different dimensions and aligning them with each other is not very easy. Hence some space gets wasted if lots are not well aligned and roads are not of the same width. In a layout, lots located at awkward junctions and corners are generally of different size than the typical lot size. To draw these lots accurately with ArcView program can be cumbersome.

4.2.7 Roads

In an AutoCAD generated layout, roads can be easily made into polygons, once drafting of the layout is complete. These road polygons can be incorporated in ArcView. In the ArcView program, there is no provision for drawing of roads separately. Drawing of lots implies road spaces. However, there is one drawback of this method. It is difficult to calculate road area in an ArcView generated layout.

4.2.8 Polygon theme

ArcView program creates a polygon theme. Default method for importing an AutoCAD drawing is a line theme. The importation of a line drawing as a polygon theme is not successful. It is necessary to convert line drawing into polygons using boundary (bpoly) command in AutoCAD. However one can specify the import theme format as the polygon theme. Then all the lot polygons can be as polygons into ArcView.

4.3 Advantages and limitations of using these two methods

From the discussion above, it is clear that while AutoCAD or drafting software produces an accurate and detailed layout, ArcView generates a sort of rough layout. However, AutoCAD method is time consuming and ArcView program is relatively fast. The build out analysis requires drawing of subdivision layouts for a large number of land parcels. For that reason, faster method of drawing subdivision layouts is preferable.

Besides, the build out analysis does not require a very accurate layout as far as location of lots is concerned, as long as the layout conveys an idea of the possible pattern of development. It is also true for drawing of detailed features like the curvature of lots at corners, or drawing of lots with different dimensions at awkward junctions. Moreover, less efficient use of the land can be adjusted by assigning some percentage of lots to the layout prepared using this program.

If accurate quality of work is desired, one can still use the program to generate a rough layout for rapid appraisal and use AutoCAD later to refine the layouts. We can further refine the process of doing the build out analysis by using both these methods of drawing a subdivision layout. Different patterns of subdivision of lots can be developed using AutoCAD. Then these patterns can be used as a reference while doing the layout in ArcView and lots can be drawn as per these patterns in a large number of land parcels. This can be also useful in drawing the subdivision layouts for different zones. One can do typical patterns of development according to each zone in AutoCAD. Using these patterns as templates or a visual reference, then lots can be drawn in ArcView.

Detailed level of analysis like road area percentage, percentage of impervious surfaces etc. can be done based on accurate AutoCAD layouts. Results of such analysis can then be applied to a bigger area.

Generally in the Build out process, the impacts of proposed development on other aspects are not taken into consideration at the layout preparation stage. However, since the layouts are generated in the GIS software itself it may be possible for the user to understand the impacts of development on other features using overlay of themes. This may be helpful if time constraints are present.

Chapter 5: Scope for further development

ArcView program creates an easy interface for drawing of lots, and makes the process of drawing a subdivision layout much simpler. However, creation of a subdivision layout is still a tedious process and has to be tackled at a single parcel level. This happens because of irregularity of parcels, variation in size, shape and area, differences in land uses and zoning restrictions. Possibility of generalization from one parcel to many parcels needs to be explored further. While understanding that the program does not address this issue, some useful improvements to the program are suggested below.

5.1 Scope for improvement in the ArcView program

The ArcView program can be further enhanced if some more functionality can be rendered to the program. While working with the ArcView program to generate subdivision layouts for the selected parcel, a need for additional features was felt. These features and other ideas, which can make the process of drawing of subdivision layouts in ArcView more efficient, have been identified below. Some of these suggestions are not very difficult to incorporate in the program, however have not been added at present due to the time constraint. Also I learnt the ArcView programming language 'Avenue' to write this program and that consumed quite a lot of time and effort. Other suggestions though need more thinking and research.

Table 8: Desired Improvements in the program

1. If the user can define block length with a line that can be helpful sometimes.

2. Refined tools for moving, aligning and copying operations would be helpful.

3. If automatic generation of lots can be done along the road line drawn by the user that would be useful.

4. If it were possible to copy patterns from the existing layout and paste on the parcel, that would be helpful and realistic.

5. If program can draw intuitively a layout after selection of a polygon that will be very efficient.

6. If a program could generate appropriate dimensions of lots as well as buildings using information from the zoning ordinance about FAR, Setbacks, Lot coverage, Lot frontage, Minimum Lot size and Block width then that would make process of build out analysis easier.

5.1.1 Definition of block length with a line input by the user

While writing the program, the block length was incorporated as a variable, primarily because a range for block length is specified in the development standards. If the user is given a choice to define the length of a block with a line input in the view, then it is necessary to check later if block width satisfies specified criteria. However drawing of a line to define blocks can be useful especially since it is difficult to get a sense of distance at the time of drawing lots. If the user is using the grid tool as a guideline for drawing lots, then the user will have an idea of relative distance between points.

This suggestion does not seem that difficult to incorporate in the program, however ArcView requires use of a 'Tool' to accept any sort of a user input in the view window. Right now, we use this sort of a tool to specify the start line for drawing the lots in the view. If the same line is used to specify the block length, then it is possible to incorporate this suggestion in the program. However if the user desires to specify an input line for block length at a different time during execution of the program, then this suggestion may be quite difficult to incorporate. In that case, it will be necessary to switch between two tools to define the program parameters. Use of two tools for setting the program parameters will complicate the matters and incorrect inputs may cause the program to crash.

5.1.2 Refined tools for moving, aligning, copying, rotating

As mentioned previously, these tools can be helpful in adding lots, for making better layouts and for trying out different arrangements. Drafting process can be made easy with these features. Incorporation of these features into the program may be difficult. Some research may be required to build these features into the code.

5.1.3 Automatic generation of lots along roads input by the user

One can use roads as a guideline for subdividing land space. Then a program can be designed to use the spatial information about roads and subdivided spaces, to draw lots along the roads. This is a different way of approaching the process of developing a subdivision layout. It may have certain advantages and disadvantages. However, the user input will just consist of drawing the roads and hence, that may be faster than the present method. Though, roads will have to be drawn with equal thought and calculations will have to be done for the space to be left in between to accommodate. Hence, the user input may take some time. This is a totally different way of doing a subdivision layout and existing program can't be modified to incorporate this method of drawing subdivision layouts.

5.1.4 Ability to copy and paste patterns from the existing development

While doing the layouts in AutoCAD, I studied existing patterns of development in the Town of Blacksburg. While quite a few areas resembled gridiron pattern of development, there were some areas with curved roads and non-rectangular lots. It would be very useful if we could copy existing patterns of development and just paste those on the land parcel. Layout patterns can also be obtained from the aerial photographs. We can choose typical patterns of development in different zones and use those in the build out analysis. If it is possible to develop functionality for move, copy operations as mentioned in one of the suggestions, then it may be possible to incorporate this idea into the program.

5.1.5 Use of terms given in zoning ordinances for definition of parameters

Generally zoning ordinances define values for FAR, Setbacks, Lot coverage, Lot frontage, Minimum Lot size and shape the pattern of development in each zone. Values for lot dimensions used in the subdivision process are derived from these regulations. It might be possible to use values from the regulations directly and make the program more useful. For example, we can set range for the block length. Then the user can enter block length with a line. If length of the line doesn't exceed the specified block length range, program will execute and lots will be drawn. Otherwise, the program will give a message to the user saying that the block length exceeds the regulation limit. Similarly, using parameters like FAR, lot coverage and setbacks, it might be possible for the program to calculate the building dimensions. Or maybe, the user can set one dimension for building like width or length and using that and these other parameters program can set the other dimension. Such variations can be incorporated into the program and may prove to be very useful.

It is not very difficult to incorporate these values into the program dialog box. However, Avenue interface for designing a dialog box is not very user friendly, and more controls on the dialog box require more scripts and further complicate the program. If the tools available in Avenue are improved, or another language is used for programming, then this can be easily done.

5.2 Avenue programming interface

The ArcView programming language, 'Avenue' is not a very sophisticated programming language like Visual Basic or C++. It is not very easy to use the dialog boxes, and tools available for manipulation of controls are less in number. Besides, the documentation for usage of features of the 'Dialog Designer extension' is not very detailed. Dialog boxes do not work very well with some extensions of ArcView such as '3d Analyst'. Other option is to use the message boxes instead of the dialogs. However, that is not a very good idea especially since the user input is required in setting quite a few variables.

The user input in the view window can be obtained with the use of a 'tool' button and that presents some complications. For example, I found it quite difficult to switch between the dialog box and the line tool (The tool which takes line input from the user in the view window) and had to arrange the tool function at the end of the dialog box to avoid conflict of commands.

In Avenue, actual code is written in scripts. If a script is associated with a button in the menu bar or a tool in the toolbar, one script is sufficient to incorporate the entire program. However addition of a dialog box proved very tedious. A separate script had to be written for each event of the control in the toolbar. Also, all the values obtained or calculated in each operation have to be passed to another script. This is done using object tag property or global variables. I used global variables, though that method is not memory efficient. On the whole, many separate script files had to be generated for completing the entire program.

Documentation for usage of avenue in 'help' files of ArcView is not very descriptive. Hence a lot of time is wasted in trying out things.

Most of the problems listed above are procedural problems. To an experienced avenue programmer these might not seem like problems at all. Some problems like inadequate features of dialog boxes are limitations of the ArcView.

In future though, with the new version of ArcView, 'ArcView 8.1', one may not be required to deal with Avenue at all. 'ArcView 8.1' supports use of 'Visual Basic'. Visual Basic is quite an advanced programming language in comparison to Avenue. That may completely revolutionize use of ArcView. With Visual Basic it may be very easy to customize the ArcView interface and build much better programs. With additional capabilities of Visual Basic, we may be able to develop much more sophisticated tools for the 'Build out analysis' and incorporate new features and ideas.

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Appendix A: Land Use Descriptions And Zoning Legend

Land use Descriptions

A – *Agricultural*: Parcels with no structural development, but in current ag use

C – *Commercial*: Retail sales establishments, restaurants, hotels/motesls, and service stations.

CND – *Condos*: Condo units

CV – *Civic*: Schools, churches, government offices or use, clubs and other institutional uses.

CVCEM – *Civic/ Cemetary:* Cemetaries

CVSH – *Civic/ Special Housing:* Greek social/fraternal organizations

DP – *Duplex*: Two attached units

I – *Industrial*: Medium and heavy manufacturing which may produce moderate to significant exterial effects. Uses include raw materials processing, assembly lines, and other large scale operations.

LD – *Low-density Residential/Ag*: Single family units on more than 2 acres of land

M – *Medical*: Medical services

MFC – *Multi-Family Complex*: Attached units including triplex and quadplex.

MH – *Mobile Homes*: Mobile homes and trailor parks.

MXC – *Mixed Use Commercial*: Commercial property with secondary other use.

MXCO – *Mixed Use Comm/Office*: Commercial and Office

MXCR – *Mixed Use Comm/Res*: Comercial and Residential

MXOR – *Mixed Use Office/Res*: Office and Residential

MXCOR – *Mixed Use Comm/Off/Res*: Comercial, office, residential

MXR – *Mixed Use Residential*: Residential property with secondary use

O – *Professional Offices*: Offices where professional services are being provided, but retail sales or manufacturing do not take place, includes banks

P – *Parks & Trails*: Parks, tot lots, greenspace, bike trails, etc

RD – *Light industry R&D*: Research, assembly, packaging, processing or manufacturing which does not emit smoke, noise, soot, dirt, vibration, odor, etc., Includes Tech Airport

ROW – *Right of Way*: Road ways

SF – *Single Family*: Single family detached unit up to 2 acre lot

TH – *Town Homes*: Town home units

U – *University*: All Tech owned land

V – *Vacant*: Vacant land

Zoning Legend

Residential Districts

RR-	1 Rural Residential 1
RR-	2 Rural Residential 2
R-4	Low Density Residential
R-5	Transitional Residential
OTR	Old Town Residential
RM-27	Low Density Multi-unit Residential
RM-48	Medium Density Multi-unit Residential
PR	Planned Residential
PMH	Planned Manufactured Home

Commercial Districts

DC	Downtown Commercial
GC	General Commercial
PC	Planned Commercial

Office Districts

O	Office
R&D	Research and Development

Industrial Districts

IN	Industrial
PI	Planned Industrial

University Districts

UNIV	University

Overlay Districts

CVO	Creek Valley Overlay
FHO	Flood Hazard Overlay
SHO	Special Housing Overlay
HPO	Historic Preservation Overlay
OSO	Open Space Design Overlay

Appendix B: RR1 Zone rules

DIVISION 2. RURAL RESIDENTIAL 1

Sec. 3020 Purpose.

The purpose of the Rural Residential district is to provide for residential development at a scale intended to conserve the rural character of the district. Development within the Rural Residential district is intended to promote the following goals and objectives. Development proposals shall be evaluated for their adherence to these goals: (Ord. No. 1184, adopted 6-9-98)

(1) Conservation of agricultural and forestal lands, including farm fields and pastures.

(2) Conservation of natural resources including wetlands, flood plains, natural drainage ways, aquifer recharge areas, existing tree cover, steep slopes, ridge lines, hilltops, wildlife habitats, deer wintering areas, stream valleys, locations comprising scenic views or scenic view corridors, and other outstanding natural topography.

(3) Conservation of a unified open space area.

(4) Creation of residential developments on a traditional rural scale, with small villages surrounded by agricultural, forestal, or open space lands.

(5) Flexibility and creativity in the design of residential subdivisions, with less suburban-style sprawl and less consumption of open land.

Sec. 3023 Development Standards.

Each residential lot shall be of a size and shape to provide a building site, which shall be in harmony with the natural terrain and other features of the land. Residential lots shall be designed in such a way as to promote the purposes of this chapter. The following minimum standards shall apply.

(a) Density

Maximum density shall be one dwelling unit per acre, excluding acreage within the 100 year floodplain.

(b) Minimum Lot Requirements:

Area: No minimum lot size

Minimum frontage: 20 feet on a publicly owned and maintained street

(c) Minimum Setback Requirements:

Front yard:

(1) For lots adjoining minor streets:

Building height	16--35 feet	13 feet
Building height	15 feet or less	8 feet

(2) For lots adjoining collector roads:

35 feet from the abutting right of way of any collector road of 50 feet or greater in width; 60 feet from the center line of any collector road right of way this is less than 50 feet in width.

Rear yard:	Principle structures	20 feet
Side yard:	10 feet, except on corner lots, a side yard facing the street shall be 20 feet	

Detached garages located at the rear of a lot (i.e. behind the rear building line) and attached to a similar garage on a contiguous lot may be located within the side yard setback.

(d) Maximum Floor Area Ratio

Maximum floor area ratio shall be 0.30, except townhouse maximum floor area ratio shall be 0.50.

(e) Maximum Height of Structures, except church spires, belfries, cupolas, monuments, water towers, chimneys, flues, flagpoles, television antennae, and radio aerials are exempt: 35 feet. Utility poles may have a maximum height of 45 feet.

(f) The maximum dwelling unit occupancy shall be a family, plus two persons unrelated to the family; or no more than three unrelated persons.

(g) All utility lines, electric, telephone, cable television lines, etc., shall be placed underground.

(Ord. No. 1184, adopted 6-9-98; Ord. No. 1215, § 7, 5-11-99)

Sec. 3024 Minimum Open Space.

A minimum of 50% of the total area shall be designated as permanent open space upon the first subdivision of any parcel subsequent to the creation of this district, or upon the approval of a special use permit. This requirement shall be in lieu of the requirements of Section 5-30 of the Blacksburg Subdivision Ordinance.

Appendix C: R4 Zone Rules

DIVISION 4. R-4 LOW DENSITY RESIDENTIAL DISTRICT

Sec. 3040 Purpose.

The R-4 Low Density Residential District is provided in recognition of sections of the town with low density residential development and land which appears appropriate for such development. Among these sections is land where the established use, character or density of development would be best protected by these regulations. The low density residential district is intended to define and protect residential areas of low density from the intrusion of uses not performing a function appropriate to the residential environment. Attractiveness, order and efficiency shall be encouraged by the requirement of adequate space for individual homes with adequate light, air and space, and maintaining an appropriate density of residential development. This district shall be intended to add to the physical variety of the overall residential area while promoting balance and stability.

Sec. 3042 Site Development Regulations

(a) Minimum lot requirements
  (1) Lot area 10,000 square feet
  (2) Lot frontage 40 feet

(b) Minimum setback requirements
  (1) Front yard 30 feet (may be reduced to 25 feet for uses with parking in rear)
  (2) Side yard 10 feet, except on corner lots, a side yard facing the street shall be 20 feet
  (3) Rear yard 25 feet

(c) Maximum height of structures, except church spires, belfries, cupolas, monuments, water towers, chimneys, flues, flagpoles, television antennae, and radio aerials are exempt: 30 feet; or 40 feet with an additional one foot setback per foot of additional height. Utility poles may have a maximum height of 45 feet.

(d) Maximum coverage:
  (1) Lot coverage 45%
  (2) Floor area ratio 0.25 FAR

(e) The maximum dwelling unit occupancy shall be a family plus two persons unrelated to the family; or no more than three unrelated persons.

(f) All utility lines, electric, telephone, cable television lines, etc., shall be placed underground.

(Ord. No. 1215, § 9, 5-11-99)

Appendix D: Development standards

ARTICLE V. DEVELOPMENT STANDARDS, DIVISION 1. SITE DEVELOPMENT PLANS

Sec. 5100 Developments and uses requiring a site development plan.

A site development plan must be approved by the Administrator prior to the commencement of the following uses and developments:

(a) Any use or development in all zoning districts, including special uses, except for individually developed single-family detached dwelling units and individually developed two-family dwellings. (Ord. No. 1184, adopted 6-9-98)

(b) Any change in a previously approved site development plan.

(c) The conversion of an existing residential use to a commercial, industrial or higher density residential use.

(d) All public or semipublic buildings.

(e) All other uses involving a structure requiring review by the planning commission under section 15.2-2232 of the Code of Virginia, as amended.

(f) Development of lot or land without access to or abutting on a public right-of-way.

(g) Any addition of 400 square feet or more to an existing development and any addition to an existing development which implicates other site development plan requirements.

(h) Modification to an existing site where other site development plan requirements are implicated.

(Ord. No. 1247, § 18, 9-12-00)

Sec. 5101 Exceptions.

A site development plan shall not be required for a building addition which is under 400 square feet in size and which does not implicate any other site development plan requirement, and for any modification to an existing site where no other site development plan requirements are implicated. A site development plan is not required for the development of an accessory structure in the RR-1, RR-2, R-4, R-5 and OTR zoning districts.

Sec. 5120 Minimum Standards and Improvements Required.

(a) Any improvement required by this ordinance, or any other ordinance of the Town shall be installed at the cost of the developer unless other written agreements have been reached between the developer, the Town, the Virginia Department of Transportation, and/or any other governmental agency. Where cost-sharing or reimbursement agreements between the Town and applicant are entered into they shall be recognized by formal written agreement prior to site development approval.

(b) All proposed construction and site improvements shall conform to the provisions of this Chapter (the Zoning Ordinance) and Town Code. Further, streets, utilities, storm management, and sidewalks shall conform to the applicable provisions of the Subdivision Ordinance, Water System Specifications, and Sewer System Specifications. Erosion and sedimentation provisions shall comply with Chapter 8, Town Code.

(c) The arrangement of streets on the site shall make provision for the continuation of existing streets in adjoining areas and the incorporation of all mapped rights-of-way within the property. This function shall be governed by the standards prescribed therefore in the subdivision ordinance.

(d) (1) Sidewalks meeting the design standards of the subdivision ordinance shall be provided on public or private land along all parts of a site abutting a developed public street, where such sidewalks do not exist as of the date of the application for site plan approval. The provision of these sidewalks will advance the goal of the Blacksburg comprehensive plan of development of "a network of walkways in the town to increase the safety and convenience of pedestrian travel." The town council finds that the need for such sidewalks in this town is substantially generated by the development.

(2) The zoning administrator may eliminate or lessen the requirements of this subsection based on the following standards; proximity of the site to public schools, public parks, and the campus of Virginia Polytechnic Institute and State University; the existing sidewalk network in the area; the location of transit stops, and topographic or other natural constrains. In addition, provision shall be made for sidewalks and pedestrian walkways which will enable patrons and tenants to walk safely and conveniently from one building to another within the site and to buildings or uses on adjacent sites.

(e) Adequate easements shall be provided for drainage and all utilities. Minimum easement width shall be fifteen feet unless specifically reduced by the administrator, based on

need or the physical characteristics of the site. Where easements do not follow the established lot lines, the nearest edge of any easement shall be a minimum of five feet from any building.

(f) The site development plan for each phase of a multi-phased development shall demonstrate compliance with the Zoning Ordinance for each phase.

h) Streets:

Mandatory:

(1) Existing and proposed streets including street rights-of-way, their names, width, width of surface or distance between curb faces and relation to center line, and street names and route numbers, if applicable, of all adjoining streets.

Sec. 5204 Driveways.

(a) All driveways shall be no less than three feet from a lot line or may be adjacent to the lot line if a common driveway is provided for two adjoining lots.

(b) Vehicular access to public rights-of-way shall be governed by the standards of the subdivision ordinance, Town Code Appendix B.

(c) All entrances constructed from a new or existing street shall be constructed in accordance with the standards of the subdivision ordinance, Town Code Appendix B.

(d) Minimum driveway width for developments requiring a site development plan shall be 20' for two-way directional use and 14' for one-way directional use.

(e) The pavement of vehicular travel lanes, driveways or alleys designed to permit vehicular travel on the site and to and from adjacent property and parking areas shall be as prescribed by the subdivision ordinance.

(f) All driveways shall have a maximum grade of 12%.

(g) All driveways and travel lanes shall not be longer than 900 feet, unless a second means of access is provided to a publicly maintained street. (Ord. No. 1184, adopted 6-9-98)

Sec. 5-200. Lot shape.

The lot arrangement, design and shape shall be such that lots will provide appropriate sites for buildings and be properly related to topography so that each lot has an acceptable building site with direct access from an improved street. Lots shall not contain peculiarly shaped elongations solely to provide necessary square footage of area which would be unusable for normal purposes. Subdividers are encouraged to shape and orient lots to maximize solar access.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-201. Lot dimensions.

Lot dimensions shall comply with the minimum standards of the Blacksburg Zoning Ordinance. Where lots are more than double the minimum required area for the zoning district, the planning commission or agent may require that those lots be arranged so as to allow further subdivision and the opening of future streets where they would be necessary to serve potential lots, all in compliance with the zoning ordinance and this ordinance. In general, side lot lines shall be at right angles to street lines (or radial to curving street lines) unless a variation from this rule will give a better street or lot plan. Depth and width of properties reserved or laid out for business, commercial, or industrial purposes shall be adequate to provide for the off-street parking and loading facilities required for the type of use and development contemplated, as established in the zoning ordinance. Townhouse lots may be subdivided along the party walls into lots smaller than those normally allowed for single-unit dwellings.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-202. Lot orientation.

Each lot shall be served by and abut on a public street dedicated by the subdivision plat or on an existing public street. Lots shall be arranged so that each lot may access a local street, unless the parent parcel fronts only on an arterial or collector street and the parcel depth is insufficient to accommodate the construction of a new local street.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-203. Lots dedicated to public use; common areas.

Lots dedicated to the town for a public use and lots set aside as common area or open space are not required to meet the standards of this chapter.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-204. Remnants.

All land below minimum lot size left over after subdividing a tract shall be added to adjacent lots, or designated if appropriate as common area or parkland.

(Ord. No. 1217, § 2, 12-14-99)

DIVISION 3. STREETS

Sec. 5-300. Subdivider to dedicate streets; private streets prohibited.

(a) Subject to all other applicable provisions of this ordinance, the following street improvements shall be installed and provided by the subdivider and shall be dedicated to the town:

(1) Cross drains and catch basins
(2) Curbs and gutters
(3) Street paving
(4) Street name signs
(5) Traffic signalization

(b) Private streets shall not be allowed in any subdivision, nor shall there be private reserve strips controlling access to the street. This section shall not preclude the approval of parking lots and access drives for parking lots serving townhouse, attached housing or multifamily dwellings.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-301. Street names.

Street names shall be indicated on the preliminary and final plats and shall be approved by the agent or planning commission, as appropriate. Proposed streets which are in alignment with others already existing and named shall bear the name of the existing street. In no case shall the name of the proposed streets duplicate or be similar, literally or phonetically, to existing street names, regardless of the use of the terms street, avenue, boulevard, driveway, place, lane or court. Names of existing streets shall not be changed except by the approval of the town council.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-302. Dedication of streets.

The subdivider shall make provision for the dedication to the town of proposed street extensions as set forth in the comprehensive plan or in other formal documents approved by the planning commission and town council and for the dedication to the town of the fee simple title to land for other proposed streets in the subdivision.

Sec. 5-305. Coordination of streets with existing streets.

(a) The arrangement of streets in new subdivisions shall make provision for the continuation of existing streets in adjoining areas where streets already exist. Major, collector and local streets shall be respectively extended as such. The street arrangement must be such as to cause no unnecessary hardship to owners of adjoining property when the subdividers plat their land and seek to provide for convenient vehicle access to it.

(b) Access points to and from the subdivision and the arrangement of streets within the proposed subdivision and their relationship to adjoining, existing streets shall be such as to minimize the effects of traffic, noise, light and danger to pedestrians and children caused by vehicular traffic to and from the proposed subdivision.

Ord. No. 1217, § 2, 12-14-99)

State law reference(s)--Va. Code § 15.2-2241.

Sec. 5-309. Minimum right-of-way widths.

(a) The minimum right-of-way width of proposed streets shall be fifty (50) feet except for permanent cul-de-sacs in which case the minimum width of the linear part of the cul-de-sac shall be forty (40) feet.

(b) If the existing streets within the subdivision are not fifty (50) feet in width the subdivider shall dedicate by subdivision plat so that such streets will meet the standards of this ordinance.

(c) If the existing streets abutting the subdivision are not fifty (50) feet in width, and if the need for additional right of way width is generated, in whole or in part, by the proposed subdivision, the subdivider shall dedicate by subdivision plat additional right of way so that such streets will have a width of 25 feet from the center line where the street abuts the subdivided parcel.

(d) The agent may require additional right-of-way width where Virginia Department of Transportation standards for the traffic generated by the subdivision require additional width.

(Ord. No. 1217, § 2, 12-14-99)

a) A permanent cul-de-sac shall not be longer than nine hundred (900) feet, including the turnaround. The paved area of the bulb turnaround at the end of the cul-de-sac shall be a minimum of ninety (90) feet in diameter. In lieu of a bulb cul-de-sac, the agent or planning commission may permit a "T" or a "Y" cul-de-sac.

(b) Pavement on "T" turnarounds shall be at least forty (40) feet long and twenty (20) feet wide, which does not include the thirty (30) feet of roadway width at the "T."

(c) The pavement at a "Y" turnaround shall be at least twenty (20) feet wide and each leg shall be forty (40) feet long, and the radius and angle shall be adequate to permit vehicles to turn around on the paved surface.

(d) Rights-of-way at turnarounds and cul-de-sacs shall be at least five (5) feet beyond the edge of the pavement or the back of the curve.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-312. Turn lanes.

Turn lanes shall be provided on all streets adjacent to and within a subdivision where warranted by the standards of the "Minimum Standards of Entrances to State Highways," latest edition, published by the Virginia Department of Transportation.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-313. Street design.

Streets shall be designed as follows:

(1) Street grades may not exceed 10%, nor be less than 0.5% except as expressly approved by the agent or planning commission.

(2) Street intersections shall provide landings of not more than 5% grade for a distance of not less than 100 feet.

(3) All streets shall be designed and constructed with VDOT standard CG-6 curb and gutter and be a minimum of 30 feet in width or greater as required by VDOT subdivision street standards, based upon projected traffic generated by the development, except in the Rural Residential I, and Rural Residential II zoning districts or as expressly approved by town council as part of a planned residential or planned commercial zoning.

(4) In the Rural Residential I and II districts curb and gutter is not required. Further, the minimum street pavement width shall be 24 feet, or greater as required by VDOT subdivision street standards based upon projected traffic generated by the development.

(5) Street intersections shall be designed so as to provide a minimum stopping sight distance of 10 x the posted speed limit of the street. Intersection sight distance shall meet VDOT standards.

(6) Street pavement sections shall meet VDOT pavement design guidelines based upon a California Bearing Ratio ("CBR") of 10. The minimum roadway section shall be six (6) inches of aggregate base material (21-B) and two (2) inches of compacted SM2-A pavement. During construction, prior to subgrade approval by the town, CBR test results must be provided to the town, one per 400 feet of proposed roadway, or a minimum of three CBRs per subdivision. Pavement design based upon the actual CBRs shall be provided by a professional engineer.

(7) For design standards not explicitly set forth herein, Virginia Department of Transportation standards shall apply.

Sec. 5-317. Blocks.

Design standards for blocks are as follows:

(1) Length: The length of blocks shall be determined by public safety, traffic flow, and natural topography considerations. Where streets are approximately parallel, connecting streets

shall be provided between the parallel streets at reasonable intervals as established by application of the criteria in the preceding sentence. In general, residential blocks should be between five hundred fee (500') and twelve hundred feet (1200') in length.

(2) Width: Blocks shall be designed in two (2) tiers of lots, except where prevented by the natural topography, size of the property, or adjoining railroads or waterways, in which case the agent may approve a single tier of lots. Where the property to be subdivided adjoins an arterial road, the agent may require a single tier of lots and a restricted access easement along the arterial road.

(3) Orientation: Where a proposed subdivision adjoins an arterial or collector road, the agent may require that blocks be oriented and designed to limit or reduce the number of points of access to that road.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-318. Driveways.

(a) A maximum of two driveway entrances per lot is permitted for single family dwellings and two family dwellings. The curb cut shall be a minimum of 12 feet in width and a maximum of 20 feet in width at the right-of-way line. Curb cuts on the same lot shall be separated by a minimum of 40 feet, measured from center line to center line.

(b) All entrances constructed from a new or existing street or road shall be in accordance with the "Minimum Standards of Entrances to State Highways" of the Virginia Department of Transportation, as amended from time to time, incorporated by reference except as these may be varied by this section.

(c) Driveways shall be located not less than 3 feet from a side lot line, unless a common drive is provided for two adjoining lots, in which case the driveway may be located adjacent to the side lot line.

(d) On local and collector streets, driveways shall be no closer than 40 feet to an intersection with a public street.

(e) On arterial streets, driveways shall be no closer than 75 feet to an intersection with a public street. This dimension may be reduced by the agent or planning commission for lots without access to collector or local streets and where by reason of topography, sight distance or other similar considerations the 75 foot dimension is not feasible.

(f) In the Rural Residential I and Rural Residential II zoning districts, the provisions of this section shall apply to all residential uses; provided, however, that no new driveway

entrance shall be located on existing or proposed collector or arterial streets. All driveway entrances shall be located on local streets, unless the agent or town council by variance shall approve the location of an entrance on a collector street.

(Ord. No. 1217, § 2, 12-14-99)

State law reference(s)--Va. Code § 15.2-2241.

Sec. 5-324. Location of right-of-way iron rod.

Iron rods not less than five-eighths-inch in diameter and twenty-four (24) inches long shall be driven so as to be flush with the finished pavement at the following locations in the subdivision: the intersection of street center lines, intersection of street center lines with exterior boundaries of the subdivision, right-angle points and points of curve in street center lines and at all lot corners. When rock is encountered, a hole shall be drilled four (4) inches deep in the rock, and an iron rod shall be cemented therein with the top flush with the finished grade.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-325. Standards for alleys.

In certain situations, the use of alleys may be a desirable alternative to the more traditional type of residential development. When new alleys are proposed for a subdivision, or when the improvement of existing alleys is proposed, the following standards shall apply:

(1) Frontage on an alley shall not be construed to satisfy any lot frontage requirements.

(2) Alleys shall be maintained and perpetuated by a duly constituted property owners' association and notations to this effect shall be clearly indicated on the face of the record plat.

(3) Alleys shall be designed to minimize or eliminate the potential for through traffic.

(4) Alleys shall have a minimum paved or sealed surface width of 10 feet. New alleys shall have a minimum right-of-way width of 20 feet.

(5) Alleys to serve single-unit residential uses shall have chip and seal surface. Alleys to serve developments of greater intensity than single-unit residential uses shall have an asphalt surface constructed in accordance with section 5-313 of this chapter.

(6) Sight distances which comply with Virginia Department of Transportation standards, and the standards of Town Code (1998) section 21-304 shall be provided at intersections with public streets. Alleys shall be built with a minimum pavement edge radius of 25 feet at their intersections with public streets.

(7) Alleys shall not dead end. Alleys shall end in an intersection with a public street, or in a cul-de-sac constructed to comply with the standards of section 5-310 of this ordinance.

(8) Alley length shall not exceed 1,000 feet without an intersecting street.

Sec. 5-401. Sidewalks required.

(a) The subdivider shall install and dedicate to the town sidewalks along at least one side of all public streets within and adjacent to the subdivision. The sidewalks shall connect with existing sidewalks on streets adjacent to or within the land subdivided, and shall be placed so as to provide for eventual continuation with proposed or future sidewalks in the vicinity of the land subdivided.

(b) Sidewalks shall be constructed of concrete and shall be a minimum of 5 feet in width. A minimum two foot planting strip is required between the curb and sidewalk for pedestrian/vehicle separation and to provide for mail box and utility service placement.

(c) Where there is no curb between the sidewalk and the street, the sidewalk shall be placed beyond the road shoulder and roadside ditch. Minimum separation in this case shall be as approved by the agent.

(d) Sidewalk construction materials and specifications shall meet current VDOT subdivision street standards, incorporated by reference.

(Ord. No. 1217, § 2, 12-14-99)

Sec. 5-402. Access to open space.

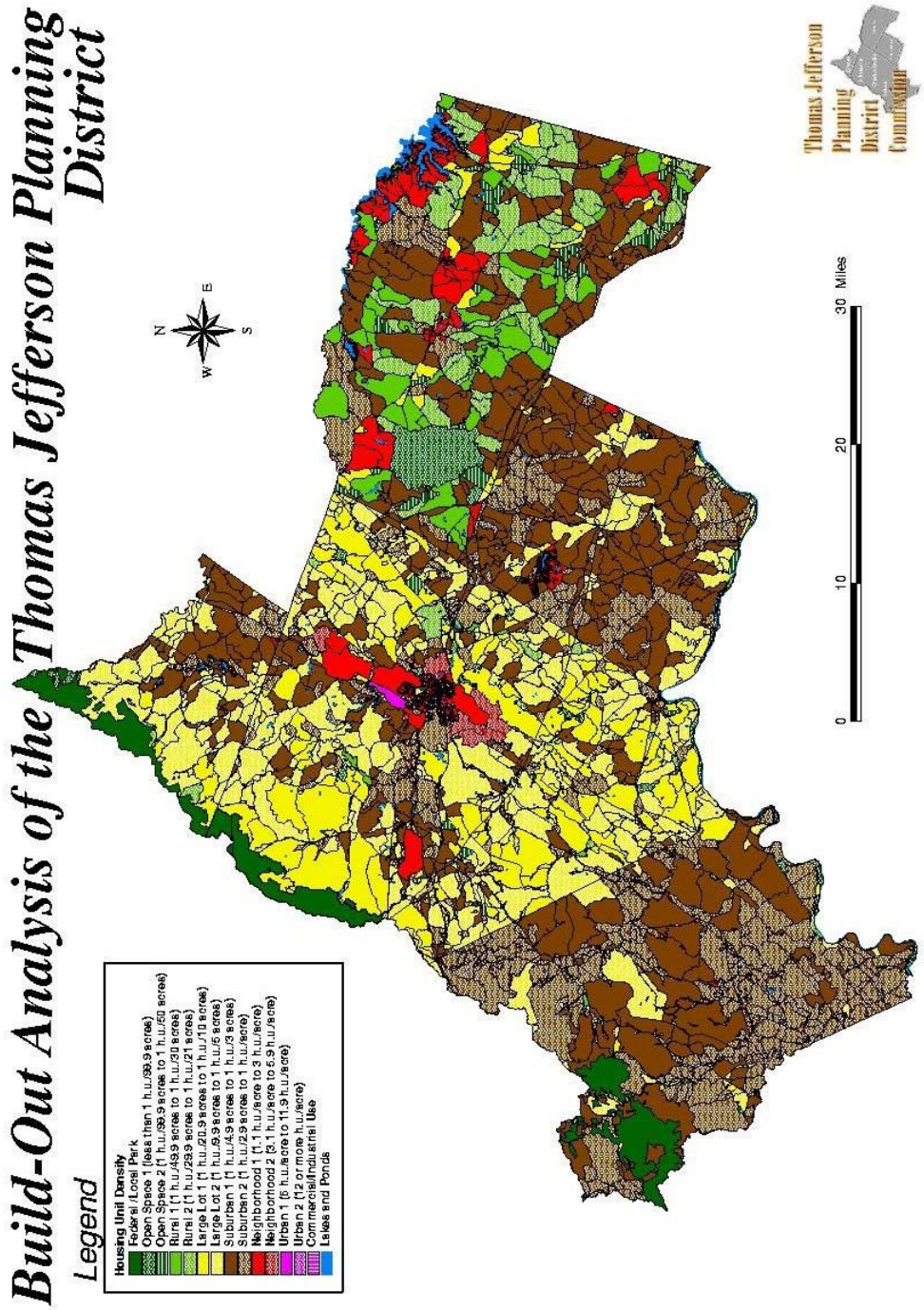
(a) Where common open space or public parkland is provided in a development, the subdivider shall provide pedestrian access to the site.

(b) Access to public parkland shall be dedicated to the Town. The access shall consist of a sidewalk which meets the requirements of section 5-401, above, or a bikeway, which meets the standards of section 5-503, below.

(c) Access to private common open space may be by a private access way. The access shall be paved with gravel, limestone dust, or asphalt. No minimum width is required by this chapter.

Appendix E: An image of a Build Out Analysis

An image of a build out analysis of the Thomas Jefferson Planning District (www.ruralnelson.org/GeoMaps/Nelson_Build-Out.jpg)



Vita: Ashwini Wakchaure

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Objective ***To build a career in the field of Geographical Information Systems***

Education (USA) ***Master of Urban and Regional Planning*****,** Aug 1999-Dec 2001 GPA 3.42
Virginia Polytechnic Institute & State University, Blacksburg, Virginia,

Education (India) ***Master of Urban & Regional Planning*****,** Aug 1993 – Feb 1995 GPA 3.7 (69%)
School of Planning, CEPT, Ahmedabad, India
Bachelor of Architecture, Jun 1988 – May 1993 GPA 3.9 (67%)
L. S. Raheja School of Architecture, Board of Technical Education, Mumbai

Computer Skills ***Applications*** MS Office, MS Project, PhotoShop, Dreamweaver
GIS ArcGIS**,** ArcView3.2, ArcInfo 8, ArcIMS ***CAD*** AutoCAD 2000
Programming Visual Basic 6, Map Objects 2.0, Avenue, SQL, Html, Java
Database Management SQL Server 7, Access, ASP

GIS Projects Study of relationship of forest type and land factors, Ski resort location, Business Office Location, Habitat Identification, Development of a Tourism Information System for a County

Programs Applications for Interpolation, Visibility analysis, Redistricting, Housing, Developed an ArcView tool for simulating land subdivision for Build Out Analysis, ArcObjects programming, Automated the process of creation of layouts

Projects Developed a database project for a school library, also worked on web enabled databases, Storm water management and Flood plain management for Roanoke

Activities Photography, Bird watching, Hiking, Camping

W*ork Experience*

2nd *Summer Project* - Urban Affairs Department, Virginia Tech, June 2001 – Aug 2001
Developed ArcView 8.1 tutorials for students.

1st Summer Project - Political Science Department, Virginia Tech, May 2000 – Aug 2000
Created an exercise in ArcView for 'Urban Politics' class on Redistricting of voting precincts

Deputy Planner - Mumbai Metropolitan Region Development Authority, India. 1997–Aug 99
Worked on various planning projects.

Assistant Architect - Stup Consultants Ltd. Mumbai, India. July 95 - Jun 97
Coordinated various infrastructure services for 'Khandeshwar Railway Station cum Commercial Complex' Navi Mumbai, Supervised a team of Architects and Draftsmen

Project Assistant - School of Planning, Ahmedabad, India. Feb - May 1995