

Amherst Town Square Conceptual Design



Conceptual Master Plan
prepared for
Town of Amherst, Virginia
May 2008

c|d community design
a|c assistance center

College of Architecture and Urban Studies
Virginia Polytechnic Institute and State University

CDAC Project Team for Amherst Town Square Conceptual Plan

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The Community Design Assistance Center (CDAC) is an outreach center of the College of Architecture and Urban Studies at Virginia Tech that assists communities, neighborhood groups and non-profit organizations in improving the natural and built environments through design, planning, and research. Through the integration of the learning and working environment, the Center will execute projects that link instruction and research and share its knowledge base with the general public.

ACKNOWLEDGEMENTS

The CDAC Team would like to thank the following individuals for offering their assistance and expertise to the project:

The Amherst Town Council

The Community of Amherst

Jack Hobbs, Amherst Town Manager

Jason Campbell, Town Councilman

Jacob P. Bailey, Amherst Mayor

Susan Day, Urban Forestry Professor, Virginia Tech

C. W. Gillespie, Consultant, MRG Consulting LLC

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PROJECT DESCRIPTION

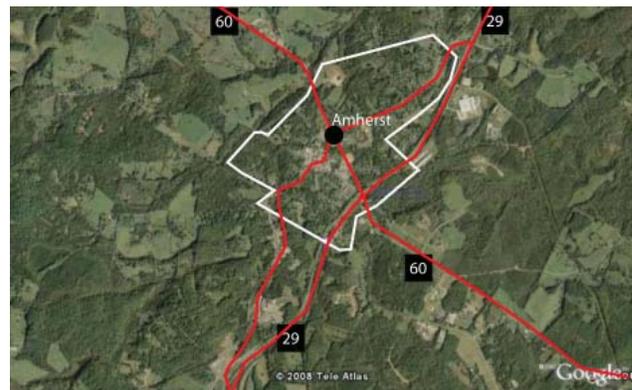
Amherst's future town square is an urban space located at the terminus of East Court Street, in front of the Historic Courthouse. This area is very important to the community of Amherst due to its central location within the town and its flexibility to accommodate a number of uses. As far back as the 1950s, plans have been developed for this space and East Court Street yet it still remains as an urban void. In the 1980s, Virginia Tech developed a plan to convert East Court Street into a pedestrian mall leading up the courthouse. Most recently however, Muldrow Arnett developed an economic study of Amherst as well as proposed plans for the downtown improvement, which included a plan for the town square. Due to a lack of consensus, the town of Amherst approached The Community Design Assistance Center (CDAC) to develop a plan for the town square that considers the previous plans and abides by the communities desires.

The Community Design Assistance Center, an outreach center in the College of Architecture & Urban Studies was asked to develop a conceptual design for the plaza area utilizing community input. The design addresses parking, space for art shows, a farmer's market, music events, festivals, and other similar uses¹. The plan utilizes new spatial boundaries, flexible uses, pavement changes, varying site features and overall streetscape improvements to create a successful town square.

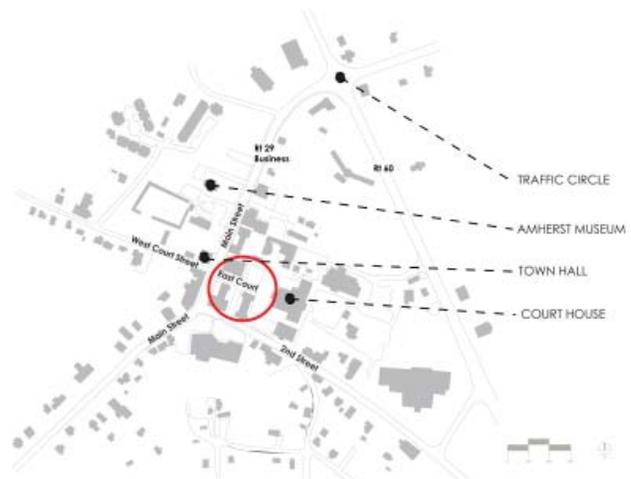
Final products include a conceptual master plan for the court square area, supporting sketches, tree pit and species recommendations, and this supporting report that describes the design process and final design.



State context map highlighting Amherst County



Town of Amherst Map



Town plan showing the Town Square Site

¹ Application for Planning or Design Assistance to CDAC from the Town of Amherst, 4/30/07.

GOALS AND OBJECTIVES

The goals and benefits of the project are:

- Create a visual focal point and central community gathering space for the Town of Amherst.
- Establish a design precedent and palette that serves as a catalyst for the future design projects of Amherst.
- Assist in creating a unified experience upon visiting and traveling through the Town.
- Create a pedestrian friendly space in front of the historic courthouse to accommodate festivals as well as day to day use.

The objectives for accomplishing the goals are as follows:

- Work with the current Amherst character to expose and celebrate historical features.
- Design the town square to be flexible as to accommodate the changing uses of the space.
- Work with the community by providing several concepts for review and input.
- Utilize street trees and other site amenities to create a more pedestrian friendly environment and enhance East Court Street as well as the town square.

DESIGN PROCESS

The design process for the Amherst Town Square began with a site visit and introductory meeting on September 21, 2007. The CDAC design team met with Jack Hobbs, Town Manager, and Jason Campbell, a Town Councilman to gather both information and the Town's vision for the square. Walking around Amherst, Mr. Hobbs and Mr. Campbell provided the CDAC Team with an orientation to the essence of Amherst, which includes its history, current successes and struggles, and more specifically, the goals of the Town for the East Court Square.

After the site visit, the design team developed a set of base maps and performed a set of studies that looked at the broader context of downtown and how it related to the project area. The team did this in an attempt to further understand how people experience the Town and what role the site can play in achieving the vision for the entire town. Through photographic studies the team then noted design challenges and opportunities for the site itself. During this time, the team also did precedent research on successful town squares and William Whyte's suggestions on what makes public space successful. Places such as Ghirardelli Square in San Francisco, and Boston Square at Harvard University, provided useful concepts and details.

Following the analysis and research phase of the project the design team held a community meeting where the findings were presented in an effort to receive feedback and obtain a vision from various community members. The meeting was held on November 14th,



CDAC team on initial site visit with Town staff



CDAC presents analysis and case studies to the Town Council



CDAC team member Doug Rodes (r) talks with a community member at the open house

DESIGN PROCESS (CONT'D)

where the bulk of the discussion was centered around memorable public spaces that had been visited. This would give the design team a sense of community preference and vision for the project area.

Following this meeting the design team developed three design concepts accompanied by sketches and precedents. An open house was held in the Amherst Town Hall where two presentations were given at set times: community members were encouraged to stop by at their convenience. Valuable feedback was taken from the members of the community by comment card and by e-mail in order for the design team to refine the concepts into a final design. Overall, the community preferred concept A which possessed a large flexible space that could accommodate both parking and festivities.

The development of the design proceeded until a final presentation was given on February 13, 2008 at the Amherst Board of Supervisors facility to the Amherst Town Council. A final plan was developed and images from a 3-D computer model were prepared and presented at this meeting. Following the final presentation this report was prepared describing the design concepts including drawings, sketches, and conclusions to give to the Town of Amherst for future project development.



CDAC team member Doug Rodes (r) discusses preliminary concepts with a community member



CDAC team member Eliza Furedy (standing, left) presents the final concept to Town Council



Final presentation to Town Council

SITE INVENTORY AND ANALYSIS

The site inventory entails documenting the physical attributes and existing conditions on the site. This includes the location of structures, paving, and other such site elements. The analysis synthesizes this information in drawings and descriptions that depict key issues and opportunities on the site.

The CDAC team began the site inventory and analysis with a site visit where key issues were examined and documented. This included taking photographs, documenting issues and opportunities on the maps, assessing spatial quality, and examining existing conditions in the areas in close proximity to the Amherst Courthouse. Major issues, features, and design opportunities noted as a result of the site analysis are as follows:

- The view traveling south on Main Street coming from the traffic circle introduces the visitor to the Town. Similarly, the street walls frame the view to the intersection of East Court Street, where there is the opportunity to enhance the intersection to invite visitors into East Court Street and the town square.

- The view looking into the East Court Street Corridor is the most important view within the Town involving the town square. Upon arriving at the intersection of Main Street and East Court Street the passerby needs to be directed to this view.

- The adjacent building uses provide both obstacles and opportunities related to the design of the town square. The circulation patterns of vehicles and delivery trucks to the various businesses may need to be rerouted to ensure the success of East



CDAC Team looking at view from the top of town square



View from Main Street towards the Courthouse



View down Main Street from the intersection of Main and West Court Street

Court Street and the town square as pedestrian friendly space.

- The topography on the site presented a challenge in finding ways to create level planes for activities and festivals. The topography also presents a challenge for ADA accessibility. The site slopes from the courthouse down to Main Street. The eventual design shows that the topography is utilized to create steps and to establish the courthouse as a more dominant figure within the town.

- Utilities currently running through the site detract from the value of East Court Street and disrupt the view looking towards the courthouse. Moving these power lines either underground or rerouting them to an adjacent street is optimal in establishing the town square as a valued and sacred space.

- Lastly, the current parking on-site does not allow for a pedestrian friendly environment and limits the use of the space. It currently interrupts the view up to the courthouse. Parking can be utilized as a tool to create a more pedestrian friendly environment as well as adding additional spaces surrounding the town square.



CDAC team examines circulation issues with Town Manager Jack Hobbs (r).



Current parking lot adjacent to the town square site

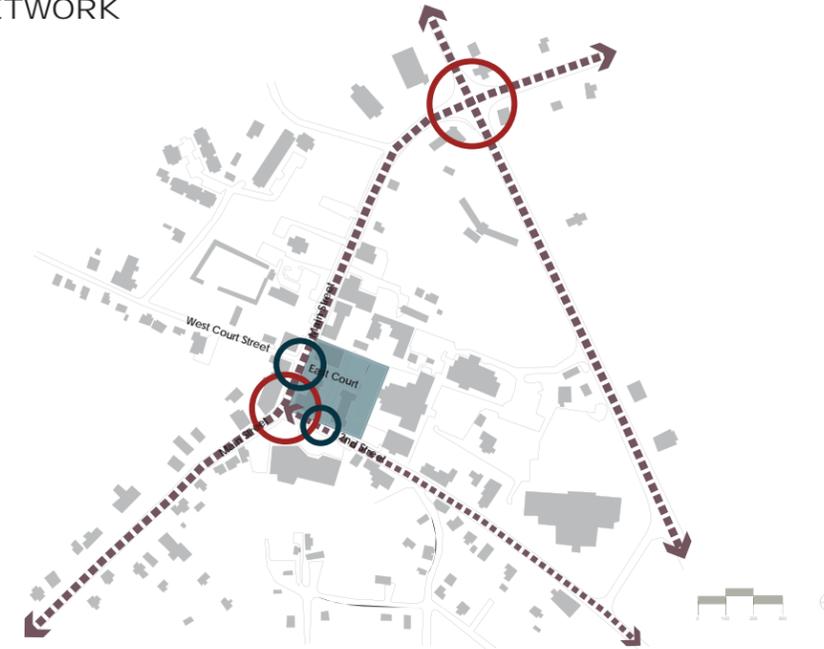


East Court Street during *Amherst Live*

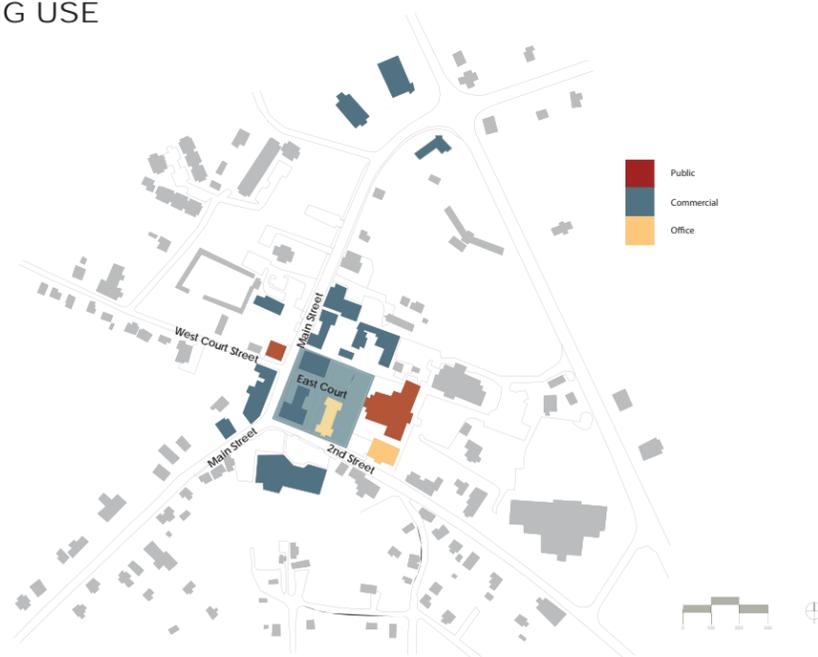
TOWN VIEWS



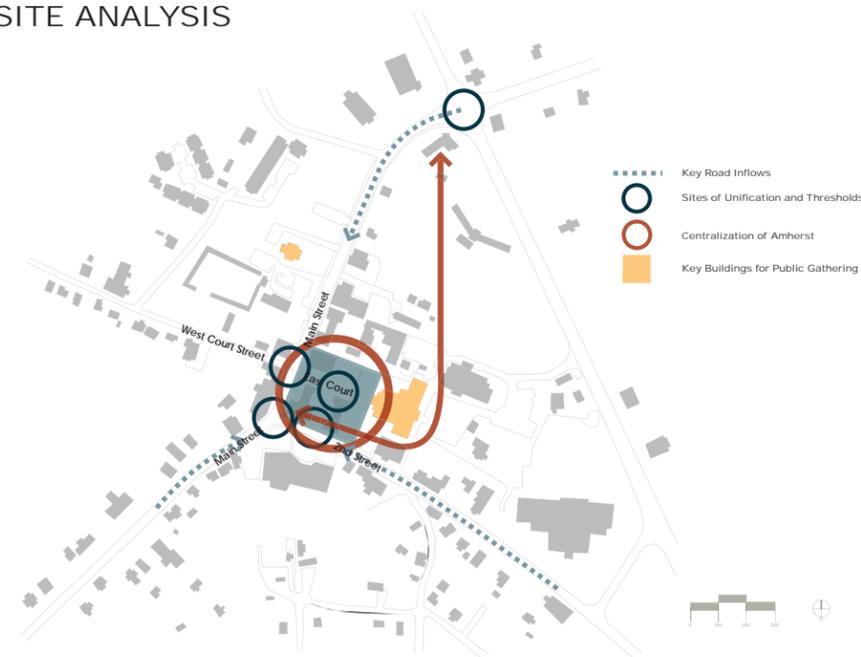
ROAD NETWORK



BUILDING USE



COMPOSITE ANALYSIS



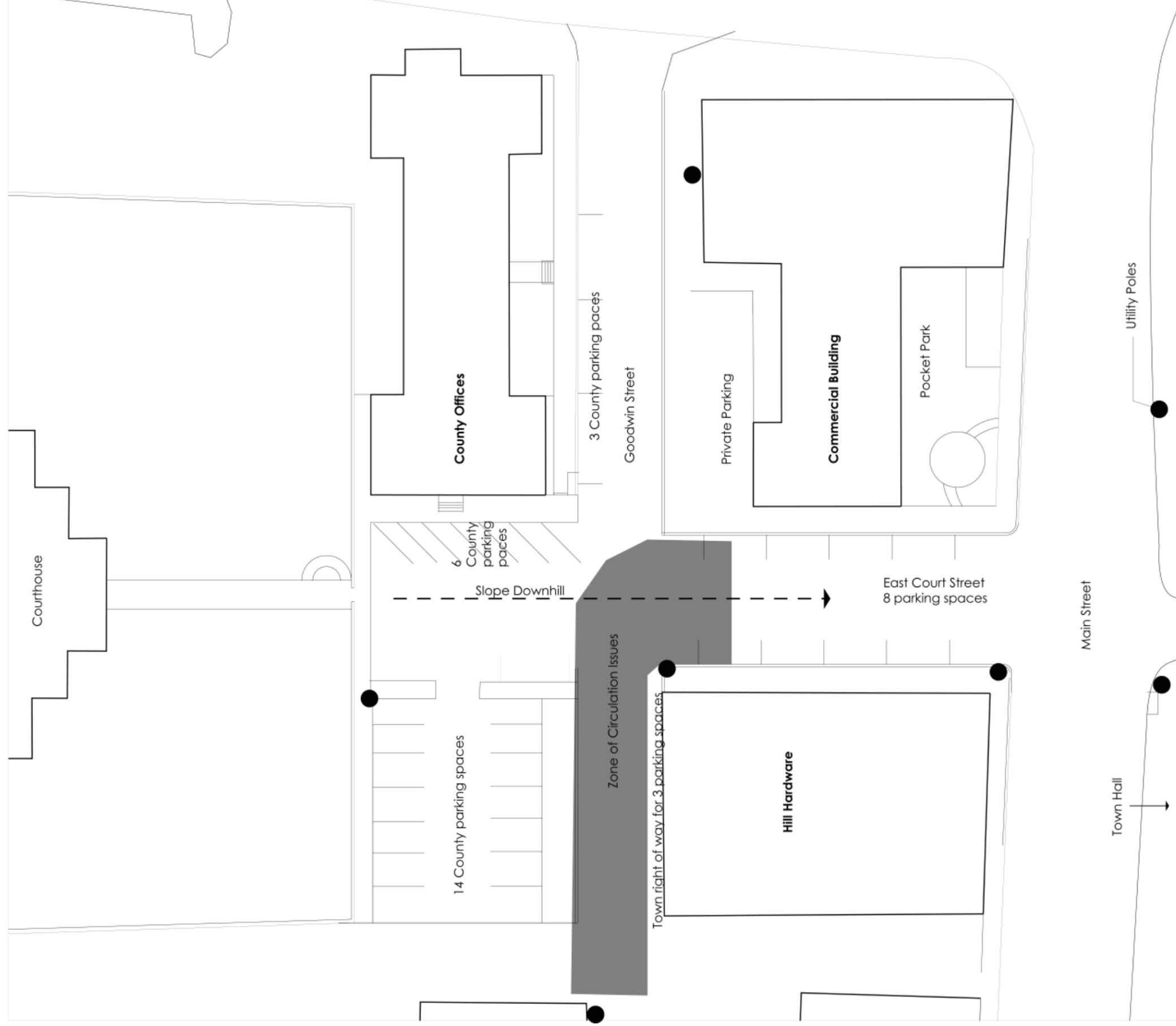
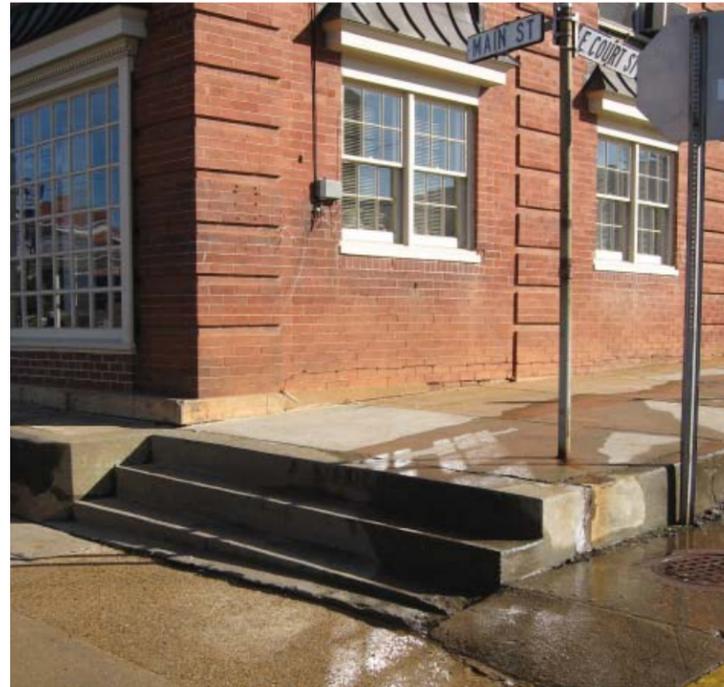


PHOTO ANALYSIS



View looking towards the courthouse. Steeply sloping street with parking along both sides.



Walkway along East Court Street. Stairs added to deal with the steep slope, making the curb higher than average.



View from courthouse down East Court Street towards the mountains. There is parking along the street and in a parking lot directly in front of the courthouse building, servicing the surrounding county offices and businesses.



Sidewalk with an unusual curb situation, along with runoff problems. The sidewalk terminates into the grass along an access road.



View down Goodwin street servicing Hill Hardware. Used for large truck parking and unloading. Grassy area serves as an infiltration trench and is accidentally parked on.



Parking lot located close to courthouse.

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TOWN SQUARE RESEARCH

Ghirardelli Square

San Francisco, California

Ghirardelli's successes stem from the following features of the site:

- Occupied stores and attractive businesses surround the square subsequently drawing large crowds into the space.
- An abundance of primary and secondary seating, consisting of stairs and walls, offer visitors comfortable places to sit.
- The design material palette is derived from the historic architecture of the Ghirardelli Chocolate Factory.
- A fountain located at the center of the square gives the space a focal point and creates a pleasing atmosphere for visitors with its appearance and sound.

Harvard Square

Boston, Massachusetts

Harvard Square boasts a rich history and an abundance of current activities.

- A rich cultural scene gives activity to Harvard Square. The cultural events include musical performances, festivals, and student activities.
- There is primary and secondary seating to give visitors options for seating.

Roanoke Farmers Market

The farmer's market located in Roanoke, Virginia was studied for its success in accommodating both parking and public activity.

- Parking is allowed in the farmer's market area on weekdays and weekends even during the farmer's market.
- Parking is temporarily prohibited when musical or other events are scheduled.



Bird's eye view of Ghirardelli Square
Image Taken From www.pps.org



Harvard Square during a concert
Image taken from www.bostonsquares.com



Roanoke Farmer's Market
Image taken from www.careerconnect.state.va.us

COMMUNITY INPUT

The CDAC team considered this project a “Community Project” and sought to include the visions and opinions of the people of Amherst. The team developed an understanding of Amherst through site visits, district analysis, and site analysis. The team also studied similar town square designs and principles. After these were developed, the design team heard from the citizens through holding a discussion-based meeting with citizens of Amherst. As an open forum, the design team listened to the desires and visions of the citizens for the town square. The conclusions derived from this meeting that directed the efforts of CDAC are as follows;

Examples of memorable public places

- Chattanooga Pedestrian Bridge
- 14th Street in Richmond, Virginia
- Canal Basin Park, Scottsville, Virginia
- Jonesboro, Tennessee
- Roanoke Farmer’s Market

Community Desires for the Town Square

- Include temporary exhibit space for elements like a Christmas Tree.
- Use brick as the material choice to coordinate with the historical wall.
- Locate an abundance of secondary seating and incorporate a small number of benches
- Retain as much parking as possible
- Create a space that can accommodate both large and small events
- Ensure the space is bicycle and pedestrian friendly
- Include common streetscape improvements along East Court Street such as trees, new sidewalk paving, trash cans, and banners.
- Provide an informational kiosk for visitors.
- Incorporate other streets into the design.

CONCEPTUAL DESIGN A

Conceptual Design A was based on the idea of making East Court Street and the current parking lot in front of the courthouse into a large open space that if designed in totality, can create a larger flexible space. This concept is designed to enhance the view from Main Street up the East Street Corridor to the courthouse. The key aspects of Concept A include:

1. A transition is designed along East Court Street by installing a series of pavement changes that introduces the visitor to the town square before actual arrival.
2. Within the town square a small space is designed at the center for temporary installations (Label B in the 11x17 pullout). Parking in front of the county building has been relocated to Goodwin Street. A community market is designed in the current parking lot through the addition of built elements. The current entrance to the parking lot has been relocated to Goodwin Street. This allows the parking lot to stay in use during the weekdays, while also creating a defined pedestrian space on East Court Street.
3. Once the visitor journeys to the town square, they will find the space is much larger than expected. Concept A recommends altering the parking lot's surface material to be consistent with the pavers proposed for the town square space. The town square is terraced at two points to create a diversity of space as well as accommodate for the change in topography on site. This addition of steps at the edge of Goodwin Street and toward the courthouse wall also serves to create a formal progression to the courthouse, thus enhancing the view from Main Street.



View of Community Market and Town Square.



Example of Tensile Structure for Events.
Image taken from Fabricarchitecture.com

CONCEPTUAL PLAN A



- A. Town Square
- B. Temporary Installation
- C. Community Market and Stage Area
- D. Transitional Area

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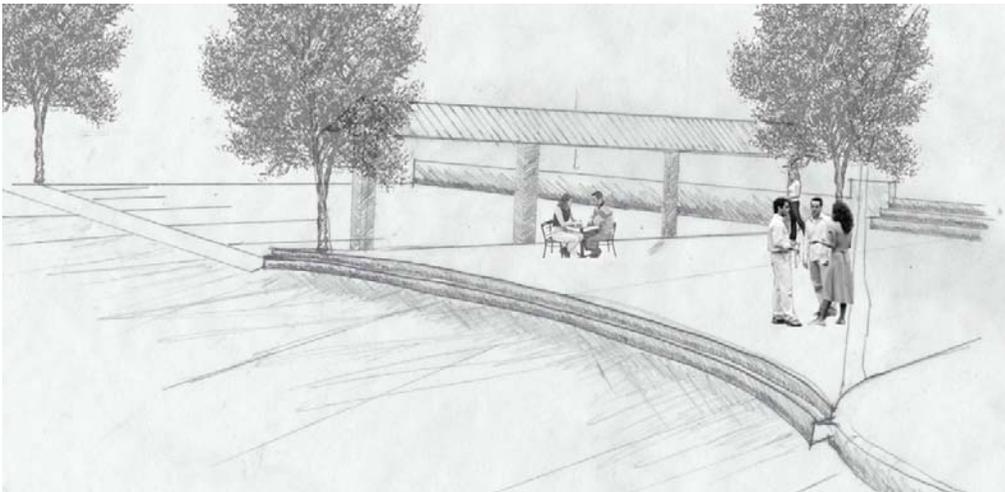
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CONCEPTUAL DESIGN B

Concept Design B concentrates on establishing East Court Street as a dominant axis within the town.

Street trees frame the view from Main Street to the courthouse. The community market has been located alongside the Town Square to bring a consistency to the facade of the buildings along East Court Street. Thereby strengthening the linear view along the main axis.

Terracing at the entrance of the Town Square, creates a progression to the courthouse. The terracing manages the topographical change in addition to serving as a more formal entry in the town square.



View of market and terrace.

CONCEPTUAL PLAN B



- A. Town Square
- B. East Court Street
- C. Community Market
- D. Tent/Event Space

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CONCEPTUAL DESIGN C

Concept Design C concentrates on simple design gestures within the East Court Street area that have the greatest impact on the perception of the space.

Starting on East Court Street, the community market has been relocated to the street to create a promenade and to instigate activity along the corridor. In addition, the sidewalks have been widened to create a pedestrian friendly ratio of street to sidewalk while maintaining the parking and driving widths on East Court Street.

The proposed market stalls frame the town square and the courthouse. The area for the town square becomes paved with a unique pattern. Street trees have been added to offer shade and continue to frame the courthouse.

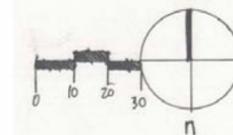


View of market along East Court Street.

CONCEPTUAL PLAN C



- A. Town Square
- B. East Court Street/Community Market
- C. Parking Lot/Tent Laydown Area/Additional Event Space



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CONCEPT FEEDBACK

Citizens were an integral component to the design of the Town Square. Considering the opinions and visions of the people of Amherst helped the CDAC team in making decisions. Comment sheets were collected during and after the open house on December 18, 2007 where citizens were encouraged to express initial desires for the town square and reactions to the three initial concepts presented. Some of the major comments and feedback were as follows;

1. Placement of farmer's market in concept A is most successful.
2. Like the idea of a temporary installation space within the town square.
3. Concerns about flow of traffic with Concept C.
4. Wider sidewalks should be a priority for East Court Street.
5. A more strategic placing of the farmer's market structure will help to frame the space.



Jack Hobbs (r) reviews design concept with a community member at the open house



CDAC team member Doug Rodes (r) describes a preliminary design concept to a community member at the open house

FINAL CONCEPTUAL PLAN

The Final Conceptual Plan is an adaptation of the preliminary concept Design A, with a goal to create a large and flexible public open space. Through the unified paving of the existing parking in front of the courthouse and along Goodwin Street, Amherst is able to achieve an open space adaptable to their changing needs. The creation of an interesting approach along the main corridor allows for a formal entry to the historic courthouse. The use of terraced stairs creates spaces for pause and seating, in addition to being a visually pleasing element within the town square. A year-round temporary installation space gives opportunity for various groups and organizations to be represented within the public town square.

The approach to the square is lined with newly planted trees. The addition of trees creates a pleasing experience, as well as frames the view of the courthouse.

Brick paved crosswalks along Main Street call attention to the new Town Square, drawing people up along East Court Street to discover the space. Additionally, the crosswalks continue up East Court Street and across Goodwin, defining pedestrian zones and directing people into the town square. The extension of continuous paving throughout the square and the parking lot creates a space that is flexible for events.

During large events that need more space, the parking lot can become an extension of the square, suitable for concerts or a market. However, the parking lot is still available for use by shoppers and visitors during the weekdays. This design results

in maintaining the amount of parking spaces within the immediate area.

Framing the parking lot is an existing rain water management system that is undefined and unnoticed. By turning the space into a visible rain garden, it showcases the Town's interest in sustainability while creating an interesting border to the lot.

In the Town's existing pocket park along Main Street, there is the new implementation of an information kiosk. This kiosk allows for the posting of events, activities and sights within the Town of Amherst, made easily visible to residents and those visiting the Town.





Close Up Axonometric View of Town Square



Overhead View Into East Court Street and Town Square



Axonometric View from right of Town Square

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View down left sidewalk of East Court Street into Town Square



View into square from cross walk.



View into square from right of East Court Street



View from back stairs of town square



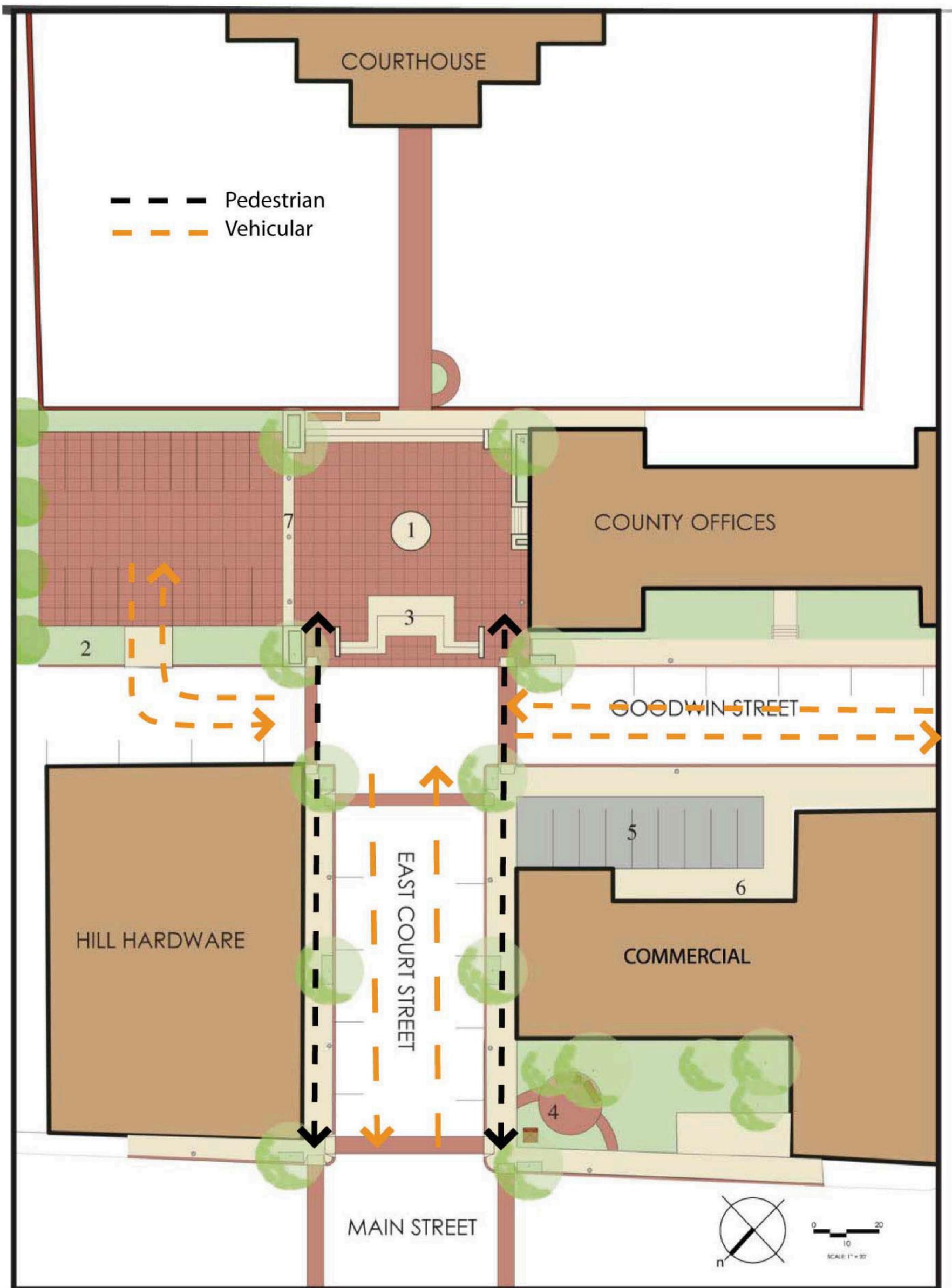
View into town square from temporary stage/parking lot.



View of back stairs leading down to upper terrace

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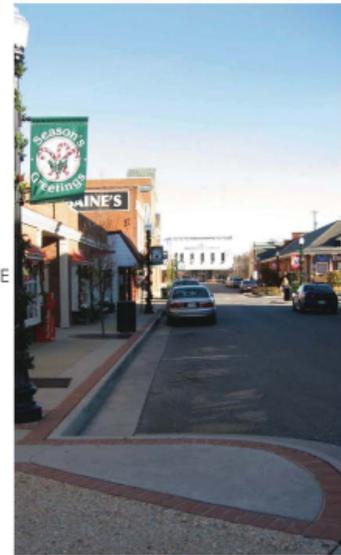
SUGGESTED MATERIALS



STAMPED ASPHALT

STAMPED CONCRETE

UNIT PAVERS



CONCRETE SIDEWALKS EDGED WITH LAID BRICK BANDING



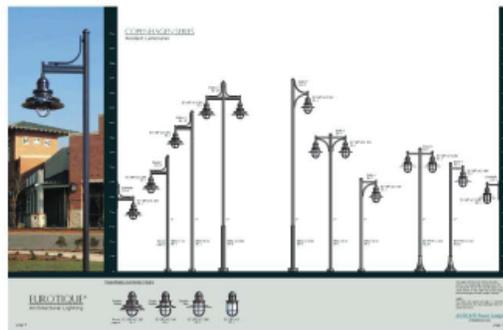
UNIT PAVER CROSSWALK WITH CONCRETE



BALTIMORE, MD: AN EXAMPLE OF UNIT PAVERS WITH CONCRETE BANDING



Suggested options for streetscape elements (benches, bollards, paving)



Images taken from antiquetstreetlamps.com

Suggested lighting styles

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CONCLUSION

This vision for Amherst's town square will create a central location community activity that will likely encourage additional economic development. Moreover, it will establish an identity for the Town to use to advertise tourism. By creating a central town square, larger events can be held within the space, thus showcasing the cultural festivities of Amherst.

Aesthetically, the town square will enhance perceptions of Amherst and can serve as a catalyst, encouraging further architectural beautification of the downtown area. This activity will likely encourage people to visit the Town to stop and visit and in the process, shop, dine, and participate in events. The improvements could also serve to attract additional private business owners to open shops and other attractions within the downtown area.

Lastly, the Town of Amherst has a rich history that could be more prominently highlighted. The town square can serve as a starting point for discovery of the history of Amherst. Located immediately adjacent to the courthouse and near the museum, its central location could become the starting point for historic walking tours.

Overall, this design is driven by the vision of the people of Amherst. Allowing citizens to be the most important piece of the design will help ensure its use and success. Community involvement will ultimately drive the success of future developments and efforts within the Town.

APPENDICES

Appendix 1:
Tree Pit Recommendations.....a1.0

Appendix 2:
Street Tree Recommendations.....a2.0

Appendix 3:
Rain Garden Planting Suggestions.....a3.0

Appendix 1: TREE PIT RECOMMENDATIONS

The tree pits along East Court Street should be constructed to the dimensions 4' by 10', with a depth of 3 feet. This allows for a greater area for root development and growth, resulting in healthier trees.

It is suggested that the tree pits along East Court Street be supported by structural soil. Structural soil is used where space is limited; replacing restrictive soils with materials that have two key characteristics: they provide a suitable growing medium for roots, and they meet hardscape engineering requirements. Structural soil is composed of soil and stone. The stone provides a load-bearing lattice, while the soils provides a medium for root growth. The structural soil is placed underneath a concrete slab, and has a depth of 18". More detailed information about structural soil can be found on page a1.3.

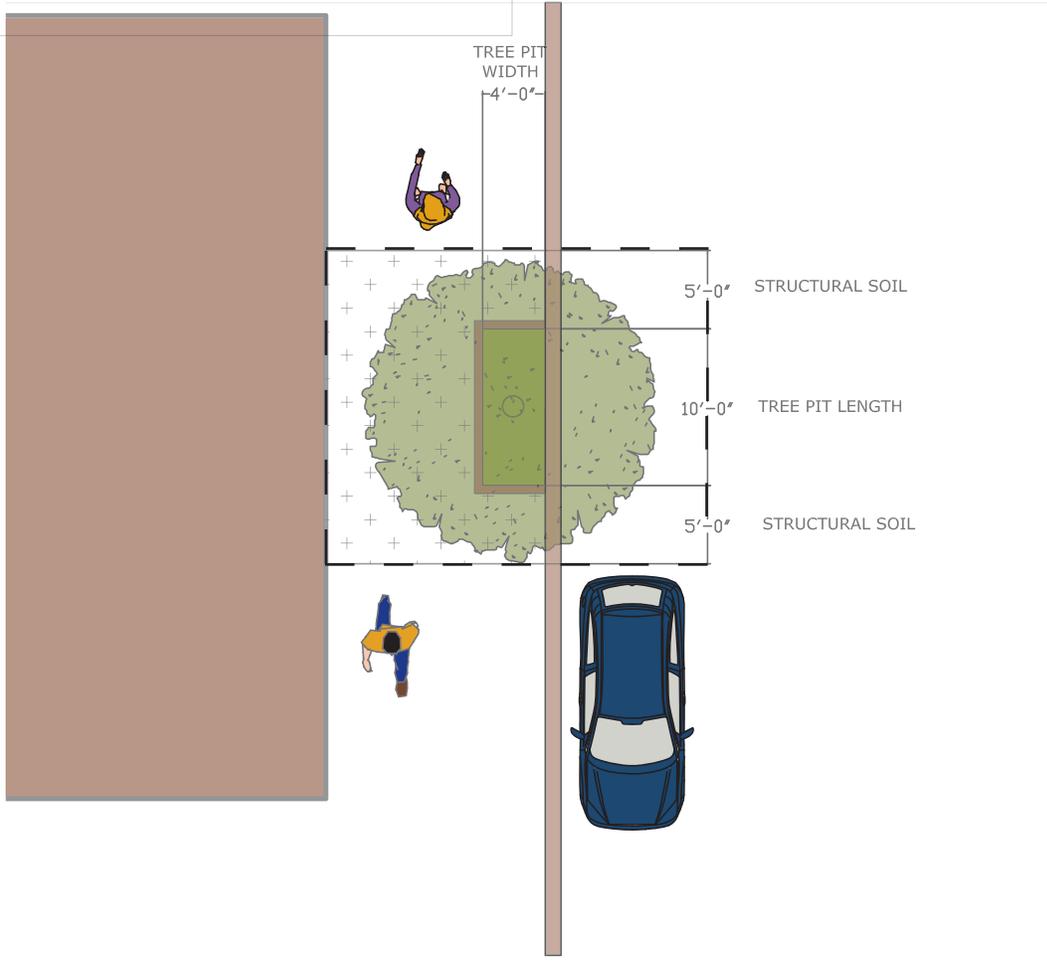


East Court Street:
Note enlarged tree pits.

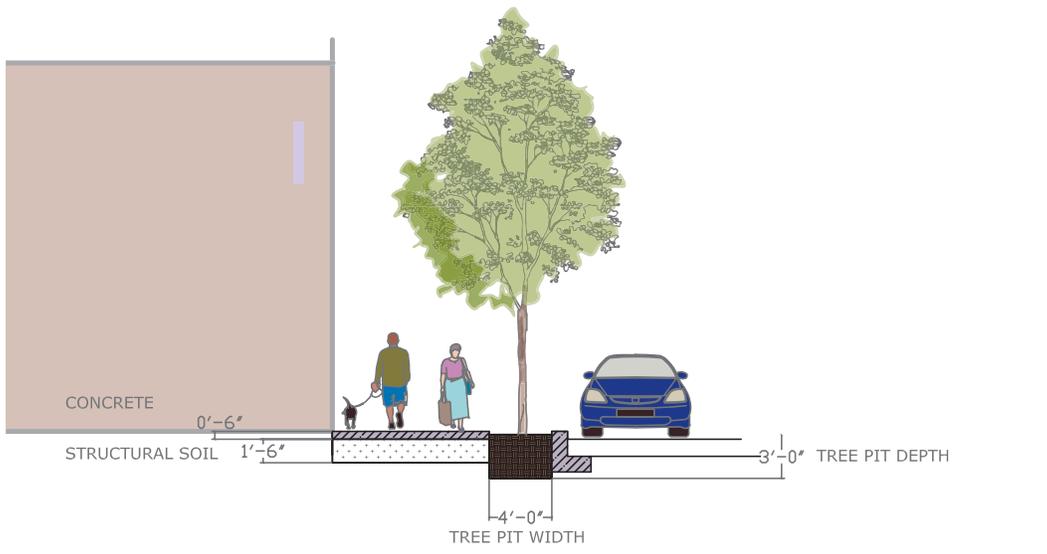
TREE PIT SECTIONS

Plan and Section: Structural Soil for East Court Street.

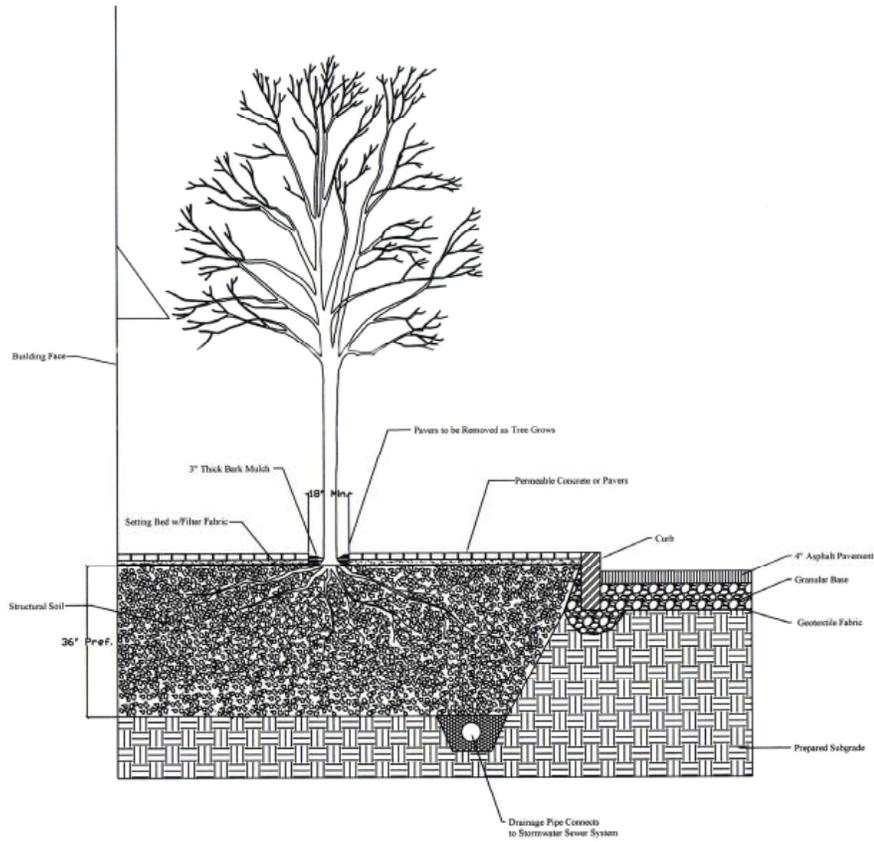
A



B



TREE PIT SECTIONS



STREET TREE DETAIL W/ PERMEABLE PAVERS

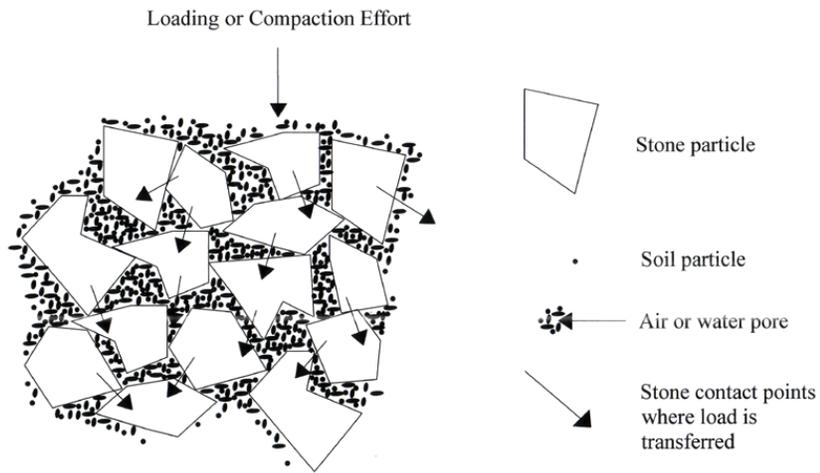


Diagram of Structural Soil Composition.
(Cornell's Urban Horticulture Institute)

CU-Structural Soil:

An Update after More than a Decade of Use in the Urban Environment

by Nina Bassuk, Director, Urban Horticulture Institute, Cornell University



These *Pyrus calleryana* ‘Chanticleer’ were planted in a plaza space in Ithaca about five years ago. They have grown exceptionally well. Our experience with species that do well in CU-Structural Soil suggests that those trees that are both alkaline soil tolerant and moderately to highly drought-tolerant make the best candidates for this soil type.

In 1995, Jason Grabosky (now a professor at Rutgers University) and I published the first scientific paper on what would come to be known as structural soil—later, CU-Structural Soil. The development of this soil medium came about as we recognized that the single most important factor limiting the healthy growth of trees in urban areas was a lack of an adequate volume of soil.

There appeared to be plenty of soil under sidewalk pavement and gravel for tree roots to grow into. However, most of that soil was so highly compacted as to make it inaccessible to tree roots. The soil was too dense. So tree roots were contained within the hole into which they were planted, or managed to grow out of the hole into the gravelly base course directly under the paved

surface—often heaving sidewalks in the process. Neither outcome was acceptable. Trees in sidewalk “containers” grew poorly and never attained the envisioned size for which they were planted, and tree roots that “broke out” under the sidewalk often caused a tripping hazard as the pavement was raised.

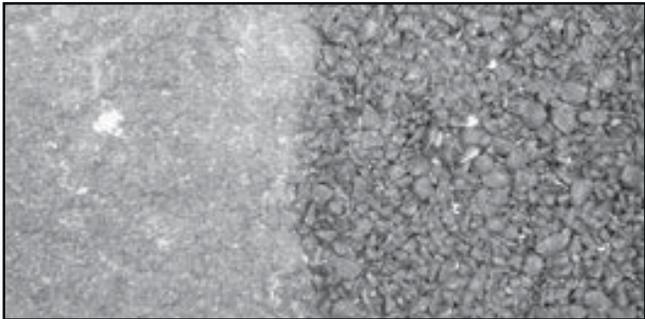
Soil under pavements of any kind—concrete, asphalt, block pavers, etc.—is required to be compacted to bear the weight of the pavement surface. Engineering specifications for pavement installation call for a high degree of compaction, often specified as 95% Proctor or peak density, to ensure that pavements would not subside, crack, or fail.

Thus the problem for us: trees require a large volume of soil in order to grow and provide the benefits for which we plant them, yet pavement installation specifications require that the soil below the pavement be highly compacted, limiting root growth. Could we develop a soil that would meet engineers’ requirements for soil compaction while allowing tree root growth? The outgrowth was CU-Structural Soil.

Simply put, CU-Structural Soil is a mixture of crushed gravel and soil with a small amount of hydrogel to prevent the soil and stone from separating during the mixing and installation process. Many years of research went into finding the right blend of these three elements so that the requirements of pavement installation and the growth of the tree could be satisfied. The keys to success were the following: the gravel should consist of crushed stone approximately one inch in diameter, with no finer particles, to provide the greatest porosity. The soil needed for structural soil was loam to clay loam that contained at least 20% clay to maximize water and nutrient holding capacity. The proportion of soil to stone was approximately 80% stone to 20% soil by dry weight, with a small amount of hydrogel aiding in the uniform blending of the two materials. This proportion ensured that each stone touched another stone, creating a rigid lattice or skeleton, while the soil almost filled the large pore spaces that were created. This way, when compacted, the load would be born from stone to stone, and the soil in between the stones would remain uncompacted.



Here is the Ithaca, NY parking lot in the first year after planting. 'Accolade' elms were planted in the porous asphalt and traditional asphalt. Both surfaces have CU-Structural Soil underneath. We will be evaluating the growth of all trees in both surfaces over time.



The comparison of traditional asphalt (left) and porous asphalt (right). Porous asphalt lacks the fine particles of stone and binder course that makes it impervious. Porous asphalt works very well; however, it is important not to use sand for de-icing as that will clog up the pores. It is recommended that once a year the surface be vacuumed to remove debris that has fallen on the site.



'Accolade' elms in the parking lot towards the end of their second year of growth in CU-Structural Soil overlaid with porous or traditional asphalt. All trees are doing very well, putting out one-and-a-half to two feet of new growth in their second year, with no differences due to surface treatment at this date. Evaluations will be ongoing.



This is a 14-car parking lot in the city of Ithaca entirely built on 24" of CU-Structural Soil. In this rainy picture you can clearly see the traditional asphalt as it looks slick from the water running off it compared with the porous asphalt, which looks dull as rainwater goes through its surface. Subsequent to this construction, areas of both types of asphalt were cut out and elm trees were planted.



These *Acer campestre* have grown for nine years in a trench of CU-Structural Soil overlaid with un-mortared concrete pavers. Although when these trees were planted, we only used 15" of CU-Structural Soil in a continuous trench under the brick pavers, we now believe that 24" should be the minimum depth of structural soil, appropriate for smaller trees, while 36" is preferable in order to maximize rooting space and water availability.

After testing this soil in controlled experimental sites at Cornell, we were ready to begin using it in installations. We also decided that we needed to patent the material to ensure its quality control. As we were developing CU-Structural Soil, we often spoke about it at conferences so that several people decided to try it for themselves. Often during these attempts the user would change the proportions of soil to stone by adding more soil than we specified. In doing this, stone did not touch stone, because stones were pushed apart by too much soil. When that mixture was compacted, the stone lattice would not occur and the end result was compacted stony soil. These mixes were also called "structural soil," yet they had nothing to do with the carefully researched proportions we had developed. Therefore we decided to patent our structural soil as CU-Structural Soil® in 1998 (U.S. Patent # 5,849,069). Cornell University owns the patent and Amereq, Inc. (www.amereq.com) is the licensee who sublicenses it all over the U.S. and Canada. There are other structural soils; however, only CU-Structural Soil has over a decade of research and hundreds of installations.

There are now 71 licensed producers of CU-Structural Soil in the U.S. and Canada and over 500 installations, from Quebec to

Puerto Rico to California. CU-Structural Soil has been used in many different climates and is compatible with irrigation when that is necessary. As with any new technology, we're learning more about it as we continue to do research on its uses.

Frequently Asked Questions

What is the average cost of CU-Structural Soil?

Our most recent analysis from licensed producers across the country showed an average selling price of CU-Structural Soil of between \$35-\$42 per ton. There are some producers that are able to sell the material for a little less, but this is a very good estimate of the average price.

What volume of CU-Structural Soil is needed for a given tree?

The Urban Horticulture Institute at Cornell has found that, with the exception of the desert Southwest, two cubic feet of soil is needed for every square foot of crown projection (the anticipated area under the drip line of the tree at expected maturity). Trees growing in CU-Structural Soil in areas that normally use irrigation to grow trees should also provide low-volume drip irrigation in CU-Structural Soil installations.

What is the recommended depth for CU-Structural Soil?

We suggest a minimum of 24", but 36" is preferred. Roots will grow to the full depth of CU-Structural Soil. A base course of gravel is not needed on top of CU-Structural Soil below the pavement, because it was designed to be as strong as a base course. Properly compacted to 95-100% Proctor Density or Modified Proctor Density, it has a CBR (California Bearing Ratio) of 50 or greater.

Is CU-Structural Soil compatible with underground utilities?

If underground utilities are encountered within the proposed rooting zone, CU-Structural Soil can conform to the backfill needed around utilities and can be easily installed.

What is the recommended length and width for CU-Structural Soil installation?

There is no established minimum. However, CU-Structural Soil was designed to go under the entire pavement area. This homogeneity would ensure uniform engineering characteristics below the pavement, particularly in regard to frost heaving and drainage. Ideally, the installation should focus on a whole sidewalk section from building face to curb, potentially for a whole block. If it is impossible to use the entire sidewalk area using CU-Structural Soil, it can be placed in a 5- to 8-foot-wide trench parallel to the curb.

Should CU-Structural Soil be used in a tree pit if it is not placed below the surrounding pavement? This is the wrong use of this material. The success that we've seen with CU-Structural Soil is due the large soil volume that the roots can grow into. CU-Structural Soil was designed to be used where soil compaction is required, such as under sidewalks, parking lots, medians, plazas, and low-access roads. Where soils are not required to be compacted, a good, well draining soil should be used.

Won't the soil migrate down through a CU-Structural Soil profile after installation?

The excavation of a seven-year-old installation did not show any aggregate migration. The pores between stones in CU-Structural Soil are mostly filled with soil so there are few empty spaces for soil to migrate to.

Does hydrogel break down over time?

Over a long period of time, the soluble salts from which the hydrogel was produced, i.e. potassium (from potassium hydroxide) and ammoniacal nitrogen (from acrylamide) are released. The inert hydrogel becomes a very minimum part of the soil system. Beyond that, we believe that colonizing roots and other organisms will, over time, replace the spatial and tackifying roles of the hydrogel. Research on this subject is ongoing.

What happens when roots expand in CU-Structural Soil?

There will come a time when larger buttress roots will likely displace the stone, but if the roots were, as we have observed, deep down in the profile, the pressure they generate during expansion would be spread over a larger surface area. We have seen roots move around the stone and actually surround and encapsulate some stones in older installations, rather than displace the stones.

Is CU-Structural Soil susceptible to frost heave?

This topic has not been rigorously tested, but we have not observed frost heave damage in the Ithaca, New York installations. Based on drainage testing and swell data on this extremely porous system, CU-Structural Soil appears quite stable.

Can you add normal soil in the tree pit and CU-Structural Soil under the pavement?

If the tree pit is sufficiently large, greater than 5 feet x 5 feet, and the opening unpaved, a conventional soil should be used in the open tree pit surrounding the root ball with CU-Structural Soil extending under the pavement. The available water in CU-Structural Soil is approximately 7%. Using a good sandy loam or well-structured loam in the tree pit opening will provide more moisture.

What type of trees should be grown in CU-Structural Soil?

Depending on the stone type and subsequent soil pH, moderate to highly drought tolerant and alkaline soil tolerant trees should be used. In Ithaca, New York where we make CU-Structural Soil using limestone as the crushed gravel in the mix, we have had success with numerous trees. For more information see www.hort.cornell.edu/uhi/outreach/csc/index.html

Can you use balled-and-burlapped, bare root, containerized or boxed trees in CU-Structural Soil?

Trees from any production system can and have been used. It is important to water the newly planted tree as would be expected in any soil.

Can you store large quantities of CU-Structural Soil?

CU-Structural Soil is produced by licensed producers and is preferably not stockpiled. It is mixed as necessary and should be delivered and installed in a timely manner. If any stockpiling is required, protection from rain and contamination should be provided.

Can CU-Structural Soil be utilized around existing trees?

There are several instances where CU-Structural Soil was utilized adjacent to existing trees. It appears that if few tree roots are damaged during the installation, the trees continue to grow well. Research is currently underway to investigate this issue.

Has CU-Structural Soil been used to mitigate storm water runoff?

Through the efforts of Ted Haffner, graduate student at Cornell, and Ithaca City Forester Andy Hillman, we created a parking lot in Ithaca that combined porous asphalt and CU-Structural Soil. This parking lot reduces or eliminates surface run-off and allows trees to grow within it. The porosity of CU-Structural Soil after compaction is about 26%. Moreover, of that porosity, about 31% are large pores that determine water infiltration.

The infiltration rate of water through porous asphalt into CU-Structural Soil is greater than 24" per hour. Conventional loamy soil compacted to engineers' specifications for pavement installation has only about 2% large pores and 0.5% water infiltration per hour. A 24" base of CU-Structural Soil under a porous asphalt parking lot can accommodate 6" of rainfall in 24 hours within its pores. The water will then seep back into the ground water over time.

Can turf be grown on CU-Structural Soil?

Trials at Cornell University have shown that tall fescue grows well on compacted CU-Structural Soil and is wear tolerant. Sod installation or seed with cellulose mulch works well when laid directly on the compacted CU-Structural Soil. Irrigation needs to be applied in both installations to establish the turf and can be subsequently eliminated where turf can be grown without irrigation.

We are continuing to work on CU-Structural Soil. Given the need for trees within heavily urbanized paved areas and the requirements for compacting the soil under pavement, CU-Structural Soil is a proven, viable option to help green our cities.



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Appendix 2: STREET TREE RECOMMENDATIONS

Carpinus betulus - European Hornbeam

Height: 35'-40'

Flowers: April

Fall Color: Green, brown, pale yellow

Soil: Grows in all textured soils. Tolerates occasionally wet soils and moderate drought.

Sun: Full sun to part shade

Propagates by: Seed (catkins)

Establishment: Commonly available in ball and burlap form. Sensitive to being transplanted in Autumn, and care should be taken to amend the soil, fertilize, water, mulch adequately, and avoid winter salt spray.



Image taken from www.plantations.cornell.edu

Gleditsia triacanthos var. inermis - Honeylocust

Height: up to 65'

Flowers: May - June

Fall Color: Yellow

Soil: Grows in all textured soils. Tolerates wet soils, drought, and compaction.

Sun: Full sun to part shade

Propagates by: Seed (legumes)

Establishment: Scarified seeds will germinate readily. Thornless forms come true about half of the time. Transplanting is easy. Cutting from male-flowered branches grow into trees with pollen flowers only, so they do not produce fruit.

Notes: Very tolerant of urban stresses, but susceptible to a number of pests. Inermis is a thornless variety. Pruning when young is needed to develop a central trunk. Attracts wildlife.



Photo by Tom Spencer
Image taken from www.soulofthegarden.com

All plant culture information was taken from Gerhold, Henry D., Norman L. Lacasse, and Willet N. Wandell, eds. Street Tree Fact Sheets. University Park, PA: Penn State University, 1993.

Platanus x acerifolia 'Bloodgood'

Height: 70' - 80'

Fall Color: yellow brown

Features: Patchy olive green, creamy gray, and brown bark.

Sun: Full sun to part shade

Establishment: Large durable tree suited to city conditions where there is ample space. It tolerates compacted soils, drought, and seacoast environments.

Culture: Transplants readily, and is adaptable to a wide range of sites but needs a wide tree lawn. Plants propagated on their own roots are preferable.

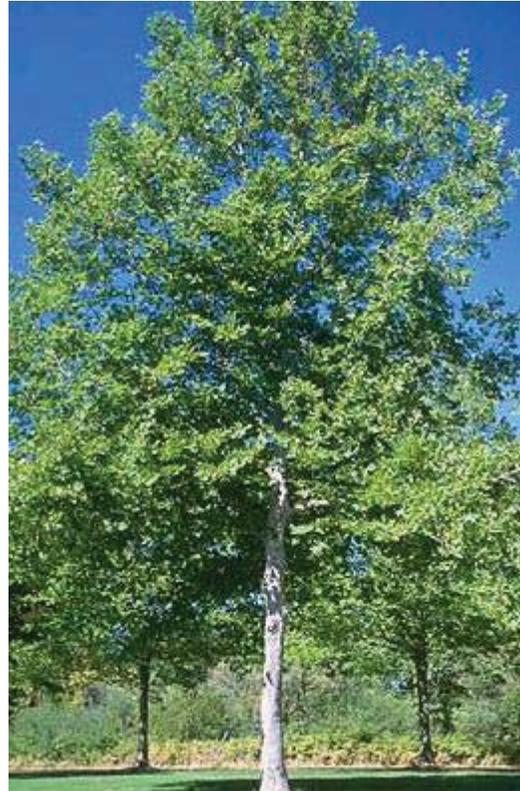


Image taken from www.ci.troy.mi.us

Zelkova serrata 'Halka' - Japanese Zelkova

Height: 60' - 70' (50' at age 30)

Fall Color: Yellow

Features: With its gracefully arching branches, it resembles American elm more closely than other cultivars, and grows rapidly

Sun: Full sun to part shade

Culture: Transplants readily in the spring; avoid planting in the fall. Adaptable to pH, compacted soil, pollution, partial shade, and drought once established. Young trees are susceptible to frost.

Advantages: Can be used as a substitute for American elm, having similar leaves and graceful form, though the branches are more numerous and the size is not as majestic. It is highly resistant to Dutch elm disease, and no serious pest problems are known. Has good tolerance of urban environments.

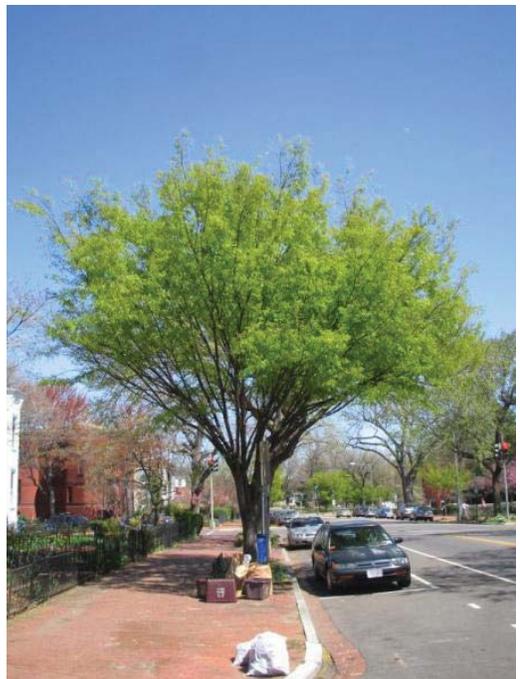


Image taken from www.cnr.vt.edu

Ulmus japonica x wilsoniana 'Morton'
(*Accolade Elm TM*)

Height: 70'

Fall Color: yellow

Features: Vase shaped with arching limbs, very similar to American elm. Glossy, dark green summer foliage

Sun: Full sun

Establishment: Will tolerate dry soils; medium to fast growth rate; easy to transplant

Culture: Outstanding tree; attractive foliage is resistant to elm leaf beetle feeding.

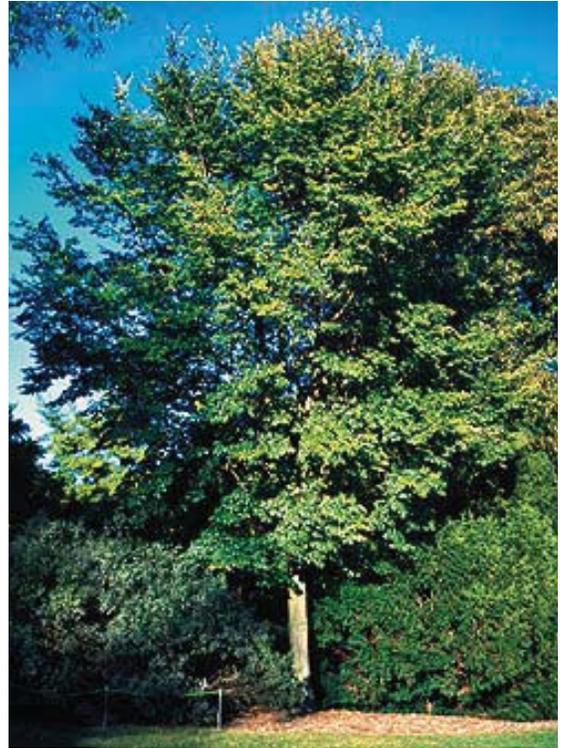


Image taken from <http://www.greenbeam.com/features/images/MortonGlossy.jpg>

Urban Water-Quality Management

Rain Garden Plants

Mike Andruczyk, Extension Agent, Chesapeake

Lynnette Swanson, Extension Agent, Norfolk

Laurie Fox, Horticulture Associate, Hampton Roads Agricultural Research and Extension Center

Susan French, Extension Agent, Virginia Beach

Traci Gilland, Extension Agent, Portsmouth

A rain garden is a landscaped area specially designed to collect rainfall and storm-water runoff. The plants and soil in the rain garden clean pollutants from the water as it seeps into the ground and evaporates back into the atmosphere. For a rain garden to work, plants must be selected, installed, and maintained properly.

Plant Selection

- Choose plants tolerant of both occasional flooding as well as dry periods.
- Choose noninvasive plants that are adapted to the local environment.
- Choose a mixture of species. A good rule of thumb is one plant species for every 10 to 20 square feet. For example – a 140-square-foot garden would have 7 to 14 different plant species.
- Choose plants for vertical layering – a mix of tall-, medium-, and low-growing species.

Plant Installation

- Install plants in their proper moisture zones (see Fig. 1).
- Plant shrubs and perennials in groups of three to five of the same species. Trees can be planted in groups or individually.
- Plant taller and larger plants in the center or at one end of the garden, depending on the views.
- Plant shorter plants where they can be seen easily, around the garden edges, in front of larger plants, or underneath taller plants.

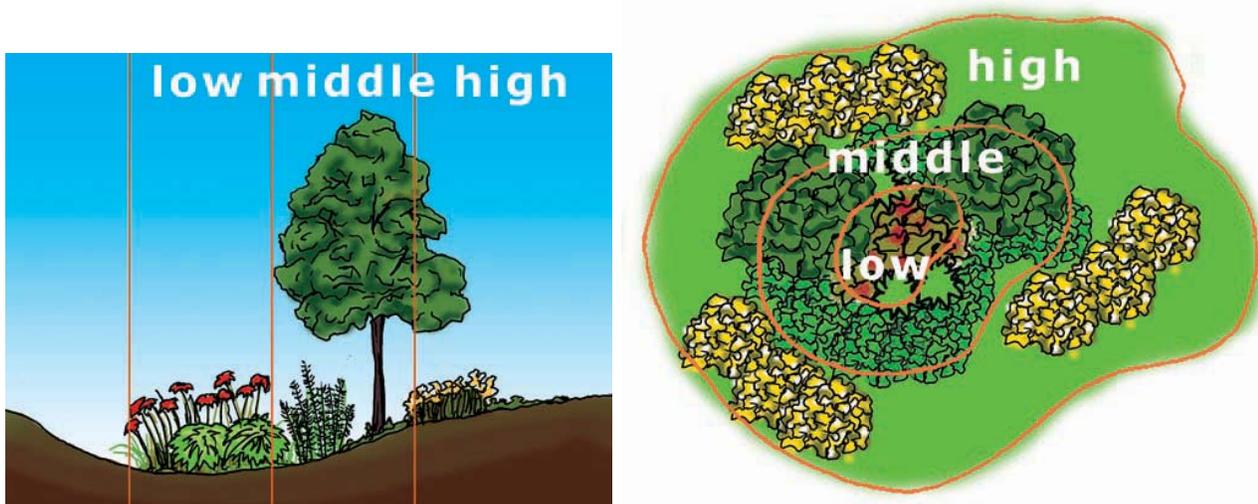


Figure 1. Rain Garden

- Space and plant perennials so that their canopies will grow together and cover the ground to minimize weeds.
- Space and plant trees and shrubs according to their mature size. For example – beautyberry shrubs, that grow to six feet wide, should be planted three feet apart.
- Planting outside and around the rain garden area helps the garden blend into the overall landscape.
- More information can be found in *Tree and Shrub Planting Guidelines*, Virginia Cooperative Extension publication 430-295.

Maintenance

- Add two to four inches of organic mulch to the entire newly planted rain garden. Do not cover the crowns of the perennials. Replenish mulch in the fall as needed.
- Avoid fine cut or lighter weight mulches as they tend to float in wet conditions.
- Prune any dead, diseased, or damaged plants as soon as the problem is noticed. More information on pruning woody plants can be found in Virginia Cooperative Extension publications 430-455 through 430-462 (see References).
- Prune the foliage of perennials when they die back for the winter and ornamental grasses before new growth begins in the spring.
- Remove or spot treat weeds as necessary.
- Water the garden during its establishment and extended dry periods. One inch of water per week is recommended.

Plant Lists

Trees, shrubs, and perennials are listed with both their common and *scientific* names. Ask at local garden centers for specific cultivars, varieties, and size at maturity.

Trees

Use trees only in rain gardens larger than 150 square feet.

| | |
|------------------------|-------------------------------------|
| Alder | <i>Alnus serrulata (glutinosa)</i> |
| Arborvitae | <i>Thuja occidentalis</i> |
| Atlantic White Cedar | <i>Chamaecyparis thyoides</i> |
| Austrian Pine | <i>Pinus nigra</i> |
| Bald Cypress | <i>Taxodium distichum</i> |
| Black Gum | <i>Nyssa sylvatica</i> |
| Carolina Silverbell | <i>Halesia tetraptera</i> |
| Common Persimmon | <i>Diospyros virginicus</i> |
| Dawn Redwood | <i>Metasequoia glyptostroboides</i> |
| Downy Serviceberry | <i>Amelanchier arborea</i> |
| Eastern Redbud | <i>Cercis canadensis</i> |
| Eastern Red Cedar | <i>Juniperus virginiana</i> |
| Green Ash | <i>Fraxinus pennsylvanica</i> |
| Hackberry | <i>Celtis occidentalis</i> |
| Hornbeam | <i>Carpinus caroliniana</i> |
| Japanese Cryptomeria | <i>Cryptomeria japonica</i> |
| Japanese Zelkova | <i>Zelkova serrata</i> |
| Katsura Tree | <i>Cercidiphyllum japonicum</i> |
| Lacebark Elm | <i>Ulmus parvifolia</i> |
| Loblolly Pine | <i>Pinus taeda</i> |
| Planetrees (Sycamores) | <i>Platanus spp.</i> |
| Red Maple | <i>Acer rubrum</i> |
| River Birch | <i>Betula nigra</i> |
| Swamp White Oak | <i>Quercus bicolor</i> |
| Sweetbay Magnolia | <i>Magnolia virginiana</i> |
| Sweetgum | <i>Liquidambar styraciflua</i> |
| Water Oak | <i>Quercus nigra</i> |
| Weeping Willow | <i>Salix babylonica/alba</i> |

Willow Oak

Witch Hazel

Yaupon Holly

Quercus phellos

Hamamelis virginiana

Ilex vomitoria

Shrubs

| | |
|-----------------------|---|
| American Beautyberry | <i>Callicarpa americana</i> |
| Anise | <i>Illicium parvifolium</i> |
| Arrowwood | <i>Viburnum dentatum</i> |
| Bottlebrush Buckeye | <i>Aesculus parviflora</i> |
| Buttonbush | <i>Cephalanthus occidentalis</i> |
| Carolina Allspice | <i>Calycanthus floridus</i> |
| Chokeberry | <i>Aronia arbutifolia</i> |
| Cranberrybushes | <i>Viburnum opulus/trilobum</i> |
| Devilwood | <i>Osmanthus americana</i> |
| Dogwoods | <i>Cornus amomum/racemosam/sericea</i> |
| Elderberry | <i>Sambucus canadensis</i> |
| False Indigo | <i>Amorpha fruticosa</i> |
| Fetterbush | <i>Leucothoe racemosa</i> |
| Groundsel Bush | <i>Baccharis halimifolia</i> |
| Highbush Blueberry | <i>Vaccinium corymbosum</i> |
| Inkberry | <i>Ilex glabra</i> |
| Leucothoes | <i>Leucothoe axillaris/fontanesiana</i> |
| Oakleaf Hydrangea | <i>Hydrangea quercifolia</i> |
| Possumhaw | <i>Ilex decidua</i> |
| Rose of Sharon | <i>Hibiscus syriacus</i> |
| Shadblow Serviceberry | <i>Amelanchier canadensis</i> |
| Spicebush | <i>Lindera benzoin</i> |
| Steeplebush | <i>Spiraea tomentosa</i> |
| Summersweet Clethra | <i>Clethra alnifolia</i> |
| Swamp Azalea | <i>Rhododendron viscosum</i> |

Swamp Rose
Virginia Sweetspire
Wax Myrtles
Willows

Winterberry

Rosa palustris
Itea virginica
Myrica cerifera/pennsylvanicum
Salix caprea/discolor/matsudana
sachalinensis/purpurea
Ilex verticillata

Red Columbine
Siberian Bugloss
Spiderwort
Strawberry Begonia
Swamp Milkweed
Swamp Sunflower
Turtleheads
Virginia Bluebells
Wild Ginger
Windflowers

Aquilegia canadensis
Brunnera macrophylla
Tradescantia spp.
Saxifraga stolonifera
Asclepias incarnata
Helianthus angustifolius
Chelone lyonii/obliqua
Mertensia virginica
Asarum canadense
Anemone

Perennials

Arrowhead
Asters
Beardtongue
Beebalm
Blackeyed Susan
Blue Lobelia
Bluestar
Calla Lily
Canna Lily
Cardinal Flower
Crinum Lily
Daylilies
Gingers
Goldenrod
Hardy Begonia
Hibiscus
Ironweed
Irises

Joe-Pye Weed
Leopard Plant
Liatris
Lilyturf
Lizard Tail
Lungwort
Marsh Marigold
Monkey Flower
Obedient Plant
Pickerelweed
Plantain Lily
Primroses
Rain Lilies

Sagittaria latifolia
Aster spp.
Penstemon digitalis
Monarda didyma
Rudbeckia hirta
Lobelia siphilitica
Amsonia tabernaemontana
Zantedeschia spp.
Canna spp.
Lobelia cardinalis
Crinum spp.
Hemerocallis spp.
Hedychium spp.
Solidago flexicaulis
Begonia grandis
Hibiscus coccineus/moscheutos
Vernonia noveboracensis
Iris lousiana/pseudacorus/versicolor/virginica
Eupatorium spp.
Ligularia tussilaginea
Liatris spicata
Liriope muscari
Saururus cernuus
Pulmonaria spp.
Caltha palustris
Mimulus ringens
Physotegia virginiana
Pontederia cordata
Hosta spp.
Primula spp.
Zephyranthes spp.

Ferns

Christmas Fern
Cinnamon Fern
Holly Fern
Japanese Painted Fern
Lady Fern
Royal Fern
Tassel Fern
Wood Ferns

Polystichum acrostichoides
Osmunda cinnamomea
Cyrtomium falcatum
Athyrium nipponicum
Athyrium felix-femina
Osmunda regalis
Polystichum braunii
Dryopteris spp.

Grasses and Grass-like

Broom Sedge
Feather Reed Grass
Foxtail Grass
Rushes
Sedges
Sweetflag
Switchgrass

Andropogon virginicus
Calamagrostis acutiflora
Alopecurus pratensis
Juncus spp.
Carex spp.
Acorus spp.
Panicum virgatum

Groundcovers

Bugleweed
Foamflower
Green and Gold
Lilyturf
Mazus
Plumbago
St. Johnswort

Ajuga spp.
Tiarella cordifolia
Chrysogonum virginianum
Liriope spicata
Mazus reptans
Ceratostigma plumbaginoides
Hypericum calycinum

References

Rain Gardens, A Landscape Tool to Improve Water Quality; Virginia Department of Forestry Publication VDOF 000127, <http://www.dof.virginia.gov/>

Rain Gardens, Virginia Department of Forestry, <http://www.dof.virginia.gov/rfb/rain-gardens.shtml>

Backyard Rain Gardens, North Carolina Cooperative Extension, <http://www.bae.ncsu.edu/topic/raingarden/>

Rain Gardens, University of Wisconsin-Extension, <http://clean-water.uwex.edu/pubs/raingarden/index.html>

Rain Gardens, Rainscapes, <http://209.142.214.237/rain-scapes/garden.htm>

Rain Gardens of West Michigan, <http://www.raingardens.org/Index.php>

Tree and Shrub Planting Guidelines, Virginia Cooperative Extension publication 430-295, <http://www.ext.vt.edu/pubs/trees/430-295/430-295.html>

A Guide to Successful Pruning: Pruning Basics and Tools, Virginia Cooperative Extension publication 430-455, <http://www.ext.vt.edu/pubs/nursery/430-455/430-455.html>

A Guide to Successful Pruning, Pruning Deciduous Trees, Virginia Cooperative Extension publication 430-456, <http://www.ext.vt.edu/pubs/nursery/430-456/430-456.html>

A Guide to Successful Pruning, Pruning Evergreen Trees, Virginia Cooperative Extension publication 430-457, <http://www.ext.vt.edu/pubs/nursery/430-457/430-457.html>

A Guide to Successful Pruning: Stop Topping Trees!, Virginia Cooperative Extension publication 430-458, <http://www.ext.vt.edu/pubs/nursery/430-458/430-458.html>

A Guide to Successful Pruning, Pruning Shrubs, Virginia Cooperative Extension publication 430-459, <http://www.ext.vt.edu/pubs/nursery/430-459/430-459.html>

A Guide to Successful Pruning, Deciduous Tree Pruning Calendar, Virginia Cooperative Extension publication 430-460, <http://www.ext.vt.edu/pubs/nursery/430-460/430-460.html>

A Guide to Successful Pruning, Evergreen Tree Pruning Calendar, Virginia Cooperative Extension publication 430-461, <http://www.ext.vt.edu/pubs/nursery/430-461/430-461.html>

A Guide to Successful Pruning, Shrub Pruning Calendar, Virginia Cooperative Extension publication 430-462, <http://www.ext.vt.edu/pubs/nursery/430-462/430-462.html>

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