MICHAEL WILSON KIDD
Where the Asphalt Ends: A Systematic Approach to Designing a Better Strip Mall Parking Lot
(Under the Direction of BRUCE K. FERGUSON)

Shopping centers are among the most prominent physical features of most cities and towns in America. Because of our society's dependence on automobiles, a shopping center must provide adequate parking if it is to prosper. Based on early parking demand studies, a typical shopping center devotes nearly twice as much land to parking than it does to the shopping center itself. This is a problem because asphalt parking lots disrupt the hydrologic cycle, they contribute to heat islands, they do not represent an acceptable aesthetic to most people, and they are not designed to explicitly support multiple uses.

The purpose of this thesis is to explore alternative design solutions for surface parking lots in commercial shopping centers based on sound ecologic and aesthetic design principles. This thesis proposes unique designs for addressing hydrology, heat islands, aesthetics, and multiple uses, and a combined design approach that addresses all four concerns simultaneously.

INDEX WORDS: Parking lots, Parking, Strip malls, Porous pavement, Heat island, Parking indices, Stormwater runoff, Level spreaders, SF-Rima, Urban trees, Parking lot landscaping, Overflow parking, Bioswales, Vegetated Swales, Aesthetics

WHERE THE ASPHALT ENDS: A SYSTEMATIC APPROACH TO DESIGNING A BETTER STRIP MALL PARKING LOT

by

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CHAPTER 1

INTRODUCTION

Parking lots play a significant role in every American's life. According to Childs (51) "there are approximately 7 parking stalls for every car in an American city." The majority of the people in this country take at least one trip in a car every day whether to work, school, the grocery store, etc. Almost without exception those same people end up in a parking lot somewhere at some point during their excursion. Some of the largest and most prevalent parking lots are those that serve commercial shopping centers. We are all familiar with these acres of asphalt that provide temporary holding cells for our cherished automobiles while we race from errand to errand day-in and day-out. But how much do we really know about these places?

Several questions arose when I sat down to contemplate the design of parking lots. The first one is a question of ecology. These hydrophobic layers of aggregate and asphalt cement have a tremendous impact on the surrounding environment. They deplete ground water resources. They contribute to the degradation of stream banks and the pollution of lakes. They contribute to "heat islands" by increasing air temperatures. They also consume an enormous amount of time, money, materials, and land. Is it possible then, to simultaneously serve the automobile and the environment?

My second question is one of aesthetics. The design of parking lots play a major role in people's perceptions of a particular property's value and its relative security. Physical characteristics such as the size of a parking lot or the amount of vegetation can help attract visitors to a particular site and make them feel comfortable in it, or turn them away. Is it possible then, to improve perceptions of attractiveness and safety while accommodating parking needs?

My third question is that of use or function. The primary function of a parking lot is of course to provide space for parking cars. However, parking lots serve other functions for which they have not been designed. As a child growing up in the small town of Hammond, Louisiana, I spent many a recess playing games like dodge ball and freeze tag on the smooth black asphalt surface of my school's parking lot. My school also hosted a fair every year in that same parking lot. I remember seeing tent revivals set up camp in our grocery store parking lot. I have also seen parking lots being used for car washes, driving school, car shows, and obedience classes for dogs. On Friday and Saturday nights teenagers across the country congregate in strip mall parking lots showing off their cars and whispering sweet nothings. Is it possible then, to design parking lots in such a way that they could explicitly support multiple functions in addition to providing space for parking cars?

These massive expanses of asphalt and concrete are an underutilized resource and an unrecognized opportunity. The parking environment can be improved both ecologically and aesthetically through creative and sensitive design. The objective of this thesis is to explore alternative design solutions for surface parking in commercial shopping centers based on sound ecological and aesthetic design principles. For purposes of this thesis, "strip mall" and "shopping center" are used interchangeably. This thesis will use the Urban Land Institute's definition of a shopping center. The Urban Land Institute (199) defines a shopping center as "a group of architecturally unified commercial establishments built on a site which is planned, developed, owned, and managed as an operating unit related in its location, size, and type of shops to the trade area that the unit serves. The unit provides on-site parking in definite relationship to the types and total size of the stores." In a typical shopping center at least 80% of the center's gross leasable area is devoted to retail selling. The Urban Land Institute (199) defines gross leasable area (GLA) as the total floor area from interior wall to interior wall excluding elevator shafts, stairwells, public toilets, and enclosed common areas.

CHAPTER 2

A BRIEF HISTORY OF PARKING LOTS

Parking lots have been around since the invention of the wheel nearly five thousand years ago. Archaeological evidence dates the first use of a wheeled vehicle to 3000 BC in the city of Ur in ancient Mesopotamia. The vehicle was a small cart, probably pulled by a man or a mule, used to transport anything too heavy or too bulky to carry by hand. As simple as it sounds, accommodating this wheeled vehicle required permanent physical changes to the city's infrastructure like the rounding of street corners. Perhaps the most significant change it demanded was the designation of specific “parking” areas to keep the carts from clogging the streets. In ancient cities, streets belonged to the pedestrian. They were public places where trade, commerce, and the minutia of everyday life occurred. Idle carts were simply in the way (Childs 3).

Some three thousand years later during the Roman Empire, the streets still belonged to the pedestrian, and accommodations still had to be made for the wheeled vehicle. Keeping streets free of idle carts was so essential to the function of daily life that Romans banned the use of vehicles during peak hours of the day. Ancient Roman cities were meticulously laid out with extensive networks of streets including “broad ways” that were sacred avenues leading to palaces and temples. Although these streets provided an infrastructure for transportation, they were first and foremost, pedestrian spaces. Consequently, Romans went to great lengths to prevent “traffic jams” on their streets.

Today's parking fines pale in comparison to the penalty of death administered to anyone illegally parked along a "broad way". Convicted felons were beheaded and their heads were impaled on a pole outside the palace gates to discourage anyone else from committing such a heinous crime as that of a parking violation (Miller 1988).

Another, much less violent way Romans prevented traffic jams was by designating specific areas for parking like their predecessors had done in Mesopotamia. The word "parking" comes from the Medieval Latin word *parricus*, which means enclosure (Simpson 1989). And so for three thousand years parking lots provided temporary enclosures for vehicles, or carts, to keep them off the street.

In 1769, Nicolas-Joseph Cugnot, a French artillery officer, launched the first self-propelled vehicle, a wheeled cart attached to a small steam engine, and metaphorically launched the race to develop a more convenient mode of transportation. In the early 1800's many people around the world were simultaneously and independently working on the development of the automobile. But the public was not yet aware of this invention and resisted any vehicular encroachments on their streets (Wright 1988).

In Richard Wright's book Love and Revolution, 101 Years of the Automobile (1988), he claims that the automobile has had the greatest impact on the human race since agriculture. Three factors in the late 1800's led to the automobile explosion in the U.S. after the turn of the century. The first was the advancing technology of the bicycle, much of which was directly transferable to the manufacture of the car. A second was the development of the internal combustion engine that still powers cars today. The third, and perhaps the most important was the mass exodus of city dwellers to the suburbs that created a demand for a more convenient mode of transportation to and from the city

(Childs 1999). In 1903 Henry Ford introduced the Model T and gave the country what it was craving (Wright 1988). After thousands of years, the city street suddenly shifted from a pedestrian venue to a vehicular artery. Streets were no longer places for people to conduct business and socialize; they were now pipelines for the automobile to carry people to and from their destinations.

Now that streets served the automobile, it became necessary to keep them clear for vehicular rather than pedestrian traffic. In 1912, just nine years after the creation of the Model T, the mayor of Chicago called for the development of large paved lots along the waterfront to relieve the vehicular congestion of downtown streets, and the modern parking lot was born (Wright 1988). The function of the twentieth century parking lot is essentially the same as that of parking lots five thousand years earlier - to relieve vehicular congestion. There is, however, a contextual difference between the two. Ancient parking lots were built to clear the streets for people; modern lots are built to clear the streets for cars.

CHAPTER 3

DEFINING THE PROBLEM

> "…what is so subtle and difficult is to design a beautiful and organic landscape, regardless of whether it is presently a wasteland, thriving city, suburbia or wilderness, that reflects a series of interacting relationships and is an integral whole (Franklin 19)."

In the introduction three questions were posed regarding surface parking lots: what is their effect on the environment; can they be designed to enhance perceptions of attractiveness and safety; and, can they better accommodate multiple uses? These questions led to the identification of four specific problems associated with parking lots. They degrade the hydrological cycle, they contribute to heat islands, they do not represent an acceptable aesthetic to most people, and they are not designed to explicitly support multiple uses. In this chapter I will analyze the mechanisms behind these problems to facilitate the development of alternative designs that address them. It is first necessary, to understand why strip mall parking lots exist in the first place.

3.1 The Business of Parking

Parking lots exist to facilitate the economic prosperity of businesses. There are many business constraints to consider when designing a parking lot. These include, but are not limited to finances, building codes, zoning regulations, marketing demands and consumer expectations. Designing a parking facility to meet all of these needs has evolved into an art. It is a complex process that includes accounting for everything from drainage requirements to regulations and guidelines specified by the American Disabilities Act.

Over the past several decades three factors have resulted in an increase in land devoted to parking cars. First, the trend in local governments has been to segregate land uses, resulting in an increased dependence on personal automobiles. Most businesses were once located in a downtown area that supported multiple modes of transportation and reduced the number of trips necessary by providing a multitude of services within walking distance of each other. Now that many businesses are segregated, people have to drive almost everywhere making storefront parking a necessity (SED 5). Many zoning regulations now require a minimum amount of on-site parking for different development densities to avoid conflicts with moving traffic, to facilitate smooth traffic flow, and to meet peak parking expectations of business owners and customers.

A second factor that has increased the amount of land devoted to parking is that parking lots have gotten bigger. This is in large part due to the availability of inexpensive land in the suburbs. As single-family residents fled to the suburbs, many businesses followed to remain close to their customer base. Suburban land is cheaper and more abundant than land in the city. Consequently, suburban retailers can provide conveniences like parking lots with larger stalls, aisles and driveways than their urban counterparts (ULI 86). As a result, consumers have come to expect such conditions and consider it a nuisance when they are not met.

A third factor is that parking lots in this country are considerably overbuilt. In an attempt to reduce their impervious surface coverage, the City of Olympia, Washington conducted a study revealing that on average, developers were providing 51% more parking than non-peak business days demanded (Thompson 60). According to the Urban Land Institute (1993), strip mall parking lots are almost never full. Large retailers tend to provide enough parking to accommodate their busiest shopping days of the year, which are the Friday after Thanksgiving and the three weekends leading up to Christmas (ULI 1993). However, this peak shopping season represents only a small portion of the year. An appropriate parking lot design should reflect a proper balance between community, consumer and business needs.

Determining the right number of spaces for a particular parking lot is the single most important and most difficult task for the designer. It is possible to hire a specialist to calculate a fairly accurate number of parking stalls needed for a particular development. However, this process is time consuming, expensive, and will never result in the perfect solution. Therefore, it is often ignored in favor of a loose approximation based on generalized national standards, the experience of the builder, and precedents set by surrounding businesses. National parking standards for strip malls are based a “demand hour.” Studies are done that calculate hourly parking demands for an entire year and one demand hour is chosen to determine the parking index. The difficult part of this process is determining which demand hour most accurately reflects the needs of the community, the consumer and the retailer. A parking lot that provides enough spaces for an average shopping day is not adequate because it neglects those days of the year that account for the majority or a retailer’s business (ULI 1993). However, it is also unreasonable to design for the peak demand hour as this would result in a facility that is ninety-nine percent underutilized (Childs 1999). Therefore selecting the appropriate demand hour becomes an educated guess.

In the 1960's researchers determined that the tenth highest demand hour was the most appropriate (ULI 200). Based on this demand hour, in 1965 the national shopping center industry standard was to provide a maximum of 5.5 parking stalls per 1,000 square feet of gross leasable area (GLA). In 1977 the parking index for shopping centers was reduced to 5.0 stalls per 1,000 square feet GLA. A suburban commercial parking lot typically provides 350 square feet per stall to accommodate the stall plus driveways and driving lanes (ULI 200). Assuming a parking index of 5.0 means that a typical strip mall provides approximately 1,750 square feet of parking for every 1,000 square feet of building. In other words, for more than thirty years strip mall parking lots have consumed 1.75 times more land than their associated businesses.

In 1980 the Urban Land Institute (199) completed a thirty-two year study of more than twenty-two shopping centers to determine a more accurate demand hour. The data from this study was aggregated by center size and ranked in order of descending hourly demand. After this data was analyzed it was determined by parking and retail specialists that the twentieth highest demand hour was more appropriate to design for than the tenth. Table 1 shows the new parking indices broken down by size of shopping centers.

Since most strip malls fall into the first and second categories their parking indices should be reduced from 5.0 to 4.5 or 4.0. This results in a ten to twenty percent reduction in land devoted to parking. It also results in considerable financial savings since an average surface-parking stall costs between $3,000.00 and $8,000.00 (ULI 1993). The money saved by eliminating excess parking could be spent on amenities for the facility.

Table 1. Parking indices for strip malls broken down by size (ULI 1993).

SHOPPING CENTER SIZE	PARKING INDEX
25,000 – 400,000 square feet GLA	4.0 spaces per 1000 square feet GLA
400,000 – 600,000 square feet GLA	4.5 spaces per 1000 square feet GLA
>600,000 square feet GLA	5.0 spaces per 1000 square feet GLA

Another possible area of financial and environmental savings is in the treatment of overflow parking. Overflow parking is that area of a parking lot that is used only marginally throughout the year. The Urban Land Institute states “Fifty percent of the hours in a day serve less than half of the parking demand of the peak *hour* of that day” (ULI 201). The parking index for strip malls is based on the twentieth highest demand hour, which means that “during [only] 19 hours of each year, distributed over ten days, some patrons will be unable to find parking spaces immediately upon entering a center” (ULI 201). It also means that during approximately 40% of the entire year more than half of the spaces will remain unoccupied (ULI 201). Although no ratio has been established, based on the information above, a significant portion of strip mall parking could be considered overflow. Thus overflow parking represents an opportunity to reduce the environmental impacts of surface lots, enhance their attractiveness, and expand their function.

3.2 Environment

The natural environment exists as a delicate balance of countless interconnected relationships in a constant state of flux. It was once thought that if left undisturbed a natural environment would reach a climax state in which all things exist in harmony with each other. Now we understand that this state can never be achieved because environmental conditions and components are constantly changing. The health of the environment is not determined by its ability to achieve a climax state but rather its ability to adapt to chaotic changes and to persist in a state of dynamic equilibrium (Ferguson

129). In a healthy landscape, processes like vegetative succession and species evolution counteract destructive forces such as hurricanes and tornadoes. Unfortunately many of our current development practices disrupt these processes and prevent the land from healing itself. The impervious surfaces of parking lots have two such harmful effects on the environment. They disrupt the balance of the hydrologic cycle, and they contribute to a phenomenon know as the heat island.

Hydrology

The layers of the earth in which we live are primarily composed of water. Although the earth's crust is more than 75% water, only about 2.5% percent of that is fresh water. Even more amazing is that only 0.01% of all fresh water is available for human consumption (Donahue and Johnston 1988). The hydrologic cycle shown in Figure 1 illustrates the movement, storage, and change in phase of all that water.

This system exists in a state of dynamic equilibrium in which water is constantly circulating, changing physical states, and being filtered. In this cycle, solar radiation causes water to evaporate from land and water bodies and collect in the atmosphere. When air temperatures drop, water vapor condenses and falls to the ground in the form of precipitation. Once it reaches the ground, a small portion migrates towards water bodies in the form of runoff, but most of the water is absorbed into the soil (Wanielista 4).

Soil is composed of minerals, organic matter, air, and water (Brady 11). A large amount of the water in the soil eventually evaporates and ends up back in the atmosphere. Some soil water is taken up by plants and used in photosynthesis. The remainder of soil water either travels as base flow that feeds streams and rivers, or percolates into aquifers.

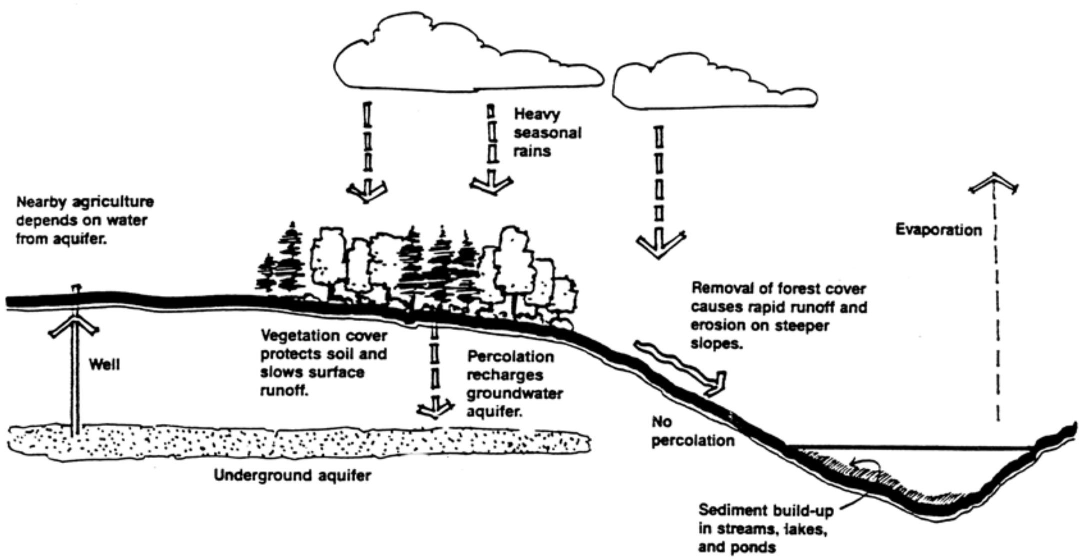


Figure 1. Diagram of the hydrologic cycle (Pittman 25).

Impervious surfaces, including parking lots, rooftops, roads, driveways, sidewalks and patios, inhibit the infiltration of water into the ground. These surfaces provide a permanent seal over the soil, depriving it of water and oxygen (SED 6) resulting in two detrimental effects on the hydrological cycle.

The first problem is that impervious surfaces reduce ground water recharge. When an impervious surface is introduced into an ecosystem, rainwater that would normally infiltrate into the soil now has nowhere to go except to flow along the top of the pavement. Almost all of the water that falls on paved streets and parking lots is diverted into storm drains where it is conveyed via impervious culverts directly into a stream or river. Table 2 shows typical runoff coefficients for various surfaces (ULI 1993). The higher coefficients produce greater amounts of runoff, which has less of an opportunity to return to the soil. Thus impervious surfaces alter the dynamic equilibrium of the hydrological cycle. In this country we pave and repave half a million acres of impervious asphalt every year (SED 6). So long as the area of impervious surfaces continues to increase, ground water recharge will continue to decrease.

A second problem resulting from the use of impervious surfaces is the degradation of streams and rivers. Streams and rivers are drainage outlets for watersheds. A healthy watershed can handle close to ten percent coverage by impervious surfaces (SED 6). Significant impacts to the ecosystems associated with streams and rivers begin to show at about ten percent coverage. Once a watershed reaches thirty percent coverage, the impacts become severe and degradation is almost unavoidable (SED 6). Typical developments range anywhere from ten percent impervious surface coverage for a two-acre residential lot, to almost one hundred percent coverage for a commercial shopping

Table 2. Runoff coefficients for various surfaces (ULI 1993).

	RUNOFF COEFFICIENT
Roofs and Paved Streets	
Roofs	0.95
Concrete or asphalt roads and pavements	0.95
Bituminous Macadam roads	0.80
Gravel Areas and Walks	
Loose	0.30
Compact	0.70
Vacant Lots and Unpaved Streets	
Light plant growth	0.60
No plant growth	0.75
Lawns, parks and golf courses	0.35
Wooded areas	0.20

center as shown in Figure 2. Parking lots can account for up to 40% of a watershed's impervious cover (Childs 191). The cumulative effect of these development types has a severe impact on the health of a watershed.

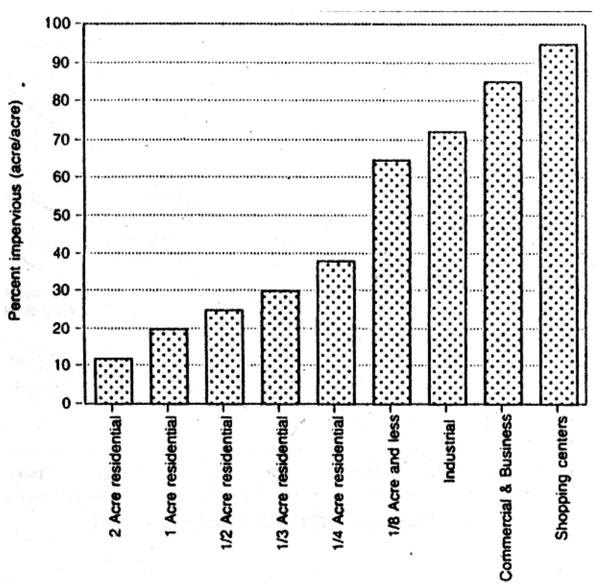


Figure 2. Bar graph illustrating percentage of impervious cover for various development types (SED 6).

The effects of impervious surface coverage on a watershed are complex and can be devastating. In her article entitled *Designing as if the Earth Really Mattered* (20), Franklin states "Increased runoff from impervious surfaces associated with development is one of the most pervasive problems in the landscape today…Each additional square foot of impervious surface produces as much as 3 additional feet of runoff per year." Runoff from impervious surfaces increases water pollutant levels, increases water temperatures during the warmer months, decreases base flow (water that travels horizontally through the soil and feeds streams and rivers), and hastens stream bank erosion. In between storms, impervious surfaces accumulate various pollutants. When it rains, the runoff from these surfaces picks up all of the sediment and pollutants from parking lots, maintenance yards, storage areas, etc., and washes them into a stream and a river. As it continues to rain, the volume of runoff increases, creating a greater than normal flow within a stream or river (SED 6). The increased volume and velocity of water rapidly erodes stream banks inundating the streams with large amounts of sediment that destroys fragile aquatic habitats.

Increased sedimentation in streams and rivers adversely affects aquatic wildlife in various ways. Sediment collects along channel bottoms creating smooth stream channels, which destroys spawning sites and reduces dissolved oxygen in the water. It increases turbidity, or cloudiness, which in turn reduces plant life. It clogs fish gills and destroys benthic organisms. Pollutants such as nutrients, pesticides, and heavy metals, readily adhere to soil particles causing the pollutants to accumulate in streambeds, which leads to higher toxicity levels with each rainfall. The consequences of increased sedimentation from impervious surface runoff include reduced fishing, increased water treatment costs, and species diversity and number losses (Erosion and Sedimentation 1999).

Heat Island

A second environmental problem associated with parking lots is their contribution to the phenomenon known as a "heat island." Heat islands are extreme microclimatic conditions characterized by unusually high temperatures created when naturally vegetated areas are replaced with intense development. Figure 3 illustrates a profile of a typical heat island. Heat islands occur in urban and suburban areas and can have severe impacts on the surrounding environment.

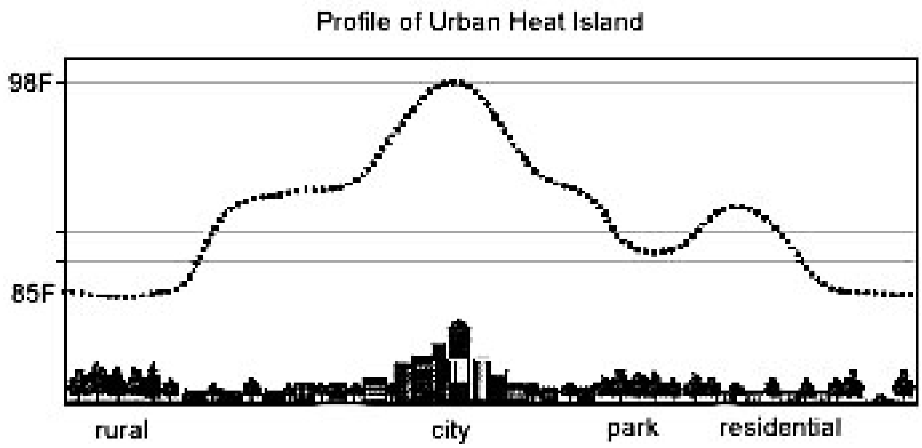


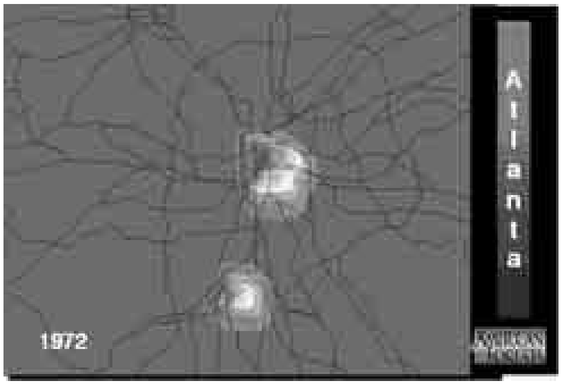
Figure 3. Profile of a typical urban heat island (Urban Air Quality and Climatology 2001).

Large surface parking lots significantly contribute to heat islands in several ways. First, asphalt, which is the primary material used for the construction of parking lots, is dark and dense. Dark colored materials have a low albedo, or reflectivity, and thus absorb more solar radiation than do lighter materials. Absorption of solar radiation by asphalt pavements causes developed areas to be 2°F to 15°F than rural areas (Urban Climatology and Air Quality 2001). In addition, dense materials have a greater storage capacity for solar energy than do less dense materials. Asphalt pavement is very dense and stores a large amount of solar radiation throughout the day that is later reemitted as heat. This increases the sensible heat of the pavement and the reemission of heat to the surroundings.

Another condition of the parking environment that leads to higher temperatures is the elimination of natural cooling processes. Perhaps the most significant of these processes is evaporation. During the process of evaporation heat is absorbed by the liquid phase of water causing individual water molecules disperse resulting in a phase change from a liquid to a gas. The heat absorbed by the liquid phase results in a cooling of the evaporative surface. Much of the water that soaks in to the ground eventually evaporates resulting in significant cooling (Claiborne 1970). Although there may be water in the soil below pavements, impervious surfaces inhibit the exchange of water between the soil and the atmosphere and prevent evaporation from taking place.

Removal of vegetation has various consequences that also result in higher temperatures. In Parking Lot Landscaping (1978), Corwin states "it is 20ºF cooler on a tree-shaded surface than on a surface in direct sunlight when it is 84º F.” This is due to several factors. Much of the water absorbed by plants eventually exits the leaves in a process called transpiration. This water eventually evaporates from leaf surfaces resulting in cooler air temperatures. Plant leaves intercept a large amount of solar radiation before it ever reaches the ground. Some of that radiation is reflected back into the atmosphere, and some of it is absorbed by the leaves and used in photosynthesis. By shading the ground, plants reduce the amount of radiation absorbed by other materials that would later be emitted as heat. In a parking lot however, there is little or no vegetation to moderate temperatures (Claiborne 1970). The infrared maps in Figure 4 illustrate Atlanta's increasing heat island since 1972. The dark areas in the 1993 map coincide with the city's core and Hartsfield International Airport. These areas are 12°F warmer than the rural areas surrounding the city (Stevens Roofing Systems 2001).

The major factors leading to parking lot heat islands are dense and dark construction materials, reduced vegetation, and impervious surfaces. Improving one or all of these factors would result in cooler air temperatures and reduce the impact of heat islands. The option for lighter colored, lower density paving materials that would reduce absorption of solar radiation has existed for many years. We have also had the ability to incorporate vegetation into a parking lot for many years. Porous pavements that permit the exchange of water and gases between the soil and the atmosphere have been available for more than thirty years. Unfortunately there is fear the alternative paving materials would increase cost, and that incorporating vegetation would require the removal of parking stalls.



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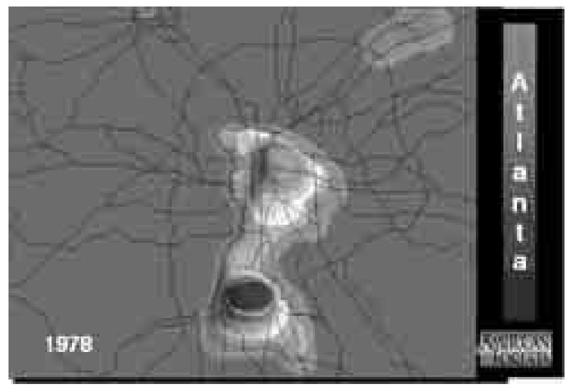

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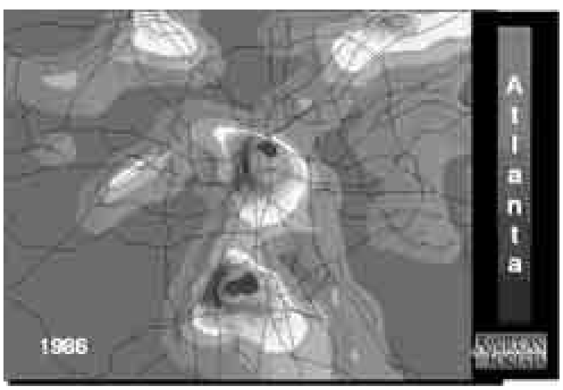

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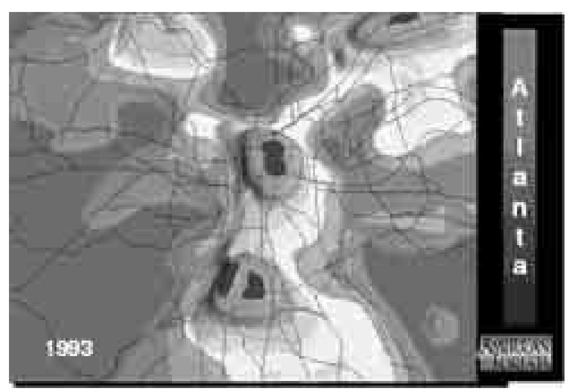


D

Figure 4. Infrared images showing the increase in Atlanta’s heat island: A) 1972, B) 1978, C) 1986, D) 1993. The darkest areas in B, C, and D are 12 degrees F warmer than the rural areas surrounding the heat island (Stevens Roofing Systems 2001).

3.3 Perceptions of Attractiveness and Safety

> "…much of the decline in the aesthetic quality of the environment is typically piece-meal and insidious, the by-product of a multitude of planning and development decisions taken with other criteria in mind. Such changes go either unnoticed or unchallenged although the cumulative effect on the landscape is considerable" (Sadler and Carlson 1982).

It is difficult to determine what makes a landscape look attractive or feel safe. Kevin Lynch wrote "Esthetics is often considered a kind of froth, difficult to analyze, easy to blow away" (1994). A quote from the Taciturn Annals reads "The desire for safety stands against every great and noble enterprise" (Childs 165). Each of these perceptions is subjective and based on an individuals experiences and preconceived notions. However, it is generally recognized that we all interpret the physical features of our surrounding environment to be either positive or negative. "A sense of beauty or even harmony enhances our lives; a sense of blight or discordance correspondingly diminishes it" (Sadler and Carlson 1). The difficulty is defining what it is that specifically contributes to or detracts from these perceptions.

The Oxford English Dictionary defines an aesthetic object as something that is "in accordance with the principles of good taste (or what is conventionally regarded as such)" (Simpson 1989). According to Anderson and Schroeder (219) most people do not regard suburban commercial parking lots as aesthetic objects. "New York, Toronto, and San Francisco…have higher attractiveness ratings and fewer parking spaces per person than Detroit or Houston" (Childs 37). In her article entitled *Designing as if the Earth Really Mattered* (21), Franklin states "Traditionally roads and parking devour land and are often bleak, unaesthetic and insensitive to the landscapes they pass through." In <u>Carscape</u>

(1988), Miller says that single-use parking lots are "dead spaces plagued by visual monotony," devoid of basic elements that make the built environment a pleasant and inviting place to be. In addition to being unattractive, parking lots are also perceived to be relatively unsafe. According to the U.S. Department of Justice, approximately 40% of all violent crimes reported in 1994 took place in parking garages and lots (Childs 165). Despite these facts, parking lots are necessary and in many cases mandatory. Many zoning regulations require a minimum amount of parking for different development densities, and customer flow depends in part on adequate and convenient parking (Schuler 331).

In order to specifically address the issues of attractiveness and safety it is necessary to identify and evaluate specific physical elements that contribute to or detract from perceptions of attractiveness and safety. In 1983 Shaffer and Anderson set out to determine the influence of certain physical characteristics on people's perception of aesthetics and safety in the urban landscape. They used the wildland scenic assessment method to evaluate random scenes from the city of Athens, Georgia. Slides of the urban landscape were systematically taken at sixty random points throughout the city. The slides were then evaluated by the following sample groups: a college psychology class, a small group of middle-aged white men, a group of primarily black men and women, a group of teachers, and a small group of landscape architecture students. Each group was shown a series of slides and was given several seconds per slide to rate the aesthetic quality of each scene. They also ranked forty-nine individual landscape features based on their influence of perceptions of attractiveness and safety (Shaffer and Anderson 311).

The results of the study showed that the sample groups consistently and strongly agreed about favorable and unfavorable scenes from the urban landscape. The study determined that development intensity is inversely related to visual satisfaction in the urban landscape. Some factors that increased perceptions of attractiveness were the prominence of manicured vegetation and flowers, and well-maintained pavements and structures. The study revealed that “one of the most widely recognized benefits of urban vegetation is its contribution to the visual quality of city landscapes” (Shaffer and Anderson 311). Factors that consistently detracted from attractiveness were overhead wires, poles, vehicles and parking lots. Parking lots were uniformly associated with low visual satisfaction (Shaffer and Anderson 311). Kaplan’s research from 1983 corroborates that views of parking areas and intrusive elements, like power lines and busy streets, reduce visual satisfaction of participants. Commercial property with prominent parking lots and very little vegetation consistently performed worse than any other development type. Paradoxically the elements that were found to reduce people’s visual satisfaction are some of the most prominent elements in the urban environment.

Anderson and Schroeder (219) found several factors that improved perceptions of safety are proximity of an entrance, high degree of lot use, number of cars present, well-maintained vegetation, and open sight lines. Factors that contributed to low safety ratings were inadequate lighting, trash and obstructed sight lines. Large, dense shrubs, in particular tend to obstruct sight lines and create areas that are perceived as being unsafe. In the Rocksprings Park Project, which was a rehabilitation of a community park in a low-income housing neighborhood with a high crime rate, the number one recommendation from local police officers was to preserve open views through the park and not to obstruct them with medium size shrubs.

Because perceptions of both attractiveness and safety of parking lots influence people’s shopping decisions, it is important to strike a balance between them. Although it is easy to recommend enhancing the attractiveness of a parking lot by planting vegetation, an equally strong argument exists to remove certain types of vegetation in order to increase perceptions of security (Anderson and Schroeder 219). Some research suggests that safety and attractiveness can be achieved simultaneously with the appropriate combination of design elements. For example, limbed-up trees and well-maintained ground covers combined with sufficient lighting and well-maintained site features might prove to be safe and attractive (Schroeder and Anderson 178). Landscape elements such as vegetation, benches, arbors, and kiosks can be used to break up large spaces, reduce scale, and terminate long vistas, making parking lots more attractive landscapes. Although these amenities cost money, they provided an added value to the property and surrounding businesses. In any case, these elements must be considered on an individual basis, and must respond to client needs and site limitations.

3.4 Multiple Uses

Strip mall parking lots are used in many different ways for which they are not designed. They provide a setting for county fairs, fundraisers, car shows, driving schools, etc. In many cities they are one of the few places for teenagers to hangout. Parking lots inadvertently serve a valuable role in our society in that they are among the few public open spaces we have left in our cities. The fact that they are large, paved areas makes them suitable to host many different activities and events. Figure 5 is a photograph of a carnival being set up in the Georgia Square Mall parking lot in Athens, Georgia. Figure 6 is a photograph of a March of Dimes fundraiser taking place in the Sam's Club parking lot in Athens. Although these events seem to be self-sufficient, they could benefit from certain support facilities. Carnivals require access to electricity, water, and sanitary sewers. Car washes need water hook-ups and drainage. Many events could benefit from shade. These types of support can be explicitly provided for in parking lots.

Determining what if any support should be provided to accommodate multiple uses in a parking lot would require some research such as observations, surveys, and interviews. There are essentially three different types of use that call for various levels of investment and support. "Neutral" uses demand the least amount of support. Many events that currently take place in parking lots would fall in this category such as carnivals, county fairs, car washes, car shows, etc. These events require little more than a large, paved open area. Although strip malls are often open seven days a week, empty overflow-parking areas allow for shared use of the parking lot during most of the year.

Incidental uses demand a slightly higher level of investment. These activities, which include snacking, sitting, or hanging out might be accommodated with a food vendor and a shaded seating area. One vendor cart typically requires one to two parking spaces and access to water and electricity. Other amenities such as public toilets, phones, trashcans, ATM's and drink machines might also facilitate this type of use (Childs 139).

Figure 5. Photograph of a carnival being set up in the Georgia Square Mall parking lot in Athens, Gerogia (Oct. 2000).

Figure 6. Photograph of a March of Dimes fundraiser taking place in the Sam's Club parking lot in Athens, Georgia (Oct. 2000).

Integrated uses generally demand the highest level of investment. These activities include specific uses such as skateboard parks, art galleries, outdoor theaters, etc. Accommodating integrated uses typically requires some level of infrastructure beyond the parking lot. For instance, in order to avoid conflicts between skateboarders and shoppers a certain area of the parking lot might be specifically designed as a skateboard park. The park might have temporary structures that could be removed during peak shopping seasons or it might be a permanent feature within the parking lot. An outdoor art gallery would require small pockets of space throughout the lot to display artwork. These display areas could be positioned to take advantage of natural sunlight at different times of the day. The large blank sidewalls of strip malls provide an opportunity for an outdoor theater that might require temporary tables and chairs, a projection system, and one or two staff people.

CHAPTER 4

CASES

The following case studies were chosen based on their unique attempts to solve the problems of hydrology, heat islands, aesthetics, and multiple uses discussed in chapter three. Projects that address issues other than parking needs have most commonly addressed the hydrologic issues of a site. The first four case studies provide alternative solutions to treating storm water runoff. No examples have been found in this study that specifically address the effects of the urban heat island although the fifth case study addresses the issue of growing healthy trees in an urban environment. Parking lots that address the issue of attractiveness have become more than parking lots as seen in the sixth case study. Multiple uses of strip mall parking lots are rarely explicitly provided for although the seventh case study illustrates a creative solution to this problem.

The Westfarms Mall in Farmington, Connecticut is a regional mall that addressed storm water runoff and the community's desire for "green space" with grass paving. In 1993 the mall proposed 4.7 additional acres of parking to accommodate the Christmas season's parking overflow. The local zoning board reminded the mall that a certain portion of any developed site in the area had to remain green space (Thompson 60). In order to provide their overflow parking and still meet zoning regulations, the mall investigated using a plastic lattice called Grasspave2 for their paving surface. Grass grows within the voids of the lattice, which is strong enough to support vehicular traffic, and allows for natural infiltration of storm water. Figure 6 provides an aerial view of the overflow parking area. Although it took two years to get approval for the construction, the grassed paving surface has been a success. Not only does it accommodate overflow parking for the holiday season, it has also been the site of football rallies and other events (White 1996). Bill Bonhoff, a landscape architect with Invisible Structures that manufactures Grasspave2, stated, “once installed, the added parking percolates so well that existing storm drains did not have to be modified” (Thompson 60). Although cost comparisons have not been documented, the mall estimates that it saved nearly one million dollars using Grasspave2 instead of a traditional parking lot that requires an expensive drainage infrastructure and has ongoing maintenance costs that exceed that of Grasspave2 (White 1996).

Figure 7. Aerial photograph of Westfarms Mall in Farmington, Connecticut showing grassed overflow parking (Invisible Structures 2001).

Grasspave2 was also used for the new parking stalls at the Orange Bowl in Miami, Florida. As seen in Figure 8, the parking bays for this installation are constructed of Grasspave2 and the driving lanes and driveways are asphalt. Although the site has a traditional storm water system, Enrique Nunez, ASLA, a landscape architect with the Department of Community Planning and Revitalization who was involved in the design and installation of the project, claims that the lattice has helped to reduce runoff (Thompson 60).

Figure 8. Aerial photograph of the Grasspave2 installation at the Orange Bowl in Miami, Florida (Invisible Structures 2001).

In Portland, Oregon a demonstration project was installed at the Oregon Museum of Science and Industry (OMSI) to reduce runoff from its parking lot. Tom Liptan, ASLA, a landscape architect with the Bureau of Environmental Services in Portland, came up with the idea to incorporate vegetated swales to slow the runoff down and let it infiltrate into the ground rather than being carried off site (Thompson 60). Murase

Associates, a local landscape architecture firm, was hired to design the parking lot and its swales. They first proposed to reduce the length of the parking stalls by nearly two feet to 16.5’ in order to accommodate larger swales. The swales were constructed with a long, gradual incline and a series of check dams and river rocks placed at thirty-foot intervals that force the water to pool before it flows to the next check dam. As seen in Figure 9 the swales are planted with wetland vegetation, including cattails, bulrushes and yellow irises, to further reduce the flow of the runoff and help filter sediment and other pollutants. Surface inlets are placed at the low end of the swales to remove any excess water, but in operation, these are rarely needed (Thompson 60). Curb cuts like the one seen in Figure 10 allow rainwater to flow from the parking lot into the swale. In Thompson’s article entitled *Let That Soak In* (60) he states that the swales hold water for a longer period of time than was originally thought. This allows them to “fully infiltrate .83 inches of rainfall in a twenty-four hour period.” According to Liptan “this accounts for about seventy-five percent of all the rains that fall on Portland annually” (Thompson 60). The modeling also estimates that nearly sixty percent of the suspended solids are trapped in the swale. This design solution saved the OMSI approximately $78,000 in construction costs compared to a traditional parking lot with a conventional drainage infrastructure (Liptan 222).

The Somerset housing development in Prince George’s County, Maryland provides another creative solution to on-site infiltration of storm water. This development features rain gardens as part of the treatment system. These small gardens are designed to trap rainwater and allow it to infiltrate rather than run off. They are strategically positioned at low points throughout the development and are a source of pride for the

Figure 9. Image of a vegetated swale in the OMSI parking lot in Portland Oregon (Thompson 60).

Figure 10. Image of a curb cut that allows water to enter the swales in the OMSI parking lot (Thompson 60).

community who maintains the gardens. TABCO, the developer, claims that substituting a conventional drainage system with rain gardens reduced construction costs by an estimated $300,000 (Russel 24).

In an attempt to grow healthy street trees, the City of Westminster, British Columbia planted 100 street trees using a structural soil mix for a downtown renovation project in 1995. Four years later the trees were reported to be in good condition, and the diameter of the trunks had increased by 3 to 3.5 times their diameters at the time of planting. In order to monitor root growth, a view port was installed in the sidewalk when the trees were planted. The view port was opened in the spring of 1999 and “a root 0.5 cm in diameter was observed 2 meters from the planting site (Wade 2000).” Although it will take many years to determine the project’s success, the trees are currently thriving. The cost of the soil mix used in the project was $75 per cubic meter, which included the materials and mixing. Increased installation costs associated with the use of the structural soil should be offset by reduced long-term repair costs to the sidewalks and curbs (Wade 2000).

Perceptions of attractiveness can be improved in various ways. A parking lot in Albuquerque, New Mexico was transformed into the Mirage Sculpture Park, which displays artists’ work in the open spaces of the parking lot. Figure 11 illustrates a large iron sculpture by George Manus that seems to cast a watchful eye over the parking lot. Although art is often controversial and seldom appeals to everyone, incorporating commercial artwork into this parking lot has increased perceptions of attractiveness because the lot is well maintained and appears to be cared for. The park provides a prominent venue within the city for artists to display their artwork and attracts visitors to this shopping center that might otherwise not come. As of 1999, after seven years of operation, one art piece had been stolen and one vandalized. George Reiche, the proprietor of the sculpture park, believes that the benefits to him, the artists, and the public far outweigh these incidents (Childs 155).

A final case study illustrates a simple and creative way to facilitate multiple uses. “In 1987, the Children’s Creative Project, a nonprofit arts education program of the Santa Barbara County Education Office, created and produced the first street-painting festival in the western hemisphere to benefit the organization” (Childs 163). This event is named the *I Madonnari* Italian Street Painting Festival. It takes place every year in the streets of the historic California Missions. It can be seen in San Luis Obispo throughout April, and in Santa Barbara during May. The festival invites local and regional artists to display their talents on the smooth canvas of the asphalt streets using either chalk or paint. Figure 12 illustrates the chalk art of architects Tim Steele, Pat Pouler, and Lori Kari (Childs 163). Although this festival takes place in the streets, a parking lot would lend itself very well to this type of use. Each parking stall could become a canvas. The rows of parking or different areas of the parking lot could celebrate the artwork of various cities or counties.

Figure 11. Photograph of the Mirage Sculpture Park in Albuquerque, New Mexico (Childs 155).

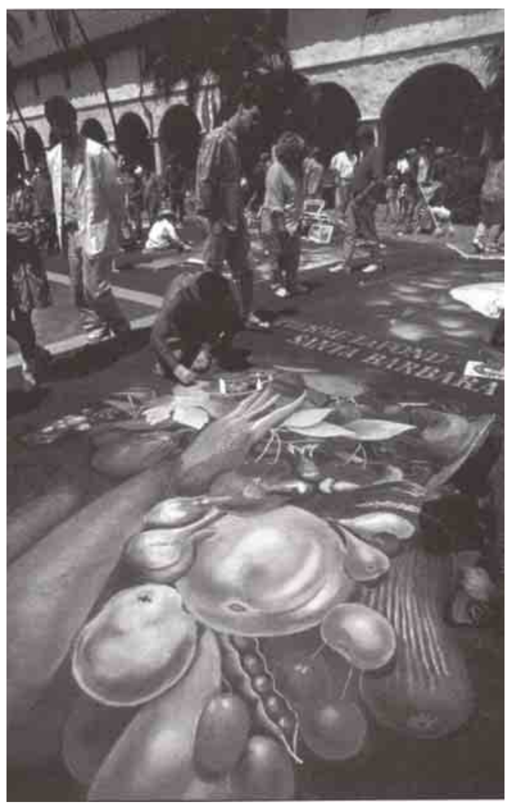


Figure 12. Photograph of the *I Madonnari* Street Painting Festival (Childs 163).

CHAPTER 5

DESIGN EXPLORATION

The Perimeter Square shopping center at 10 Huntington Rd., Athens, Georgia was chosen to investigate design alternatives for suburban commercial parking lots. Perimeter Square is a good case study because it represents a typical suburban strip mall. It consists of a Wal-Mart, some other stores, and a considerable amount of parking. It is also a good case study because it exhibits the four problems identified in chapter three. Almost all of the rainwater that falls on site is conveyed downstream as runoff. The large amounts of black asphalt exacerbate day and nighttime temperatures. It exhibits many of the characteristics associated with an unattractive urban landscape that were discussed earlier such as lack of trees, lack of well maintained vegetation, and a prominence of parking and vehicles. Finally, it provides little or no explicit support for multiple uses.

It is assumed for purposes of this thesis that this property could be redeveloped within its role as a commercial shopping center. It is also assumed that the building footprints would not change and that the gross leasable area (GLA) would remain 320,000 square feet. Finally it is assumed that the sixteen-acre parking lot footprint would remain the same. Only the land devoted to parking will altered for this design exploration. Initially each of the four problems identified in chapter three will be addressed with a unique design. Each design will attempt to solve one problem while disregarding the others. A final design will attempt to address all four factors simultaneously. All five designs will then be evaluated based on how well they address the four criteria.

5.1 Property Description

The property of approximately 28 acres is located in Athens, Georgia, USA off of the Atlanta Highway just outside the Athens loop highway. It is visible from the Athens loop highway but has only indirect access via the Atlanta Highway. Figure 13 shows the location of the property in Athens. As of May 2001 major stores include Wal-Mart, Books-A-Million, Michael’s, and T.J. Maxx. A large vacant store was until recently occupied by Uptons. The smaller stores are Cato’s Fashions, Hobby Center, The Shoe Carnival, Catherine’s, J. Anthony’s Big and Tall Store, Powertel, The Hair Cuttery, Mantooths, Washington Mutual Finance. There is also a dry cleaner, an Aerobics and Fitness center, and two restaurants, China Hing Buffet, and Shoki of Japan.

Figure 14 illustrates the existing layout of the property and locates vegetation, drainage structures and handicapped parking. The configuration of the buildings and position of the three anchor stores resulted in three separate parking lots that occupy the same space. The existing layout provides 5.0 parking stalls per 1,000 square feet GLA, or 1,594 parking stalls. More than 700,000 square feet, or approximately sixteen acres, is devoted to parking. Fourteen percent of this parking area, or approximately 2 ¼ acres, is landscaped. Table 3 provides a list of existing vegetation. The condition of the vegetation was based on factors such as the thin canopy and considerable dieback of the Sugar Maples that were rated poorly. The majority of the landscaped area is located within the

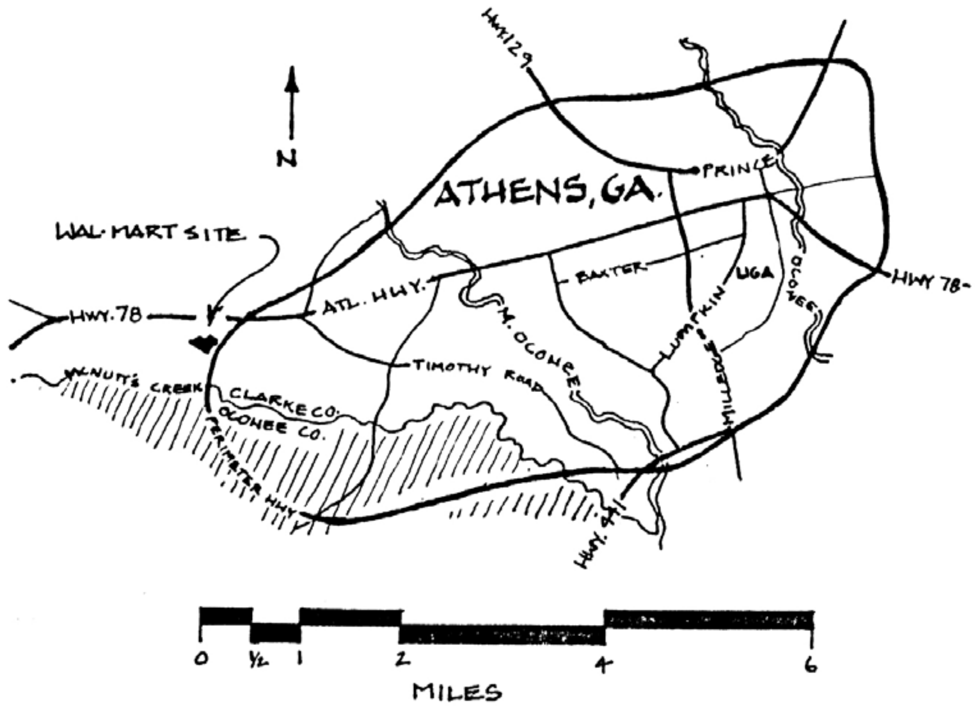


Figure 13. Map showing the location of the Perimeter Square development in Athens, Georgia (Pittman 32).

Figure 14. Existing Conditions for the Perimeter Square develpment

Site Data:
- approx. 28 acres
- 318,671 sf GLA
- 706,594 sf surface parking
- 1594 parking stalls (22 H/C)
- 14% of surface parking devoted to landscaping
- approx 191,000 sf devoted to Wal-Mart's outdoor garden center
- 5 stalls/1000 sf GLA
- avg. stall size - 9'x18'
- approx. 370 sf/stall (includes dirveways and aisles)

Vegetation:
- 37 Willow Oak
- 20 Sugar Maple
- 11 River Birch
- 40 Kwanzan Cherry
- 15 Crape Myrtle
- 57 Wax Myrtle
- 2 Annual Beds
- 33 4'x4' concrete tree pits (13 are empty)
- planting islands with cherry trees are underplanted with juniper, those with wax myrtle are underplanted with chinese holly

Drainage Infrastructure:
- 14 12' curb inlets
- 5 surface drain inlets
- 2435 linear feet pvc drain pipe

Table 3. List of existing vegetation and current condition.

	SCIENTIFIC NAME	COMMON NAME	CONDITION
TREES	*Acer saccharum*	Sugar Maple	Poor
	Betulus nigra	River Birch	Good
	Prunus sp.	Ornamental Cherry	Fair
	Qurecus phellos	Willow Oak	Good
SHRUBS	*Ilex cornuta 'Rotunda'*	Chinese Holly	Fair
	Ilex crenata	Japanese Holly	Fair
	Juniperus horizontalis 'Pfitzeriana'	Pfitzer Juniper	Fair
	Lagerstroemia indica	Crape Myrtle	Fair
	Myrica cerifera	Wax Myrtle	Fair
	Rapheolepis indica	Indian Hawthorn	Fair
TURF	*Cynodon dactylon*	Bermuda Grass	Good

thirty-five foot, setback that runs along Huntington Road. The vegetated setback contains Willow Oaks, River Birch, Pfitzer Juniper, and Bermuda grass that are in relatively good condition. The remaining vegetation exists in small curbed and raised planters within the parking lot. Most of this vegetation is in fair condition, but because it is sparse and not very well maintained it provides little aesthetic or ecological function. The primary function of this vegetation is to provide visual cues for circulation and parking organization. The trees within the parking lot were originally Norway Maples that have since been replaced with Sugar Maples like the one in Figure 15. Only nineteen of the thirty-three Sugar Maples planted are still alive. The remaining Maples are in poor condition reaching a height of roughly twelve feet and a spread of roughly eight feet after nearly eight years of growth. These trees are struggling to survive in 4’ by 4’ raised planters like the one in Figure 16, and consequently fourteen of the thirty-three tree pits are now empty.

As seen in Figure 17, 92% of the property is covered with impervious surfaces that include rooftops and pavements. All of the paved parking surfaces on the property are bituminous asphalt pavement. Curbs and sidewalks are concrete. Currently almost all of the rainwater that falls on the lot is diverted to one of fourteen curb inlets or four surface inlets, where it flows through 2,435 linear feet of pipe before emptying into a detention pond at the south end of the property. From there it overflows into the DOT culvert under the Route 10 loop and eventually makes it way into McNutt’s Creek.

Figure 15. Photograph of a Sugar Maple in the Perimeter Square parking lot (Sept. 2000).

Figure 16. Photograph of an empty 4’ by 4’ tree pit in the Perimeter Square parking lot (Dec. 2000).

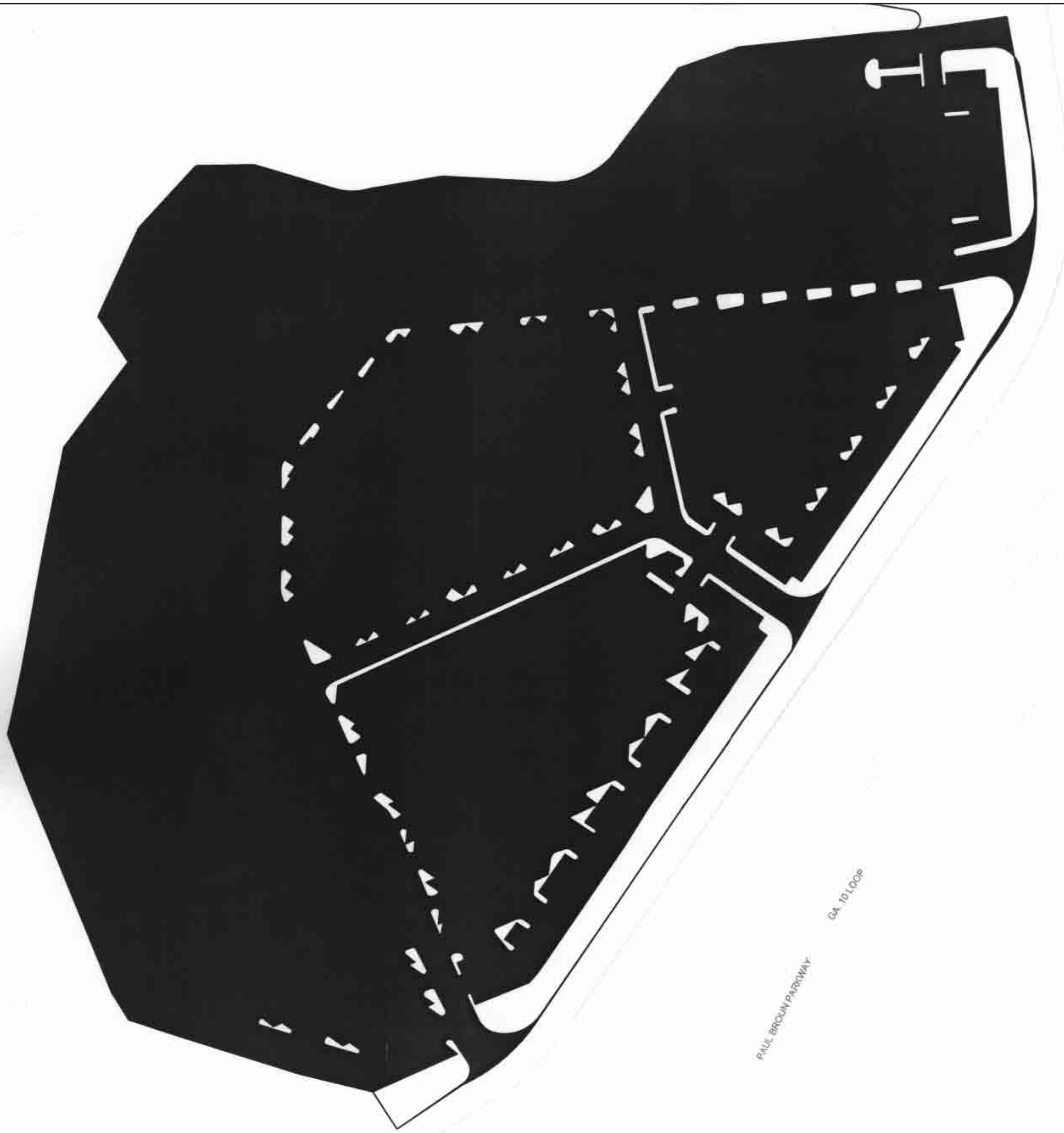


Figure 17. Figure/Ground Image of Perimeter Square Shopping Center

The Perimeter Square development is 92% covered with impervious surfaces that include rooftops, sidewalks, and pavements. Permeable surfaces, including vegetated setbacks and raised vegetated planters comprise 8 % of the site.

Impervious surfaces (92 %)

Permeable surfaces (8 %)

north

50 0 50 100 150

Scale: 1" = 50'

5.2 Materials Description

Available land is the most important material in the five designs described below. This section will describe the means for reclaiming land within the limits of this property. Because varieties of paving and vegetation need to be used in all five scenarios, this section will also give a description of the different types of paving and vegetation that could be used in all of the designs. A special soil mixture that will be used in most paving and planting applications will be described as well.

Available land

All five of the designs described below rely on the fact that this parking lot was considerably overbuilt when it was constructed in 1990. The original layout provides 5.0 parking spaces per 1000 square feet GLA, which yields 1,594 spaces. Based on ULI's parking demand study (1993) the parking index for this strip mall should be reduced to 4.0 spaces per 1,000 square feet GLA. This parking index requires only 1,270 spaces for the strip mall, which results in a twenty percent reduction or nearly 320 spaces. An area equivalent to 80 additional spaces could be gained from realigning Wal-Mart's parking from 45° to 90°. Based on these two assumptions, the total amount of land that could be reclaimed within this property is approximately three acres out of the sixteen acres currently used for parking. The shaded area in Figure 18 represents the reclaimed land. A parking index of 4.0 spaces per 1000 square feet GLA was considered an absolute for all five designs. All of the designs use the three acres of reclaimed land in various ways to achieve their specific goals while providing enough parking to meet this parking index.

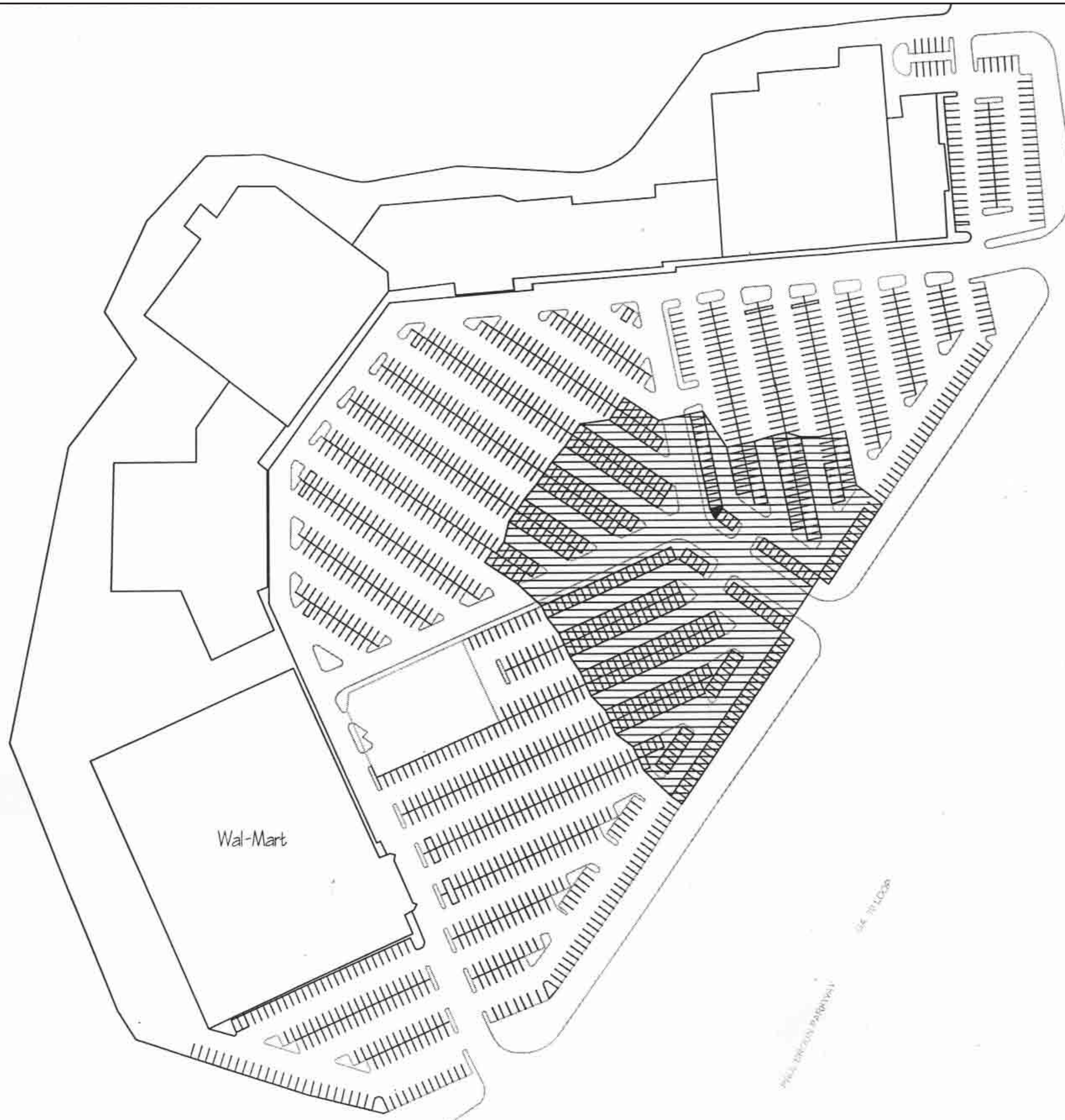


Figure 18. Excess Parking

Based on the results of the most recent parking demand study released by the Urban Land Institute in 1993, this strip mall is overbuilt by twenty percent. The parking index for a strip mall this size should be reduced from 5 stalls per 1000 square feet to 4 stalls per 1000 square feet. That reduction allows for removing 320 existing spaces. An additional 80 spaces can be recovered by realigning Wal-Mart's parking to 90°. The total area associated with those 400 spaces is approximately 3 acres, which is represented by the shaded area in this diagram.

Legend:

3 acres of excess parking

north

50 0 50 100 150

Scale: 1' = 50'

Options in paving materials

A typical strip mall parking lot is constructed with bituminous asphaltic concrete because of its low initial cost and ease of installation. This flexible concrete paving surface is composed of large and fine aggregates that are bound together with asphalt cement. Figure 19 shows a standard construction detail for asphalt pavement used in a parking lot. It requires a compacted sub-grade covered with a graded aggregate, on top of which lies the asphalt pavement. The entire structure is between twelve and eighteen inches thick for vehicular traffic. This type of construction, which is a standard practice, destroys the soil structure below the pavement and provides a permanent seal over it that is impervious to water. It does however, provide a smooth, reliable, and inexpensive driving surface.

Alternative paving materials that provide a similar driving surface, while allowing water to infiltrate into the ground below the pavement have been available for a many years. A number of different options exist including turf, open-graded aggregate, plastic lattices, open-jointed paving blocks, concrete grids, porous concrete and porous asphalt. All of these are suitable for vehicular traffic, but those with unbound aggregate are not recommended for use in commercial parking lots that receive heavy traffic. A good option for this application is the open-jointed paving block. This type of concrete paver is constructed so that controlled gaps are left between each unit. The gaps are then filled with an open-graded aggregate that allows water to penetrate the otherwise impervious surface of the pavement.

SF-Rima stone will be used for all non-asphalt areas in this project. This paving block was developed in Germany and is relatively new in the United States. Unicon

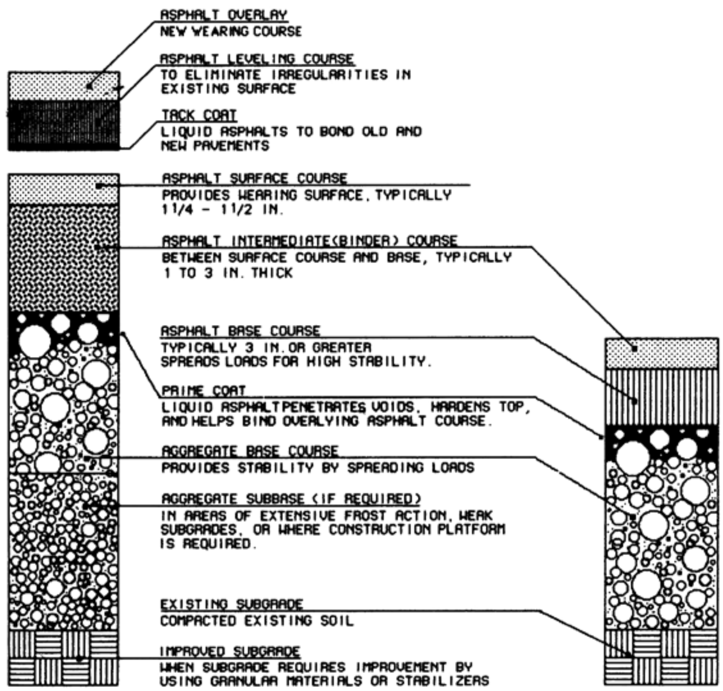
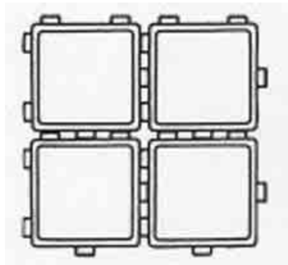


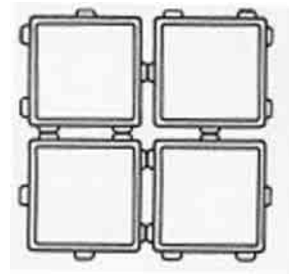
Figure 19. Construction detail for vehicular asphalt pavement. Only the detail on the right applies to the Georgia Piedmont (Harris 820-13).

Concrete in Holly Hill, South Carolina, manufactures the paving block. The paver is larger than other porous pavers on the market, which makes it more conducive to pedestrian traffic. It has a 7 ½” surface with options for a ½” or 1” gap between adjacent units. The wide joints are filled with a course aggregate such as #89 stone to ensure rapid and long-lasting permeability (Unicon Concrete 2001). Figure 20 illustrates a construction detail for the paving block in a parking lot situation. Empirical data suggests that an 18” structural base is sufficient to accommodate vehicular traffic (Ferguson 2001). In the designs below structural soil, which is essentially stone with soil bound to it, is used for the base course where increased rooting zone is needed. A bare, open-graded aggregate such as #57 stone is used for the base course where no rooting zone is needed. A layer of geotextile is then placed on top of the structural soil followed by 1 to 1½” of bedding sand or #89 stone. Finally, a 31/8” paving block is used for the driving surface. Special care must be taken during construction to prevent clogging of the drainage and filter materials and to ensure proper infiltration of the pavement (Rollings 14).

The two basic methods for determining rainfall runoff rates for this type of paving are the rational method and the Soil Conservation Service (SCS) method. The rational method has been around for over one hundred years and is widely used and accepted in the United States. In this method peak flows are calculated using a runoff coefficient or cover factor (C) that ranges from 0.1 for porous undeveloped forests to 0.95 for impervious pavements. “An appropriate C value for SF-Rima stone can be estimated as $C=I-1.1/I$ where I is the rainfall intensity and 1.1 is the long-term design infiltration rate” (Rollings 17). The SCS is a newer method, but it is well documented and is starting to



Option A: Alternating the spacers leaves 1/2” gaps between adjacent units.



Option B: Aligning the spacers leaves 1” gaps between adjacent units.

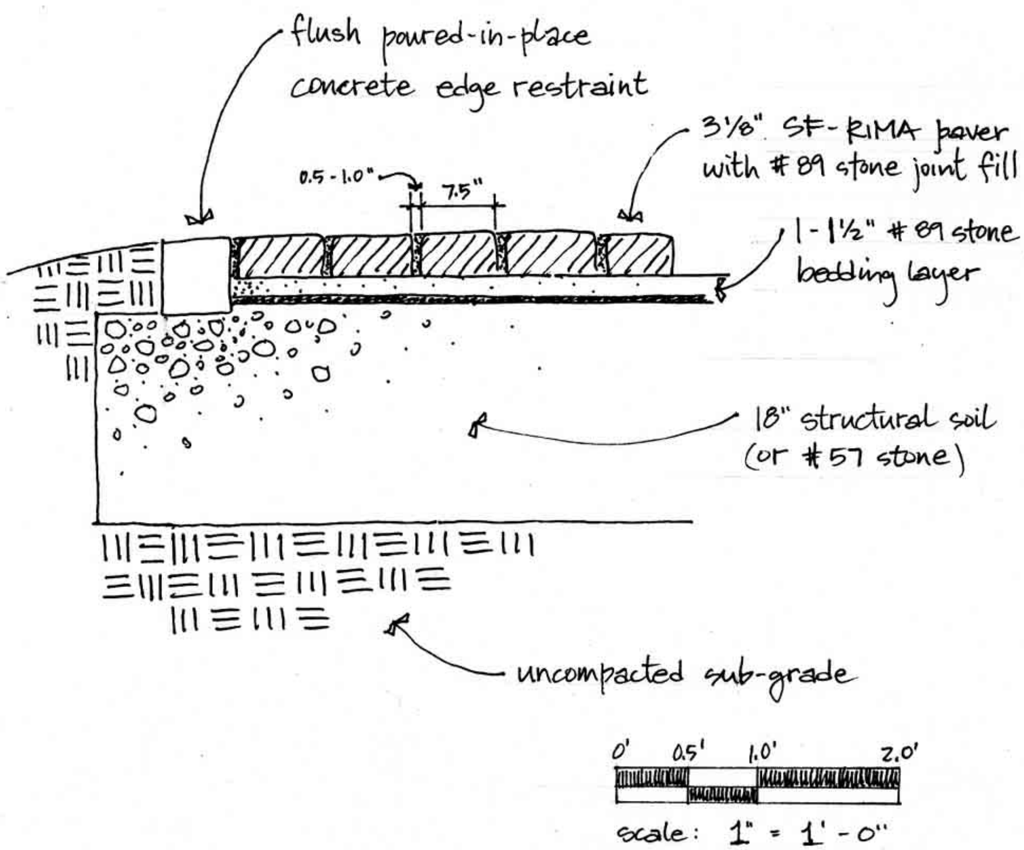


Figure 20. Plan and section of SF-Rima porous paving installation. If no rooting zone is needed, substitute # 57 stone for structural soil.

gain acceptance. This method calculates peak flows using a curve number (CN) that varies from 30 for a forest with no grazing on porous soil to 98 for impervious pavements on any soil. Rollings (15) estimates an appropriate CN value for an established surface of SF-Rima stone at approximately 65, which is equivalent to that of a turf lawn with moderately drained soils.

Options in vegetation materials

Vegetation is another critical component for addressing the problems identified in chapter three. Properly selected vegetation can aid in the mitigation of storm water runoff, reduce ambient air temperatures, increase perceptions of attractiveness and safety, and provide amenities like shade and backdrops for multiple uses. Table 4 provides a list of potential plant species suitable for use in a parking lot in Athens, Georgia. Because of the harsh growing conditions, both native and adapted plants are considered. All are hardy in zone 7b, which is Athens' USDA hardiness zone classification (Dirr 1998). In general, these plants will tolerate the harsh conditions of a parking lot such as pollution, excessive heat, and fluctuations of available water. Some of these plants come under recommendations from the following professors at the University of Georgia: Darrel Morrisson, School of Environmental Design, Alan Armitage and Michael Dirr, Horticulture Department. Some trees were suggested by Southern Tree: an expert system for selecting trees, developed by Ed Gilman of the University of Florida.

Trees were chosen for their size and structure so as to provide maximum canopy cover while maintaining open sight lines through the parking lot. They were also chosen for their abilities to tolerate heat and pollution. Low growing perennials were chosen for

Table 4. List of recommended plant species.

	SCIENTIFIC	COMMON
TREES	*Acer saccharum* ‘Legacy’	Legacy Sugar Maple
	Celtis laevigata	Sugar Hackberry
	Platanus occidentalis ‘Yarwood’	Yarwood Sycamore
	Quercus lyrata	Overcup Oak
	Quercus nutalli	Nutal Oak
	Quercus phellos	Willow Oak
	Qercus shumardii	Shumard Oak
	Taxodium distichum	Common Bald Cypress
PERENNIALS	*Amsonia tabernaemontana*	Blue Star Flower
	Buphthalmum alicifolium	Oxeye Daisy
	Canna sp.	Canna Lily
	Carex sp.	Sedge
	Chasmanthium latifolium	Northern River Oats
	Eschscholzia californica	California Poppy
	Gaura lindheimeri	White Gaura
	Hemerocallis sp.	Daylily
	Iris pseudacorus	Yellow Flag Iris
	Juncus effusa	Soft Rush
	Leymus arenarius	Blue Lyme Grass
	Oenothera sp.	Evening Primrose
	Panicum vergatum	Switch Grass
	Perovskia atriplicifolia	Russian Sage
	Sedum x ‘Autumn Joy’	Autumn Joy Sedum
	Tradescantia virginiana	Spiderwort
	Yucca filamentosa	Adam’s Needle Yucca

their abilities to tolerate heat, pollution, and seasonal flooding as well as to provide aesthetic interest. Many of the perennials would grow in the vegetated swales. Species such as the Yucca, Soft Rush, Carex, and Blue Lyme Grass are evergreen and could provide essential cover in the winter to prevent crusting and erosion. Swales would need to be heavily mulched during the winter months.

Structural Soil

Soil is a necessary and critical component for pavement construction and plant growth. The construction of pavements that will support vehicular traffic requires a severely compacted base course and sub-grade that will not settle or shift under the weight of a car. The healthy growth of a plant requires vast amounts of soil that has adequate pore space to support root growth. Until recently these two conditions did not exist simultaneously and urban vegetation was never provided with an adequate rooting zone. Over the last decade the Urban Horticulture Institute at Cornell University has been working to remedy this. They have developed a mixture of stone aggregate and small soil particles called “structural soil” that provides support for vehicular pavements without sacrificing rooting zone. “Structural soil is a designed medium which can meet or exceed pavement design and installation requirements while remaining root penetrable and supportive of tree growth” (Grabosky and Bassuk 197). Structural soil is composed of crushed rock that varies in size from ½” to 1 ½” and small soil particles that are bound to the rock with a hydrogel. The rock allows the structural soil to be compressed without losing pore space. The pore space allows tree roots to grow within this matrix. The critical component is how much soil to add. Too much soil leaves insufficient pore space and too little soil results in inadequate nutrients for root growth. The proper ratio is “30 grams of hydrogel per 100 kilograms of soil and 500 kilograms of crushed rock” (Bassuk, 1999). This ratio provides structural stability for pedestrian and vehicular traffic and provides an adequate medium for tree root growth. Soil testing is necessary to assure soil performance.

In the following sections the first four designs seek to address each of the four problems identified in chapter three. Each design disregards the other three factors, and will be evaluated in chapter six based on those other criteria. The fifth design is a combined approach that addresses all four concerns in one design.

5.3 CONCEPT A: Hydrologic Restoration

The goals for this design are to increase groundwater recharge, minimize storm water runoff, and improve the quality of the water that leaves the site. The strategies for achieving these goals are to maximize pervious surface coverage and provide additional opportunities for on-site infiltration. The ways this can be done are by using pervious materials for overflow parking areas, using permeable paving materials for construction of paved areas, using vegetated swales for conveyance of runoff, lengthening the path of conveyance, and detaining excess runoff to allow settling and infiltration.

The overriding concept for this design was to establish the hydrologic goals stated above within the detailed parking needs of the businesses occupying the site. Figure 21 illustrates two gradients that were established in order to achieve this balance. The first is a gradient of parking demand based on observations, research and common sense that tell

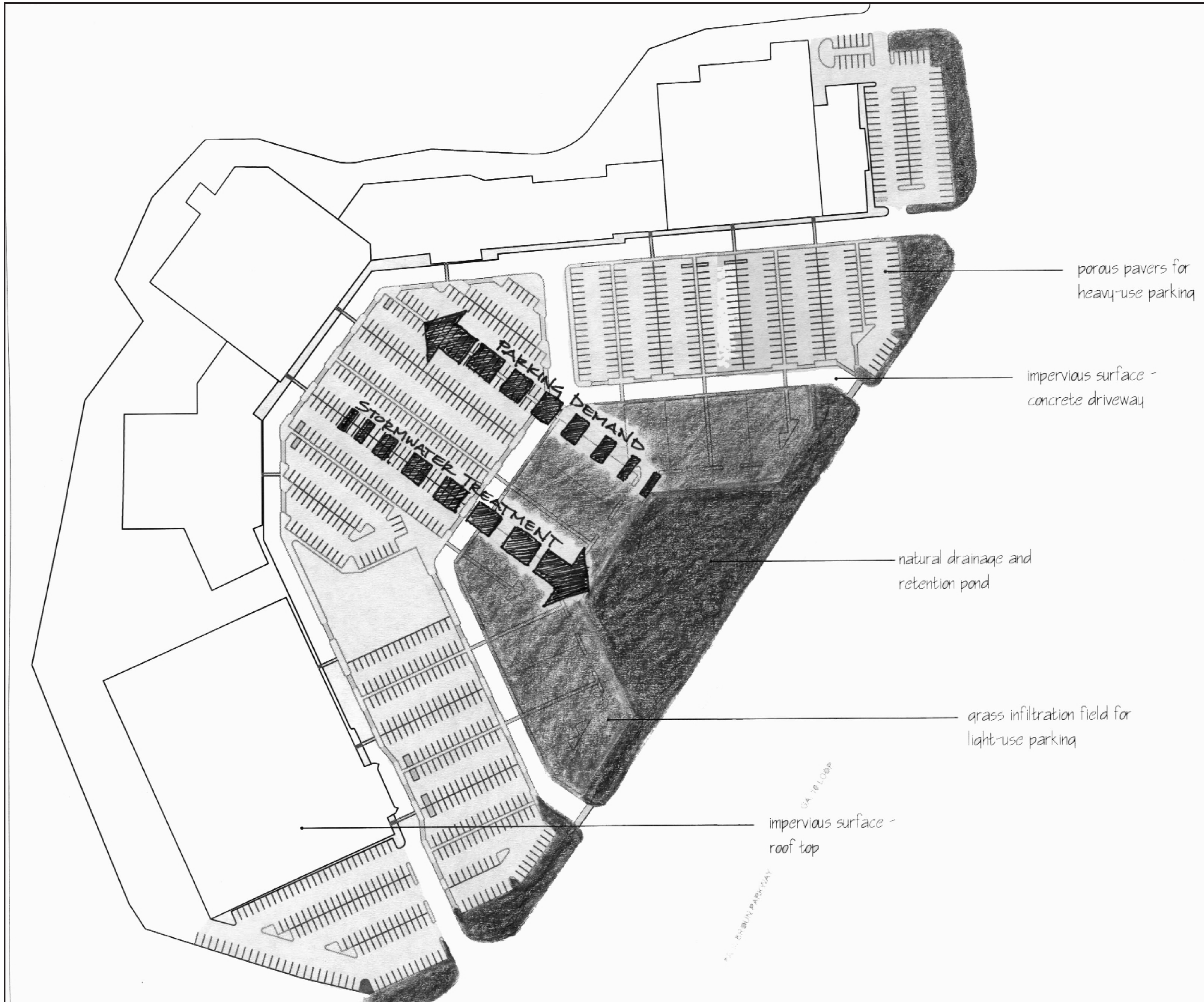
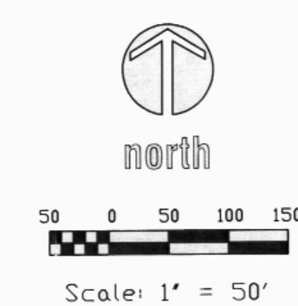


Figure 21. Zones of usage and storm water treatment for the Hydrologic Restoration design

This diagram illustrates the two gradients established for this design. The first is one of parking demand that diminishes as one moves away from the buildings. The second is one of permeability that increases as one moves away from the buildings. These opposing gradients reduce the occurence of heavy traffic on highly permeable surfaces.

The two zones of heavy-use and light-use parking demand are visually distinguished by material changes and physically separated by a concrete driveway.



us the heaviest parking demand is located closest to the entrance of a store and decreases as one moves away from the entrance. The second gradient is one of permeability that increases as one moves away from the storefront. The gradients are important in order to minimize the occurrence of heavy traffic on highly permeable surfaces as frequent traffic may damage these surfaces and reduce their permeability.

Based on observations of this parking lot and other facilities similar to it during peak and non-peak shopping days, a 70/30 split between heavy-use and light-use parking demand is used for this design. This split between heavy and light-use parking is illustrated in Figure 21. The heavy-use zone represents seventy percent of the parking demand and is the most firmly paved and therefore “least” permeable surface for parking. As mentioned earlier, SF-Rima paving blocks are roughly equivalent in permeability to a turf lawn (Rollings 16). The light-use zone, or overflow parking area, represents thirty percent of the parking demand and has the highest permeability of the paved surfaces. An impervious concrete driveway separates the two zones of parking and distinguishes between average and peak parking needs. This physical separation between the two is a visual reminder to customers that many parking spaces sit vacant for most of the year. The natural drainage zone represents the land that was reclaimed by reducing the parking index and realigning Wal-Mart’s parking. This zone has the highest storm water treatment capacity.

Figure 22 illustrates the plan for this concept. All of the design components work together to maximize on-site infiltration and minimize runoff. Figure 23 is a more detailed plan that shows the relationships between the elements of the design. The roofs of the buildings are the least permeable surfaces on the property. All of the roof water is

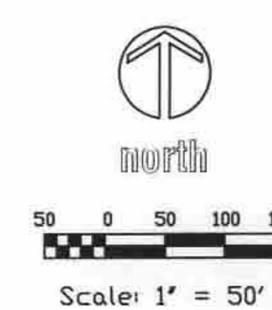


Figure 22. CONCEPT A: Hydrologic Restoration

The goals for this concept are to minimize stormwater runoff and restore the opportunity for natural infiltration of stormwater.

The strategies to achieve this goal are:
·to reduce impervious surface coverage,
·to slow down runoff with the use of bioswales and level spreaders,
·to provide an on-site retention pond, and
·to provide the longest drainage channel possible, before runoff is discharged from the site.

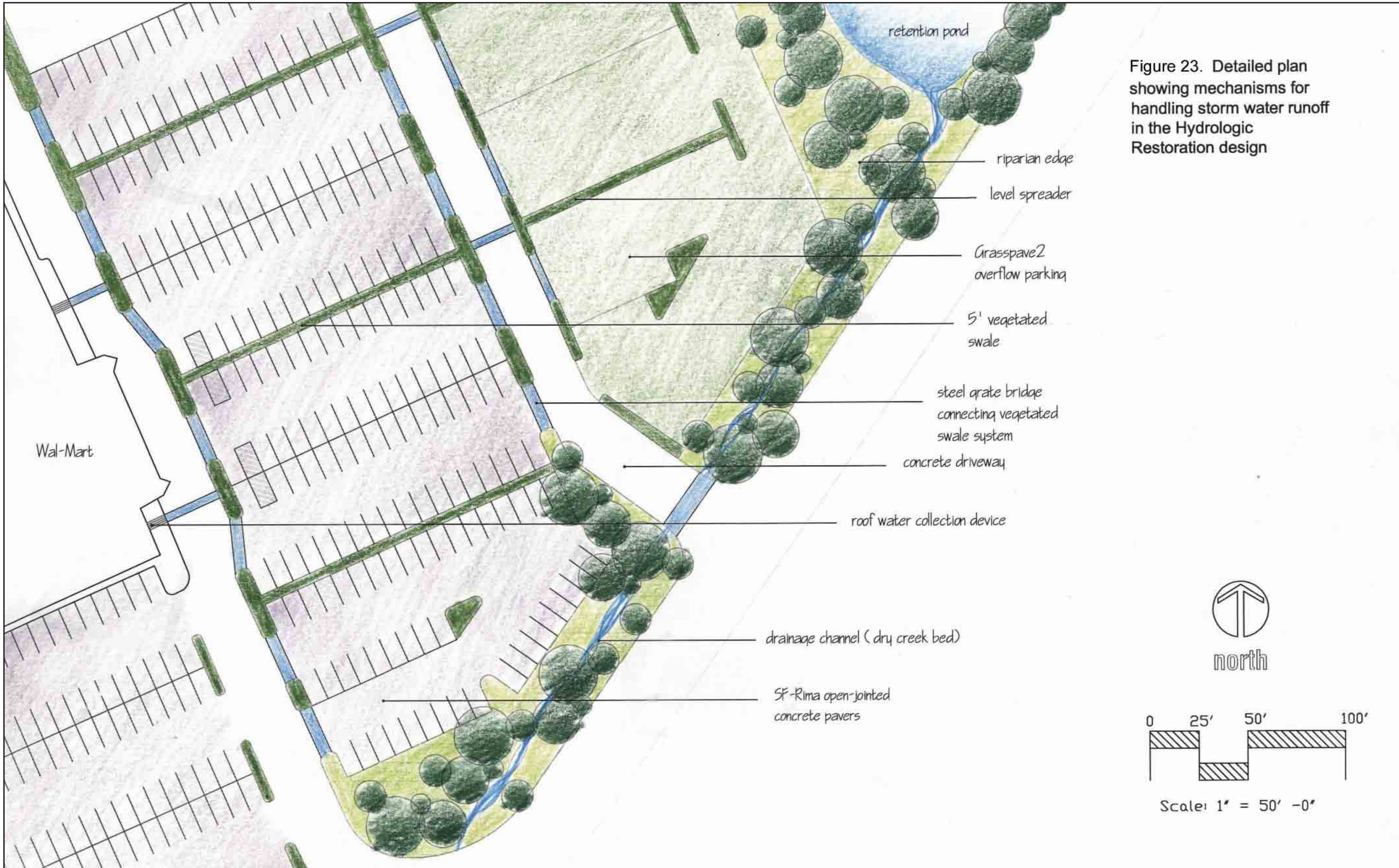


Figure 23. Detailed plan showing mechanisms for handling storm water runoff in the Hydrologic Restoration design

diverted to the front of the buildings where it is transported down the storefronts and into the open storm water system, which conveys runoff through the heavy-use parking zone.

The heavy-use parking zone is constructed with SF-RIMA porous paving blocks that allow rainwater to penetrate. Figure 24 is a bar graph showing the distribution of rainfall in Atlanta, Georgia. We receive about eighty storms each year that average less than half an inch of rainfall in a twenty-four hour period. For most storms in Georgia almost all of the water that falls in this zone will percolate through the pavement and into a storage area below where it will have time to naturally infiltrate into the ground. In the case of heavy storms that exceed the infiltration rate of the pavement or persistent storms that saturate the underground storage area runoff will be diverted into vegetated swales joining the runoff from the rooftops.

Vegetated swales are provided between the parking bays to convey runoff from the heavy-use zone to the light-use zone. Based on the work done by Murase Associates at the Oregon Museum of Science and Industry (OMSI) in Portland, parking stalls in this zone were shortened to 16.5', not including vehicle overhang, to provide space for the swales. As seen in Figure 25, these swales are 5' wide and 1' deep, and they have earthen sides with a 1v:2h slope. The swale channels are sloped at .5% downward away from the buildings and are heavily vegetated with perennials selected from Table 4 in order to slow down the runoff. They also have strategically placed rocks that act as weirs to slow the water down even further. This is modeled after the swales at the OMSI that "handle 0.83 inches of water in a twenty-four hour period, which accounts for seventy-five percent of the rains that fall in Portland on an annual basis" (Thompson 60). As mentioned above, most of the storms in Georgia average less than 0.50 inches of rainfall

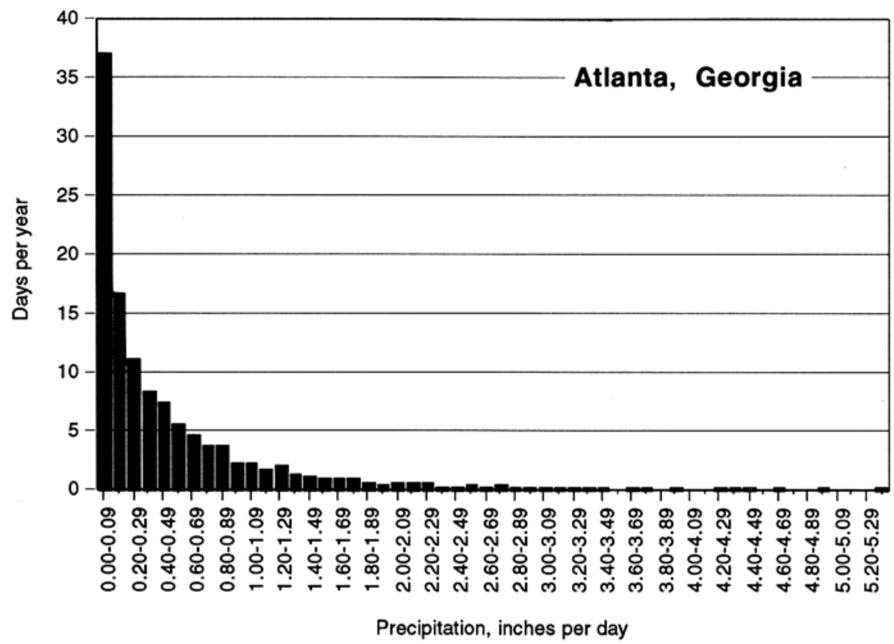


Figure 24. Bar graph illustrating the rainfall distribution in Atlanta, Georgia (Ferguson unpublished).

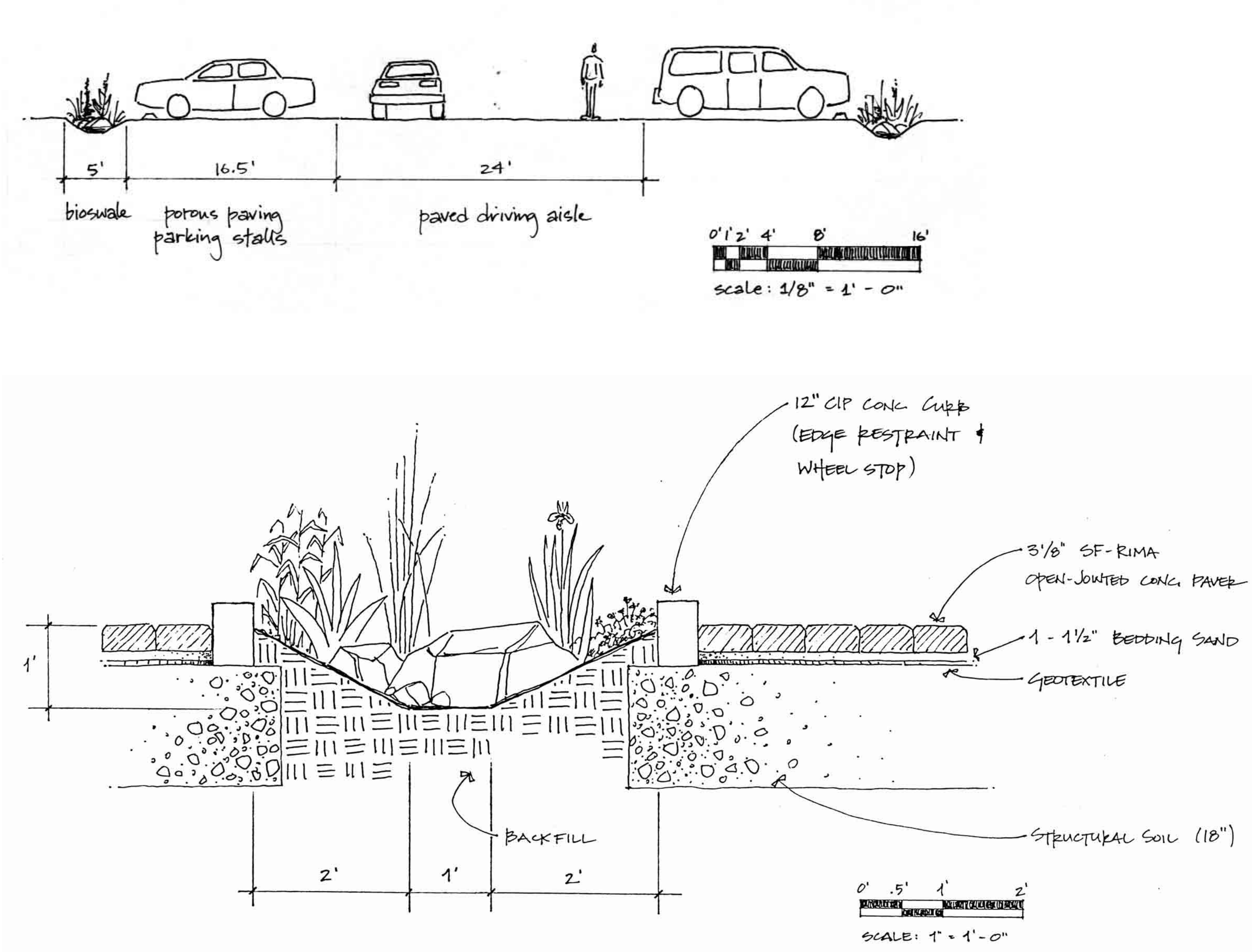


Figure 25. Sections illustrating a bioswale in the Hydrologic Restoration design

in a twenty-four hour period. Any runoff from the swales makes its way under a bridge across the driveway that separates the two parking zones. From here it enters a modified level spreader that distributes the water across the grass surface of the overflow parking area. Level spreaders are by definition level. As shown in Figure 26, the level spreaders in this concept have been modified with a slight slope so that water drains out the far end and drains out the near end only in the rare instances when the water level is high. This was done to reduce the occurrence of vehicular traffic on a saturated surface.

Level spreaders are vegetated trenches that are designed to "convert concentrated runoff to sheet flow and release it onto an area stabilized by existing vegetation" (Level Spreaders 2001). They are primarily used to control agricultural runoff. Dispersing water over a large surface area increases surface retention, surface detention and soil contact, which all result in higher infiltration (Hazel 8). In Hazel's dissertation on level spreaders (3) he explains that forested filter zones are more effective at removing suspended and dissolved pollutants from runoff than are grassed filter zones. In this design the water that leaves the modified level spreader passes first over a grassed filter zone and then through a forested filter zone.

The entire overflow area in this concept is used as a zone of infiltration. This area is paved with turf that is reinforced with a plastic lattice. Invisible Structures makes a product called Grasspave2 that is strong enough to support occasional vehicular traffic and provides a void storage volume of 94% (Invisible Structures 2001). Any remaining runoff from the grass overflow area drains into a riparian zone heavily vegetated with water's edge species. From here the water finds its way into a 31,000 square foot retention pond. Any overflow from the pond would travel down the length of

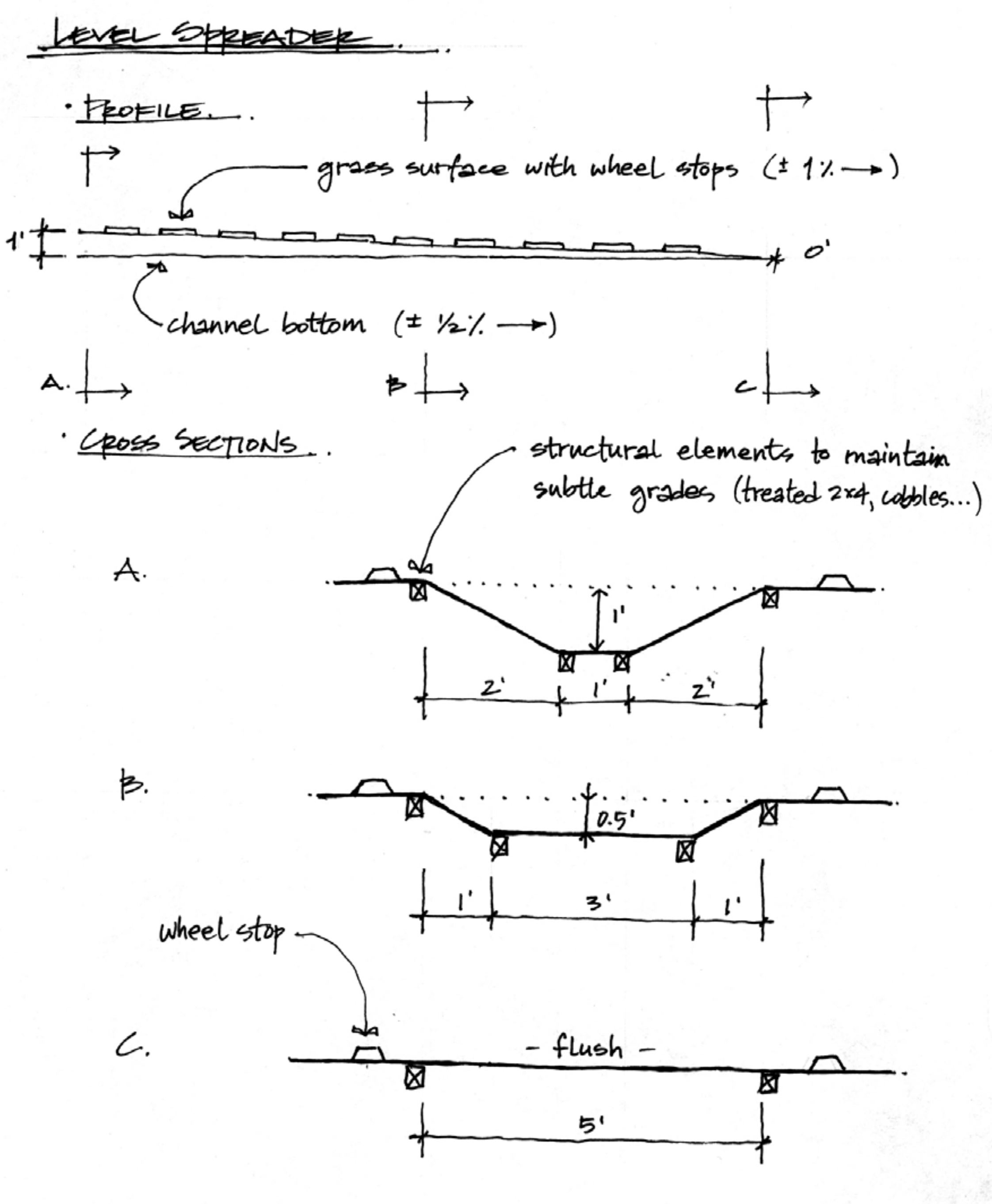


Figure 26. Profile and sections of a level spreader for the Hydrologic Restoration design.

a meandering dry creek bed constructed similar to the vegetated swales mentioned earlier. The total length of this open, vegetated drainage channel ranges from 1,480 to 1,282 linear feet**,** which is 100 to 500 feet longer than the previous route in underground pipes. Figure 27 diagrams the flow off the runoff and provides watershed information that suggests this design would sufficiently handle most storms in Georgia (Ferguson 2001). Figure 28 illustrates the impervious surface coverage from the proposed design. In this scenario the impervious coverage of the parking lot was reduced from 84% existing, to 30% proposed. Hydrologic modeling would be needed to determine the actual treatment capacity of this design. A device could be placed at the discharge area to monitor the quantity and quality of the runoff from the site.

A potential aspect of this design is public education about the importance and the process of treating storm water on site. One way to do this is with signs. Interpretive signage could be placed throughout the site to explain the different design elements and teach people about the importance of reducing storm water runoff. Another way to educate people about water is to bring it to the forefront of the design. Not only to expose it, but to have it be an integral part of the design aesthetic. Figure 29 illustrates two creative and aesthetic ways to incorporate storm water into a design and facilitate passive education regarding water conservation.

Figure 27. Flow diagram and watershed square footage for the Hydrologic Restoration design

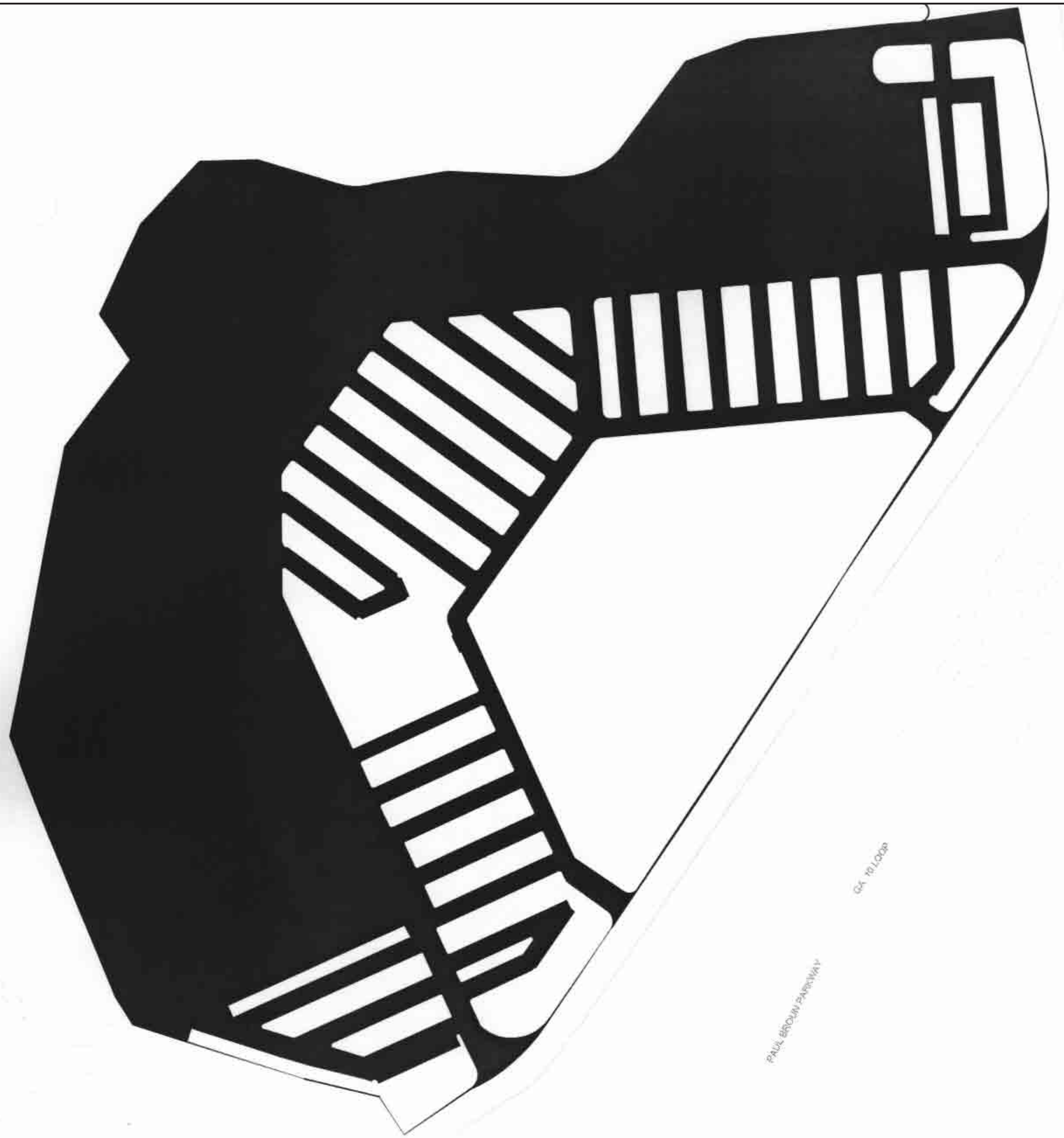


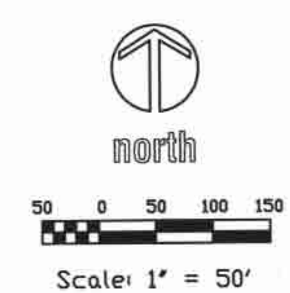
Figure 28. Figure/Ground Image of Hydrologic Restoration Proposal

Typical shopping centers are nearly 100% covered with impervious surfaces. As shown in Figure 17, the Perimeter Square development is currently 92% impervious.

Replacing impervious surfaces with pervious ones helps to reduce storm water runoff, improve ground water recharge and improve water quality. In this scenario much of the impervious asphalt has been replaced with permeable paving block, turf and vegetated areas. This design increases the total permeable area from 2.25 acres (current) to nearly 11 acres (proposed).

■ Impervious surfaces (60%)

□ Permeable surfaces (40%)



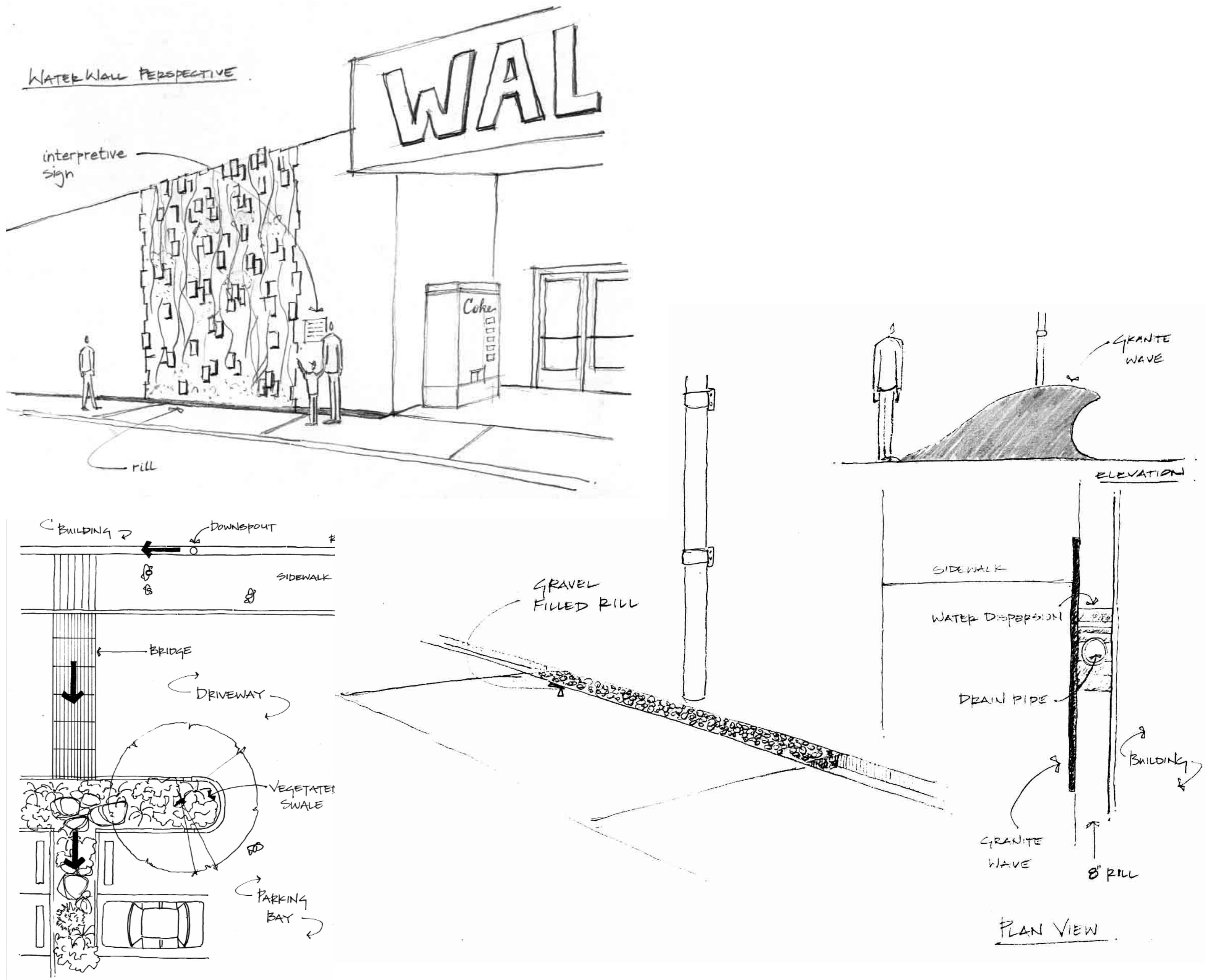


Figure 29. Two concepts for incorporating roof water into the open storm water treatment system of the Hydrologic Restoration design

5.4 CONCEPT B: Heat Island Reduction

The goal for this design is to minimize surface and air temperatures associated with the parking lot. The strategies for achieving this goal are to maximize canopy cover and evapotranspiration, and to reduce thermal conductivity of paved surfaces. Figure 30 illustrates the master plan for this concept. Retaining the original layout of the parking lot, the reclaimed land shown in Figure 18 is redistributed evenly across the entire parking surface by replacing every fourth parking stall with a tree pit. In addition, parking areas are paved with a light colored, lower density porous paving block. Unilock, who manufactures a porous paver called Ecostone, will customize the color of the paver as long as the order is over 2000 square feet.

Based on empirical data we can assume a 30’ diameter canopy after ten years of growth (Coder 2001), which equates to 59% canopy cover over the paved parking area. In this design, canopy cover is calculated based on the area of a thirty-foot circle, multiplied by the number of trees used, and divided by the total parking area. Based on satellite imagery, American Forests recommends 40% canopy coverage in an urban area to ensure ecological, environmental and social sustainability (American Forests 2001). Figure 31 is a more detailed plan showing possible patterns that could be created with various species of trees. In this example driveways are lined with Willow Oaks, aisle ends are clustered with Legacy Sugar Maples and the parking aisles are planted with Yarwood Sycamore. This type of pattern allows for some level of species diversity while improving the legibility of the parking lot within the goal of reducing the heat island effect. Trees are also a major contributor to the visual satisfaction of an urban landscape.

Figure 30. CONCEPT B:
Heat Island Reduction

The goal for this concept is to reduce temperatures in and around the parking lot.

The strategies to achieve this goal are:
·to reduce absorbed heat through maximum shade coverage and the use of lighter colored paving materials and,
·to reduce advected heat thorugh wind breaks.

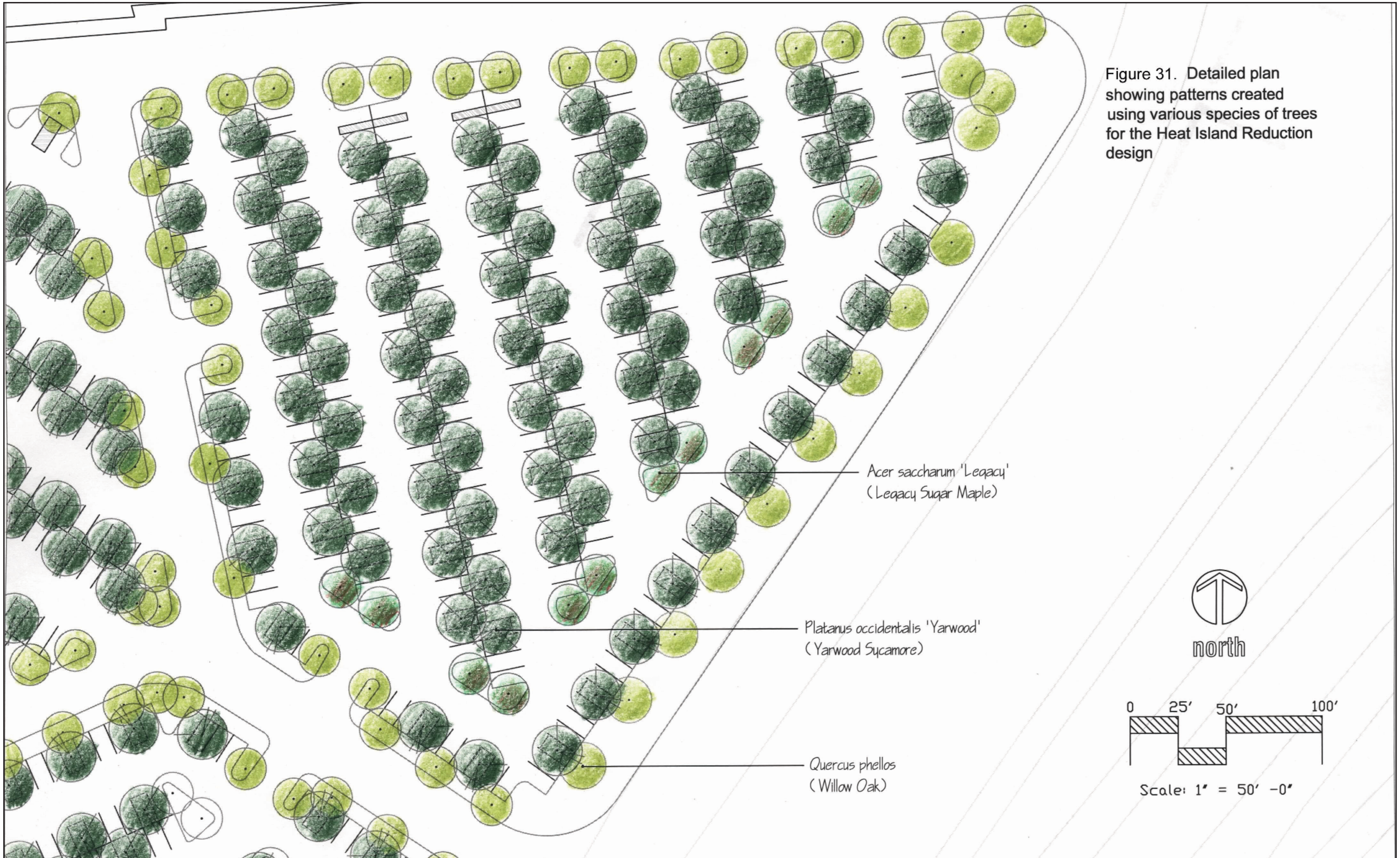


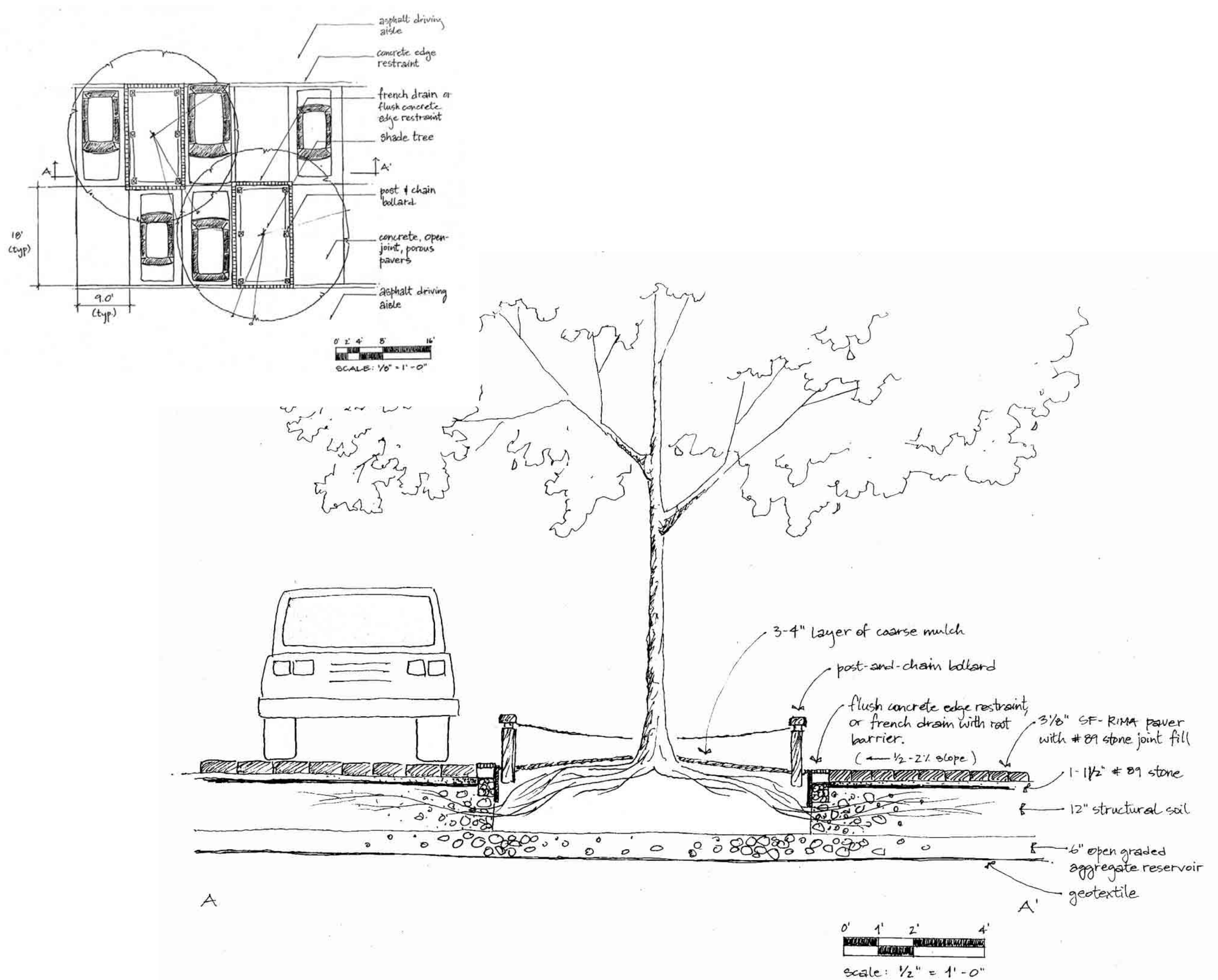
Figure 31. Detailed plan showing patterns created using various species of trees for the Heat Island Reduction design

Although this seems simple enough, the prospect of growing a healthy shade tree in the hostile environment of a parking lot is a tricky endeavor that requires a basic understanding of what a tree needs to live a long and healthy life. Plant growth requires sunlight, water, air and essential elements. Just as leaves absorb carbon dioxide from the air for photosynthesis, roots absorb water, oxygen and elements from the soil for other basic functions like the production of starch. Good soil structure is essential for tree roots to function properly. An ideal soil is essentially composed of 45% minerals, 5% organic matter and 50% pore space. About 25% of the pore space is filled with water, and the other 25% is filled air (Brady 11). Opportunistic tree roots push through this pore space and colonize the surrounding soil in search of water, oxygen and elements. Because oxygen is the limiting factor in tree root depth, and there is rapid decline of available oxygen below the first couple feet of soil, most of a tree's roots grow in the top twelve to eighteen inches (Craul 1992). A typical tree root system has several large structural roots near the trunk of the tree that extend in a radial pattern. These roots taper off relatively quickly and give way to an extensive network of small, fibrous, absorbing roots that lie just below the soil surface. The entire root network typically extends 1 ½ to 2 times the tree's height or 4 to 5 times the diameter of the canopy (Coder 2001). This is possible only with good soil structure.

The number one killer of trees in an urban environment is soil compaction (Craul 1992). Soil compaction destroys soil structure and inhibits root growth. It results from construction and from frequent heavy traffic over an area of soil. In a parking lot, trees are typically placed in small, raised planters that represent less than 1/1000 their normal rooting area. The paved-over soil around these tree pits has been replaced with something that more closely resembles concrete. The topsoil, which contains most of the elements essential for root growth, has been removed and the remaining subsoil compacted to 95% or greater. In other words, the soil surrounding these tree pits is hard as a rock and devoid of oxygen and water. In order for roots to penetrate this “soil” they must thicken much more than normal to provide enough force to send their small growing tips through the even smaller pore spaces. This often results in pavement heaving near the trunk of the tree (Craul 1992). If the roots should happen to succeed in penetrating and exploring this soil, they quickly find no available oxygen or water. In short, the roots are never allowed to develop, the tree performs poorly, and its life is abridged. In such a stressful environment these trees can only be expected to live for about seven to ten years (Coder 2001).

Figure 32 shows a tree planting detail that provides suitable growing conditions for a tree in a parking lot. As shown in the diagram, the open-soil tree pit takes up an entire parking stall, which is roughly 150 square feet. The tree pits could technically be constructed to temporarily detain water, which would allow them to act as a rain garden that would further reduce runoff. In that case the trees would be planted below grade (Wenk 82). However, since the goal here is to reduce temperatures by growing healthy trees, the trees in this scenario are planted 1-3" above grade to prevent water from collecting around the trunk. In order to increase the volume of rooting zone the parking aisles that surround the tree pits are paved with porous paving blocks that sit on 12” of structural soil and a 6” gravel reservoir. This provides roughly 922 cubic feet of rooting zone per tree. The porous paving allows storm water to infiltrate evenly over the entire area, which filters pollutants and provides water for tree roots. A layer of geotextile

Figure 32. Plan and section of a standard tree pit in the Heat Island Reduction scenario.



would be placed between the bedding sand underneath the pavers and the structural soil below to prevent the sand from eroding. The structural soil provides a stable base for vehicular pavements and a suitable growing medium for tree roots. The gravel reservoir allows the structural soil to drain to tree roots from sitting in saturated soil. It also provides the opportunity for storm water to slowly infiltrate into the ground below. A second layer of geotextile would be placed underneath the gravel reservoir to prevent it from being clogged with sub-grade soil. In lieu of an irrigation system, trees would be watered from a truck for the first two years or until they are established. Post-and-chain bollards could be used to prevent vehicular and pedestrian traffic from compacting the open soil in the tree pit.

An edge restraint would be needed around the perimeter of each tree pit to stabilize the porous pavers. This could be a flush, poured-in-place concrete curb or plastic or metal edging. Slit drains that would collect small amounts of surface runoff before it reached the tree could also be used as an edge restraint. This might help prevent pollutants and trash from building up around the trunk of the tree. In this instance a root barrier would be placed between the slit drain and the tree pit to prevent roots from clogging the drain. The slit drains would need to be cleaned out periodically to remove any trash and debris.

In the event that base reservoirs become saturated an overflow system is provided to remove excess water. Figure 33 is a pipe diagram that illustrates the drainage infrastructure needed to accommodate excess water. Figures 34 and 35 illustrate key features of the system. In this design each parking aisle is a separate reservoir that is slightly sloped away from the buildings toward an overflow pipe. Excess water is

Figure33. Overflow pipe diagram for the Heat Island Reduction design

Drain pipes would need to be installed to ensure drainage of excess water. This design requires 527 linear feet of 12" pvc pipe and 156 linear feet of 36" pvc pipe.

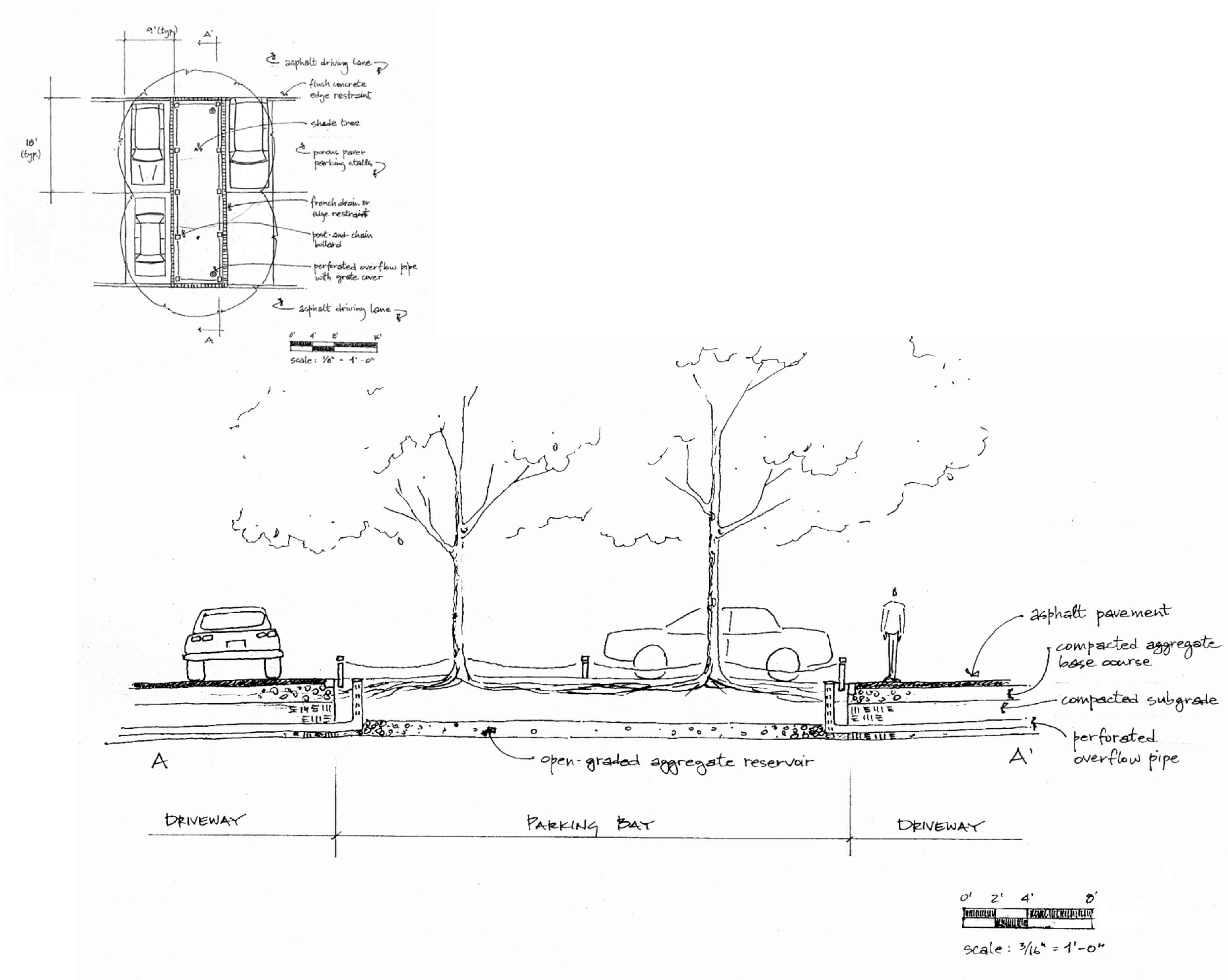


Figure 34. Plan and section of overflow pipe between parking bays in the Heat Island Reduction scenario.

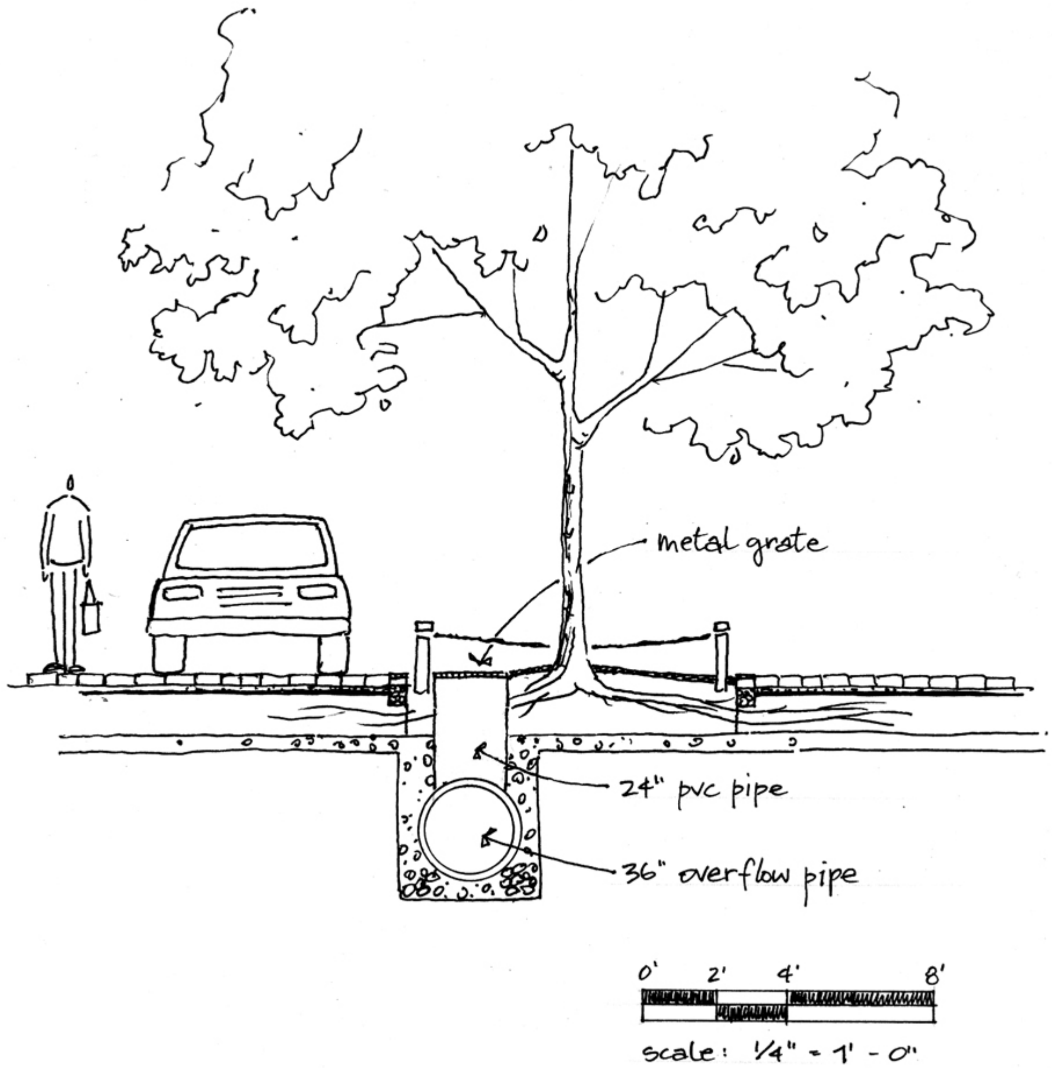


Figure 35. Detailed section of the overflow infrastructure for the Hydrologic Restoration design.

discharged into the detention pond at the south end of the site. Four grated surface inlets are also provided to divert surface runoff into the overflow system. The overflow system would require approximately 527 linear feet of 12” perforated pipe, 156 linear feet of 36” perforated pipe and 4 surface inlets.

In order to verify the success or failure of the design, the lot would need to be monitored well in to the future. Hourly temperature readings would need to be taken to determine the net effect of providing canopy cover over a paved surface. A comparable vegetated area would be used as a control. View ports, or Rhizotron lift plates, could be placed within the porous paving blocks to monitor tree root growth as mentioned in the Westminster case study in chapter four. A monitor could also be placed at the discharge pipe in the detention pond to evaluate the quantity and quality of runoff form the site.

5.5 CONCEPT C: Improving Perceptions of Attractiveness and Safety

The goal for this design concept is to improve overall perceptions of visual satisfaction and safety within this parking lot. The overriding strategy for this design is that the aesthetic investment of the parking facility increases as one moves closer to the buildings. Safety considerations do not change except for the unavoidable fact that as one moves away from the buildings one is farther from an entrance, which decreases perceptions of safety. As discussed in chapter three there are specific physical features that both enhance and reduce each of these perceptions. The studies of Anderson and Schroeder (219) provide us with a checklist of these elements that are listed in Table 5.

Table 5. Elements that affect perceptions of attractiveness and safety in an urban landscape (Shaffer and Anderson 1983).

	ATTRACTIVENESS		SAFETY	
	POS.	NEG.	POS.	NEG.
Trees	•			
Well-maintained vegetation and flowers	•			
Well-maintained structures	•			
Prominence of parking		•		
Poles and overhead wires		•		
Reduced scale	•		•	
Color, texture, rhythm, balance	•			
Open sight lines			•	
Close proximity of an entrance			•	
Adequate lighting			•	
High degree of use			•	

Figure 36 illustrates the plan for this scenario. The plan shows two distinct zones within this scheme that establish a hierarchy of parking demand by distinguishing between peak use (thirty percent of total spaces) and average use (seventy percent of total spaces). Peak use, or overflow parking, is represented by the gray zone farthest from the buildings and is the area of lower aesthetic investment. Average use is represented by the tan zone closest to the buildings and is the area of higher aesthetic investment. These two zones are separated by an asphalt entrance drive and are divided into smaller sections that serve each of the three anchor stores.

Figure 37 provides a more detailed plan of the individual components that make up this scheme. Each parking bay is broken down with cross-bay rows of tree plantings that transect the bay, dividing it into halves or thirds. Each planting area contains two trees that would be selected from the list in Table 4. Tree pits would be constructed as illustrated in Figure 32. Each tree pit would be heavily mulched and planted with a low maintenance, evergreen ground cover selected from Table 4. The rows of tree plantings divide the parking aisles into parking courtyards, each of which contain twelve to twenty parking spaces. These courtyards are in turn divided in half with small lighting standards. Trashcans would be placed at regular intervals throughout the parking lot to facilitate its cleanliness.

The treatment of the paving surface distinguishes between the two zones of parking demand. The overflow parking area is entirely paved with asphalt. The average use parking area is treated with the detailed paving patterns illustrated in Figure 38. Parking stalls are paved with open-jointed concrete paving blocks. Different colored blocks are used to designate individual stalls as well as handicapped loading zones. These

Figure 36. CONCEPT C: Improving Perceptions of Attractiveness and Safety

The goal for this concept is to maximize perceptions of attractiveness and safety within the parking lot. The overriding concept is that the aesthetic investment increases as one moves toward the buildings. This creates a hierarchy of parking demand and a visual distinction between average-use and overflow parking.

Positive contributing factors are:
·presence of trees
·well maintained vegetation and flowers
·legibility
·rhythm, scale, texture
·open sight lines
·lighting
·high degree of use

Detracters are:
·prominence of large parking areas
·prominence of vehicles
·poles and overhead wires
·obstructed sight lines
·overwhelming scale

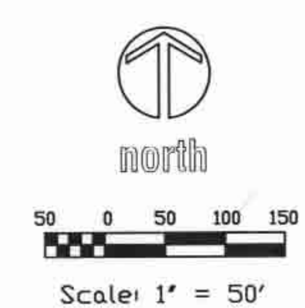


Figure 37. Detailed plan showing various components of the Attractiveness and Safety design

Figure 37. Detailed plan showing paving patterns for the Attractiveness and Safety design

pavers lie on top of a layer of structural soil that provides the necessary rooting zone for healthy tree growth. The driving aisles between the rows of parking are made of poured concrete and have a specific scoring pattern. The aisles are broken down into small units that coincide with half of the parking courtyard. Each of these areas has a brick inlay pattern that is coincidentally the same square footage as two average size automobiles. The scored concrete surrounding the brick inlay coincides with the square footage required to accommodate two automobiles in a surface parking lot. A sign could be placed nearby to explain the paving detail. The driveway between the parking areas and the buildings is also made of poured concrete. This driveway has a stamped and colored pattern that designates pedestrian crossing areas. Figures 39 and 40 illustrate what the parking lot currently looks like and what it might look like after these changes were made.

According to the checklist at the beginning of this section, we can verify that perceptions of attractiveness and safety are positively influenced by this design. Stately trees and clean ground covers are provided in an organized fashion throughout the parking lot. Underground wires are used as in the original plan. Smaller lighting standards are used at more frequent intervals to provide adequate lighting. Breaking up the lot into several smaller parking bays diminishes the prominence and scale of parking. Scale is further reduced with the use of tree plantings, site furnishings and paving details. Rhythm is achieved with the use of site furnishings and organized tree plantings. Texture and color are provided with variations in vegetation and paving materials. Open sight lines are maintained by avoiding medium sized shrubs.

Figure 39. Photograph of the Perimeter Square parking lot as it currently exists (April 2001).

Figure 40. Image of the Perimeter Square parking lot with proposed changes from the Attractiveness and Safety design

5.6 CONCEPT D: Provisions for Multiple Uses

The goal for this design is to accommodate multiple uses that may occur in a strip mall parking lot. “Perhaps the most fundamental way to integrate the parking lot into a town or city is to realize that they have multiple uses and to make physical improvements to support these other uses” (Childs 137). Many of us have observed or participated in these activities at one time or another.

Activities that take place in parking lots can be planned or unplanned. Some activities like carnivals or fundraisers typically don’t require much more than large open paved areas. However, they usually require at least limited access to electricity and water. This type of support could be provided for in the design of the parking facility. Other activities that take place in parking lots might require a different type of support. Teenagers often use strip mall parking lots as hangouts or serendipitous skateboard parks. These activities usually occur because of a lack of suitable alternatives for teenagers within the community and perhaps because parking lots are appealing places to that age group. Designing to accommodate these uses is more deliberate and complicated. The first step would be to determine what type of facility a particular community might need. This could be done by conducting surveys and interviews, which is beyond the scope of this thesis. Once a community need is determined the design could specifically address it. In Childs’s book entitled Parking Spaces (35) he states that “smooth asphalt pavements with slopes to area drains have unintentionally led to the use of parking lots as prime sites for skateboarding.” Figure 41 provides a graphic suggestion of how a skateboard park might become an integral part of a parking lot.

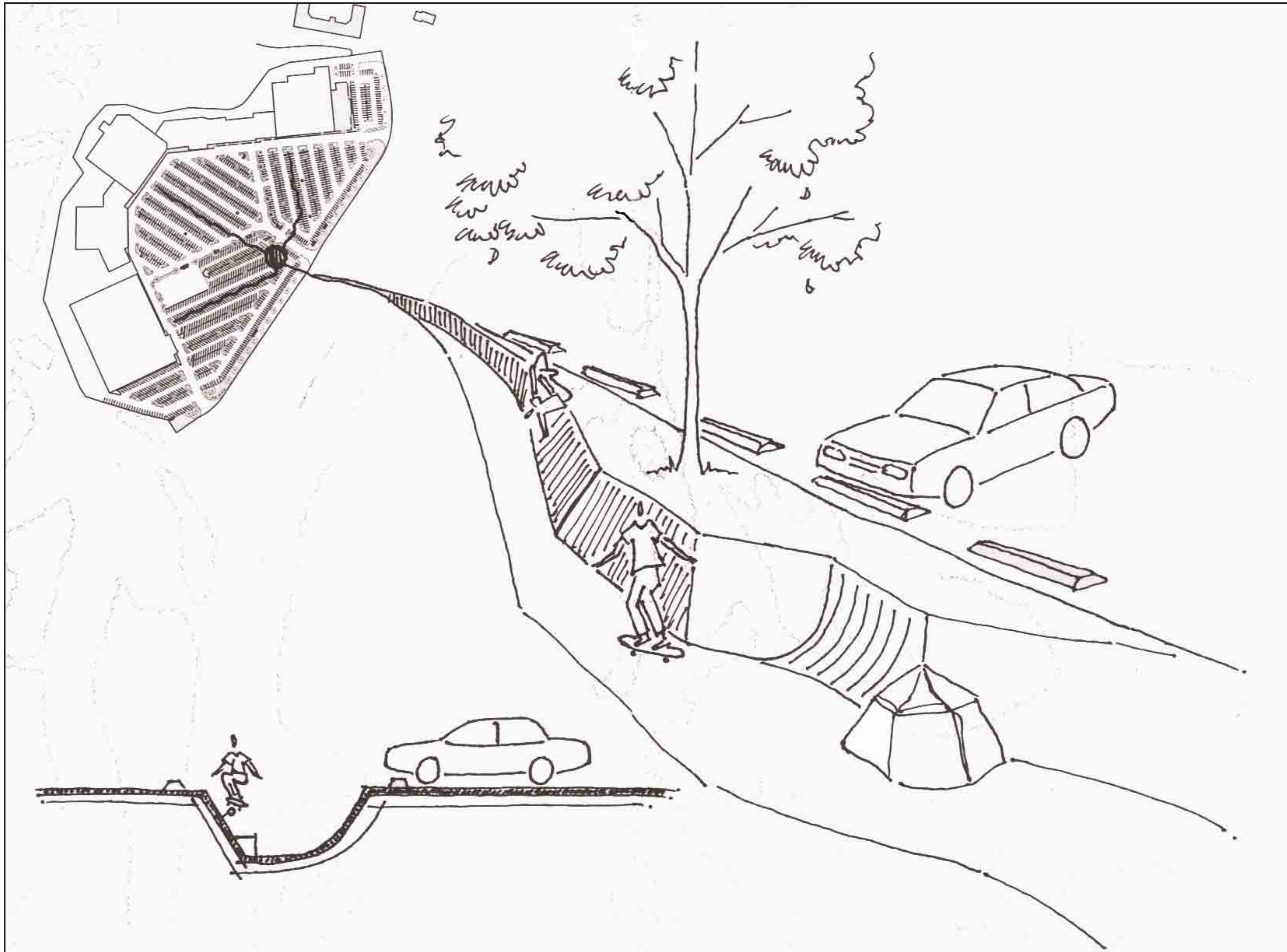


Figure 41. Graphic illustration of an integrated skateboard park for the Multiple Uses design

Food service vendors are a type of multiple use that falls somewhere between a planned and unplanned event. Strategically located vendors can provide a great amenity for customers provided that they don’t conflict with current businesses. They can also improve perceptions of safety by increasing the activity within the parking lot and by providing monitors for the facility. Vendors can become the eyes of a parking lot. Figure 42 is a picture of a Hotdog vendor at the Lowes store in Athens. This vendor has been in that location for several years and is very successful. It doesn’t take much to accommodate a vendor. Location is the most important factor. Vendor carts typically require from 100 to 150 square feet, which is roughly the size of one parking stall. They usually require access to electricity and potable water. Allowing for multiple vendors in a single location tends to increase their security and commercial viability (Childs 141). Figure 43 illustrates a possible design for a group of vendors in this particular parking lot.

There are further possibilities for multiple uses in parking lots. Figure 44 is a photograph of a car show taking place in the Sam’s Club parking lot in Athens, Georgia. Figure 45 is a photograph of the outdoor garden center in the Home Depot parking lot in Ahtens. These examples illustrate some of the ways parking lots can be incorporated into the fabric of a community allowing them to become civic spaces rather than just car yards. Figure 46 diagrams some of these possibilities for the Perimeter Square lot.

Figure 42. Photograph of a hotdog vendor in the Lowes parking lot in Athens, Gerogia (Oct. 2000).

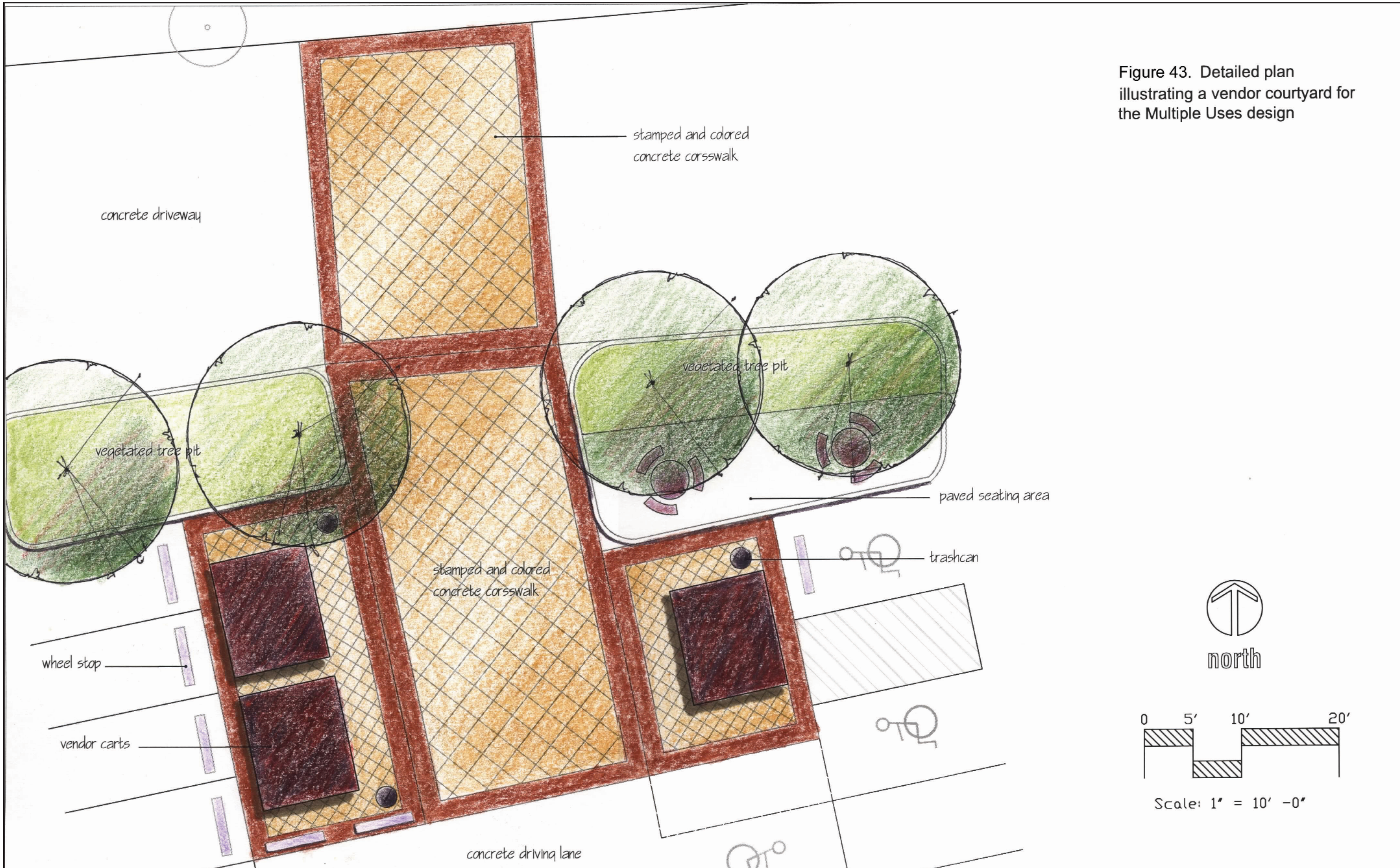


Figure 43. Detailed plan illustrating a vendor courtyard for the Multiple Uses design

Figure 44. Photograph of a car show in the Sam's parking lot in Athens, Georgia (Oct. 2000).

Figure45. Photograph of the outdoor garden center at the Home Depot in Athens, Georgia (Oct. 2000).

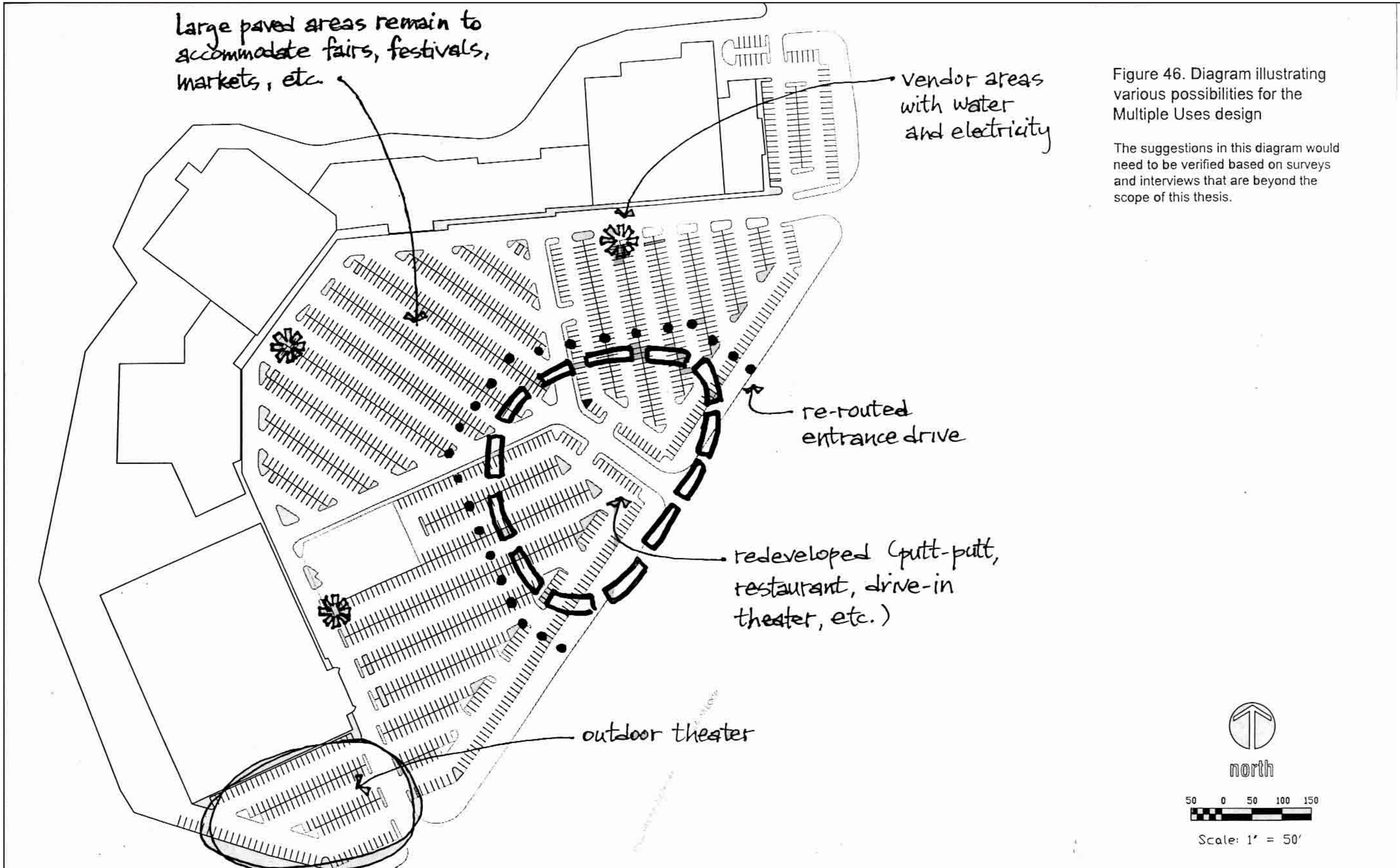


Figure 46. Diagram illustrating various possibilities for the Multiple Uses design

The suggestions in this diagram would need to be verified based on surveys and interviews that are beyond the scope of this thesis.

5.7 CONCEPT E: Combined Design Approach

The goal for this design is to meet all four stated purposes in a single design. There are many different configurations that could accomplish this. Figure 47 illustrates one such plan. 1,270 parking stalls are needed to meet a parking index of 4.0 stalls per 1,000 square feet GLA. In this design, as in the previous designs, a 70/30 split was used to differentiate between average and peak parking demands. These two zones are separated by a concrete entrance drive. Parking areas receiving heavier traffic are treated with a more durable paving surface. The overflow parking area is turf.

Each section of the site has components that allow for on-site infiltration of rainwater. Rainwater that falls on the rooftops is diverted to the fronts of the buildings where it is transported down the storefront into an open storm water system. This water travels under bridges that cross the main driveway and enters a system of vegetated swales that drain the runoff from the heavy-use parking zone. The parking bays in this zone are paved with SF-Rima open-jointed porous pavers. A twelve-inch layer of structural soil on top of a six-inch aggregate reservoir underneath the parking bays provides rooting zone and water storage. As mentioned before, these pavers have an infiltration rate equivalent to that of a grass lawn and would infiltrate many of Athens' smaller storms illustrated in Figure 24. Any runoff from this zone drains into the bioswales and joins the water from the rooftops. Runoff from this zone crosses the second driveway and enters a series of level spreaders that distribute it evenly over the grassed overflow area. Any runoff from this zone flows through a forested filter zone surrounding a retention

Figure 47. CONCEPT E: Combined Design Approach

This design improves on-site infiltration and ground water recharge, reduces the heat island effect, increases perceptions of attractiveness and safety and provides facilties that support multiple uses while accommodating a parking index of 4.0 stalls per 1000 square feet GLA.

pond. Excess water from the retention pond flows down the length of a dry creek bed that runs parallel to Huntington Road before it leaves the site.

Sufficient tree canopy is provided throughout the paved and grassed parking areas to reduce the heat island according to American Forests in Washington, D.C. American Forests recommends 40% canopy coverage to reduce the effects of the urban heat island (American Forests 2001). Assuming the trees would have a 30-foot canopy after ten years of growth, 324 trees uniformly distributed throughout the parking lot are needed to achieve 40% canopy coverage. The trees are planted in 150 square foot tree pits located between every fourth and fifth parking stall. Tree pits would be constructed as shown in Figure 32. Replacing the asphalt in the overflow parking area with grass would further reduce the heat island.

Providing trees and well maintained ground layer vegetation improves perceptions of attractiveness. Reducing the perceived scale of the parking lot by dividing it into smaller parking bays also assists in achieving this goal. A five-foot grid pattern is scored into the concrete driving lanes between the parking aisles to further reduce the perceived scale of the parking lot. The various textures and colors of vegetation and paving also improve perceptions of attractiveness. Maintaining open sight lines and providing adequate lighting throughout the parking lot as well as reducing its perceived scale all assist in improving perceptions of safety.

Facilities are provided to accommodate several vendors at three locations within the parking lot. As illustrated in Figure 48, these vendor courts accommodate two to three vendors in each location with access to water and electricity. Each court has a small paved seating area adjacent to it with picnic benches and trashcans. The paving in these areas is treated with a different color and pattern as a visual cue for drivers to watch out for pedestrians. Vendors act as unofficial monitors for the parking lot and their presence improves perceptions of safety.

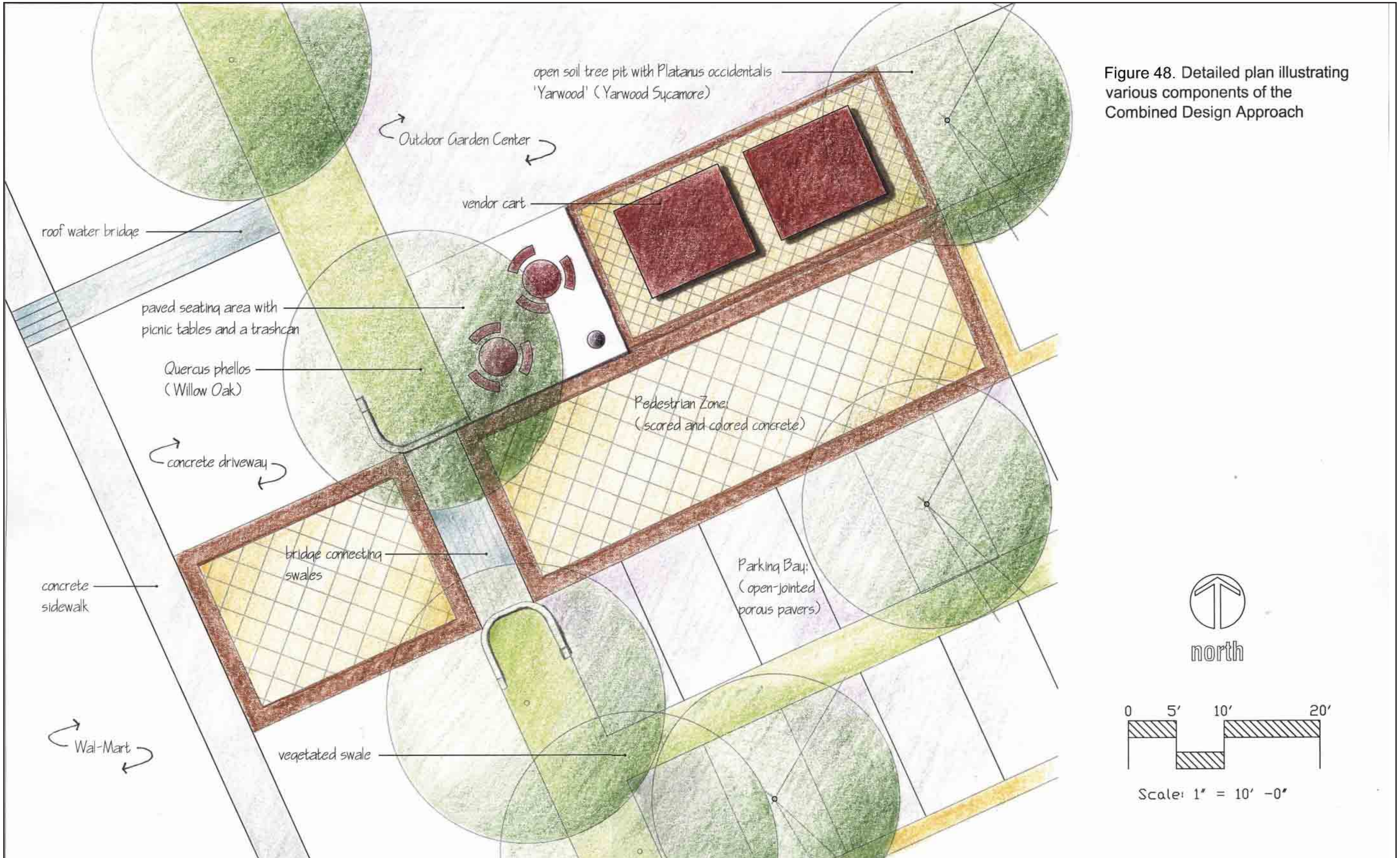


Figure 48. Detailed plan illustrating various components of the Combined Design Approach

CHAPTER 6

EVALUATION AND CONCLUSION

This thesis demonstrates potential solutions to the four concerns with strip mall parking lots identified in chapter three. Although all of these designs are based on the assumption that this site would be redeveloped, each one demonstrates approaches that would be suitable and beneficial for new construction on other sites as well. In Table 6 the marked boxes indicate the success of a particular design in any of seven different categories. Each design is evaluated based on its relative improvement over the conditions of the existing parking lot in that category. This is helpful in evaluating the success of the designs and consequently determining possible solutions to these four problems. Addressing each problem in isolation allowed for a focused exploration of a possible solution for that problem. The final combined scenario was helpful in determining the feasibility of combining elements from the previous four approaches in a unique design that addresses all four problems simultaneously.

The Hydrologic Restoration design was intended to improve the current hydrologic conditions of the site. As shown in figure 28, impervious surface coverage of the parking lot in this scenario was reduced from 84% to 30%. Rainwater that falls on the impervious surfaces of the rooftops and driveways is diverted to the open treatment system within the parking lot. The porous pavers, vegetated swales, level spreaders, grassed overflow, forested filter zone, retention pond and dry creek bed all work together to slow down rainwater and allow it to infiltrate into the ground. This reduces runoff and improves groundwater recharge. The vegetated components of the design improve the quality of any excess water that leaves the site by filtering sediment and other pollutants. Temperatures are further reduced because solid paving materials are replaced with porous materials that have lower thermal conductivity. In addition a large portion of the paved surface has been replaced with vegetation that reduces absorbed heat and increases evapotranspiration. Hydrologic modeling would be necessary to determine the amount of rainfall this design could infiltrate and the possibility that the hydrologic capacity of this design exceeds any necessary quantitative requirement.

The Heat Island Reduction design was intended to reduce temperatures. By uniformly distributing the maximum number of shade trees throughout the site without compromising a parking index of 4.0 spaces per 1,000 square feet GLA, 59% canopy coverage was achieved over the parking areas. This exceeds the American Forests recommendation of 40% coverage to reduce heat island effects. Much of the solar radiation that would have been absorbed by the pavement and later released as heat is now either reflected by the leaves of the trees or used in evapotranspiration. Trees dissipate through the process of transpiration. In order to accommodate a healthy root zone for the trees the parking bays are paved with porous pavers that allow for the exchange of water and gases between the rooting zone and the atmosphere further reducing temperatures through the process of evaporation. The porous nature of the construction materials reduces thermal conductivity and heat island contribution. These areas also reduce runoff, increase groundwater recharge and improve water quality. In addition, the presence of trees improves perceptions of attractiveness.

Table 6. Evaluation of all five designs on their response to the specific issues discussed in the text.

	Hydrologic Restoration	**Heat Island Reduction**	**Improving Perceptions of Attractiveness and Safety**	**Provisions for Multiple Uses**	**Combined Design Approach**
WATER					
Reduces runoff	+	+	+		+
Improves groundwater recharge	+	+	+		+
Improves water quality	+	+	+		+
HEAT ISLAND					
Reduces temperatures	+	+			+
ATTRACTIVENESS AND SAFETY					
Improves perceptions of attractiveness	+	+	+		+
Improves perceptions of safety			+	+	+
MULTIPLE USES					
Supports multiple uses				+	+

The Attractiveness and Safety design was intended to improve perceptions of attractiveness and safety. Various design elements such as trees, reduced scale, lighting, open sight lines, and paving details help to achieve this goal. Porous pavers are used for the parking bays in order to support healthy trees in the heavy-use parking zone. These pavers incidentally reduce runoff, increase groundwater recharge and improve water quality.

The Multiple Use design was intended to support multiple uses within the parking lot. Further research, which is beyond the scope of this thesis, would be needed to determine which such uses would be appropriate on this site. However, some generalized treatments are illustrated in chapter four that support various uses including a skateboard park, and vendor courts. Incorporating a vendor into the parking lot would also improve perceptions of safety by providing an inadvertent monitor for the facility. Although vendors do not officially double as security guards their presence is a perceived deterrent for delinquent behavior.

The Combined Design Approach design was intended to address all of these issues. This design strikes a balance between the previous four designs and meets all of the goals to some degree. The roof water collection, porous paving, vegetated swales, level spreaders, grassed overflow parking, forested filter zone, retention pond, and dry creek bed all reduce runoff, increase ground water recharge and improve water quality. 40% canopy cover is achieved, which adequately reduces the heat island effect according to American Forests. The porous pavements, grassed overflow and forested filter zone also reduce temperatures. The trees throughout the parking lot as well as the reduced scale of the parking bays and the paving patterns in the driveways improve perceptions of attractiveness. The grassed overflow area also improves perceptions of attractiveness by reducing the prominence of parking. Adequate lighting, open sight lines, and crosswalks improve perceptions of safety. Three vendor courts are provided with facilities such as water and electricity, paved seating areas and trashcans that support incidental multiple use.

This thesis demonstrates that it is possible to address each of the four issues associated with strip mall parking lots mentioned above with a specific design solution. Some single-purpose solutions inadvertently address other issues as well. A number of issues can be designed for explicitly in a single design. Although this requires balancing one against another, it is possible to succeed adequately according to contemporary professional standards. Strip mall parking lots provide opportunities for creative and integrative design that can reduce the ecological impacts of development and provide functional public open spaces within communities. The designs in this thesis represent five solutions for the Perimeter Square site in Athens, Georgia and by no means exhaust the possibilities. Designs for other sites should be based on site-specific conditions and should address the problems associated with those specific sites.

The functions and effects of parking lots encompass more than parking. Their multiple functions and effects require multiple design approaches. The designs in this thesis illustrate that different designs emerge when different functions and effects are focused upon. They also illustrate that it is possible to meet multiple functional and environmental purposes within given parking needs. Typical parking lots in recent decades have been single-purpose (for parking) and have been unsatisfactory in their other functions and effects. Parking lots of the future should be more complex and diverse in the kinds of ways illustrated in this thesis in order to satisfactorily address multiple purposes.

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