

8. DESIGN CRITERIA

Following the adoption of the Broadway Boulevard: Euclid to Country Club Project Baseline Alignment Concept, the Project Team is moving forward with further development of the design, developing refined design criteria, and drafting this Design Concept Report. Where Chapter 7 focused on design refinement descriptions and illustrations, Chapter 8 defines the design criteria for the preparation of final design and construction of the improvements.

8.1 Geometric Design Criteria

Geometric criteria guide the design of street projects to meet the physical requirements, safety consideration, and desire for comfort of the various users of a street – people walking, riding bicycles, using wheelchairs, travelling in cars or buses, delivering goods in a truck, etc. The criteria that have been defined for the Broadway Boulevard project have been derived from the following sources:

- *A Policy on Geometric Design of Highways and Streets*, American Association of State Highway and Transportation Officials (AASHTO); 2014.
- *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, Institute of Transportation Engineers (ITE) Recommended Practice; 2010.
- *Pima County Roadway Design Manual, Third Edition*; Pima County Department of Transportation (PCDOT); 2010.
- “Development Standards”, City of Tucson (COT).
- “Memo -- Streetside Width Considerations”, HDR; November 27, 2014.

Table 8.1 provides a summary of the widths of various street elements that are to be used for the Broadway Boulevard project as compared to the reference documents and guidelines that are cited above, and the Grant Road project.

8.1.2 Street Classification

The City of Tucson Major Streets and Routes Plan designate this section of Broadway Boulevard as an arterial street. This is an important designation that drives much of the design criteria. Under the ITE *Designing Walkable Urban Thoroughfares* manual, the context zone for Broadway would be either General Urban Zone (C-4) or Urban Core Zone (C-5). The context zone is important primarily in regards to the width of the cross section elements as discussed below.

Table 8.1: Street Element Widths

Street Element	AASHTO	PCDOT	COT	ITE	Grant Road Corridor	Adopted for Broadway
Travel Lanes	10'-12' ⁽¹⁾	12'	12' ⁽²⁾	10-12' (C-4) 10-11' (C-5)	11'	11'
Right turn lane	10'-12' ⁽³⁾	13'	12' ⁽²⁾	10-12' (C-4) 10-11' (C-5)	12'	10'
Left turn lane	10'-12' ⁽⁴⁾	13'	12' ⁽²⁾	10-12' (C-4) 10-11' (C-5)	12'	10'
Double left turn lanes						
Inside lane (next to curb)	10'-12' ⁽⁴⁾	12'	11' ⁽²⁾	10-12' (C-4)	11'	11'
Second lane (next to offset)				10-11' (C-5)		10' ⁽⁵⁾
Bike lane	5'	6'	5' min, 6' preferred	5' min, 6' preferred	7'	6'
Median (mid-block)	4' min	20-24'	20' ⁽⁶⁾	4' to 18'	17'	8', 6' min
Median at left turn lane	4' min	6'	7'	4'	6', 8' ⁽⁷⁾	6' ⁽⁸⁾
Sidewalks	4' min, 6' next to curb	5'	6' ⁽⁴⁾	8' (C-4) 10' (C-5)	8'	6'

(1) AASHTO (page 7-29) -- 11' lanes used extensively for urban arterial streets. 10' lanes may be used in constrained areas with low truck and bus volumes. 12' lanes are desirable for high-speed free-flowing principal arterials.

(2) COT allows 10' lane (11' against curb) when there is not a bus route.

(3) AASHTO state that "auxiliary" lanes at intersections should be as wide as through-traffic lanes but not less than 10'. (page 4-8)

(4) AASHTO (page 7-29) -- Left-turn lanes may be 10' in width.

(5) 10' when adjacent to 5' offset from through lanes.

(6) 20' required when curb to curb distance exceeds 75'.

(7) 6' at non-indirect left turn signalized intersections. Otherwise 8'

(8) 6' required for sheltering pedestrians and wheel chairs.

8.1.1 Design Year

The design year is 2045. The traffic study for the project will be updated accordingly.

8.1.2 Design Speed, Target Speed/Posted Speed

The design speed will be 35 mph. The posted speeds will be the same as currently exists—30 mph between Euclid and Campbell, and 35 mph between Campbell and Country Club.



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8.1.3 Vehicular Criteria

8.1.3.1 Design Vehicle

The applicability of design vehicles to the project is in the configuration of intersections to accommodate turns, both from Broadway to the intersecting street and vice versa. Intersections with local and collector streets will be designed to accommodate a 3-axle single unit truck (AASHTO designation SU-40). Arterial intersections will be designed to accommodate AASHTO's interstate semitrailer designation WB-62. The ability of arterial intersections to accommodate buses (CITY-BUS) will be checked as well.

Several intersections will receive special consideration. Mountain Avenue extending north from Broadway is quite narrow and may be unable to accommodate vehicles larger than passenger cars.

A special median opening is being provided at Vine Avenue to accommodate school buses serving Miles Exploratory Learning Center. Left turns from Broadway will be provided in the westbound direction only. This opening will be designed to accommodate a conventional school bus (BUS-36). This turn will also be convenient for dropping off or picking up students as well as neighborhood access.

A special median opening will also be provided at Norris Avenue to accommodate Tucson Fire Department Station No. 3, just north of Broadway, and to provide westbound access from Broadway to Safeway. Eastbound traffic from Broadway will not be permitted to turn left at this location. The southbound to eastbound (fire truck) left turn movement will be designed for an SU-40 truck as above. The westbound to southbound left turn movement will be designed for an interstate semitrailer (WB- 62) to accommodate deliveries to Safeway.

Table 8.2 summarizes the design vehicles to be used for various conditions on the project. AutoTURN software will be used to evaluate turning movements of these vehicles at various types of intersections.

Table 8.2 Summary of Design Vehicles for Intersection Turning Movements

Location	Design Vehicle
Local and Collector Intersections	
Typical:	3-axle single unit truck (SU-40)
Mountain (narrow street):	Passenger car (P)
WB to Vine (Miles ELC):	Conventional school bus (S-BUS 36)
SB to Broadway (Fire Station):	3-axle single unit truck (SU-40)
WB to Norris (Safeway):	Interstate Semitrailer (WB-62)
Arterial Intersections	
Typical:	Interstate Semitrailer (WB-62)
Check:	City Transit Bus (CITY-BUS)

8.1.3.2 Lane Widths

Travel lane widths will be 11 feet. Left and right turn lane widths will be 10 feet except for double left turn lanes where one will be 11 feet.

8.1.3.3 Sight Distance

Vertical sight distance will not be an issue with this project. Crests and sags in the profile will not be pronounced enough to limit sight distance.

Horizontal sight distance is a consideration though, particularly given the curvature of the roadway. Sight distance triangles will need to be examined at unsignalized intersections, and some restrictions to types of landscaping in those areas may be necessary.

8.1.3.4 Horizontal and Vertical Alignments

The horizontal alignment is the product of the Mayor and Council adopted alignment, adjusted as needed to meet technical and cost constraints. As a result, the alignment will vary from side to side to best avoid acquisition impacts and cost. The 11-foot travel lane width constrains the radius of curvature to 1,400 feet based on tracking and other issues associated with trucks and buses remaining in their lanes through curves.

These tracking and other issues relate to the fact that the space needed between vehicles for comfortable and safe operation increases through curves--particularly for larger vehicles. This is due to several factors: (1) the fact that rear wheels do not follow the track of the front wheels but rather diverge in the direction of the inside of the curve; (2) the overhang of the front of the vehicle; (3) the separation between vehicles needed for drivers to feel comfortable; and (4) the fact that drivers are not able to remain precisely in the center of the lane throughout the curve.

8.1.3.5 Bicycle Criteria

The 6-foot bike lanes are not conducive to additional buffer width from traffic, raised cycle track, delineators, or other enhanced pavement markings. To narrow the street, an enhanced bike environment will not be built into the street design. Depending on right-of-way conditions that emerge during the acquisition process, such enhancements may be possible on a block-by-block basis; although the issue of bicycle facility consistency as it factors into predictability of driver and bicycle rider behavior may limit applicability of block-by-block variations, particularly if they are significant variations. It may also be possible to route bike traffic behind bus pullouts in some locations to avoid bus-bike conflicts.

Bike boxes and other enhanced pavement markings should be considered where possible, particularly at wide, complex intersections such as Campbell.

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8.1.3.6 Pedestrian Criteria

The sidewalk width will typically be 6-feet though it will increase to 8 feet adjacent to buildings to account for potential 3-foot doors opening into the sidewalk area and the need to maintain a 5-foot clear sidewalk for disabled access. In some cases, it may be strategically narrowed if an acquisition or demolition can be avoided.

A defined pedestrian buffer will not be built into this project. The separation distance from the street will typically be the 5 feet included in the streetside width though this can be less to avoid direct impacts to buildings. It can also be greater where right-of-way width allows.

In most cases, driveway crossings will consist of slight dips in the sidewalk as described earlier. Where driveway turnouts are used, directional ramps similar to those provided at street intersections will be provided. All sidewalks, driveway crossings, and street crossings will necessarily meet ADA requirements.

8.2 Pavement Design Criteria

To be determined.

8.3 Drainage Design Criteria

City of Tucson drainage criteria will be observed in design of the pavement drainage system. Applicable criteria are the following:

1. In a 10-year storm, the storm flows in Broadway can be contained within curbs. That results in an allowable depth of 0.50 feet which will be the height of the curbs.
2. Also in a 10-year storm, one lane is to be kept free from flowing or ponded water. The allowable width of flow is the width of two travel lanes and the bike lane, or 28 feet. Since the cross-slope of the roadway will generally be 2%, the allowable depth at the gutter is 0.56 feet. Criterion 1 is more restrictive and will apply for this project.
3. In a 100-year storm, all-weather access for emergency vehicles is to be maintained. Flows up to one foot in depth are considered traversable, resulting in allowable depth of 1.00 foot at curb.
4. A 100-year flow must be contained in right-of-way. The corresponding depth would be the height of curb plus any extra height afforded by the right-of-way behind the curb. For a 12 foot streetside width sloping at 2%, that affords an additional 0.24 feet. The overall depth would then be at least 0.82 feet. Where the edge of the right-of-way is below existing ground, the allowable depth can be increased by that amount. Generally, this criterion will be more restrictive than the 1.00-foot depth of criterion 3.

Preliminary analysis indicates that the 100-year criterion is likely to govern for this project.

Catch basins will be located along the Broadway gutter lines as needed to meeting these criteria. They will also be placed upstream of intersecting streets and at locations to intercept offsite flows prior to entering Broadway where practicable. It is normally impractical to size catch basins to capture the entire flow reaching it. They will typically be sized to capture a reasonable fraction of that flow however—typically 30% to 70%. Storm drain mains and laterals will be sized such that the function of the catch basins is not impeded.

8.4 Street and Intersection Lighting Design Criteria

Intersection and continuous street lighting will be provided along Broadway. The existing high-pressure sodium (HPS) lighting will be replaced with LED lighting fixtures following the City of Tucson Roadway Lighting Policy. LED fixtures shall have a color temperature of 3000K. Street light pole layout will be determined based on an analysis of lighting levels required to meet City street illumination requirements for an arterial street with the amount of pedestrian activity that exists in the project area, as well as consideration of potential conflicts with overhead facilities.

8.5 Streetscape, Landscape, and Public Art

The design treatments of the streetside, medians, and other land outside the curbs of the street will help to establish the design and community character of Broadway Boulevard as well as serve an important role in creating an environment that supports and encourages people walking. The landscaped areas within the right-of-way can also be designed as green streets infrastructure that can be part of the stormwater management system for the street.

8.5.1 Relation to Project Vision Statement and Goals

The streetscape and landscape designs, and the public art, along Broadway Boulevard will relate to the following goals that were developed by the CTF through the project's public process:

Neighborhoods and Districts

- Recognize and support the distinct character of Broadway and its context of Neighborhoods and Districts
 - Goal: Recognize and support the distinct character of Broadway as a series of places, defined by their historic and significant structures, signage, landscape, and uses.
 - Goal: Recognize and reinforce existing areas with distinct character and support the creation of distinct new places so that Broadway is a linked series of places, defined by their historic and significant structures, signage, landscape, and uses.



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Multimodal Street Design

- Landscape/Streetscape design (Improve the environment along Broadway/Select context appropriate plants and other design elements)
 - Goal: Increase the amount and quality of landscaping and lighting along Broadway through an approach that is efficient in terms of capital and maintenance costs.
 - Goal: Use plants that are native to the Sonoran Desert or plants that are adaptive to the Tucson environment, and that, along with other streetscape elements, help to create the desired character for the districts along Broadway.
- Public Art
 - Goal: Provide opportunities for public art that complement the aesthetic and placemaking goals for Broadway

Sustainability

- Environmental (General environmental impact)
 - Utilize materials and design techniques in the improvements to Broadway that minimize environmental impacts, including energy efficient lighting and other means.
- Environmental (Water use and stormwater management)
 - Emphasize use of water harvesting and stormwater management techniques in landscaped areas and the use of permeable surfaces and paving to extent feasible.
- Environmental (Shade)
 - Reduce heat island effect through various design measures, such as shading and high albedo pavement, while also providing shade for pedestrian comfort.

8.5.2 Concept Overview

In the earlier planning and design phases of the project, various alignment studies that explored ways to minimize impacts to adjacent properties and buildings while maintaining certain streetscape and landscape widths within the right-of-way. In particular, the design concepts worked to maintain enough area to plant trees along the sidewalks to provide shade and buffering between vehicle traffic and people walking. With the narrowing of the streetside that occurred just prior to the CTF making their final recommendations, the streetside narrowed to the extent that trees cannot be accommodated in most locations given the TDOT landscape architect's standards for clearances between trees and traffic and bicycle lanes. These and the City's Active Practices Guidelines will guide the development of the streetscape and landscape concept moving forward.

City of Tucson Active Practices Guidelines for landscape design

The safety requirements of the Active Practices Guidelines establish minimum dimensions for locations where landscape can be installed.

Landscaping in Medians: A 4-foot minimum clearance from back of curb to back of curb is needed for any planting to be allowed within a median. Trees in medians need to be 7 feet from the face of curb and the tree canopy cannot extend more than 2 feet into the adjacent lanes; a tree with a mature trunk caliper of less than 6 inches may be planted closer to the curb. Shrubs and groundcovers in medians shall be planted so that, when mature, the clearance from back of curb to the plant edge is at least 2 feet.

Landscaping in Streetside: A minimum 3-foot wide area is needed for the planting of a shrub or tree. Trees should be selected and located so that they provide a 5-foot wide and 7-foot high clear safety zone. The mature edge of any shrub or ground cover shall be 2-foot clear of the sidewalk edge; and cacti, yuccas, and agaves shall be planted so that the mature growth is at least 3 feet clear for the sidewalk edge.

In discussions during the conceptual design for Broadway Boulevard, the TDOT Landscape Architect expressed the desire to not have tree branching extend into the bicycle lanes or cycle tracks. But in recognition of the right-of-way constraints of the project, an agreement was reached to allow a narrow canopy tree species, Desert Willow (*Chilopsis linearis*, likely a narrower cultivar), to be planted in the 8-foot landscape area with some branching of mature trees extending over the cycle track or bicycle lane. But the final recommendation of the CTF and the approved alignment by the Mayor and Council has resulted in a typical sidewalk width of 5-feet and a 5-foot off-set from the curb. This will not allow for the planting of a tree without an additional exception from the TDOT Landscape Architect; the 12-foot wide streetside area defined in Section 7.1.2 of the DCR would also need further discussion with the TDOT Landscape Architect.

Utility Clearances: Trees shall be not closer than 15-feet from a light pole. Trees shall be at least 10-foot clear of sewer lines, unless the sewer line is 5 or more feet deep in which case small or shallow rooting trees may be planted closer than 10-feet but not directly over the sewer line. At the TDOT Landscape Architect's discretion, in some cases, trees may be planted within the 10-foot clear area if a root barrier or other approved measure is used.

Maintenance and Plant Selection: Use of native Mesquites is encouraged, preferably in an upright multi-trunk form. All plant materials shall be on the City of Tucson Unified Development Code approved plant list and selection should consider watering needs in Categories 1 and 2. Groundcover planting should be kept to a minimum and placed so one side of each plant is accessible for maintenance. In order to maximize the plant material investment, shrubs and groundcovers should be minimal. Tree planting should be emphasized.

8.5.3 Rainwater Harvesting: Tucson's Green Streets Policy

The City of Tucson's Green Streets Policy calls for capturing and detaining a half inch of precipitation falling in the project right-of-way. That water is to be retained or detained in ponding areas, and used to provide supplemental irrigation for landscaping. The ponded depth can be no greater than 8 inches. In cases where the green streets goal cannot be fully met, measures to retain as much rainfall as possible should be taken.

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Given the limited right-of-way width, it is unlikely that this goal can be met over the entire length of the Broadway Boulevard project. There are however several locations where meaningful retention may be possible. Existing excess right-of-way on the north side of Broadway between Euclid and Park may be large enough to accommodate some amount of detention. The large city-owned parcel on the north side of Broadway between Olsen and Plumer appears to have already been graded and landscaped with the intention of providing green street effects. There are also several parcels in the vicinity of Campbell that are potential full acquisitions but lack the depth for redevelopment. The ability to use these for retention should also be explored.

As the right-of-way acquisition process proceeds, other parcel remnants may be found that are not large enough for redevelopment and could potentially be used for retention. The ultimate green streets scheme will become clearer as the acquisition process unfolds.

City Green Streets Active Practices Guidelines

City of Tucson policy for green infrastructure is for designs that retain, detain, infiltrate, and/or filter runoff from the street and sidewalk in landscaped areas behind existing or proposed curbs (parkways and medians). Water is retained or detained in depressions (basins, swales) or back of mounding (berms). This runoff is to be used for supplemental watering of plant materials within the public right-of-way. Where runoff exceeds retention and infiltration capacity, it should be slowed, spread, and/or filtered through vegetation to remove debris and sediment from the water before it returns to natural watercourses. Civil and landscape design shall include infrastructure to meet the intent of this process and incorporate materials, grading, and amenities to be compatible with both this effort and the project functions for street, drainage, pedestrian, and landscape.

8.5.4 Use of Desert Plants

Low Impact Development and Green Infrastructure principles apply to selecting plants that can live within the available resources of Tucson's desert southwest climate. Water is a limited resource; therefore, plants that require the least are the most preferred. Many plants imported from all over the world can survive in Tucson, but they often require diligent attention as well as unreasonable amounts of water. Therefore, native plants are preferred. A full list of recommended plants can be found in Pima County's *Low Impact Development and Green Infrastructure Guidance Manual*.

Though desert plants can survive on minimal water or endure drought conditions, they will typically look better and bloom more profusely with a rainy year. When there is a year of abundant rainfall, these plants will look their best. If the year leans toward a drier average rainfall, then the supplemental water that green streets practices provide may be the difference between the plant's survival and its demise.

The survival capabilities of these plants are dependent on many conditions: prevailing winds, sun exposure, soil type and quality, duration of extreme cold or heat, adjacent surfaces or structures, etc. One plant may not do well in cold seasons, but when placed against a west or south facing wall, it will perform year-round. Another plant may like wet conditions, but if the soil doesn't drain well, and the wet condition lasts too long, that plant may not survive. Sometimes a simple adjustment to a current condition will permit the plant to thrive in your landscape.

Although some native plants look good or are evergreen year round, many plants in this region have a dormant season. For some plants, looking poorly doesn't last too long and occurs during the heat of the summer; for others it falls in the chill of winter. Once the dormancy is over, the plant may need to be cut back to prepare for the growth season.

Plant selection depends on a careful evaluation of specific site conditions. Local nurseries that have a history of providing plants that work in harmony with Tucson's local conditions should be consulted before selection and planting.

8.5.5 Streetscape to Enhance Corridor Character

The 2012 Existing Conditions report noted that walkable neighborhoods, proximity to major transportation routes, strong and active neighborhoods, and independent businesses were major assets to the Broadway corridor. Streetscape improvements present an opportunity to enhance these existing assets.

For example, banners or public art can highlight the Sunshine Mile business district identity or historic neighborhoods. Selection of flowering plants or those with unique forms or other characteristics can be used to highlight the different nodes and segments of community activity along Broadway.

8.5.6 Public Art in Streetscape Design

Public art can be a strong visual component of streetscape design in support of defining community character, highlighting nodes of activity and gateways, as well as other important characteristics of the street and the community along it.

The specific locations of and designs for public art as part of the Broadway Boulevard project will be identified as the design of the project progresses. There will be opportunities for public input as locations are identified and designs are created.

The following describes some concepts that can be considered as the Broadway Boulevard design progresses:



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Corridor Art Projects

A series of art projects can be crafted by one or more artists to make a collection of related artworks that compositionally and thematically form a whole. This approach would add unity to the Broadway Boulevard improvements, and could lay the groundwork for the other art opportunities.

Gateway Art Projects

A sequence of gateway projects could be placed at major intersections to announce various districts/community nodes along Broadway Boulevard. These could emphasize both the individual character of each district, as well as the concept of continuity for the Broadway Boulevard corridor. Each Gateway could be created by an individual artist or artist team and have its own unique identity and approach.

Medium-Scale Streetscape Art Projects

Medium-scale streetscape projects can be proposed for a variety of locations. These could include elements such as solar lighting, shade structures, street furniture, recycling stations, street light attachments, and bus-stop related amenities. They should reference the history of the specific location or Tucson itself. It is recommended that the artworks be located close to the bus stops. Approaches may range between a small number of objects located near a bus stop to a larger collection of small elements along the entire section.

Pavement Art Projects

Pavement art projects may be located in heavily used pedestrian areas such as adjacent to bus stops, on sidewalks, walkways, and medians associated with HAWK crossings. These projects could be imbedded directly into the sidewalk or median island pavement. These small-scale works will provide a sense of discovery and delight for pedestrians of all ages. They may also provide neighborhood identification and markers for specific places.