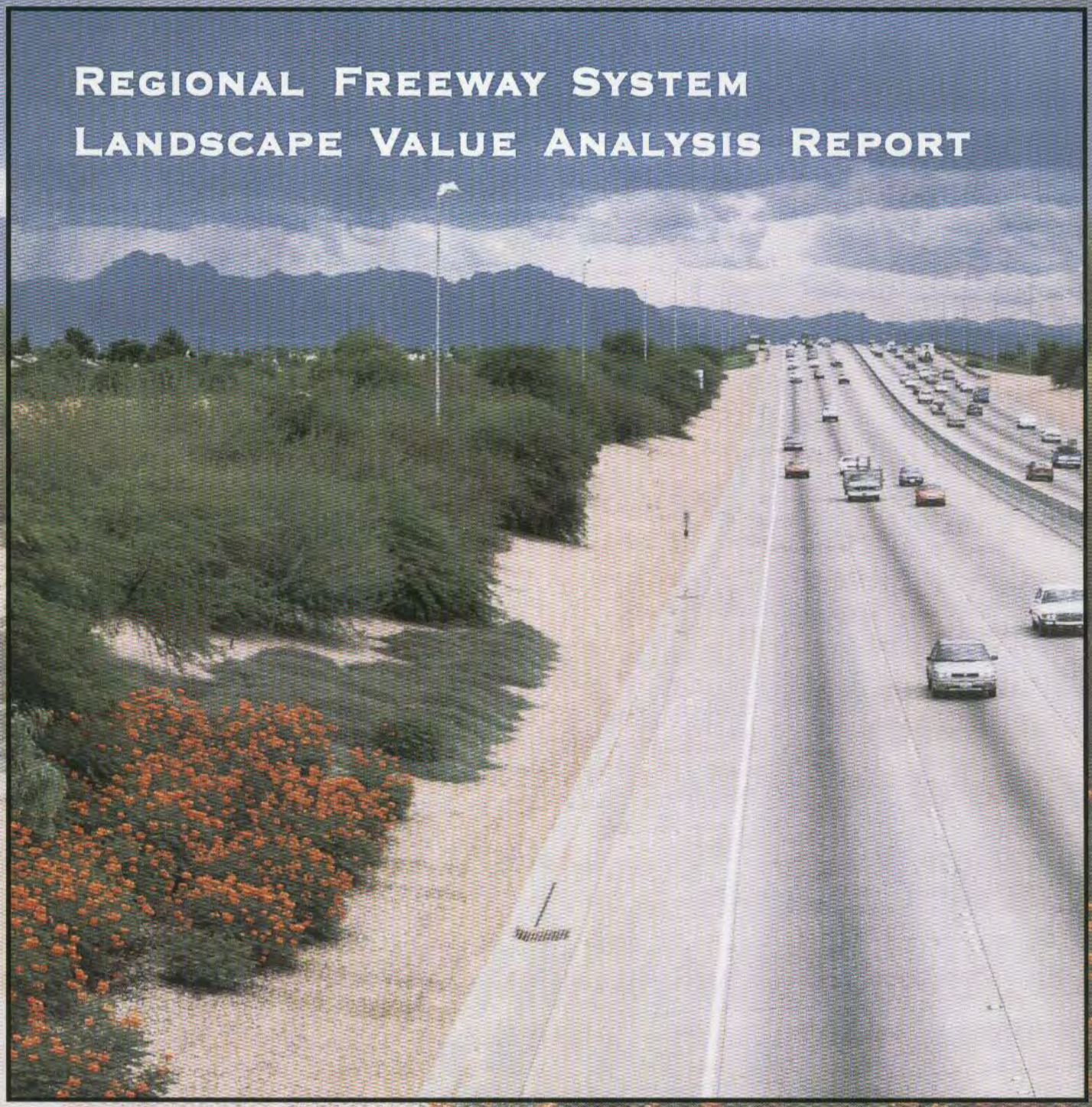
Regional Freeway System
Landscape Value Analysis Report



Arizona Department of Transportation

August 1997

Arizona Department of Transportation
Regional Freeway System
Landscape Value Analysis Report

Written, edited and prepared by

Wheat Scharf Associates

under the direction of

Joseph R. Salazar

ADOT Transportation Roadway Engineering Group

Roadside Development Section

Published and Copyright held by the

Arizona Department of Transportation, Intermodal Transportation Division

Roadside Development Section

205 South 17th Avenue, Room 297

Phoenix, Arizona 85007

ACKNOWLEDGEMENTS

VALUE ANALYSIS COMMITTEE

Following is a list of participants:

LeRoy Brady	Arizona Department Of Transportation (ADOT) Roadside Development
Harry Woelzlein	ADOT Roadside Development
Joseph R. Salazar	ADOT Roadside Development
Hope Nasco-Gibson	ADOT Roadside Development
Dan Lance	ADOT Construction District
Ted Littlefield	ADOT Construction District
Mark Schalliol	ADOT Maintenance District
Clifton Taylor	ADOT Maintenance Group
Steve Bruflat	ADOT Roadway Design Group
Rod Curtis	ADOT Special Programs Section
Bob Gustafson	ADOT Special Programs Section
Dennis Scholtz	City of Phoenix
Mark Landrith	City of Phoenix
Steve Priebe	City of Phoenix
Katherine Emery	City of Glendale
Viesturs Kalva	City of Mesa
Ruben Valenzuela	Daniel, Mann, Johnson, & Mendenhall
Elizabeth Wheat	Wheat Scharf Associates
Joanne Gallaher	Wheat Scharf Associates
Rick Genteman	Former ADOT Department State Engineer

Also participating as technical experts were:

George Hull	V & P Nursery
Niko Vlachos	V & P Nursery
Rob Palfreyman	V & P Nursery
Bob Underwood	AAA Landscape
Tom Yerkey	Valley Crest Landscape
Cheryl Goar	Arizona Nursery Association
Bart Worthington	Arizona Nursery Association
Ron Gass	Mountain States Wholesale Nursery

Thank you to the Citizens Transportation Oversight Committee (CTOC) members for their time and effort in reviewing and adopting the contents of this report:

Robert Bergstrom	Carefree
Fred Burkhart	Gila Bend
Chuck Coughlin	Phoenix (Chairman)
Rick Duncan	Maricopa Co. District 5
Keno Hawker	Mesa
Ed Johnson	Youngtown
Ernest Kleinschmidt	Goodyear
Janet W. Lee	Scottsdale
Rev. Al Lindemulder	Chandler
Leo Mahoney	Maricopa Co. District 2
Jack Murphy	Wickenburg
Jack Nylund	Maricopa Co. District 4
John M. Rotz III	Glendale
Richard Ruth	Paradise Valley
Barry Starr	Maricopa Co. District 3

EXECUTIVE SUMMARY

GOALS OF REPORT

The goals of this report are to identify the baseline needs and requirements for landscape treatment along the Maricopa Association of Governments (MAG) freeway system and recommend the most cost effective approach to meet these needs and requirements.

THE GOVERNOR'S PLAN

In January of 1995, the Governor's Office issued the "Governor's Plan" which commits to the completion of the MAG Regional Freeway System. A primary aspect of the Plan was cost reductions on future freeway segments, to allow for the construction of additional miles of freeway. The Plan proposed cost savings that reduced lighting, landscape treatments and widths of structures (bridges), and eliminated lanes. This proposal raised significant aesthetic and environmental concerns for the surrounding communities.

The Plan -- approved by the MAG Regional Council in January 1995 -- called for elimination of all trees and shrubs from traditional landscape treatments, restricted all future efforts to a nominal layer of rock mulch (i.e., decomposed granite), and reduced construction budgets accordingly.

The elimination of landscape treatments was the most contested part of the Governor's Plan. Plantings greatly enhance the aesthetic appeal of urban freeways and are one of the reasons for widespread acceptance of freeways. The majority of the public and the local jurisdictions recognized that landscape was included when the initial corridor studies and design concepts were adopted and they did not support the elimination of this feature.

This Report analyzes the proposed reductions in landscape treatments, suggests alternatives and recommends a course of action.

THE COMMITTEE'S WORK

The landscape budget previous to the Governor's Plan was based on $750,000 per mile (1992), which included approximately $350,000 for decomposed granite and $400,000 for plants, irrigation and miscellaneous items (Actual costs on some freeway segments were approximately $900,000 per mile).

A Value Analysis Committee, including the Arizona Department of Transportation (ADOT) and representatives from the MAG cities and from the engineering and landscape industries, was formed with the initial charge to develop landscape design concepts that fit the Governor's Plan budget of $350,000 per mile. After initial study, however, the Committee determined that 1) the reduced budget only provides for minimum erosion control treatment and was not sufficient for even meager planting mitigation and 2) the actual cost savings represent only a very small percentage of the cost of completing the freeway system. Given this and the environ-

mental requirement that any roadway project adequately mitigate negative impacts of its development, the Committee created alternative concepts. The concepts were then applied to the design of an actual project. The Committee's goal for the alternatives and applications is *appropriate* and *cost effective* landscape treatment along the MAG freeway system. *Appropriate* means taking advantage of the many quantitative and qualitative benefits of urban landscapes. *Cost Effective* means insuring real, measurable and long term value.

THE ANALYSIS:

- examines the comparative effectiveness of the Governor's Plan, recently and not so recently designed landscape treatments for the MAG urban freeway system
- reviews the *Landscape Design Guidelines for Urban Highways (1988)*
- considers alternative landscape concepts
- discusses quantitative and qualitative costs and benefits of the Committee's alternatives
- reviews federal NEPA and other environmental requirements (erosion control, air quality, etc.)
- reviews local development codes of the affected MAG jurisdictions for consistency
- includes a survey of potential sources of supplemental funding

THE ALTERNATIVE CONCEPTS:

- include minimum level of mitigation that development of the freeway system must provide
- meet environmental requirements
- vary the application of inert materials, grading, erosion control and water harvesting
- vary the use of trees, shrubs, ground covers, seed mixes and irrigation for them
- include short and long term maintenance and replacement (life cycle) cost considerations

APPLICATION OF THE CONCEPTS:

- recognizes that land use and design requirements change over the course of the system
- involves combining concepts in response to a visual prioritization process (see page 2-7 for a description)
- recognizes the need for additional research

CITIZENS TRANSPORTATION OVERSIGHT COMMITTEE (CTOC)

Approximately 90 percent through the Value Analysis and report writing effort, the CTOC decided to recommend re-funding landscape treatments along the MAG freeway system (December 1996). An average budget of $650,000 per mile was set. The final landscape concepts and budgets included in this report conform to this recommendation.

RECOMMENDATIONS AND CONCLUSION

The beneficial effects of plants are widely known. They filter pollutants, add oxygen to the atmosphere, help control erosion, increase the value of residential and commercial properties and provide psychological benefits. Freeway plantings provide a positive community image, attract visitors and businesses and encourage appropriate plantings by others. Arizona is a state which relies heavily on its tourism industry. Landscaped streets and freeways add to Arizona's image as a scenic state with a high quality of life and a concern for the environment. Municipalities require private developments to include landscape plans, as one way to compensate the community for the increased noise, traffic, heat and stormwater runoff associated with urban development. Unplanted freeways would not be consistent with local or national standards.

There are a variety of beneficial landscape concepts appropriate to the MAG Freeway System that conform to current budgets. The effective application of these concepts can mitigate many of the negative impacts of freeway development. The Value Analysis Committee recommends the following:

1. Incorporate plant materials as a part of the construction of all segments of the MAG Urban Freeway System.
2. Adopt a landscape construction budget of $650,000 per mile, with appropriate percentages added for design, engineering administration, and contingencies. This reflects a 20% reduction from recent projects.
3. Develop future landscape budgets based on a per acre amount on a project to project basis.
4. Maintain a flexible approach to landscaping which would allow adjacent communities to fund higher levels of landscaping (such as increased plant size and density).
5. Apply a visual prioritization process to future MAG freeway segments, in relation to funding and expenditures.
6. Consider long term maintenance and life cycle costs in the design and budgeting process.
7. Select landscape design concepts that maximize environmental, economic and aesthetic benefits of plants, while meeting cost reduction goals.
8. Update the *Landscape Design Guidelines for Urban Highways* publication.
9. Maximize the effectiveness of landscape and mitigation funds (first) within each jurisdiction, and (second) on each project.
10. Continue to include topsoil and irrigation sleeving in the roadway construction budget.
11. Adopt an appropriate budget on a per mile, per year basis, for landscape maintenance.

It is true that, with or without plants, additional freeway miles will make life easier for commuters and travelers. Easier commutes are not without a price, however. Traditionally, adjacent neighborhoods have born the brunt of urban freeways, through higher noise and air pollution levels, intrusion of traffic and incompatible land uses, and severed connections with schools and other neighborhoods. In response to this, ADOT's urban freeway investments of the past decade have included attractively designed noise walls, grade separated pedestrian and bicycle crossings, traffic intrusion controls and desert adapted plantings. These features help mitigate the impacts of the freeway on those who live nearby, as well as providing community-wide environmental, aesthetic and economic benefits.

The Value Analysis Committee recognized that the metropolitan area would be best served by effective landscape treatments along all of its freeways, even if it meant delaying construction of a few miles of freeway. The community echoed these concerns, and in December 1996 the MAG Citizens Transportation Oversight Committee recommended restoring funding for freeway landscaping, with a budget of $650,000 per mile. This budget represents enough money to plant and irrigate a modest quantity of trees and shrubs (from small containers) and to cover 60 to 80 percent of the landscape area with decomposed granite. It also allows varied treatments to be applied within a given jurisdiction or project (based on a visual prioritization process) in order to respond to varying land uses, views and screening needs. Additional funds may be contributed by municipalities and/or private sources in order to increase plant densities, add specimen plants or otherwise upgrade what can be accomplished within the $650,000 budget.

In this way, landscape costs will be reduced from what has been spent in the past decade, while maintaining vegetative cover, cohesive design themes and meeting varying environmental, aesthetic and economic goals.

TABLE OF CONTENTS

APPENDICES

PART 1
REPORT GOALS AND BACKGROUND

A. GOALS

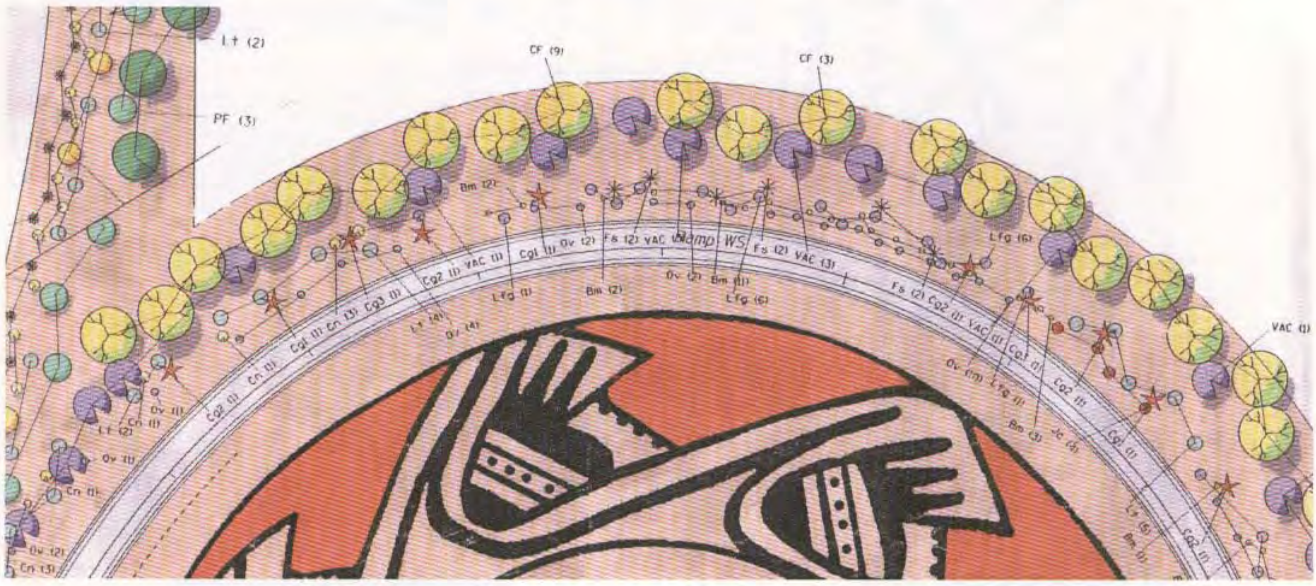
The goals of this report are identification of baseline needs and requirements for landscape treatment along the Maricopa Association of Governments (MAG) freeway system and recommendation of the most cost effective approach to meet these needs and requirements.

B. BACKGROUND

MAG freeway system facilities are constructed and maintained by the Arizona Department Of Transportation (ADOT), with cooperation of the adjacent, local jurisdictions. On October 8, 1985, the voters in Maricopa County approved Proposition 300 to establish a one-half cent, transportation excise tax for construction of the MAG regional freeway system. This legislation was in effect through December 31, 1994. These funds were supplemented by State Highway User Revenue Funds (HURF) and federal funds on some segments of the system.

On November 8, 1994, the voters rejected Proposition 400 that proposed an extension of the Proposition 300 plus a half cent sales tax for an additional 10 years (through 2015). Proceeds of the extended tax would have been divided equally among freeways and alternate modes of public transportation.

On December 13, 1994, in response to the defeat of Proposition 400, Governor Symington presented a plan to complete more of the MAG regional freeway system. The Governors' Plan (referred to as the 'Plan') in-



cluded additional funding from higher sales tax forecasts, a greater allocation of MAG federal funds earmarked for freeways, reductions in lighting, landscape treatment and structure (bridge) widths, and a reduction in the number of miles.

In January 1995, the State Transportation Board and the MAG Regional Council approved the Plan for public review and comment, and it was incorporated into the Adopted Life Cycle Program.

Project locations and the budget for each segment are shown on the Plan (see Governor's Regional Freeway Plan). Each project is evaluated for funding by MAG as part of the Transportation Improvement Program. The 1990 Federal Clean Air Act requires that all transportation plans and projects be in conformance with applicable air quality plans. To comply with this requirement, MAG conducts a conformity analysis on proposed transportation projects. Projects are partially selected based on their potential impact to air quality in the MAG area.

The current Life Cycle Program and Long Range Plan for the MAG freeway system contains a total of 155 miles of freeway, with approximately 4,650 acres of potential planting area. As of December 1996, forty (40) miles of freeway had been completed, and twelve (12) miles were under construction. Approximately 56 additional miles were funded and 47 more planned. The plan includes approximately 3,240 acres of budgeted landscape areas and an additional 1,410 acres planned. For purposes of this Analysis, the total number of miles and acres budgeted were considered to be 108 miles and 3,240 acres, respectively.

C. VALUE ANALYSIS COMMITTEE

The relatively extreme nature of the reductions proposed in the Plan implied significant aesthetic and environmental impacts to the surrounding communities and raised legal questions. This Value Analysis study was requested by ADOT's Roadside Development Section, to evaluate the portion of the Plan which addressed the reduction in landscape treatments along the MAG system. A Committee was formed in the Spring of 1995 that included representatives from each of the MAG jurisdictions; ADOT representatives from highway design, maintenance, and roadside development; and private sector landscape architecture and engineering firms.

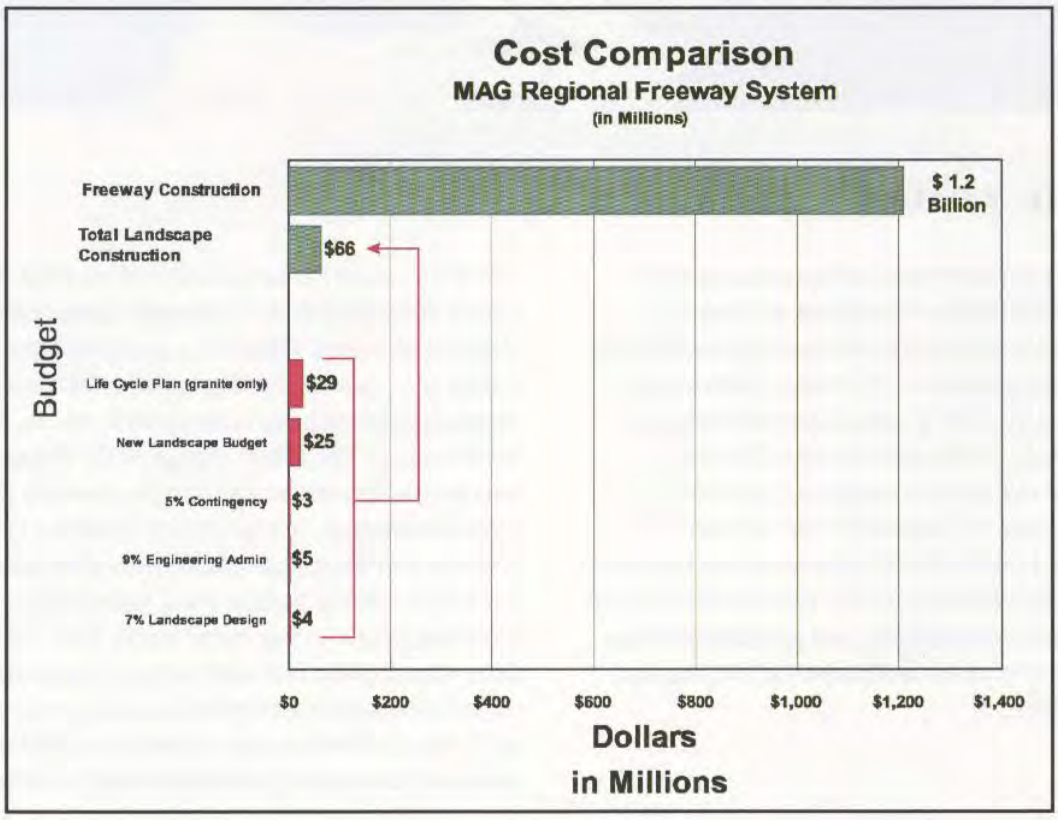
The Plan called for elimination of all trees and shrubs from traditional landscape treatments, restricting all future efforts to a nominal layer of rock mulch (i.e., decomposed granite) on freeway segments that do not have committed funds for full landscaping. The initial charge of the Committee was to develop landscape design concepts that fit the proposed budget. Committee members expressed concern that the granite mulch only alternative would not be acceptable both to local jurisdictions and the traveling public. After initial study, the Committee determined 1) the reduced budget only provides for the minimum erosion control treatment and was not sufficient for even meager planting mitigation and 2) the actual cost savings represent only a very small

percentage of the cost of completing the system (see figure showing Cost Comparisons). Accordingly, the Committee agreed to identify and analyze alternatives that would provide higher value and greater aesthetic benefit, and address the need for cost reduction.

Following the kickoff meeting, held on May 17, 1995, the Committee met monthly to discuss the potential effects of the new policy and to brainstorm alternative cost reduction ideas. There was much discussion about the many and various functions of roadway landscape: controlling erosion, increasing motorist safety, providing a buffer for the residents living adjacent to the roadway, and improving the environment. The Committee also addressed the concept of the landscape as an investment in the economic success of the community, and the role of freeway landscapes in the tourism industry.

These discussions set the stage for the generation of diverse ideas during the brainstorming sessions. Refinement and development were performed by several subcommittees.

Operating under environmental requirements that any roadway project adequately mitigate negative impacts of its development, the Committee created alternative concepts. The concepts were then applied to the design of an actual project. The Committee's goal for the alternatives and applications is *appropriate* and *cost effective* landscape treatment along the MAG freeway system. *Appropriate* means taking advantage of the many quantitative and qualitative benefits of urban landscapes. *Cost effective* means insuring real, measurable and long term value. These ideas are evaluated and documented in this report.



D. CITIZENS TRANSPORTATION OVERSIGHT COMMITTEE DECISION (CTOC)

Based on growing public and political demand and a recognition of the value associated with plant materials, the MAG Citizens Transportation Oversight Committee (CTOC) decided to recommend re-funding landscape treatments along the MAG system (December 1996) at an average budget of $650,000 per mile. This decision was made when this study was approximately 90 percent complete. The final landscape concepts and budgets included in this report conform to this decision.

E. BASELINE LANDSCAPE COST

Traditional Budgets. Construction budgets for traditional landscape treatments, which conform to ADOT's Landscape Design Guidelines, were approximately $600,000 per mile of freeway in 1985. Each mile of freeway typically includes approximately 30 acres of landscape area. These figures allow for typical traffic interchanges and above, below or at grade freeway designs. The traditional 1985 landscape budget calculated on a 'per acre' basis is approximately $20,000 per acre. Adjustments for inflation indicate that the traditional landscape budget in 1996 dollars would be $851,521 per mile, or $28,384 per acre.

The Governor's Plan called for 1) a reduction of landscape budgets to $350,000 per mile or approximately $11,700 per acre and 2) the installation of granite mulch only; no trees, shrubs, ground covers or irrigation systems. The baseline cost of $350,000 per mile (or $11,700 per acre) was taken from a 1991 cost analysis prepared by ADOT Roadside Development (see Appendix C). The baseline cost included a two inch deep layer of decomposed granite mulch (at a cost of approximately $8,800 per acre) plus allowances for mobilization, traffic control and construction administration. Recent bid tabs indicate that today's cost for the baseline treatment of decomposed granite mulch only would be in the range of $410,000 per mile, based on 100 percent coverage and 30 acres per mile. The $350,000 budget allows for approximately 80 percent coverage. Other areas would be left as raked earth.

Projected savings with the Governor's Plan was the difference between the previous budget amount of $750,000 per mile and the Governor's budget amount of $350,000 per mile, a projected savings of $400,000 per mile. This would amount to a total savings of over $43 million dollars if projected for the remaining 108 miles of the funded MAG system. While this sounds like a significant amount of money, it amounts to only four percent of the total freeway construction cost. The 43 million dollar savings would fund the construction of approximately 4.4 miles of freeway.

The Governor's Plan budget and projected savings were calculated without adjustments for inflation. It is likely that $350,000 per mile will not provide adequate erosion control on some projects today.

F. COMMITTEE VALUE ANALYSIS PROCESS

With the background of the discussions of landscape function and the budget parameters proposed in the Plan, the Committee weighed costs and benefits of the Plan, the projected savings, and the alternatives. Following review of actual construction bids for a host of recent roadway projects, the Committee acknowledged that actual costs will vary depending on a multitude of factors unique to each project.

The Committee, during the Value Analysis process, reviewed the current practice, traditional and nontraditional landscape concepts, and explored new ideas and approaches for increased cost effectiveness. Specifically, the Committee:

- reviewed the traditional and current MAG landscape policy
- identified landscape elements
- considered construction, maintenance and replacement (life cycle) costs
- reviewed environmental requirements (erosion control, air quality, etc.)
- considered codes, policies and responsibilities of adjacent jurisdictions
- reviewed the application of a visual analysis as a cost effective approach
- considered design, land use, roadway configuration and other variables

The Committee selected eight, distinct landscape concepts for analysis purposes. Application of some cost effective concepts are demonstrated on a new freeway in the metropolitan area, the Sky Harbor Expressway.

The Committee concluded its work with final recommendations for future MAG freeway system landscape efforts, summarized in Section IV.

PART 2
VALUE ANALYSIS FINDINGS

A. HISTORY OF MAG LANDSCAPE POLICY

The landscape portion of the freeway system includes treatment of residual right-of-way adjacent to road shoulders and medians through grading and the installation of plants, irrigation and inert rock materials. Guidelines for the design of these areas in urban settings were published in 1988. Budgets for implementing the landscape guidelines have been based on a per mile cost. Considering the Governor's proposal and the findings in this report, guidelines and budgeting procedures will require updating.

1. BRIEF SUMMARY OF "LANDSCAPE DESIGN GUIDELINES FOR URBAN HIGHWAYS" (1988)

The 1988 Guidelines include design features, regional context and design objectives for landscape treatments along Arizona's urban highway system. The purpose of these guidelines is "to ensure a comprehensive and unified approach to landscape design throughout the urban highway system." Highway development in residential areas often requires noise abatement walls and frontage roads. In cross-section, highways may be at grade (level), elevated, depressed or a combination.

The approach labeled as "traditional" in this report is actually an innovative approach developed by the Arizona Department of Transportation (ADOT) in the mid 1980's. This approach sets efficient standards for landscape design along urban highways. For example, the guidelines call for the use of widely spaced, desert trees planted from small containers (five gallon and one gallon). Plantings are concentrated where they are most needed.

Plants. Plant material (trees, shrubs and ground covers) has many uses along highways. Design considerations include responses to: physiographic landmarks and topography, surrounding land use, roadway profile and on-site functional requirements. Design objectives include:

- minimizing need for supplemental irrigation
- controlling stormwater runoff—using it for irrigation where possible— and protecting banks against erosion
- mitigating negative impacts to surrounding communities
- minimizing headlight glare
- helping keep drivers alert and promote motorist safety
- minimizing maintenance requirements including provision of good maintenance access
- preserving desirable views and screen undesirable views to and from the roadway
- reducing perceived scale of roadway and structures
- salvaging and/or reusing existing vegetation, when possible
- reinforcing community identity and regional character
- reduction of heat island effect

The guidelines include details for: spacing and massing —along roadsides, in medians and at interchanges—

erosion control, drainage channels, detention basins, and other site specific features.

Planting design concepts include:

- graduated height of plant materials: shorter trees closer to the roadway and taller trees at the edge of the right-of-way
- palm trees or other vertical accents at interchange bridges
- coarse textured plants used as "sculptural elements" at key decision points
- concentrating colorful shrubs and ground covers at interchanges
- plants used to define highway space and screen views of the highway
- a unique identity for the highway from community to community, or land use to land use
- grade changes to reduce the height of noise walls, direct stormwater runoff and create aesthetically pleasing land forms

Inert ground covers. The guidelines instruct that inert ground covers —decomposed granite and other rock material— be used for visual enhancement, erosion control and to complement planting, grading and drainage concepts. For example, roadsides with slopes of 1:4 and steeper should be treated with inert ground cover where not planted continuously with shrubs or ground cover plants, for erosion control purposes. The guidelines state that decomposed granite shall not be used in medians or on roadside areas along at-grade sections of roadway.

Irrigation. The guidelines state that irrigation should be an automatic, low-pressure drip system. Irrigation water is designed to stay within each jurisdiction, as the local jurisdiction provides water, at no cost to the State.

2. MAG Freeway Landscape Budgets and Actual Costs

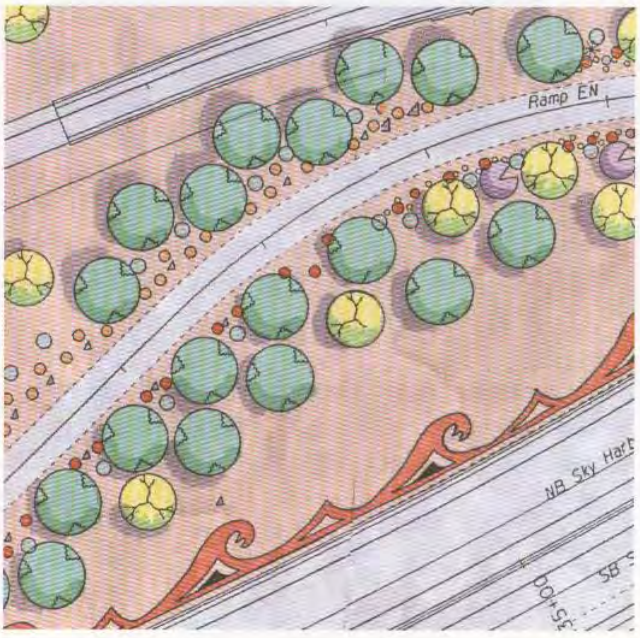
As previously mentioned, prior to the enactment of the Governor's Plan, traditional MAG freeway landscape funds were based on budgets of $600,000 per mile (1985-91) and $750,000 per mile (1992-94). Based on the Committee's analysis of eleven constructed segments of the MAG freeway system, actual costs have ranged from approximately $525,000 per mile to $865,000 per mile. Costs have averaged $675,000 per mile, and $21,800 per acre, over the past ten years.

Actual costs vary depending on site specific conditions along each segment. It is important to note that a low cost per mile does not imply a low cost per acre. The actual cost data shows a range of 19.8 to 48.5 acres per mile with an average of 30 acres per mile. Costs per acre range from $13,468 to $28,686. Further, the project with the lowest cost per acre had a higher relative cost per mile of $653,000. The variation in figures and their relationships mean that establishing accurate landscape construction budgets requires a cost per acre basis and careful review of the project for site specific requirements.

3. Landscape Practice Under the Life Cycle Program and Long Range Plan

In an effort to be responsive to the wishes of ADOT's MAG customers and still operate within the guidelines of the Governor's Plan, the Department adopted the position that landscaping can be added to the system if the local jurisdiction is willing to fund the added cost of the irrigation, plants, construction engineering and contingencies and to assume the maintenance of the landscaping (estimated to cost approximately $35,000 per mile per year). Two cities, Glendale and Phoenix, entered into Inter-Governmental Agreements (IGAs) to landscape three miles of the Agua Fria, and two miles of the Squaw Peak, respectively. As part of the IGAs, the department agreed to fund the landscaping design and to contribute $10,000 per mile annually toward the landscape maintenance.

There are several problems with the above practice. While it has resulted in plans to landscape an additional five miles of the Regional Freeway System, the two IGAs will result in a $50,000 annual maintenance commitment that cannot be met by the Phoenix Maintenance District budget. Under this scenario, it is likely that many miles of the system would remain unlandscaped, which would continue to be an issue with the public. At the same time, approximately nine miles of the Pima Freeway on the Salt River Pima Maricopa Indian Community will be landscaped as one of the conditions of their Grant of Easement for the freeway. In addition, it now appears that ADOT will be required to provide some level of landscaping of the Federal Aid eligible corridors of the system since landscaping was addressed in the environmental document approval. It would be difficult to justify why these freeways will be landscaped while many others will not. Finally, several jurisdictions have suggested that the savings from any design changes agreed to by the local jurisdiction should be used to fund the local share of the landscaping. This and other "creative contribution" proposals have resulted in on-going conflict and lack of a consistent approach to the issue of landscaping the MAG urban freeway system.



B. BENEFITS OF PLANTS

The benefits of plants are generally grouped into two separate categories - Qualitative and Quantitative. Qualitative benefits, while as important, are intangible and have significant, but no monetary value. Quantitative benefits can be assigned a tangible, monetary value.

Qualitative benefits generally include social, psychological, recreational, and aesthetic values. These beneficial aspects of plants in the urban environment are well documented. Quantitative benefits include reduction of heat island temperatures, air pollution, stormwater runoff, and energy usage. This translates to an increase in the economic value of the property.

1. QUANTITATIVE BENEFITS.

Air quality. Trees and plants improve air quality in a number of ways. These are primarily grouped into two categories: air pollution removal, and atmospheric carbon dioxide reduction. Trees and urban vegetation:

- alter air flows and lower air temperatures through transpiration, which can reduce the formation of ozone.
- trap carbon compounds and particulates, such that the removal of local pollutants is increased.
- absorb Carbon Dioxide and other gaseous pollutants, including Carbon Monoxide, Ozone, Sulphur Dioxide and Nitrogen Dioxide.
- release Oxygen, as a product of photosynthesis.
- reduces wind speed so that heavy particles can settle out.

The projected air quality benefit over the life of an urban highway tree in a recent Chicago, Illinois study was determined to be $55 per tree, at present dollar value.[7]

Incidentally, urban trees need to be carefully selected to avoid problems associated with allergenic pollen and volatile organic compounds.

Heat island reduction. The temperature in metropolitan Phoenix has increased four degrees in the past 20 years.[8] Trees planted throughout the urban area can reduce and break up heat islands, by providing shade and by increasing air flows through transpiration and localized reductions in air temperatures.[9]

Reduction of stormwater runoff and increase in groundwater recharge. Trees and other vegetation can reduce stormwater runoff and the associated costs by retaining precipitation in the canopies and increasing absorption into the ground surface. Multiuse recreation/stormwater detention basins are an example of utilizing urban vegetation to maximize these benefits.

Energy usage reduction. Significant energy and water savings can be realized from using trees and shrubs to shade buildings, as well as from evapotranspirational cooling generated by increased vegetation densities.[10]

Economic. Trees and vegetation have economic value and have been shown to increase real estate values and decrease the time needed to sell property. **The current collective value of community street trees in Mesa, AZ is approximately $21,120,000**. Other economic impacts of trees have been shown as increases in tourism and increased shopping in commercial areas.[11]

2. Qualitative Benefits.

Social. Plant materials in the urban area fulfill three main social roles: 1) as natural elements in a human made landscape, 2) as aesthetic objects in design compositions and 3) as a social object expressing power, status or prestige.[1] Trees and other plants can symbolize and evoke religious, spiritual, political, memorial and commemorative events and experiences. As aesthetically pleasing elements in the city scape, plants play an important role in the social fabric and enhance the social quality of the community.[2] Having access to yards, parks and natural areas is often an indication of economic status in the urban environment.

Health. Plant materials in the urban area can result in a restorative experience, where people are refreshed, reflection is encouraged, and pressures of the outside world are reduced. "Restorative experiences produce large benefits for a relatively small investment...".[3] Plant materials have also been shown to improve physical health.

Recreation. Detention basins and excess rights of way associated with freeway projects provide opportunities for a full spectrum of active and passive recreational activities. Providing cover and forage can attract birds and butterflies to an adjacent neighborhood.

Aesthetic. As an art form, plant materials in the urban area can bring artistic design and scenic beauty into people's everyday lives. Moreover, scenic values in the urban landscape involve people's ability to make sense of the landscape and function in it.[5] Plant materials are a common visual mitigation tool, reducing harsh, negative visual impacts of new roadways and other elements of the built environment.

3. Benefit - Cost Analysis

It is possible to project actual cost/benefit values on urban highway plantings. A comprehensive benefit-cost study was conducted on the Chicago, Illinois urban forest, utilizing a computer model (C-BAT) developed to quantify various management costs and environmental benefits of urban tree planting. A portion of the study analyzed the benefit-cost ratio of multiple plantings of a single species of tree along selected highway sites. The study took into account the following benefits and costs:

Benefits

Heating/cooling energy savings
Absorption of air pollution
Reduction in stormwater runoff

Costs

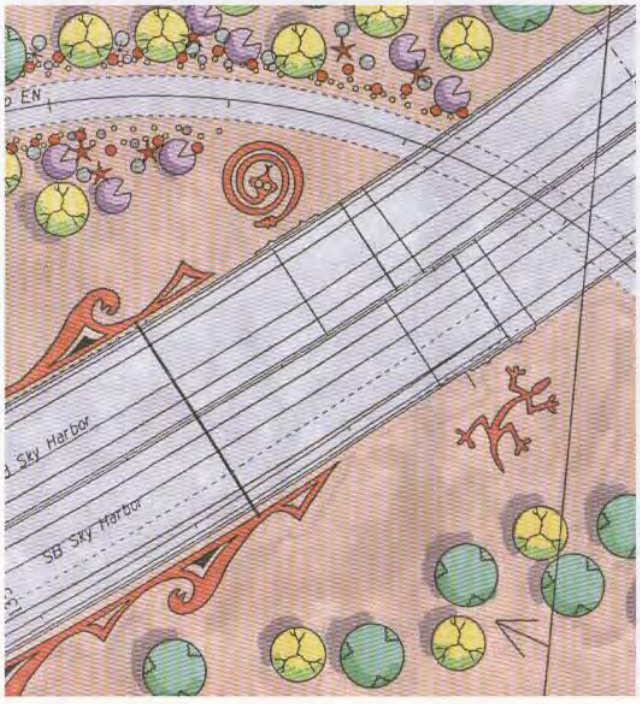
Cost of tree
Planting
Maintenance - pruning, removal
Irrigation
Infrastructure repair
Waste disposal
Liability

The resulting benefit-cost ratio was 2.3:1 for trees planted along urban highway sites.[12]

While conditions on the MAG urban freeway system differ from highways in Chicago, Illinois, many circumstances are similar. A positive benefit-cost analysis is anticipated for trees and plants along the MAG system as well.

4. Community Recognition of Benefits

The landscape ordinances developed and enforced by the various jurisdictions in the Maricopa Association of Governments (and summarized on page 2-9) are evidence of local recognition of the value of fostering the urban landscape. Developers often exceed the minimum standards in the ordinances in an effort to increase the value of their developments. Some cities and developers have expressed interest in supplementing the landscapes planted along MAG freeways. The City of Glendale and Arizona Mills in Tempe are examples of public and private entities which have contributed additional funds for landscape along the MAG freeway system; at SR 101, 75th to 51st and the US 60/I-10 Interchange, respectively.



C. LANDSCAPE DESIGN VARIABLES, REQUIREMENTS AND ISSUES

MAG Urban Freeway segments vary in their requirements and opportunities for landscape treatments. The primary variables include:

- environmental mitigation requirements and funding source(s)
- code requirements (local municipal)
- cooperation of the adjacent jurisdiction
- multi-use opportunities
- design factors:
    - desired character of the new freeway segment
    - the freeway configuration
    - land uses of adjacent properties
    - visibility and impacts of the freeway on adjacent properties and vice versa
    - life cycle costs

The MAG urban freeway designer will need to assess the above variables and issues to develop a landscape design which is responsive to the needs of the project.

1. Environmental Requirements

Vegetation plays an important role in meeting many of the environmental requirements along urban freeway projects. MAG freeway system funds come from both State and Federal sources. The environmental analysis requirements for proposed projects vary depending on the funding source.

On projects with Federal Funds, or approval, compliance with the National Environmental Policy Act (NEPA) is required. Unless a project is excluded from NEPA, an Environmental Assessment (EA) is prepared to determine if the project has the potential to create significant adverse impacts. If it is determined to create such impacts (that cannot be fully mitigated), an Environmental Impact Statement (EIS) must be prepared. The highest level of environmental study under NEPA is an EIS.

On projects with State Funds only (no Federal funds), the highest level of environmental study typically required is an Environmental Assessment (EA). A mitigated EA requires that the design of the project include measures to mitigate negative impacts such that the impacts are no longer significant.

Both an EA and an EIS disclose the project's impacts, and identify measures to mitigate (lessen) the negative impacts. With an EIS, the impacts do not have to be fully mitigated to a level that is below "significant" (as with an EA), but the expected results are fully disclosed, with public review and comment periods.[13]

Federally funded projects may be required to meet environmental criteria in excess of state funded projects. These requirements may include, but are not limited to the following:

Impacts on Minorities or Economically Disadvantaged Groups. An Environmental Justice analysis is required for Federal Aid projects. This analysis considers disproportionate impacts to minorities or economically disadvantaged groups.

Park Land Impacts. A Section 4(f) analysis, regarding impacts on park or recreation land is required for Federal Aid transportation projects.

Public and Agency Involvement. A public hearing is required for Federally funded projects in the EIS process. The review requirements are more extensive for Federally funded projects. For example, an EIS requires review by the Environmental Protection Agency and the Department of Interior. An EA also includes less extensive public

disclosure and review periods.

Aesthetic Concerns and Impacts regarding visual quality are brought forward through the public involvement process. In urban areas, there are no environmental regulations regarding impacts on visual resources. Mitigation measures are generally developed as a result of public review of visual impacts and comments regarding desired levels of mitigation. On the MAG freeway system, particularly on Federally funded projects where an EIS is conducted, it is more likely that aesthetic concerns will be identified by constituent groups, due to the longer and more formal review process required. In that case, the use of plant materials along the freeway system could be a determination or outcome of the required mitigation measures. In that situation, adjustments to the budget would have to be made to incorporate the required environmental study. Some projects, such as the Price Freeway, are committed to full landscape through the draft EIS, because of public input and mitigation of visual impacts.

Other differences include procedure, level of detail and significance of impacts and mitigation. Procedural requirements are more extensive for Federal Aid projects, that include specific Federal Register requirements. In the EIS process, a full range of alternatives must be analyzed to the same level of detail (historically, two to three action alternatives are analyzed). All impacts must be fully disclosed. In the EA process, a single alternative can be carried forward. An EA can result in a 'finding of no significant impact' (FONSI), as a result of the effectiveness of the designated mitigation measures, or as a result of not anticipating any significant impacts. If an EA determines that impacts are going to be significant, and Federal Funds or approvals are involved, the study should be reclassified as an EIS.

Several environmental requirements are the same for both Federal and State funded projects:

Air Quality Conformance processes and requirements. Air quality requirements for the MAG area are governed by the (federal) Clean Air Act.

Major air pollutants in urban areas are carbon monoxide (CO), predominantly from automobiles; nitrogen oxides (NO_x), mainly from automobiles and stationary combustion sources; ozone (O_3), formed through chemical reactions involving the principal precursors of NO_x and volatile organic compounds; sulfur dioxide (SO_2), emissions mostly from stationary combustion sources; and particulate matter (PM10 - small particulate matter such as dust and chemical reactions involving gaseous pollutants).[14]

The entire Phoenix metropolitan area is in nonattainment (an extreme condition) for CO, PM10, and ozone.

MAG freeway projects are currently prioritized and funded, in part, according to their impacts on air quality because of the extreme condition in the Phoenix area. Projects with a landscape component may be ranked higher than those without plants, in recognition of the function of plants in improving air quality by filtering particulates and sequestering carbon compounds. (See Part 2B, Benefits of Plants)

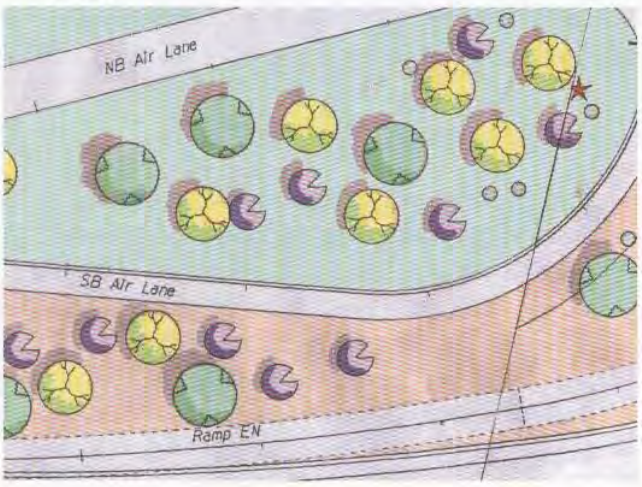
A project can result in adverse impacts on the environment by exceeding National Ambient Air Quality Standards (NAAQS). The air pollutant index compound has typically been CO. If a violation does occur, federal level measures need to be incorporated into the design to reduce the violation to a "non-violation". MAG has a list of

major projects for the five-year program for which macro scale violations have been modeled. If violations occur at this scale, then projects need to be reorganized to prevent predicted future violations.

If MAG funds a project which results in the worsening of air quality to a level which exceeds allowable Valley limits, federal funding assistance could be jeopardized.

Noise Abatement Requirements The State of Arizona has adopted Federal Highway Administration (FHWA) noise requirements. If a proposed project approaches or exceeds 67 decibels in residential areas, it will require noise mitigation. Walls are typically required to mitigate urban freeway noise.

Erosion Control Requirements The National Pollutants Discharge Elimination System (NPDES) component of the Clean Water Act regulates the point discharge of pollutants into surface waters. Granite mulch has been accepted to meet erosion control requirements for slopes up to a maximum of 3:1. Vegetation and established seeded areas with grasses and forbs also meet erosion control requirements.



2. Code Requirements of Adjacent Municipalities

The various jurisdictions in the Maricopa Association of Governments (MAG) have developed landscape ordinances that provide standards and requirements for the installation of landscape materials for all new and expanded development. The purpose of these ordinances is to:

- promote the general welfare of the public
- encourage attractive and logical development
- aid in the enhancement of property values
- create aesthetically pleasing city streets
- provide appropriate buffers between incompatible land uses and protection from intense activities
- aid in conserving water by encouraging the use of a variety of plants, trees and shrubs indigenous to arid regions and characterized by low-water consumption
- reduce heat island effect

Typical requirements of the jurisdictions include prescriptions for densities of plant material, irrigation systems and treatment of impervious surfaces as well as an accepted plant list of drought tolerant species. Comprehensive landscape ordinances have been adopted by the jurisdictions of Scottsdale, Mesa, Tempe, Chandler, Glendale, Phoenix and the Salt River Pima Maricopa Community. These exemplify visions of community, street character and development held by contemporary urban designers and planners. The communities in the MAG area have seen how urban areas around the country have deteriorated due to poor planning and the lack of restrictions concerning urban development. They have also taken a stand on making their communities more sensitive to the environment around it, by promoting plant materials that exemplify low-water use characteristics and are indigenous to the desert Southwest.

Although ADOT is not legally required to meet the code requirements of the separate jurisdictions, the level of landscape design and construction of MAG freeways to date has been compatible with the intent of the adjacent jurisdiction ordinances. ADOT has made an effort to foster a cooperative working relationship with the other jurisdictions. Several projects have moved forward with special cooperative agreements in place, resulting in a shared responsibility and use of landscape areas within the ADOT right-of-way.

3. Responsibilities of adjacent jurisdictions

Adjacent jurisdictions have traditionally been responsible for providing irrigation water for construction and continued maintenance of new landscapes along freeways within their boundaries. In addition, local jurisdictions provide maintenance on sections of cross streets that pass over or under ADOT freeways and along frontage roads and areas outside the control of access that parallel the freeway. There are also a few special agreements with local jurisdictions where multiuse retention basins, located within the ADOT right-of-way, are maintained by that jurisdiction.

4. Design Factors

a. Character of the Corridor

The designer also considers the desired character of the new freeway corridor, considering the experience of the freeway traveler, as well as how it fits into the adjacent neighborhood and community. For example, scenic views of the surrounding mountains from the freeway are protected or enhanced to add to the overall character of the corridor.

b. Land Use

Land use varies significantly along the MAG freeway system routes. Land use categories impacted by the proposed freeway system include:

- residential
- retail
- business
- recreational/open space/public parks
- industrial
- agricultural

The designer must consider the future impacts on adjacent land as part of the design process. For example, views to and from the freeway will require visual screening along residential areas and other situations.

c. Freeway Configuration

The configuration of the freeway, whether it is elevated, depressed, at grade or a combination is an additional design consideration. For example, in residential locations where the freeway is depressed below grade, screening *may* not be required to the extent of at grade or above grade freeway construction (although, air quality and traveler considerations may require the use of plants in any case).

d. Visibility

Visibility and visual mitigation are important considerations for the freeway landscape design. A cost effective visual analysis and mitigation process, the *Visual Prioritization Process*[15], is described for application on the MAG system.

Visual Prioritization Process (VPP)

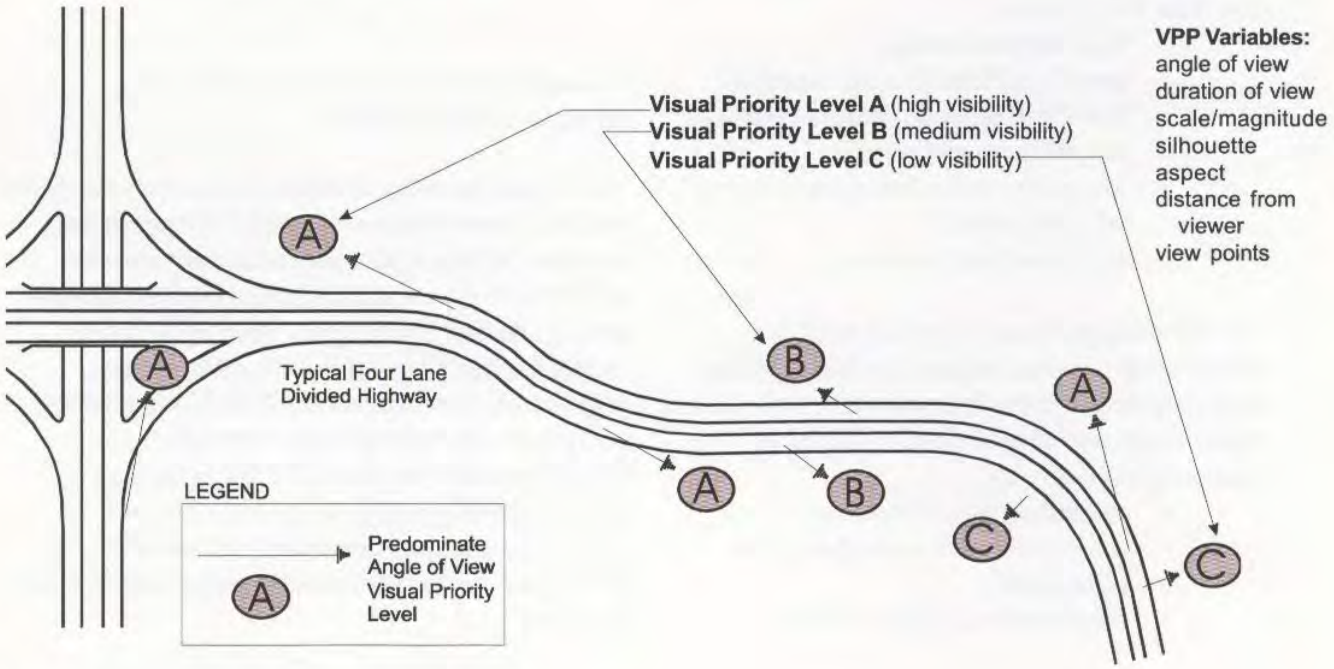
Past efforts to mitigate the negative impacts of freeway construction have tended to involve the consistent application of mitigation measures along entire corridors. The VPP recognizes that there are variations in the visual conditions, visibility and the significance of visual elements along a corridor. Available funding can be more wisely used and environmental concerns better met by varying the

amount of mitigation in various sections along the corridor according to the visibility of proposed impacts. The VPP uses numerical values, based on visual criteria, which help analyze the impacts and design appropriate mitigation measures. The VPP is also an effective communication tool for use among the planners, engineers, owners and constituent groups.

The VPP identifies visual units and elements along a corridor, quantifies impacts from alternative designs under consideration and evaluates costs and effectiveness of alternative mitigation measures. The process can be used in preliminary planning phases to analyze alternatives, construction document preparation, and has also been used during construction and maintenance. The VPP is most accurate when it is based on actual roadway plans or alternatives. It is recommended that the initial VPP be conducted for each project between the 30% and 60% roadway plan development stage.

Visibility Criteria of the VPP and Results The VPP analysis takes the following criteria into account:

- number of viewpoints from which the project is visible
- magnitude or scale of the area
- distance (or distances) from which the area is viewed
- slope or aspect
- angle of view
- time of day
- duration of view
- silhouette condition



Schematic of VPP Applied to Typical MAG Freeway Section

Based on an inventory of these criteria, the final VPP results indicate three levels of visibility known as Visual Priority Levels (VPL):

- High, areas with the highest level of mitigation needs
- Medium, areas with average level of mitigation needs
- Low, areas with the lowest, or no, level of mitigation needs

Typical Examples of Visual Priority Levels along MAG Freeway System The following areas would typically result in a High VPL, with a high Landscape Mitigation Budget per acre due to visibility within and adjacent to the right-of-way:

- interchanges
- beginning of curve
- large fill slopes facing residential areas and parks

Conditions which may be factors in the designation of a High VPL area are:

- high degree of change
- loss of significant existing vegetation
- new visual elements within the right-of-way that need mitigation
- low quality views from right-of-way to adjacent parcels
- high constituency concern

The following areas would typically result in a Medium VPL, with an average Landscape Mitigation Budget per acre due to average visibility within right-of-way, and average visibility and impact adjacent to right-of-way:

- straight sections of roadway
- medium sized fill slopes that are not highly visible
- transition from high to low area
- other visual mitigation requirements are being met with other budget items (walls, freeway alignment, etc.)
- medium constituency concern

The following areas would typically result in a Low VPL, with the lowest Landscape Mitigation Budget per acre due to low visibility within right-of-way, low visibility and nominal impacts adjacent to the right-of-way:

- straight sections of peripheral roadway that are not highly visible
- small fill slopes that are not highly visible, or that face away from the viewer

Typical freeway locations with a Low VPL are areas with :

- low levels of change and loss
- good adjacent views from right-of-way
- low constituency concern

e. Life Cycle (Maintenance and Replacement) Costs

The Committee discussed maintenance costs associated with the "decomposed granite only" concept in the Governor's Plan. A summary of an analysis —by ADOT staff— used as background for these discussions is attached to this report. Primary landscape maintenance activities are weed control, pruning, irrigation equipment repair and litter pick-up. ADOT staff reported the average annual overall cost at $40,000 per mile, of which $12,200 is the base cost associated with decomposed granite (litter pick-up, weed control, and erosion repair), with an additional $27,800 associated with planted areas (landscape and irrigation).

It can be anticipated that both weed control and litter

pick-up costs may increase from existing costs with the Governor's Plan, because planted areas "hide" weeds and litter to some extent. Public awareness of weeds and trash may actually increase, leading to lower tolerance for these unsightly elements.

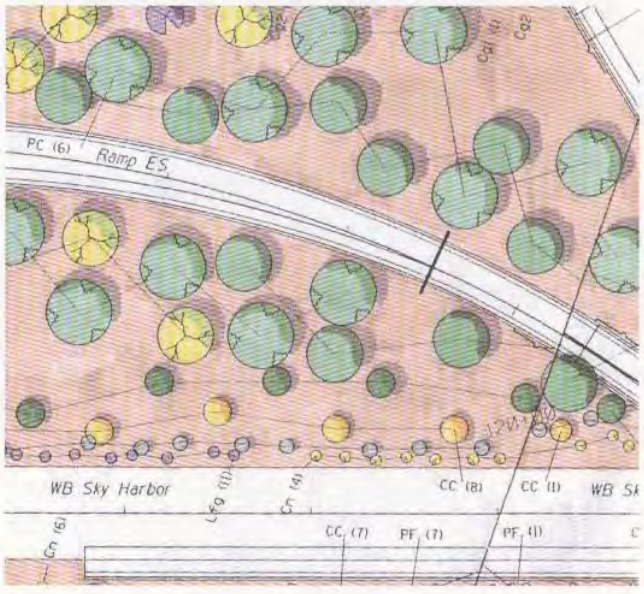
Life Cycle costs are long term expenses, analogous to preventive maintenance for utility systems. These include replacement of dead or declining plant materials and worn out or damaged irrigation equipment.

Budgeting for Life Cycle costs implies either 1) setting aside current funds for the future, 2) hoping or expecting that funds will be made available when the time comes or 3) obligating future budgets. Regarding the first of these, ADOT already has a budget set-aside type program for asphalt pavement and it may be appropriate to follow suit for landscape replacement. Secondly, it may be operationally effective to include replacement costs as an allocation of or supplement to routine maintenance budgets. As for the third implication, budgeting is an annual process and it is not legal to commit future legislatures to any expenditures.

The extent of the Life Cycle effort can range from simply removing and replanting a dead tree or shrub with a container-grown replacement, to wholesale removal and replacement of entire landscapes including irrigation.

Professional maintenance personnel confirm that drip-type irrigation systems on the whole will last ten to fifteen years. However, one should expect to replace the moving parts of control valves annually. In ADOT's experience, drip emitters may last only six months to three years, depending on other activity in the area. An accidental break in a line can contaminate and clog small orifices. Low-flow bubbler or other systems may have greater longevity though their use may be restricted to level conditions. It is generally agreed that disturbance is the greatest factor in the failure of irrigation equipment.

Plant life expectancies have been shown to be significantly shortened by the stresses associated with urban environments (e.g., excessive wind, heat build up and reradiation preventing nighttime low temperatures). Maintenance costs need to include regular replacement of dead or declining plant material in urban settings.



f. Additional Funding Sources

The Committee identified and discussed several potential funding sources to supplement the funds available through ADOT for the MAG freeway landscape construction. These include:

- ISTEA Transportation Enhancement Funds. These funds have been used for components of several projects on the MAG system where landscape treatments were over and above the 'normal' treatment, e.g., land graphics, provision of multiuse areas and tree salvage.

- Community assistance. The adjacent communities may participate in a form of landscape funding partnership. Cities already contribute to the projects by providing irrigation water and maintaining those sections of the freeway outside the Control of Access, normally including cross streets and frontage roads.

- Developer assistance. Arizona Mills in Tempe, contributed funds to increase plant sizes at the US60/I-10 interchange.

- Generating landscape funds by leasing space to outdoor advertising companies on bridge abutments, retaining walls and noise walls. This would require legislation, design guidelines and negotiations with the Outdoor Advertising Industry.

- Involve volunteer groups in the planting and maintaining of freeway sections, similar to the Adopt-a-Highway program.

- Develop an infrastructure bank. Municipalities could borrow from the bank for landscape construction, and pay the fund back at a later time, when additional funds are available.

These ideas, generated by the Committee, may be explored as potential sources of funds to supplement the funding available from Federal and State sources.

PART 3
LANDSCAPE CONCEPTS

Landscape concepts are designed to meet the multitude of functional, environmental and aesthetic requirements generated by the development of the freeway system. The Value Analysis committee produced a number of landscape concepts for future application and study.

The concepts presented are intended to compare different approaches, and show the different effects and corresponding costs for possible cost reduction strategies.

The $650,000 budget approved by the Citizens Transportation Oversight Committee represents enough money to plant and irrigate a moderate quantity of small trees and shrubs and to cover most of the landscape area with decomposed granite. Landscape Concepts 6 and 7 (pages 3-14 to 3-17) are examples of treatments which conform to this budget. The other Concepts are included for comparison. They range in cost from $7,000 to $34,000 per acre or approximately $210,000 to $1,020,000 per mile. Part 4 explains how a combination of these Concepts might be applied within a given jurisdiction or project in order to respond to varying land uses, views and screening needs.

It is important to state that the landscape concepts do not address design decisions such as: corresponding time frame for effective mitigation, water uses over time, density and massing, visual variety, character of area (informal vs. formal), adjacent jurisdiction requirements (re: overlapping right of way line with tree canopy, etc.), visual transition from one concept/application to another, sculptural statements, selection of plants for texture, color, seasonal bloom, etc. These factors are addressed in the Landscape Design Guidelines for Urban Highways.

A. LANDSCAPE ELEMENTS

The Committee identified a number of landscape elements, which are typically combined for various landscape concepts. Landscape concepts typically describe the use of one or more materials or elements. Following is the full list of landscape elements and concepts identified by the Committee:

- decomposed granite only (the proposed landscape treatment of the Governor's Plan)
- "land graphics" (two-dimensional designs using a variety of inert materials)
- planting a seed mix, resulting in a mix of plants over time
- using only native plants, (e.g. a combination of salvaged cacti and succulents, seedlings (such as mesquite, acacia and creosote) and a seed mix. This concept includes an irrigation system for plant establishment, to be turned off except during plant establishment and periods of drought.
- accent/color plantings
- walls for retaining slopes and mitigating noise (not included in landscape budget)
- use of plants for screening (typically trees and shrubs, closely spaced)
- turf in detention basins where water would collect, usually in combination with trees
- trees in combination with various ground covers —inert and living— including: decomposed granite, soil stabilizer, river rock, trailing plants, raked earth and seed mix. This concept includes the idea of a mesquite bosque.
- use of plants to enhance and frame views
- staggered ledges and other specialized grading for water harvesting and visual variety
- ground cover plants only
- shrubs only
- cactus only
- farming/gardening in right-of-way
- inert ground cover materials (other than decomposed granite)
- seedlings only (e.g. mesquite bosque, creosote stand) - to be irrigated by hand until established

B. LANDSCAPE CONCEPTS

Several of the above elements have been combined into a sampling of eight landscape concepts for further discussion and analysis. While not a prescription for all of the MAG freeway system, the landscape concepts that follow will be applicable in various locations within the system, either alone or in combination with others. The concepts must be applied in ways that meet the site, safety, environmental and design requirements of specific projects.

The first concept is an example of a traditional MAG freeway project. This concept is included as a baseline against which all other concepts are measured. Each subsequent concept has been evaluated as to its effectiveness in mitigating impacts, as compared to Concept 1. The following ranking system was used:

Less	(less effective than traditional)
Same	(same effectiveness as traditional)
More	(more effective than traditional)

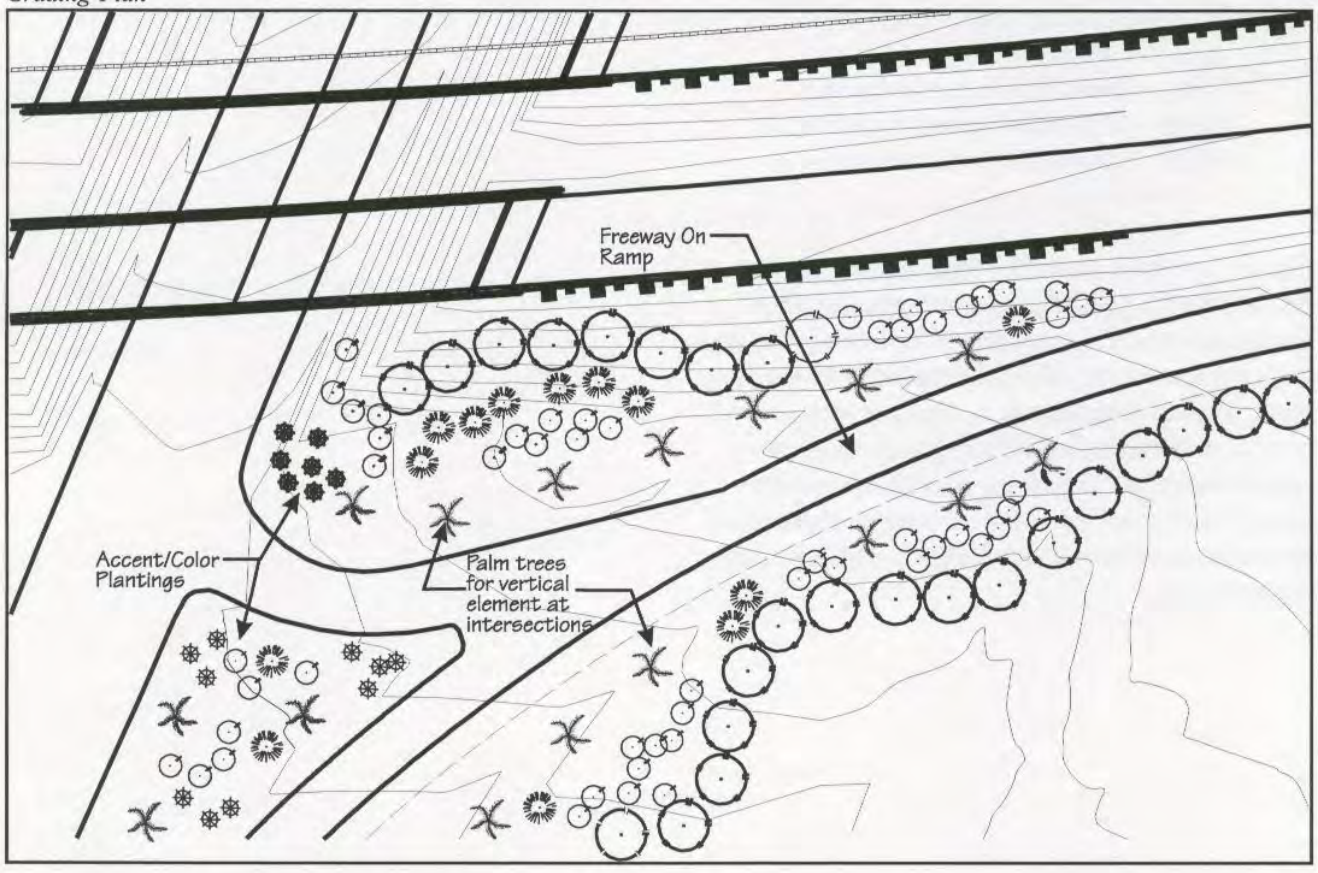
The per acre estimates of the eight landscape concepts do not include topsoil plating, rough grading, noise abatement walls, irrigation sleeves, or drainage facilities; these items are assumed to be included in the roadway costs. The estimates also do not include removal and/or salvage of existing vegetation, design, engineering administration, contingencies, or landscape maintenance. Most concepts include decomposed granite in bare areas in order to control erosion and dust. (see Appendix G)

Concept 1
Traditional Landscape

This concept includes a mixture of native and drought tolerant trees, shrubs, ground covers, and accent plants. Decomposed granite is used throughout to control erosion. This concept would typically be used in graded (nonnatural) areas and is consistent with area landscape ordinances. The Traditional Concept actually reflects a fairly modern xeriscape tradition developed over the past two decades. This concept is considered a landscape baseline against which all other Concepts are measured. Plant sizes and densities are based on a 1991 study by HNTB and are typical of MAG landscape projects from 1989 to 1994.

Coverage	
Plants	63%
Granite	100%
Irrigation	permanent
Plant Densities	
15 gal. Trees/acre	24
5 gal. Shrubs/acre	156
1gal. Shrubs/acre	88

Concept 1 - Landscape and Grading Plan



Mitigation Effectiveness of Concept 1	Less (less effective than concept 1)	Same (same effectiveness as concept 1)	More (more effective than concept 1)
aesthetics/visual benefits		Same	
air quality benefits		Same	
heat island benefits		Same	
stormwater runoff mitigation		Same	
economic benefits and impacts to tourism		Same	
urban aviary, wildlife and recreational benefits		Same	
maintenance efficiency		Same	
consistent with adjacent codes		Same	
controlling landscape installation costs		Same	
controlling irrigation installation costs		Same	
controlling water use and costs		Same	
life cycle (longevity of project)		Same	
fire hazard mitigation		Same	

Total cost per acre installed (estimate) **$34,000**

Traditional Landscape

SR 202 Red Mountain Freeway at 24th Street

Concept 2
Decomposed Granite only

A two inch thick layer of decomposed granite is spread and compacted over the entire landscape area. This type of application of decomposed granite has been shown to effectively control erosion from stormwater runoff. Other environmental effects are expected to be negative: increase in urban heat island and stormwater runoff volume, decrease in air quality. The Decomposed Granite Only concept does not conform to the landscape ordinance requirements of any of the jurisdictions within the MAG area. Litter control costs are expected to increase, however total maintenance costs would be reduced because of the lack of plants and irrigation. This type of treatment is appropriate only in low visibility areas.

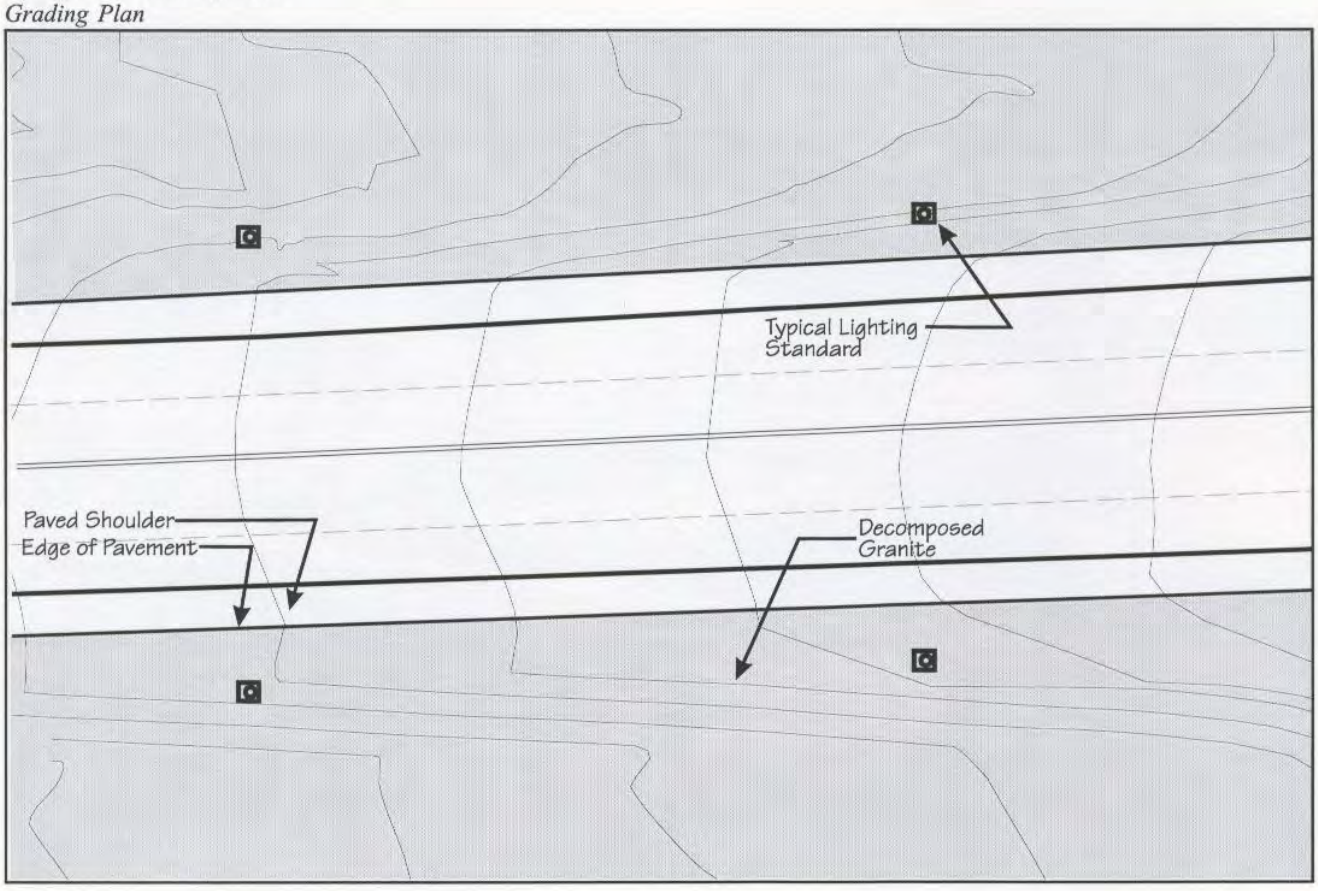
Coverage

Plants	0%
Granite	100%
Irrigation	none

Plant Densities

n/a

Concept 2 - Landscape and Grading Plan



Mitigation Effectiveness of Concept 2	Less (less effective than concept 1)	Same (same effectiveness as concept 1)	More (more effective than concept 1)
aesthetics/visual benefits	Less		
air quality benefits	Less		
heat island benefits	Less		
stormwater runoff mitigation	Less		
economic benefits and impacts to tourism	Less		
urban aviary, wildlife and recreational benefits	Less		
maintenance efficiency			More
consistent with adjacent codes	Less		
controlling landscape installation costs			More
controlling irrigation installation costs			More
controlling water use and costs			More
life cycle (longevity of project)			More
fire hazard mitigation			More

Total cost per acre installed (estimate) **$14,600**

Decomposed Granite Only

I-10 at 107th Avenue

Concept 3
Land Graphics

A variety of inert materials is placed to create a two-dimensional design that can be viewed from the highway. In this example, the design reinforces the Southwestern motif that contributes to the overall character of the freeway. Desert plantings can be added but are not included in the cost estimate. This is a good potential treatment for interchanges which have a large number of acres combined with high visibility.

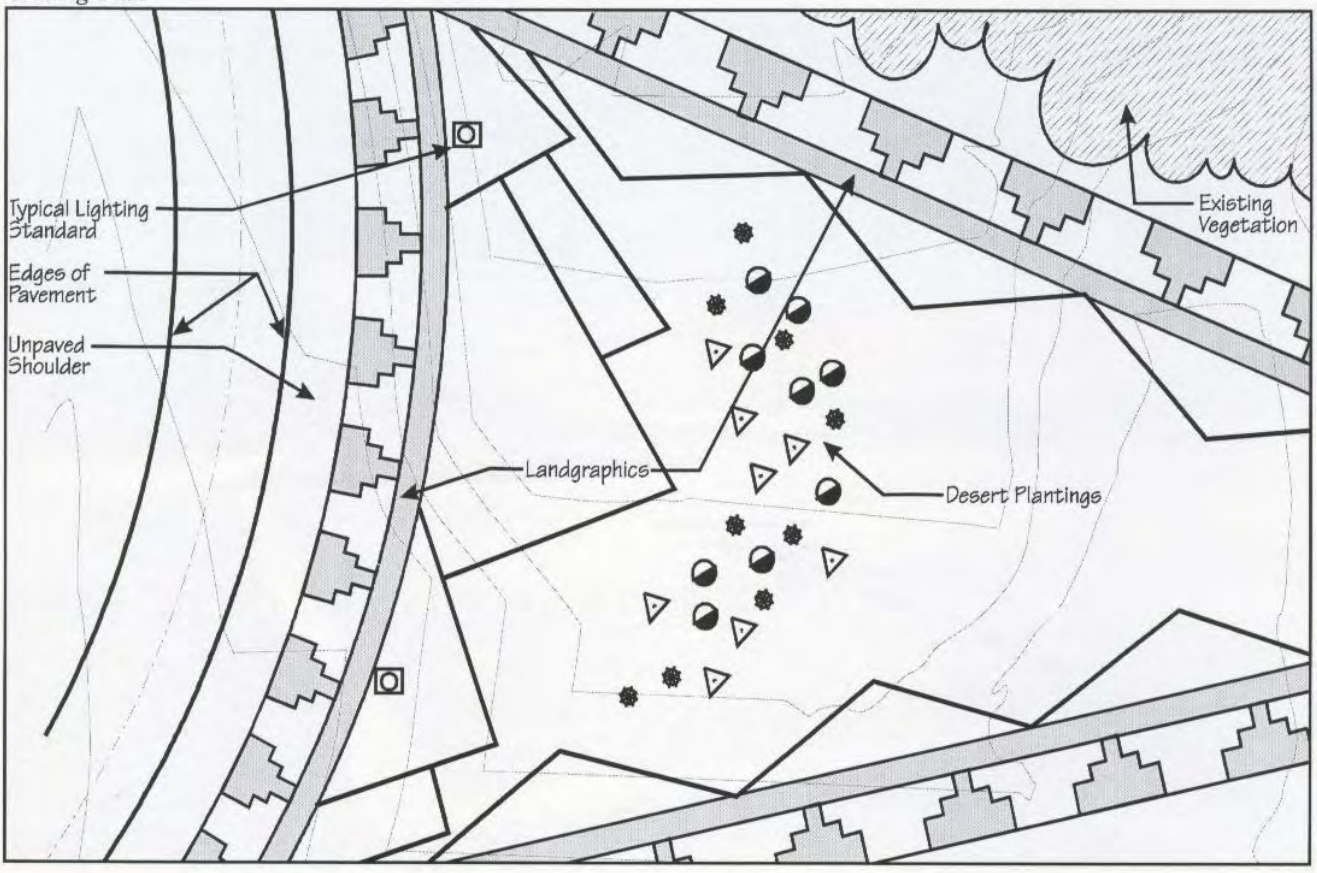
Coverage

Plants	0%
Granite	100%
Irrigation	none

Plant Densities

n/a

Concept 3 - Landscape and Grading Plan

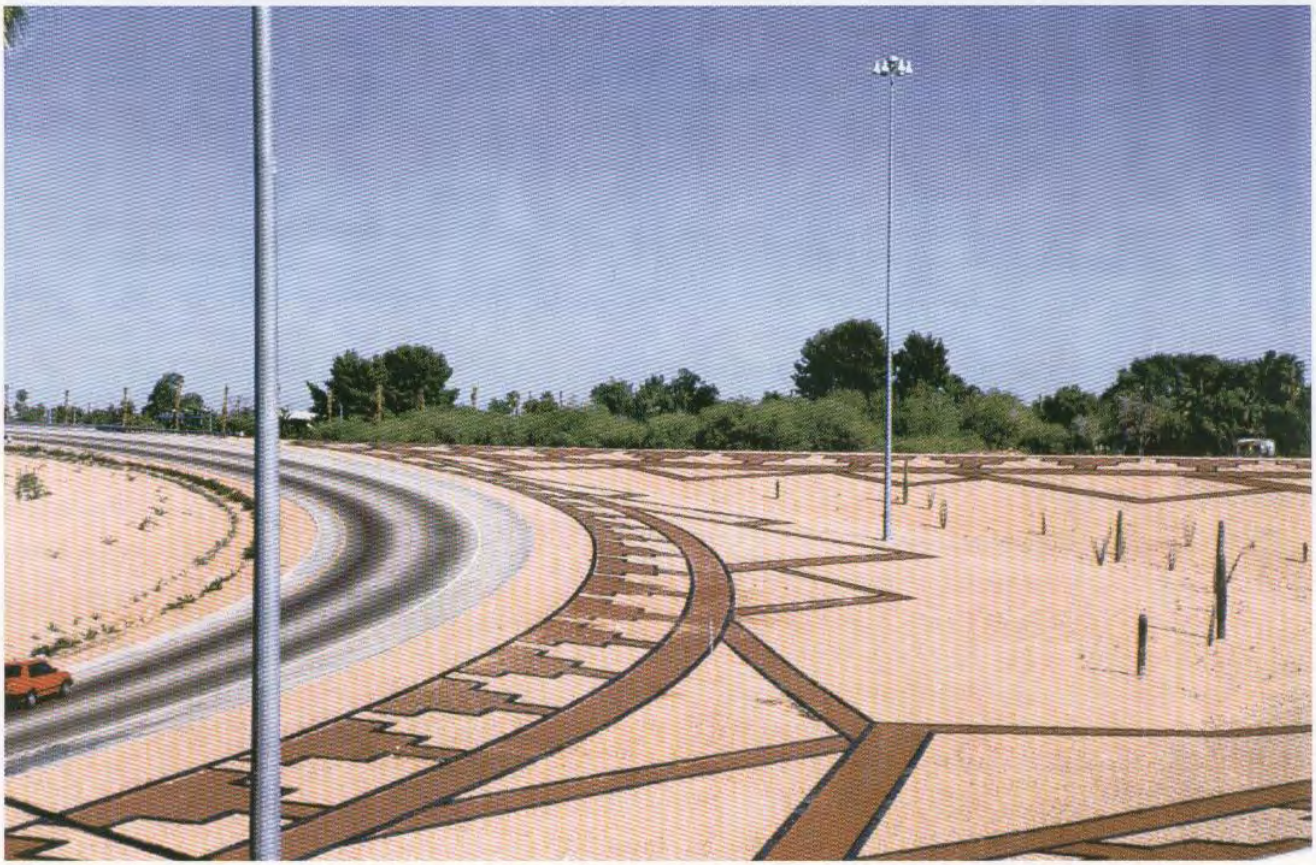


Mitigation Effectiveness of Concept 3	Less (less effective than concept 1)	Same (same effectiveness as concept 1)	More (more effective than concept 1)
aesthetics/visual benefits		Same	
air quality benefits	Less		
heat island benefits	Less		
stormwater runoff mitigation	Less		
economic benefits and impacts to tourism		Same	
urban aviary, wildlife and recreational benefits	Less		
maintenance efficiency			More
consistent with adjacent codes	Less		
controlling landscape installation costs			More
controlling irrigation installation costs			More
controlling water use and costs			More
life cycle (longevity of project)			More
fire hazard mitigation			More

Total cost per acre installed (estimate) **$25,000**

Land Graphics

Hohokam/Red Mountain Traffic Interchange

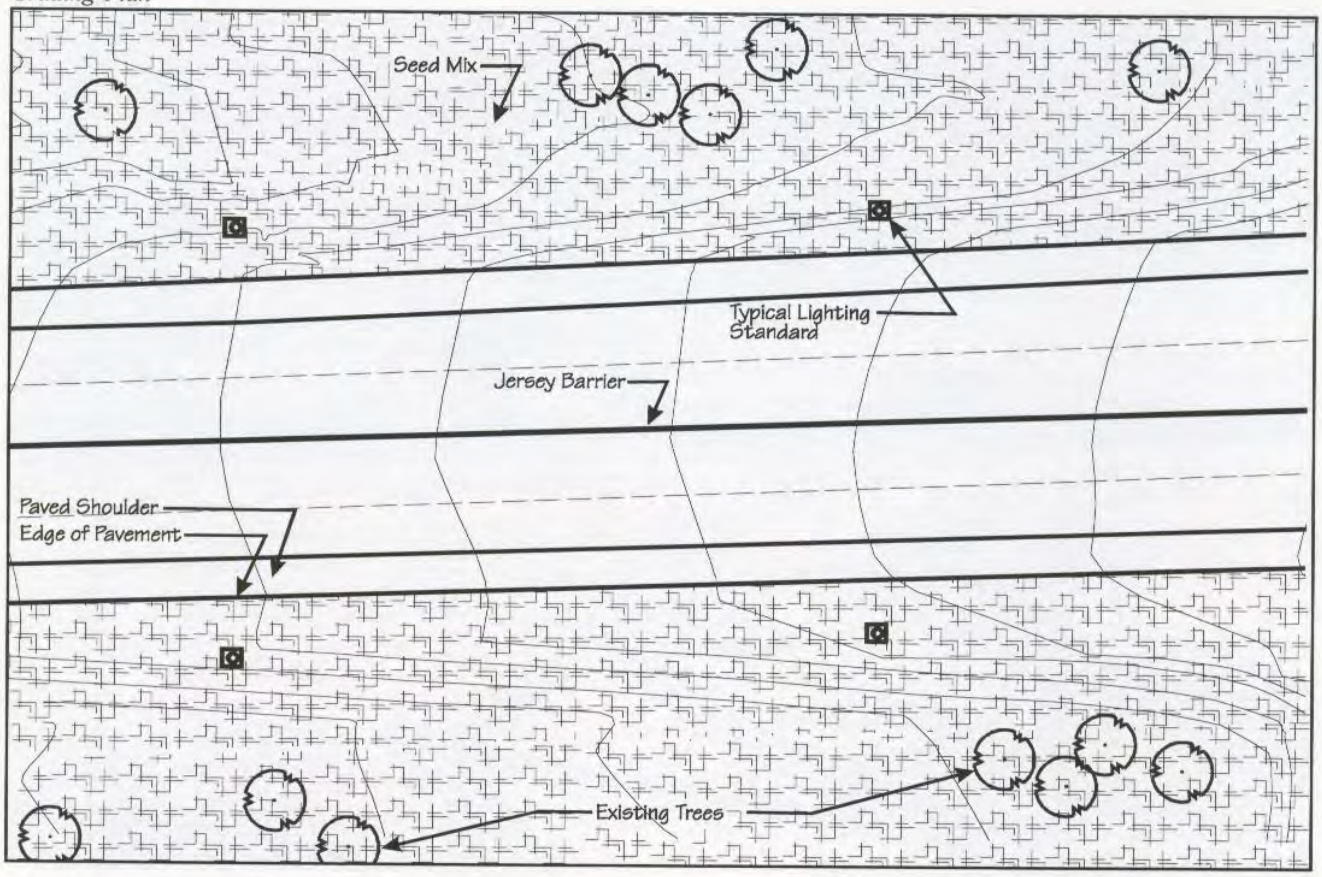


CONCEPT 4
SEED MIX ONLY

A seed mix containing native and drought tolerant species is applied to the right-of-way. The appearance of the seeded area changes dramatically with the seasons, especially if no irrigation is included - temporary irrigation is also an option. Many of the native species are drought deciduous, resulting in a browner appearance during the summer months. Maintenance is a challenge, as it is sometimes difficult to distinguish the desired plants and grasses from weedy species, until they become larger plants. Fire danger is increased in seeded areas. Seed mixes are typically used adjacent to natural or rural areas. Existing trees and shrubs can be left in the landscape with seed mix applied around them. Seasonal color is a potential benefit.

Coverage		
	Plants	up to 100% (depends on germination)
	Granite	0%
	Irrigation	none or temporary
Plant Densities		
	Seed Mix	100%

Concept 4 - Landscape and Grading Plan



MITIGATION EFFECTIVENESS OF CONCEPT 4	LESS (less effective than concept 1)	SAME (same effectiveness as concept 1)	MORE (more effective than concept 1)	Note
aesthetics/visual benefits	Less			
air quality benefits		Same		
heat island benefits		Same		
stormwater runoff mitigation		Same		
economic benefits and impacts to tourism	Less			depends on location
urban aviary, wildlife and recreational benefits		Same		depends on species
maintenance efficiency	Less		More	Initial/long term
consistent with adjacent codes	Less			
controlling landscape installation costs			More	
controlling irrigation installation costs			More	
controlling water use and costs			More	
life cyde (longevity of project)			More	
fire hazard mitigation	Less			

Total cost per acre installed (estimated) **$7,000** **(non-irrigated)**
Total cost per acre installed (estimated) **$15,000** **(temporary irrigation)**

US 60
Superstition Freeway
at Apache Junction

Spring Color

Seed Mix Only

CONCEPT 5
NATIVE SHRUBS ONLY

This concept can be used as an alternative to inert covers to stabilize slopes or as part of a revegetation concept emphasizing shrubs. In this example, native creosote bush were planted to blend with surrounding vegetation. Irrigation would typically be required for establishment. With native plants, irrigation can be greatly reduced or eliminated after approximately two years. Plant sizes are assumed to be smaller than the Traditional Landscape Concept 1. Plants native to other arid climates may also be appropriate.

Coverage

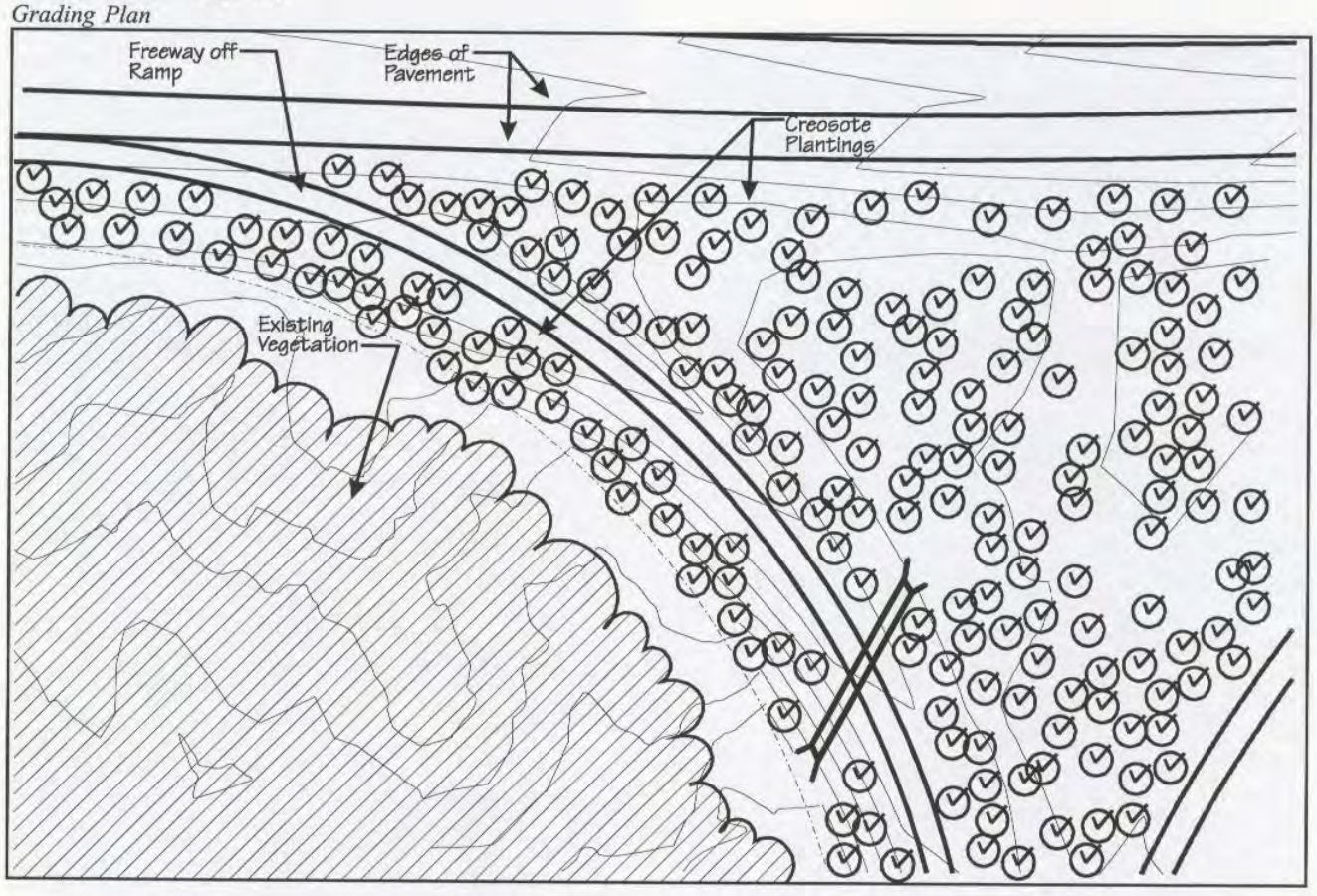
Plants	80%
Granite	0%
Irrigation	temporary or permanent

Plant Densities

1 gal. Shrubs/Acre	440

Note: Decomposed granite and irrigation may be required depending on slope conditions

Concept 5 - Landscape and Grading Plan



MITIGATION EFFECTIVENESS OF CONCEPT 5	LESS (less effective than concept 1)	SAME (same effectiveness as concept 1)	MORE (more effective than concept 1)	Note
aesthetics/visual benefits	Less			depends on location
air quality benefits		Same		
heat island benefits			More	
stormwater runoff mitigation	Less			
economic benefits and impacts to tourism	Less			depends on location
urban aviary, wildlife and recreational benefits			More	depends on species
maintenance efficiency		Same		
consistent with adjacent codes	Less			
controlling landscape installation costs			More	
controlling irrigation installation costs			More	
controlling water use and costs		Same		depends on species
life cycle (longevity of project)			More	
fire hazard mitigation	Less			

Total cost per acre installed (estimated) **$20,500.00** **(irrigated)**
Total cost per acre installed (estimated) **$8,200.00** **(non-irrigated*)**

*The non-irrigated cost is based on planting seedlings, and watering them only at the time of planting.
The survival rate would be largely dependent upon weather conditions.
Effective mitigation time would be longer, as the shrubs would grow more slowly without irrigation.

Native Shrubs Only

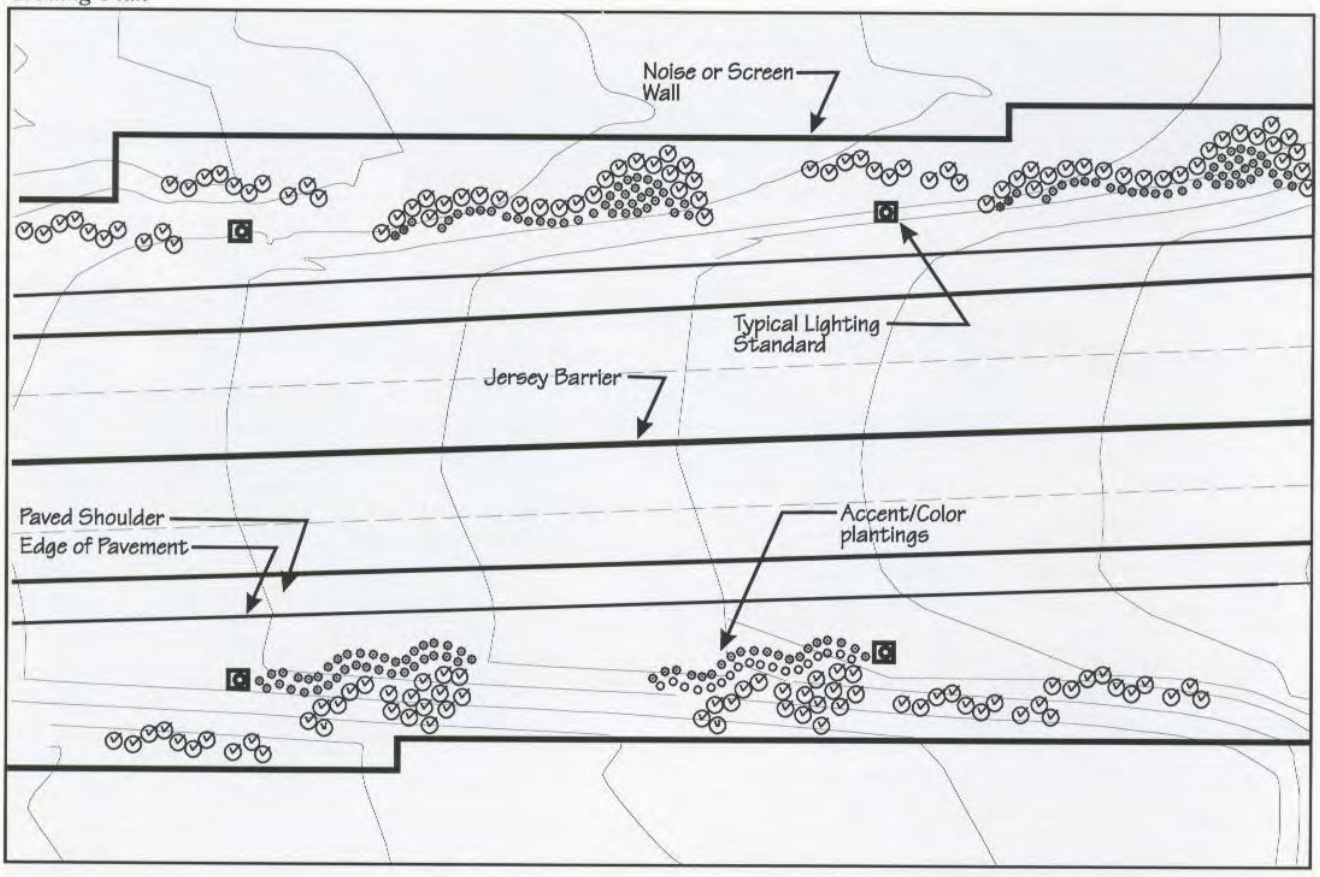
I-10 at Ajo Way

CONCEPT 6
SHRUB AND GROUND COVER EMPHASIS

This concept has traditionally been used to visually mitigate noise and retaining walls. It emphasizes a use of shrubs and ground covers, with fewer trees than average. Overall plant cover is reduced as compared to the Traditional Landscape Concept 1. Plant sizes are assumed to be smaller than the Traditional Landscape Concept 1. Concept 6 is most effective for narrow rights of way without space for trees. Additional decomposed granite may be required for dust or erosion control.

Coverage		
	Plants	40%
	Granite	60%
	Irrigation	permanent
Plant Densities		
	1 gal. Shrubs/Acre	160
	1 gal. Shrubs/Acre	140

Concept 6 - Landscape and Grading Plan



Mitigation Effectiveness of Concept 6	Less (less effective than concept 1)	Same (same effectiveness as concept 1)	More (more effective than concept 1)	Note
aesthetics/visual benefits	Less			in long term
air quality benefits	Less			
heat island benefits	Less			
stormwater runoff mitigation		Same		
economic benefits and impacts to tourism	Less			in long term
urban aviary, wildlife and recreational benefits	Less			depends on species
maintenance efficiency	Less			
consistent with adjacent codes	Less			
controlling landscape installation costs			More	
controlling irrigation installation costs		Same		
controlling water use and costs		Same		
life cycle (longevity of project)	Less			
fire hazard mitigation	Less			

Total cost per acre installed (estimate) **$21,700**

Shrub and Ground Cover Emphasis with fewer trees

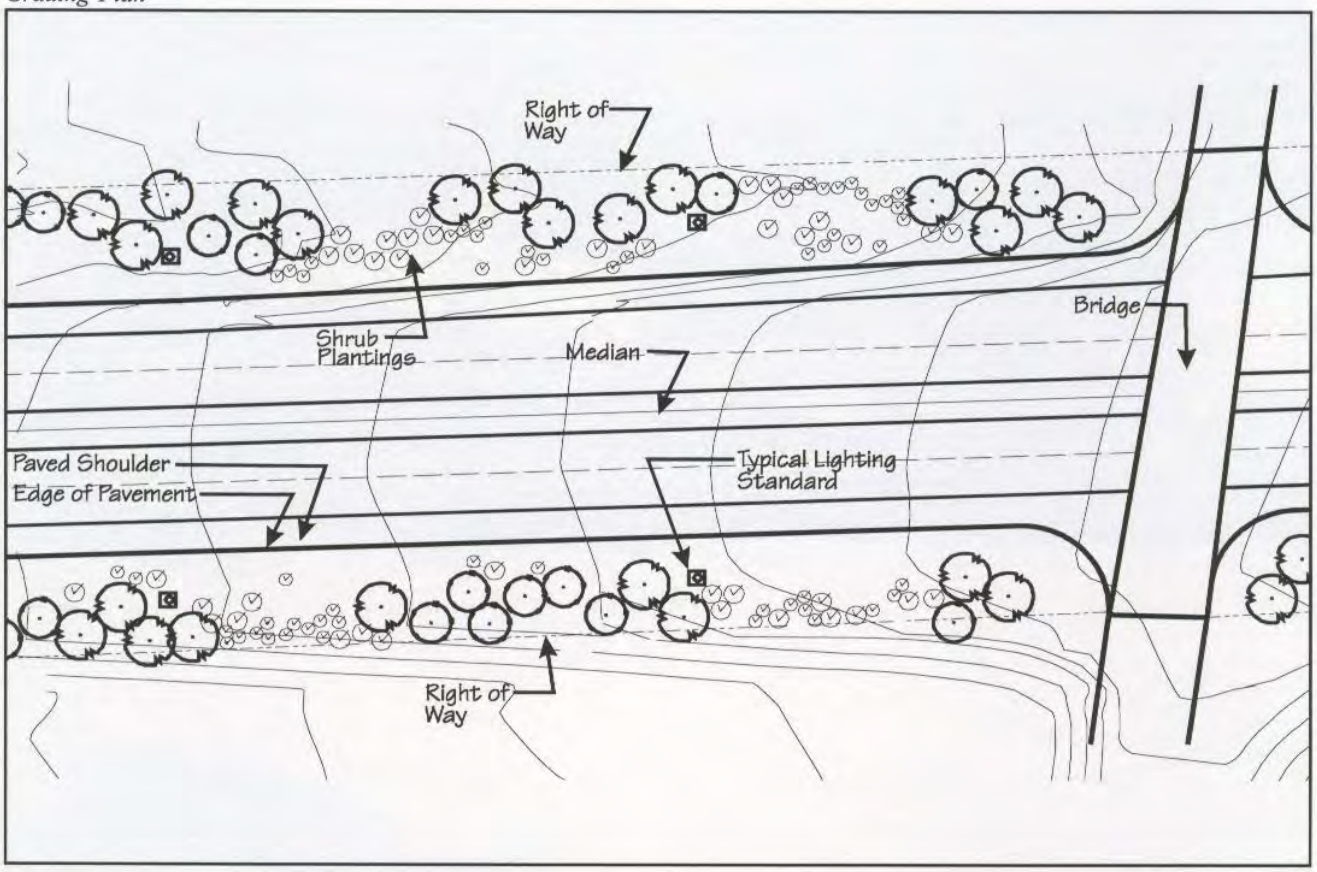
I-10, Pearl Harbor Memorial Freeway between Deck Park & Squaw Peak (north side)

Concept 7
Tree Emphasis with Shrubs

This concept emphasizes trees in combination with large shrubs to provide a similar amount of plant cover as Concept 1, using fewer plants. Plants need to be spaced to allow adequate room to grow with minimal pruning required. Plant sizes are assumed to be smaller than the Traditional Landscape Concept (1). Water harvesting can be used to supplement water from an irrigation system (see Appendix E). Due to the use of smaller and fewer plants, this type of treatment would take longer to establish than the traditional landscape. Additional plants would typically be required in order to provide screening for adjacent residential areas. More decomposed granite may be required for dust or erosion control.

Coverage		
	Plants	65%
	Granite	60%
	Irrigation	temporary or permanent
Plant Densities		
	5 gal. Trees/acre	50
	1 gal. Shrubs/acre	50

Concept 7 - Landscape and Grading Plan



Mitigation Effectiveness of Concept 7	Less (less effective than concept 1)	Same (same effectiveness as concept 1)	More (more effective than concept 1)	Note
aesthetics/visual benefits		Same		in long term
air quality benefits		Same		
heat island benefits		Same		
stormwater runoff mitigation		Same		
economic benefits and impacts to tourism		Same		in long term
urban aviary, wildlife and recreational benefits		Same		depends on species
maintenance efficiency			More	
consistent with adjacent codes		Same		
controlling landscape installation costs			More	
controlling irrigation installation costs			More	
controlling water use and costs			More	
life cycle (longevity of project)		Same		
fire hazard mitigation		Same		

Total cost per acre installed **$21,700**

Tree Emphasis with Shrubs

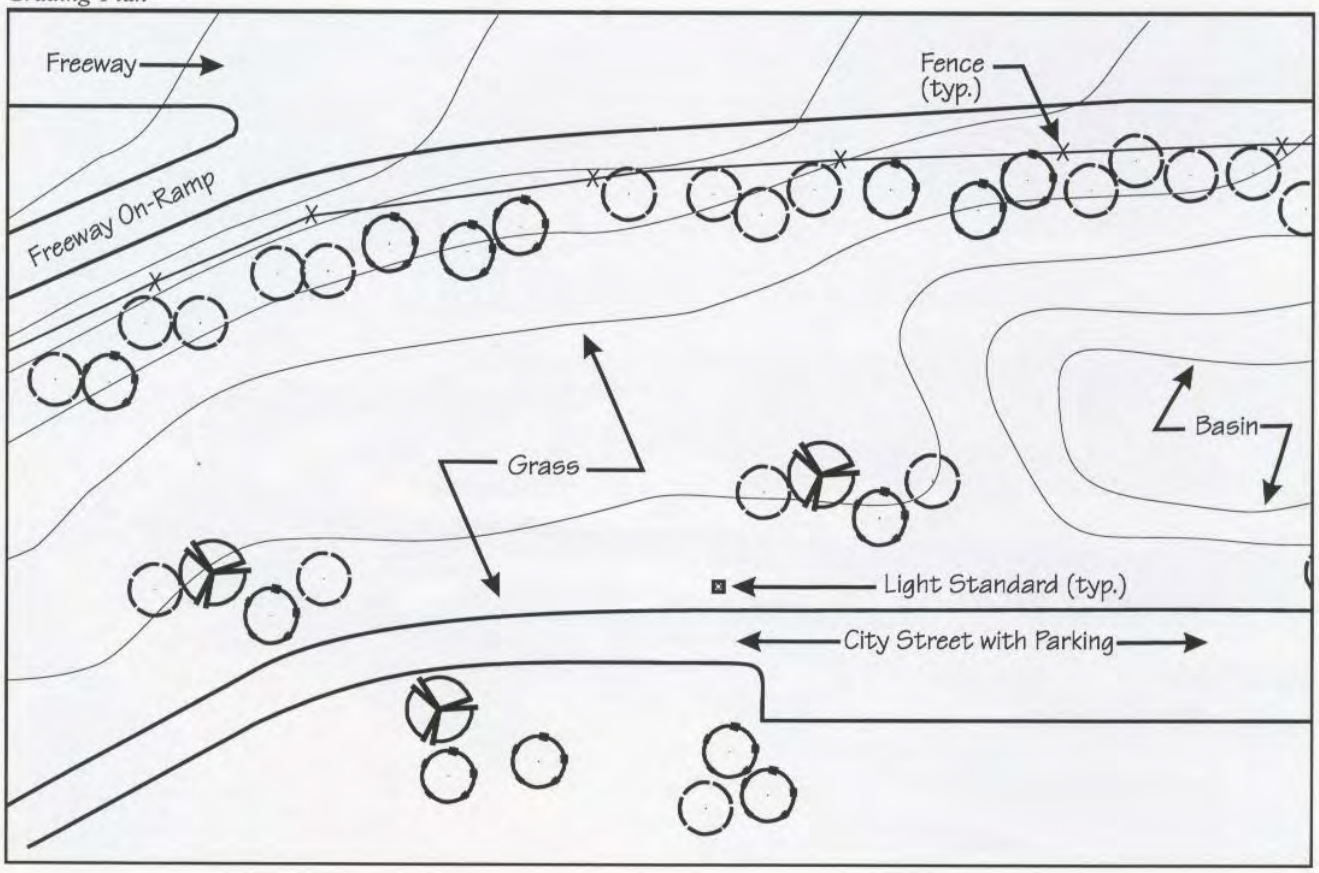
US 60 Superstition Freeway
East of Gilbert Road

Concept 8
Trees with Turf

This concept can be applied to detention basins and excess right of way areas in order to incorporate a multiuse recreational facility within ADOT right of way. The area is planted with turf with tree groupings located near the perimeter of the basin. The adjacent community provides maintenance in exchange for the use of the facility as a recreational area. In order to receive a waiver for the use of turf from the Arizona Department of Water Resources, it must be demonstrated that it is in the public interest to do so. Noise walls may be necessary at additional cost to create a usable recreation area. This would need to be done in partnership with local jurisdictions.

Coverage		
	Plants	100%
	Granite	0%
	Irrigation	permanent
Plant Densities		
	15 gal. Trees/acre	25
	Turf	100%

Concept 8 - Landscape and Grading Plan



Mitigation Effectiveness of Concept 8	Less (less effective than concept 1)	Same (same effectiveness as concept 1)	More (more effective than concept 1)
aesthetics/visual benefits		Same	
air quality benefits			More
heat island benefits			More
stormwater runoff mitigation			More
economic benefits and impacts to tourism		Same	
urban aviary, wildlife and recreational benefits			More
maintenance efficiency	Less		
consistent with adjacent codes		Same	
controlling landscape installation costs	Less		
controlling irrigation installation costs	Less		
controlling water use and costs	Less		
life cycle (longevity of project)	Less		
fire hazard mitigation			More

Total cost per acre installed (estimate) **$33,400**

Trees with Turf

US 60 Superstition Freeway
West of Mesa Drive, Heritage Park

C. SUMMARY

The eight landscape concepts range in cost from approximately $7,000 per acre to $34,000 per acre. Some of these examples include portions of the planting area left in a raked earth condition. Many different appearances can be achieved depending on plant choices and how these concepts are combined.

Several variables effect the final landscape cost and overall effectiveness in the community. These variables include: size of the plant at the time of planting, time frame to achieve visual mitigation, density of the plants, seasonal appearance, maintenance availability, water availability, environmental conditions, and proportion of plants, decomposed granite and raked earth within the project limits.

Typically, several would be combined to achieve the environmental, aesthetic and economic goals of the project, and stay within the project budget.

SR 202 Red Mountain at 24th. Street

1. Traditional Landscape $34,000/acre

I-10 at 107th Avenue

2. Decomposed Granite Only $14,600/acre

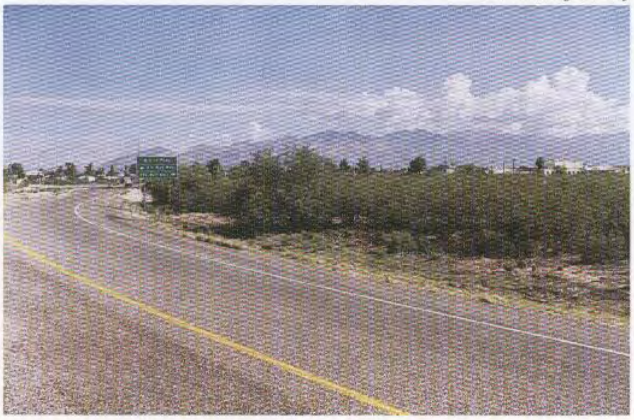
Hohokam /Red Mountain Traffic Interchange

3. Land Graphics $25,000/acre

US 60 Superstition Freeway at Apache Junction

4. Seed Mix Only $7,000/acre (non-irrigated)
$15,000/acre (temporary irrigation)

I-10 at Ajo Way

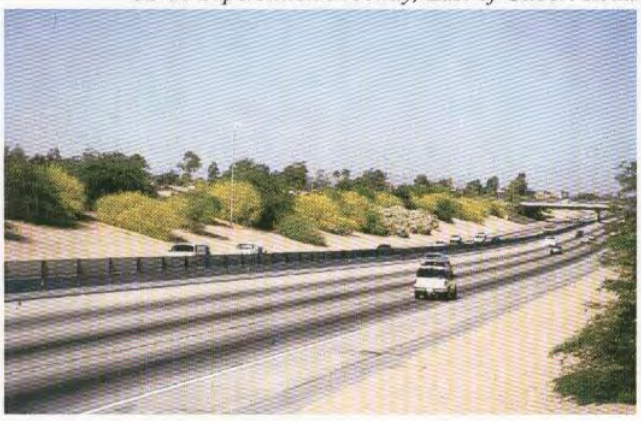


5. Native Shrubs Only $20,500/acre (irrigated)
$8,200/acre (non-irrigated)

I-10, Pearl Harbor Memorial Freeway

6. Shrub and Ground Cover Emphasis $21,700/acre

US 60 Superstition Freeway, East of Gilbert Road



7. Tree Emphasis with Shrubs $21,700/acre

US 60 Superstition Freeway, West of Mesa Drive

8. Trees with Turf $33,400/acre

PART 4
APPLICATIONS -
SKY HARBOR EXPRESSWAY

ADOT staff recently had the opportunity to apply several of the Value Analysis Committee's preliminary concepts to a new project, the Sky Harbor Expressway. This design demonstrates the principles of the Visual Prioritization Process, and the following landscape concepts, as described in Part 3:

1. Traditional Landscape, for accent and color plantings
2. Decomposed Granite Only
3. Land Graphics
4. Seed Mix Only
6. Shrub & Ground Cover Emphasis, for retaining and noise wall mitigation
7. Tree Emphasis with Shrubs, densely planted where screening is needed and in limited groupings in other areas.

This project, which began construction in 1996, will be the first application of many of the Committee's concepts along the MAG freeway system. The landscape cost for this project was approximately $485,000 per mile. ADOT funded $350,000 per mile per the Governor's Plan, with the additional landscape funding provided by ISTEA Enhancement Funds and the City of Phoenix.

The project is located on ADOT right-of-way within the City of Phoenix. Zoning and land uses in the project area are: Industrial, Recreational/Open Space, and Public Facility.

The City of Phoenix landscape code is very brief for major streets and different land uses. It includes requirements for landscape and buffering along major streets. The ADOT landscape concepts are consistent with the City's code requirements.

Following are examples of areas which demonstrate the application of visual analysis methodology in combination with selected landscape concepts.

The result is an environmentally and aesthetically pleasing landscape approach that reduces traditional costs but remains within the recommended budget.

SAMPLE 1- HIGH VISUAL PRIORITY LEVEL

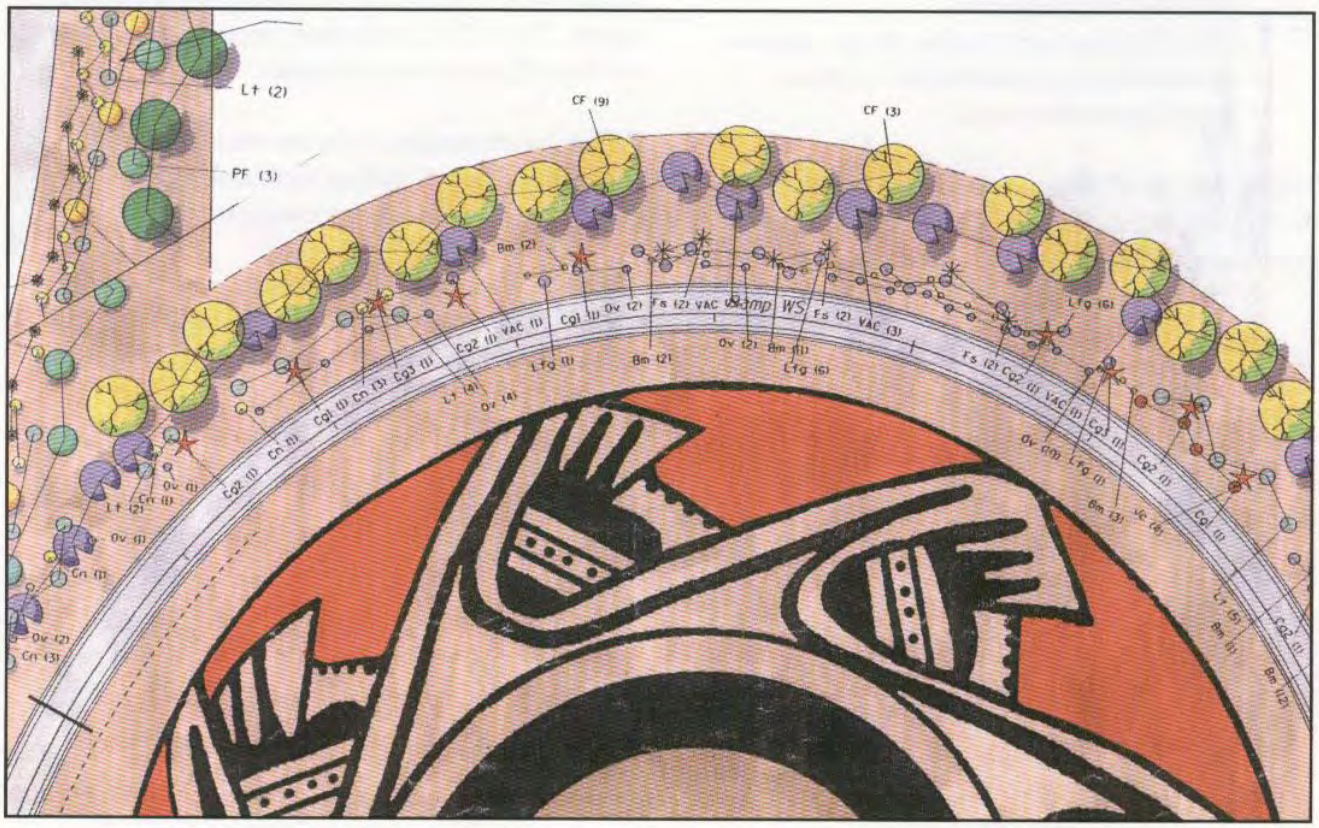
This area is on an interchange ramp, where traffic is slowed and traveling in a curved pattern. Consequently, the driver's and passengers' views will be focused directly at the planting area on the outside of the ramp. The inside of the ramp is also highly visible from traffic entering the ramp and passing by the interchange.

The landscape concepts selected for these areas are:

1. Traditional Landscape (33%) in order to screen adjacent areas.
3. Land Graphics (67%)

The combined, estimated cost per acre of the landscape concepts in this area is: $ 28,000/acre.

High Visual Priority



SAMPLE 2 - MEDIUM VISUAL PRIORITY LEVEL

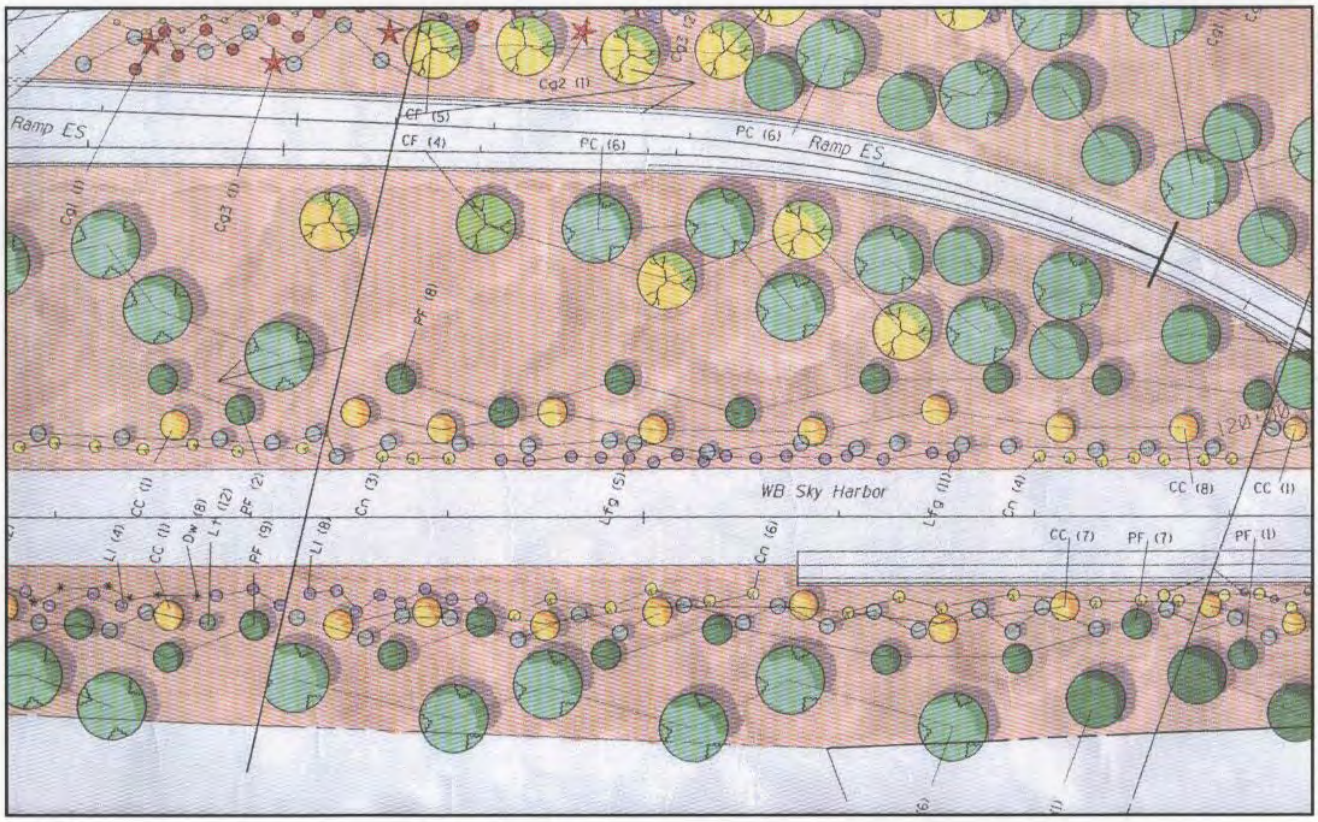
This area is a gently curved transition, where the driver's and passengers' views of the planting areas are at an angle. This area is viewed for a shorter duration of time than the interchange area, due to the higher design speed.

The landscape concepts selected for these areas are:

6. Shrub & Ground Cover Emphasis (20%) closest to travel lanes.
7. Tree Emphasis with Shrubs (60%) planted in moderate densities.
2. Decomposed Granite mulch (64%) to control dust and erosion.

The combined, estimated cost per acre of the landscape concepts in this area is: $21,700/acre.

Medium Visual Priority



SAMPLE 3 - LOW VISUAL PRIORITY LEVEL

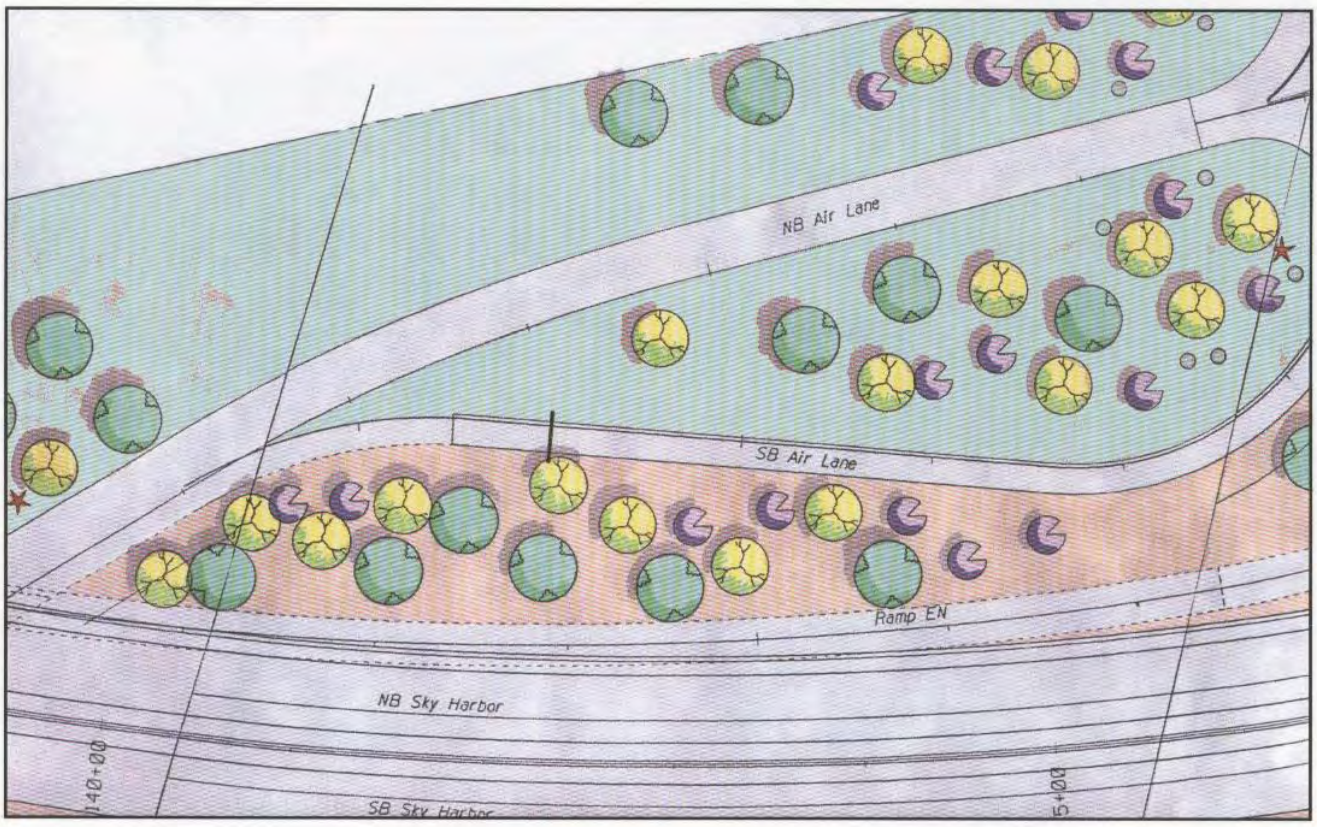
This is a peripheral landscape area with minimal views from the freeway or adjacent land uses.

The landscape concepts applied in this area include:

4. Seed Mix Only (70%) in peripheral areas.
7. Tree Emphasis with Shrubs, (80%) with decomposed granite near the freeway mainline and combined with seed mix in peripheral areas. Trees are widely spaced for viewing at higher speeds and are located near travel lanes.

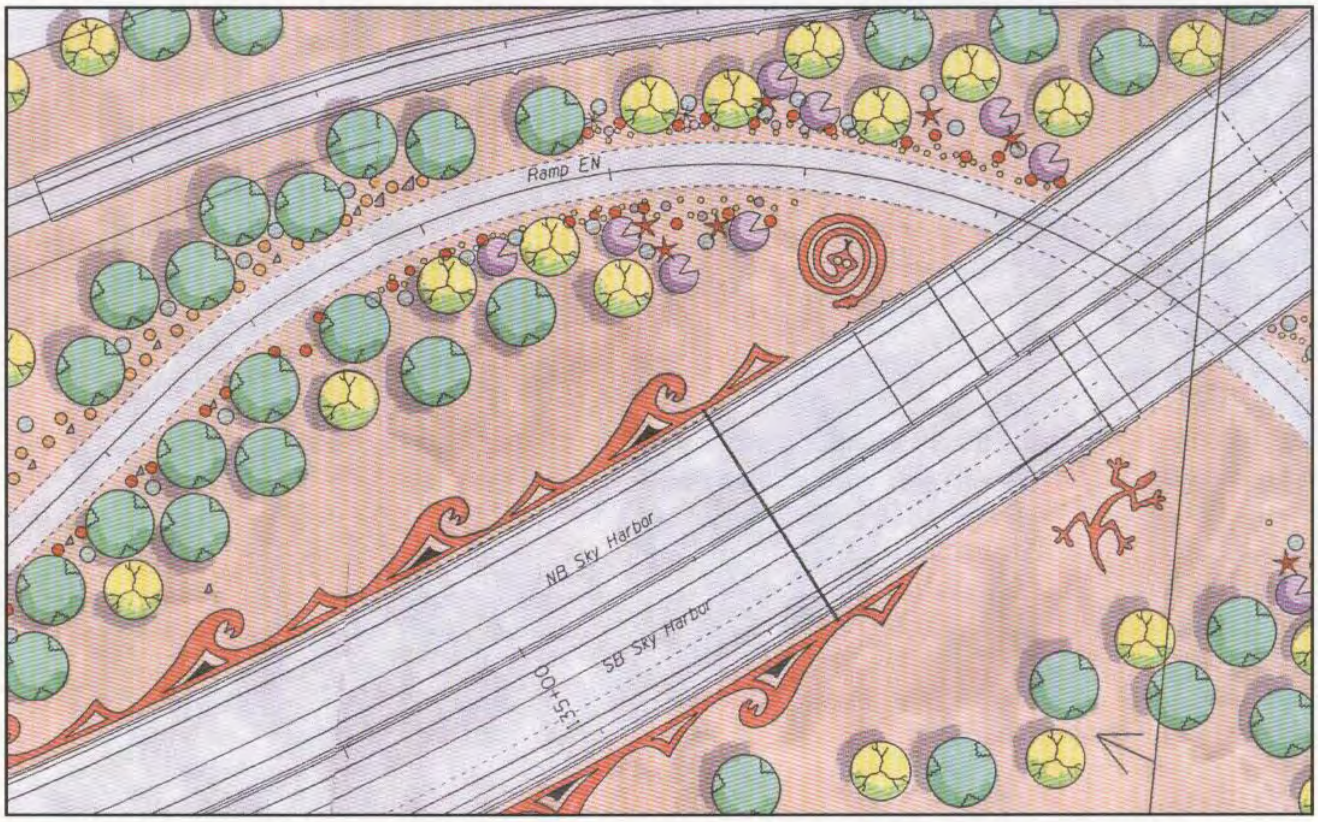
The combined, estimated cost per acre of the landscape concepts in this area is: $ 19,000/acre.

Low Visual Priority



SUMMARY

The Sky Harbor Expressway project applies a varied mitigation budget which corresponds to the visibility of the different areas along the corridor. This freeway design demonstrates the combined use of several landscape concepts to achieve a cohesive design; meet the environmental, aesthetic and economic goals of the MAG freeway system; and address the reduced budget goals as set forth by the Value Analysis Committee.



ACKNOWLEDGEMENT OF TEAM MEMBERS

I would like to express my appreciation for the support, suggestions and hard work from the Sky Harbor Project Team in making this landscape design project possible. The combined efforts and contributions were invaluable and most deeply appreciated. The spirit of cooperativeness and dedication from the team provided an environment for unique creativity in implementing the concepts presented in this Value Analysis Report.

Joseph R. Salazar
Project Designer

Bob Bortfeld	City of Phoenix Transportation Department
Dennis Shultz	City of Phoenix Transportation Department
Mark Landrith	City of Phoenix Transportation Department
Todd Bostwick	Pueblo Grande Museum
Roger Lidman	Pueblo Grande Museum
Ken Jones	Sky Harbor Airport
Leigh Jenkins	Hopi Tribe

Arizona Department of Transportation

Terry Bourland	Project Manager
Joseph R. Salazar	Project Designer
LeRoy Brady	Landscape Architect
Harry Woelzlein	Landscape Architect
Doug Matthews	Irrigation Designer
Vickie Bever	Contracts and Specifications
Karen Holloway	Summer Eng. Program Manager
Bettina Rosenberg	Historic Preservation Coordinator
Ted Littlefield	Construction
Mark Schalliol	Maintenance
Robert Johnson	Dir, Community Relations
Fred Daniels	CAD Services
Adil Kadri	Contracts and Specifications
Hope Nasco Gibson	ASU Intern
Mike Chapman	ASU Intern
Will Herrera	ASU Intern

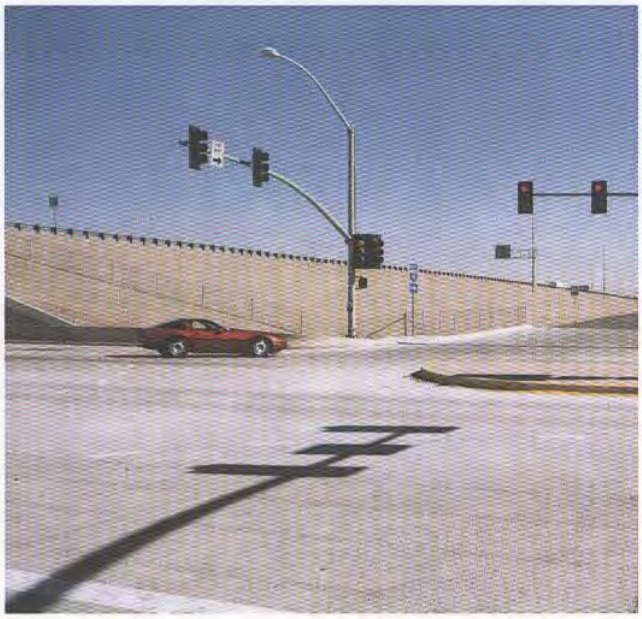
Construction Consultants:

Steve Bruflat
Stan Harwell
Bob Dahmen
Marv Small
Roger Dybas
Jim Conner

PART 5
RECOMMENDATIONS AND CONCLUSION

RECOMMENDATIONS

The beneficial effects of plants are widely known. They filter pollutants, add oxygen to the atmosphere, help control erosion, increase the value of residential properties and provide psychological benefits. As an example, people tend to shop longer in vegetated surroundings, and Arizona is a state which relies heavily on its tourism industry. Landscaped streets and freeways add to Arizona's image as a scenic state with a high quality of life. Freeway plantings provide a positive community image, attract visitors and businesses and encourage appropriate plantings by others. Municipalities require private developments to include landscape plans, as one way to compensate the community for the increased noise, traffic, heat and runoff associated with urban development. Unplanted freeways may not meet public expectations and development standards.



There are a variety of beneficial landscape concepts appropriate to the MAG Freeway System that conform to current budgets. The effective application of these concepts can mitigate many of the negative impacts of freeway development, and result in long-term environmental, aesthetic and economic benefits.

The Value Analysis Committee recommends the following:

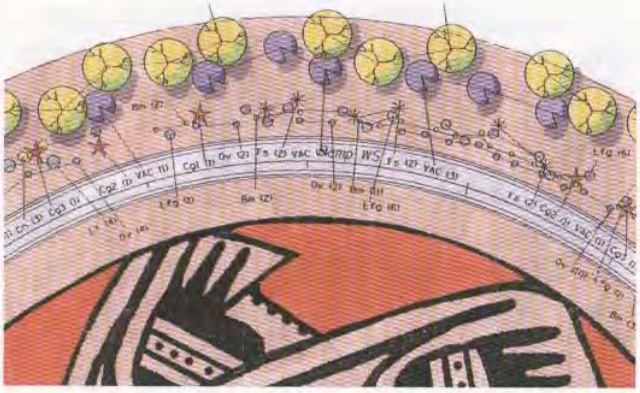
1. Incorporate plant materials as a part of the construction of all segments of the MAG Urban Freeway System.
Based on the Value Analysis Study, the Committee finds that the continued use of plants along the freeway system is an important component of the MAG freeway system program. While accurate benefit-cost studies have not been performed at this time, research in other urban areas indicate a positive ratio for urban freeway trees. **Because the metropolitan area is in an air quality nonattainment situation, the removal of plants, which improve air quality, is not appropriate**. Other, non-quantitative benefits of vegetation reinforce the positive return on investment for landscape along the system.

2. Adopt a construction budget of $650,000 per mile for landscape, irrigation and granite.
This budget is based on 30 acres/mile average and 1996 dollars. It does not include design, engineering administration, or contingency costs. The Committee respects the efforts to reduce landscaping costs to build

more miles of freeway, while reducing development costs. In light of the need for cost reduction, the Committee recommends a landscape budget cost per mile figure of $650,000. While it is expected that costs will vary from segment to segment within a given project, this range accommodates a variety of conditions, treatments and mitigation measures.

These recommended budget figures are substantially less than the traditional budget adjusted to today's dollars, however they are greater than the allowance in the Plan. The recommended budget represents approximately 13 percent in reductions from the previous budget of $750,000 per mile, and approximately 20 percent in reductions from recent projects.

As landscape treatments over the length of the system will vary depending on adjacent land use, design requirements and mitigation measures, so will the actual cost. The recommended construction budget of $650,000 per project mile is an overall average. Actual costs are expected to range from less than $450,000 to more than $900,000 per mile, depending on the local conditions and actual acreage of the project.



3. Adopt future landscape budgets based on a per acre amount at the project level.
On a project-to-project basis, it is more appropriate to create budgets using per acre rather than per mile figures, particularly where major traffic interchanges are involved. While an average cost per acre for landscape construction expenditures would be $21,700 using the above recommendations, a more accurate budget would be created for each project, which would reflect the site specific environmental, visual and mitigation requirements.

4. Maintain a flexible approach to landscaping.
This approach would allow adjacent communities and/or developers to fund higher levels of landscaping, such as increased plant size and density. This type of approach would allow a municipality to highlight a gateway or provide additional screening for a neighborhood. It would allow developers to insure an upgraded image along individual developments. ADOT would take responsibility for maintaining continuity and appropriateness of landscape treatments.

5. Apply a visual prioritization process to future MAG freeway segments.
The VPP has been shown to be a cost effective approach to preparing visual mitigation plans. With the VPP, plant materials designed for visual mitigation purposes are concentrated according to their visibility to increase the overall effectiveness of the design.

6. Consider long term maintenance and life cycle costs in the design and budgeting process.

7. Select landscape design concepts that maximize environmental, economic and aesthetic benefits of plants, while meeting cost reduction goals.

8. Update the *Landscape Design Guidelines for Urban Highways* publication.
This document has provided excellent direction for landscape treatments along urban freeways in Arizona, and has also been used by many other state Departments of Transportation. The recent emphasis on cost

effective design and cost reduction measures needs to be incorporated into the manual. New, innovative ideas generated by this Value Analysis Committee (such as greater use of seeded plants, harvesting stormwater runoff and increased reliance on plants suitable to project soil conditions) in combination with successful, field tested requirements set forth in the original guidelines, could contribute additional savings in construction and maintenance.

9. Maximize the effectiveness of landscape and mitigation funds (first) within each jurisdiction, and (second) on each project.
The Committee recognizes that funding for projects will cross jurisdictional lines. Each jurisdiction will want their proportional amount of landscape budget, to achieve the maximum benefits locally.

10. Continue to include topsoil and irrigation sleeving in the roadway construction budget.
The alternatives in this report do not include the cost of topsoil, but some do require topsoil, or using some of the topsoil budget for other landscape items. The latter makes these alternatives more feasible and their overall cost per acre less than traditional landscape scenarios.

11. Adopt a budget on a per mile, per year basis, for landscape maintenance.
There is a need to increase the landscape maintenance budget as roadway miles are added. Even decomposed granite requires weed and litter control.

With the regional freeway plan , an additional 108 miles of landscaping will be placed on an already struggling system. Maintenance funding has been held to a minimum in order to fund more construction. Without performing the required regular maintenance the landscape will deteriorate and require additional costly repairs.

The Committee urges that freeway landscape maintenance be adequately funded. Landscape maintenance costs have been estimated to be $35,000 per mile per year. More study is needed in order to determine an exact budget.

CONCLUSION

It is true that, with or without plants, additional freeway miles will make life easier for commuters and travelers. Easier commutes are not without a price, however. Traditionally, adjacent neighborhoods have born the brunt of urban freeways, through higher noise and pollution levels, intrusion of traffic and incompatible land uses, and severed connections from schools and neighborhoods. In response to this, ADOT's urban freeway investments of the past decade have included attractively designed noise walls, grade separated pedestrian and bicycle crossings, traffic intrusion controls and desert adapted plantings. These features help mitigate the impacts of the freeway on those who live nearby, as well as providing community-wide environmental, aesthetic and economic benefits.

The Value Analysis Committee recognized that the metropolitan area would be best served by effective landscape treatments along all of its freeways, even if it meant delaying construction of a few miles of freeway. The community echoed these concerns, and in December 1996 the Citizens Transportation Oversight Committee (CTOC) recommended restoring funding for freeway landscaping, with a budget of $650,000 per mile. This budget represents enough money to plant and irrigate a modest quantity of trees and shrubs (from small containers) and to cover 60 to 70 percent of the landscape area with decomposed granite. It also allows varied treatments to be applied within a given jurisdiction or project (based on a visual prioritization process) in order to respond to varying land uses, views and screening needs. Additional funds may be contributed by municipalities and/or private sources in order to increase plant densities, add specimen plants or otherwise upgrade what can be accomplished within the base level budget.

In this way, landscape costs will be reduced from what has been spent in the past decade, while maintaining vegetative cover, cohesive design themes and meeting varying environmental, aesthetic and economic goals.

APPENDIX A
NOTES

1. Urban Forest Landscapes - Integrating Multidisciplinary Perspectives, at 27.

2. Urban and Community Forestry - A Guide for the Interior Western United States, at 14.

3. Urban Forest Landscapes - Integrating Multidisciplinary Perspectives, at 106.

4. Shading Our Cities, at 5.

5. Urban Forest Landscapes - Integrating Multidisciplinary Perspectives, at 114.

6. Chicago Urban Forest Climate Project: Results of the Chicago Urban Forest Climate Project, at 64.

7. Chicago Urban Forest Climate Project: Results of the Chicago Urban Forest Climate Project, at 127.

8. Interview with Tony Brazael.

9. Shading Our Cities, at 5.

10. Shading Our Cities.

11. Urban Forestry In Arizona, at 4.

12. Urban Forest Landscapes - Integrating Multidisciplinary Perspectives, at 192; Chicago Urban Forest Climate Project: Results of the Chicago Urban Forest Climate Project.

13. Mastering NEPA: A Step-by-Step Approach, at 40.

14. Chicago Urban Forest Climate Project: Results of the Chicago Urban Forest Climate Project, at 63.

15. Visual Prioritization Process.

APPENDIX B
BIBLIOGRAPHY AND REFERENCES

Chicago Urban Forest Climate Project: Results of the Chicago Urban Forest Climate Project. U.S. Forest Service. E. Gregory McPherson, David J. Nowak, and Rowan A. Rowntree, 1994. (ch.5, ch.8).

Mastering NEPA: A Step-by-Step Approach. Ronald E. Bass and Albert I. Herson, 1993.

Shading Our Cities. American Forestry Association. Edited by Gary Moll and Sara Ebenreck, 1989.

Telephone Interview with State Climatologist Tony Brazael, Arizona State University.

Urban and Community Forestry - A Guide for the Interior Western United States. U.S. Forest Service 1990. (Section 3)

Urban Ecology Analysis for Atlanta, Georgia. Prepared by AMERICAN FORESTS. March 1996.

Urban Forest Landscapes -Integrating Multidisciplinary Perspectives. Edited by Gordon A. Bradley. Chapter 9 Written by Stephen Kaplan. Chapter 10 written by Patrick A. Miller. Chapter 13 written by E.G. McPherson, Rowan A. Rowntree and J. Alan Wagar. Chapter 17 written by E. Gregory McPherson. University of Washington Press 1995.

Urban Forestry In Arizona. David Hitchings, 1981.

Urban Trees -A Guide for Selection, Maintenance, and Master Planning. Leonard E. Philips Jr, ASLA. McGraw Hill, Inc. New York 1993.

Vegetation and Fugitive Sources - A Working Paper of the Dayton Climate Project, John J. Flynn, February 1981.

Visual Prioritization Process - User's Manual. U.S. Forest Service July, 1994.

Newsletter Sources
Environment & Development, American Planning Association. March 1992 issue.
Urban Forest, AMERICAN FORESTS. March/April 1995 issue.
Cool News - A newsletter distributed for Cool Communities - A program of the Department of Energy. Summer 1996 issue and June 1995 issue.

APPENDIX C
ADOT ROADSIDE DEVELOPMENT REPORT ON COSTS

I-10 Papago Inner Loop Landscape
Planting Density and Cost Summary
March 18, 1991. Prepared by HNTB for ADOT Roadside Development.

Average Planting Density for all Landscape Projects.

24.30	Trees Per Acre
0.00056	Trees Per Sq. Ft.
156.43	Shrubs Per Acre
0.00359	Shrubs Per Sq. Ft.
87.80	Ground cover Per Acre
0.00201	Ground cover Per Sq. Ft.

Average Planting Cost for all Landscape Projects.

Low Bid:

$7,492.00	Per Acre
$0.17	Per Sq. Ft.
15.18% of Project Cost	

Average of all Bids:

$8,733.00	Per Acre
$0.19	Per Sq. Ft.
16.73% of Project Cost	

Average Irrigation Cost for all Landscape Projects

Low Bid:

$9,689.00	Per Acre
$0.23	Per Sq. Ft.
1.02% of Project Cost	

Average of all Bids:

$10,906.00	Per Acre
$0.25	Per Sq. Ft.
28.58% of Project Cost	

Average Landscape Establishment Cost for all Landscape Projects

Low Bid:

$1,442.00	Per Acre
$0.03	Per Sq. Ft.
4.55% of Project Cost	

Average of all Bids:

$1,338.00	Per Acre
$0.03	Per Sq. Ft.
3.62% of Project Cost	

Average Granite Cost for all Landscape Projects

Low Bid:

$8,852.00	Per Acre
$0.20	Per Sq. Ft.
24.31% of Project Cost	

Average of all Bids:

$9,539.00	Per Acre
$0.22	Per Sq. Ft.
23.20% of Project Cost	

Average Miscellaneous Costs for all Landscape Projects

Low Bid:

$11,703.00	Per Acre
$0.27	Per Sq. Ft.
28.81% of Project Cost	

Average of all Bids:

$13,307.00	Per Acre
$0.27	Per Sq. Ft.
29.94% of Project Cost	

APPENDIX D
TOPSOIL PLATING AND IRRIGATION SLEEVING

The Committee had side discussions regarding topsoil and irrigation sleeving. The costs of topsoil and irrigation sleeving were not a part of the reduction in the landscape budget proposed in the Plan. (In this case, topsoil means friable, native soil compacted to the density of undisturbed conditions and assumes a depth of two feet. Engineered fill material is not considered topsoil.) ADOT administration had tentatively decided to eliminate topsoil also, presumably because of the assumption that it would not be needed in a rock mulch-only format. There are a number of issues here:

- The lack of topsoil adds to the difficulty of attracting alternate funding from municipalities or others for planting and irrigation.
- Should priorities change in coming years, adding topsoil and irrigation sleeving would require either removing or wasting the existing mulch and soil, and boring under the existing pavement.
- Slopes without topsoil might require more rock, due to inherent roughness, or considerably more preparation to receive the rock mulch.
- Topsoil provides a more cohesive surface material, subject to less erosion by wind and water.

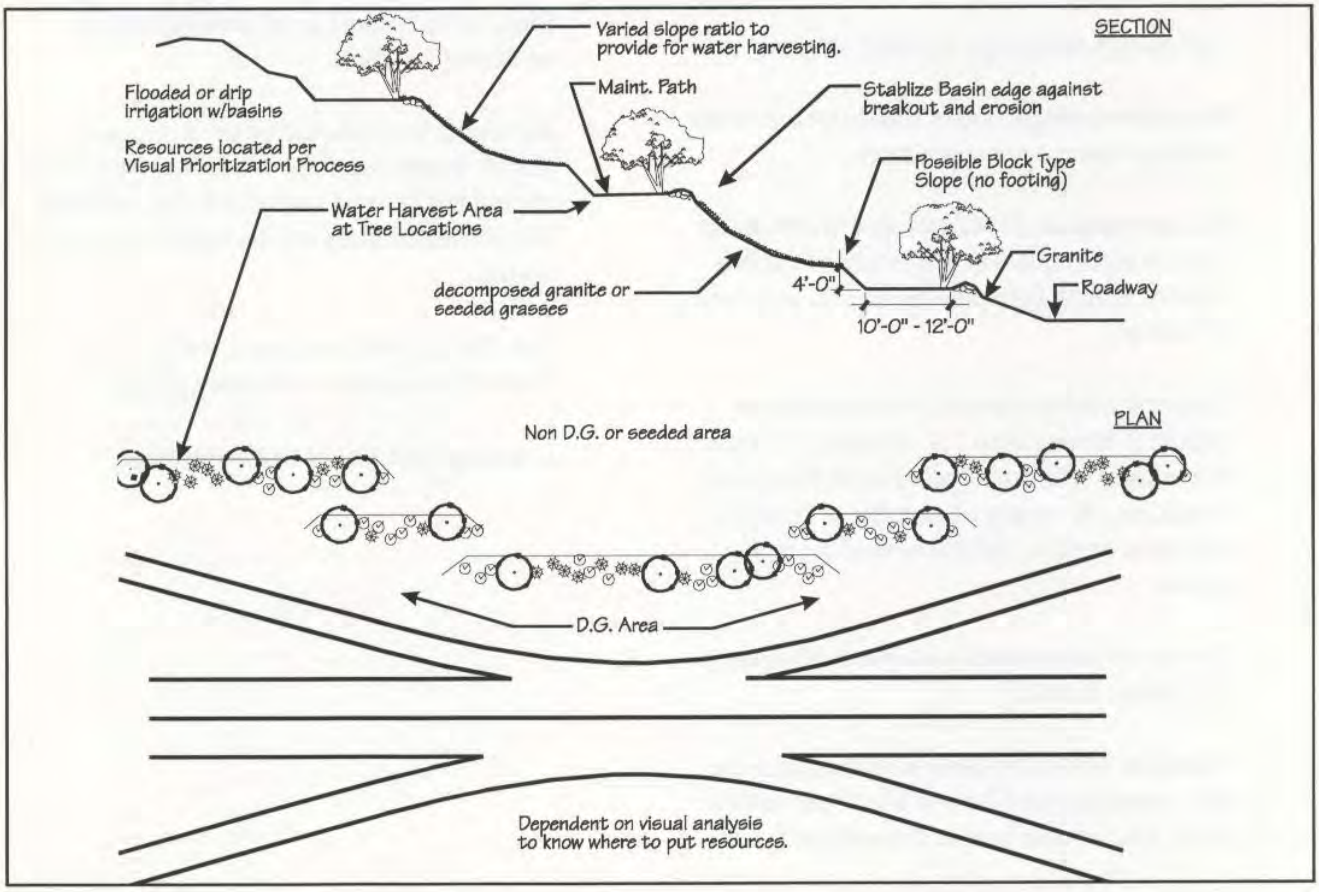
Given these concerns, the Committee recommends that topsoil and irrigation sleeving be included in the construction budget for the roadway. The alternatives in this report do not include the cost of topsoil, but some do require topsoil, or using some of the topsoil budget for other landscape items. The latter makes these alternatives more feasible and their overall cost per acre less than traditional landscape scenarios.

APPENDIX E

WATER HARVESTING TECHNIQUES AND EROSION CONTROL

A subcommittee of the Value Analysis Committee developed the following preliminary concepts regarding water harvesting and erosion control.

Supplementing irrigation with stormwater harvesting. There was consensus that water harvesting alone will not be enough to support significant landscaping. While supplemental irrigation water will be required to maintain most of the proposed landscape concepts, total irrigation water requirements can be minimized through a partial use of stormwater drainage. The use of harvesting stormwater for landscape purposes should be secondary to the stormwater drainage system. Failures of the system should not drain onto the roadway or onto private property. Downdrains to a rock basin, at catch basin locations, are recommended. Cost savings may be available by reducing the requirements of the drainage system design.



Clear zone requirements. Clear zone requirements should be checked regarding limits of undulating slopes and plant size limitations. Clear zone areas should not include fixed obstacles.

Design considerations.

- Groupings of plantings and the oasis concept, in intermittent locations, is preferred to consistent plantings.
- Use pocket areas with variable slopes.
- Water harvesting clusters should be restricted to areas close to a water source.
- The minimum depth of decomposed granite, for erosion control, is 2". A mixture of various sizes of granite is important for it to interlock effectively.
- Slopes should be covered with seeding or granite if steeper than 1:4. Slopes at 1:4 and flatter may be left in a raked earth (bare soil) condition. A variety of conditions is desirable on a project. Selective seeding is an option.
- The use of soil cement was questioned due to the change in color.
- Chemical stabilizers have a 3 year life span, and currently cost $2.50 to $2.75 per square yard. The current cost of decomposed granite is $1.50 per square yard.
- Retention basins must be fail safe. The design must insure that failure of any temporary ponding will result in water flowing to where it was originally intended to go, and not on the roadway.
- Close coordination is required between the landscape designer and the roadway designer in the development of a water harvesting plan, so that runoff is not concentrated in undesirable places.
- Retaining walls should be used to flatten slopes where possible. Decomposed granite should not be used between walls. Seeding and plant materials are desirable between walls.
- Use "living" walls to retain water and to lessen the slope in landscaped areas.
- Use rough cut slopes to slow erosion.

Appendix F - Basis for Acres/Mile and Unit Costs

Project	Location	Year	Acreage	Length (miles)	Inflation	15 Gal. Tree	5 Gal. Tree	5 Gal. Shrub	1 Gal. Shrub	DG/Acre	Seed Mix/Acre	LS Grading/Acre	LS Estab./Acre
East Papago Freeway (SR 202L) I10-40th St.	Phoenix	1992	72.3	2.31									
N.W. Outer Loops (SL 101) (Phx. Urban Area) (Peoria-Skunk	Peoria & Glen.	1989	90.0	3.20									
Red Mtn. Freeway (48th-Priest)	Phoenix	1994	97.1	2.88	4.8%	66	26	16	5	8,100			656
Squaw Peak Highway (SR51) (Northern Ave.-Shea Blvd.)	Phoenix	1995	59.7	2.27	2.5%	----	31	----	7	11,200	1,600		1,191
Hohokam (University Dr.- Washington St.) (Phx. Urban Area)	Phx & Tempe	1993	46.4	2.34									
Northeast Outer Loop (Phx. Urban Area) (University Dr.-Southern Ave.)	Tempe	1993	60.4	2.00									
Superstition Freeway (US 60) (Power Rd.-Ellsworth Rd.)	Phoenix	1991	146.0	3.01									
Priest - Juct 101	Phoenix		76.0	2.97									
Red Mtn. Freeway (SR 202L) (Priest-Jct. 101L)	Tempe	1994	76.0	2.97	4.8%	80	30	17	5	10,800	1,700		941
Sky Harbor	Phoenix	1996	22.0	2.48	----	71	29	16	7	10,700	2,800		2,082
	Overall Avg					75	30	17	6	10497	2074		1244
	Total		745.9	26.43									
	Avg Acres/Mi		28.2										

Does Not Include:
topsoil
electric service
traffic control
remove & salvage vegetation
hardscape (sidewalks, bikepaths, walls)
mobilization
force accounts
surveying

Appendix G - Basis for Landscape Concepts - Estimated Costs

Item	Trees (1)	Trees (1)	Shrubs (1)	Shrubs (1)	GC (1)	Sod (2)	DG (1)	Seed Mix (1)	LS Grading (3)	Irrigation (4)	Establish (1)	Mobiliza-tion (1)	Traffic Control	Survey	Total Cost per Acre	Cover/ Acre	% VEG Cover
Area (SF)	491	491	79	79	38	n/a											
Unit/Size	Ea/ 15 gal	Ea/ 5 gal	Ea/ 5 gal	Ea/ 1 gal	Ea/ 1 gal	SF	Acre	Acre	Acre	Acre	Acre	L.Sum	L. Sum	L. Sum	Acre	SF/Acre	
Unit Cost	$75	$30	$17	$6	$6	$0.30	$10,500	$2,100	$2,500	$12,300	$1,200	(Sub)5%	$700	$200			
Name of Concept	**Trees (1)**	**Trees (1)**	**Shrubs (1)**	**Shrubs (1)**	**GC (1)**	**Sod (2)**	**DG (1)**	**Seed Mix (1)**	**LS Grading (3)**	**Irrigation (4)**	**Establish (1)**	**Mobiliza-tion (1)**	**Traffic Control**	**Survey**	**Total Cost per Acre**	**Cover/ Acre**	**% VEG Cover**
1. Trad Landscape (5)	24		156		88		1		1	1	1	1	1	1			
Area covered	11784		12324		3344											27,452	63.02%
Extended Cost	$1,800		$2,652		$528		$10,500		$2,500	$12,300	$1,200	$1,574	$700	$200	$33,954		
2. Decomposed Granite							1		1			1	1	1			
Only							$10,500		$2,500			$650	$700	$200	$14,550		
3. Land Graphics (6)																	
												$0	$700	$200	$25,000		
4. Seed Mix Only								1	1	1	1	1	1	1			
								$2,100	$2,500		$1,200	$290	$700	$200	$6,990		100.00%
5. Native Shrubs Only				440					1	1	1	1	1	1			
Area covered				34,760												34,760	79.80%
Extended Cost				$2,640					$2,500	$12,300	$1,200	$932	$700	$200	$20,472		
6. Shrubs and Ground Cover Emphasis				160	140		1		1	1	1	1	1	1			
Area covered				12,640	5,320											17,960	41.23%
Extended Cost				$960	$840		$6,300		$2,500	$8,000	$1,200	$990	$700	$200	$21,690		
7. Tree Emphasis with Shrubs		50		50			1		1	1	1	1	1	1			
Area covered		24,550		3,950												28,500	65.43%
Extended Cost		$1,500		$300			$6,300		$2,500	$8,000	$1,200	$990	$700	$200	$21,690		
8. Trees with Turf	25					43,560			1	1	1	1	1	1			100.00%
	$1,875					$13,068			$2,500	$12,300	$1,200	$1,547	$700	$200	$33,390		

NOTES:

(1) average cost from four, recent, ADOT bid tabulations, expressed in 1996 dollars:
Sky Harbor Expressway ('96), Squaw Peak Highway, Northern to Shea ('95)
Red Mountain Freeway, Priest to I-10 ('94), Red Mountain Freeway, 48th to Priest ('94),
(2) allowance, based on recent professional experience
(3) average from bid amounts on Miracle Mile TI and Ina to Prince Mainline Widening projects
(4) allowance using average from HNTB 1991 study, inflated to 1996 dollars
(5) quantities taken from HNTB 1991 study
(6) Sky Harbor estimate +30%
(7) based on approx. 30 acres per mile

DOES NOT INCLUDE:

Topsoil
Removal and/or salvage of existing vegetation
Hardscape
Force Accounts
Design
Engineering Administration
Contingencies

Appendix G - Typical Landscape Quantities for $650,000 Landscape Mile

Area (SF)	491	491	79	79	38	n/a											
Unit/Size	Ea/ 15 gal	Ea/ 5 gal	Ea/ 5 gal	Ea/ 1 gal	Ea/ 1 gal	SF	Acre	Acre	Acre	Acre	Acre	L.Sum	L. Sum	L. Sum	Acre	SF/Acre	
Unit Cost	$75	$30	$17	$6	$6	$0.30	$10,500	$2,100	$2,500	$12,300	$1,200	(Sub)5%	$700	$200			
Name of Concept	**Trees (1)**	**Trees (1)**	**Shrubs (1)**	**Shrubs (1)**	**GC (1)**	**Sod (2)**	**DG (1)**	**Seed Mix (1)**	**LS Grading (3)**	**Irrigation (4)**	**Establish (1)**	**Mobiliza-tion (1)**	**Traffic Control**	**Survey**	**Total Cost per Acre**	**Cover/ Acre**	**% VEG Cover**
TYPICAL $650,000 MILE		30	11	30	24				1	1	1	1	1	1			
Area covered		14,730	869	2,370	912											18,881	80.26%
Extended Cost		$900	$187	$180	$144		$6,675		$2,500	$8,000	$1,200	$989	$700	$200	$21,675		

NOTE:

The densities shown correspond to those shown in Sample 2 - Medium Visual Priority Level, on page 4-3.

APPENDIX H

COMPARISON OF LANDSCAPE COSTS FOR FREEWAYS TO TYPICAL RESIDENTIAL COSTS

Appendix H - Comparison of Landscape Costs for MAG Freeways to Typical Residential Costs

	freeway landscape area cost per sf	typical residence (1) cost per sf
decomposed granite	$0.24	$0.43
traditional landscape	$0.21	$0.33
average landscape (per $650,000 budget)	$0.12	$0.25
irrigation	$0.28	$0.48
annual maintenance (excluding litter pick up)	$0.18	$0.30
Total	$1.03	$1.78

(1) The residential costs are based on typical residential front and back yards totaling approximately 2,000 square feet in area at a cost of $3,000.

APPENDIX I

MAG Landscape Construction Costs

MAG Landscape Construction & Unit Costs

Life Cycle Program Summary
(in thousands)

	Mileage and Cost		*Unit Costs (per mile)*					
	*Length *** (miles)*	*Total Project Cost*	*Life Cycle Plan (granite only)*	***New Landscape Budget***	*7% Landscape Design*	*5% Contingency*	*9% Engineering Administration*	*Total Unit Cost **
TOLLESON - Route 101	0.5	$393	$350	**$300**	46	33	59	787
GLENDALE - Route 101	5.63	$4,428	$350	**$300**	46	33	59	787
PHOENIX - Routes 101, 51, 153, 202	27.48	$21,627	$350	**$300**	46	33	59	787
SCOTTSDALE - Route 101	7.75	$6,095	$350	**$300**	46	33	59	787
MESA - Routes 101, 202	14.76	$11,616	$350	**$300**	46	33	59	787
TEMPE - Route 101	5.25	$4,132	$350	**$300**	46	33	59	787
CHANDLER - Routes 101, 202	12.18	$9,586	$350	**$300**	46	33	59	787
Subtotal	**73.55**	**$57,878**	$350	**$300**	46	33	59	787
SALT RIVER PIMA MARICOPA COMMUNITY - Route 101	9.36	$7,803 **	$350	**$339**	48	34	62	834
Grand Total	**82.91**	**$65,681**	**$350**	**$303**	**46**	**33**	**59**	**790**

* Includes 21% for Landscape Design (7%) Contingency (5%) and Engineering Admin. (9% for Construction Admin.)
** Landscape partially completed w/ interum frontage road projects
*** adjusted to include miles and acreage associated with interchanges