MEMORANDUM

Department of Transportation

DATE: November 2013

TO: Consultants with current or future DOT contracts

FROM: Ellen Barth Alster, RLA, LEED AP, Senior Landscape Architect

SUBJECT: Update Appendix 4D of the Environmentally Sensitive Roadway Design Guidelines, Pima County DOT Roadway Design Manual.

This memo is an update to Appendix 4D of the Environmentally Sensitive Roadway Design Guidelines. It shall substitute for the existing Appendix 4D.

Introduction

Landscaping on Pima County roadways is designed and maintained to preserve the natural character and vegetation density of an area and provide habitat for specific species. The objective is to leave the landscape as natural appearing as possible. Every effort should be made to re-vegetate with plant species that were removed and/or are commonly found in the project environment, matching density, relative location patterns (e.g. small cactus under shrubs), and slope and soil preferences. This process involves inventorying and measuring existing vegetation. The next step is calculating mitigation requirements based on the inventory. These inventories shall be used as a basis for recreating the existing plant communities in new roadway landscaping, including the restoration of washes and riparian areas occurring within the overall project area. The inventories are intended to provide a full representation of the vegetative communities present on the project site, so that these communities can be recreated to the best extent possible.

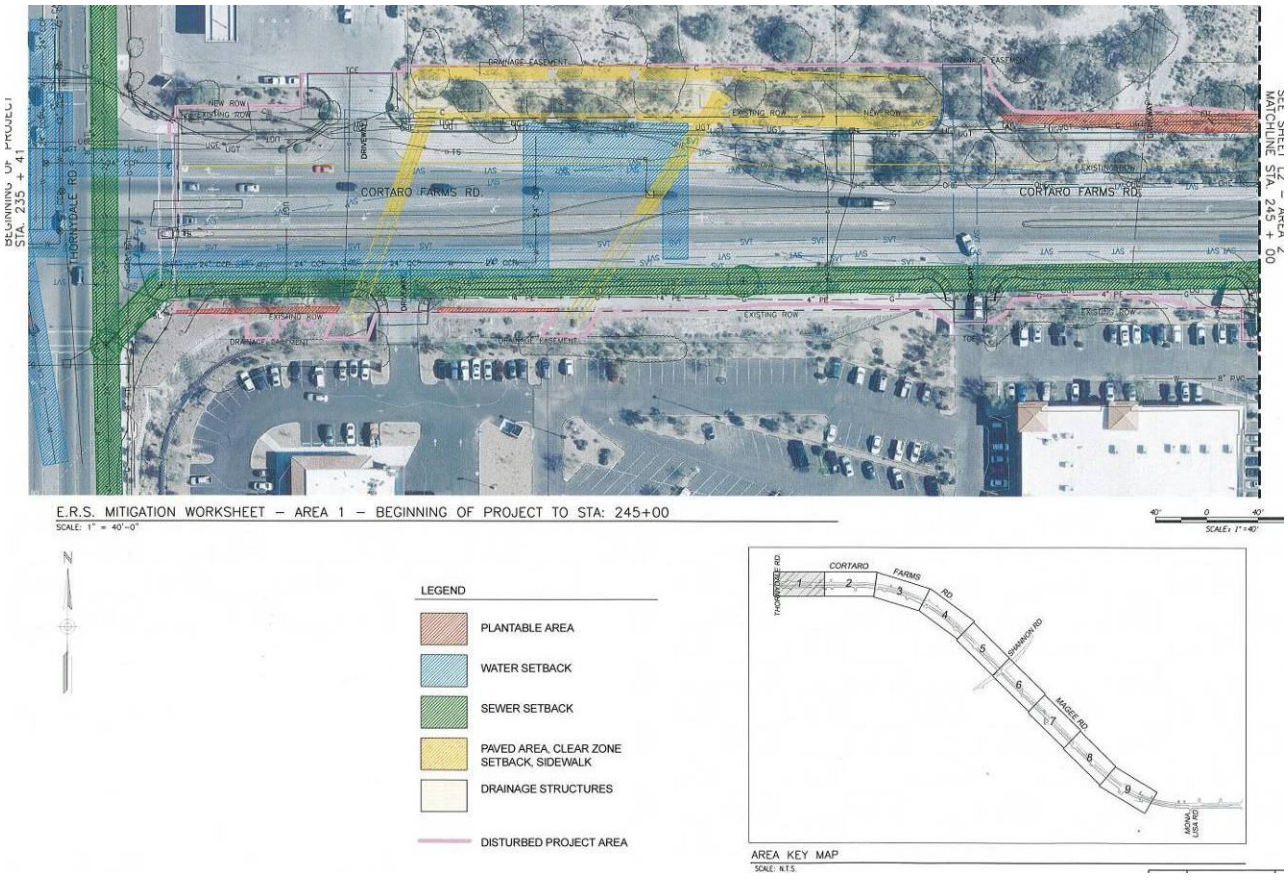
The two types of required Vegetation Measurement are listed below. The first inventory is of all saguaros and Pima County Protected Trees over 3" in caliper (the only exception to the 3" requirement is acacias - only acacias over 8" caliper are required to be inventoried). This inventory is done for the entire project area to be disturbed by construction. The second type of inventory is a sampling which is used to determine densities and types of shrubs, cacti, succulents, and seed mixes.

Inventory Type	What to Inventory	Inventory Area	Inventory Purpose
Saguaros and Pima County Protected Trees	○ All Saguaros ○ All Pima County Protected Trees > 3" caliper (see list under Step 1 below)	Entire disturbed project area of site (cut and fill limits) plus 10' beyond these limits	○ To determine number and sizes of saguaros that should be replaced ○ To determine replacements for Pima County protected tree species
All Other Plants	All plants in determined sampling area. Shall include each specific type of plant community in the project area.	Circular sampling areas (releves). These vary in size and quantity according to the project.	○ To determine seed mix ○ To determine replanting density of Pima county protected cactus and shrub species. This value shall be used as a guide in replanting the remainder of the species.

STEP 1: INVENTORY OF PROTECTED PLANT SPECIES

A. Determine ESR Multiplier by the following method:

- Calculate disturbed area of project. Disturbed area of project is defined as 10' offset from the project cut and fill limits, including all drainage improvements associated with the project. If the 10' offset falls beyond right of way limits, this area is not to be included, unless the area falls within an easement designated as part of the project limits.
- Calculate the plantable area. Plantable area is defined as the disturbed project area that can be planted with trees and saguaros. It excludes the following:
  - Road
  - Unpaved area between and curb and sidewalk
  - 10' offset from water and sewer lines and manholes
  - Medians
  - 10' offset from pavement edge if no curb
  - Sight Visibility Triangle (SVT)
  - Drainage structures
- ESR multiplier = plantable area / disturbed project area
- ESR may fluctuate throughout the project as drainage, slope and construction easements are refined throughout subsequent design phases. Consultant is to be aware of these areas changing throughout design phases.



STEP 1: INVENTORY OF PROTECTED PLANT SPECIES

B. Complete a full inventory of the entire disturbed project area for saguaros and Pima County protected tree species. These plants include:

Scientific Name	Common Name	Minimum Size
Acacia constricta	Whitethorn Acacia	8" Caliper
Acacia greggii	Catclaw Acacia	8" Caliper
Carnegiea gigantea	Saguaro	All
Chilopsis linearis	Desert Willow	3" Caliper
Celtis reticulata	Canyon Hackberry	3" Caliper
Olneya tesota	Ironwood	3" Caliper
Parkinsonia floridum	Blue Palo Verde	3" Caliper
Parkinsonia microphyllum	Foothills Palo Verde	3" Caliper
Prosopis velutina	Velvet Mesquite	3" Caliper
Prosopis pubescens	Screwbean Mesquite	3" Caliper

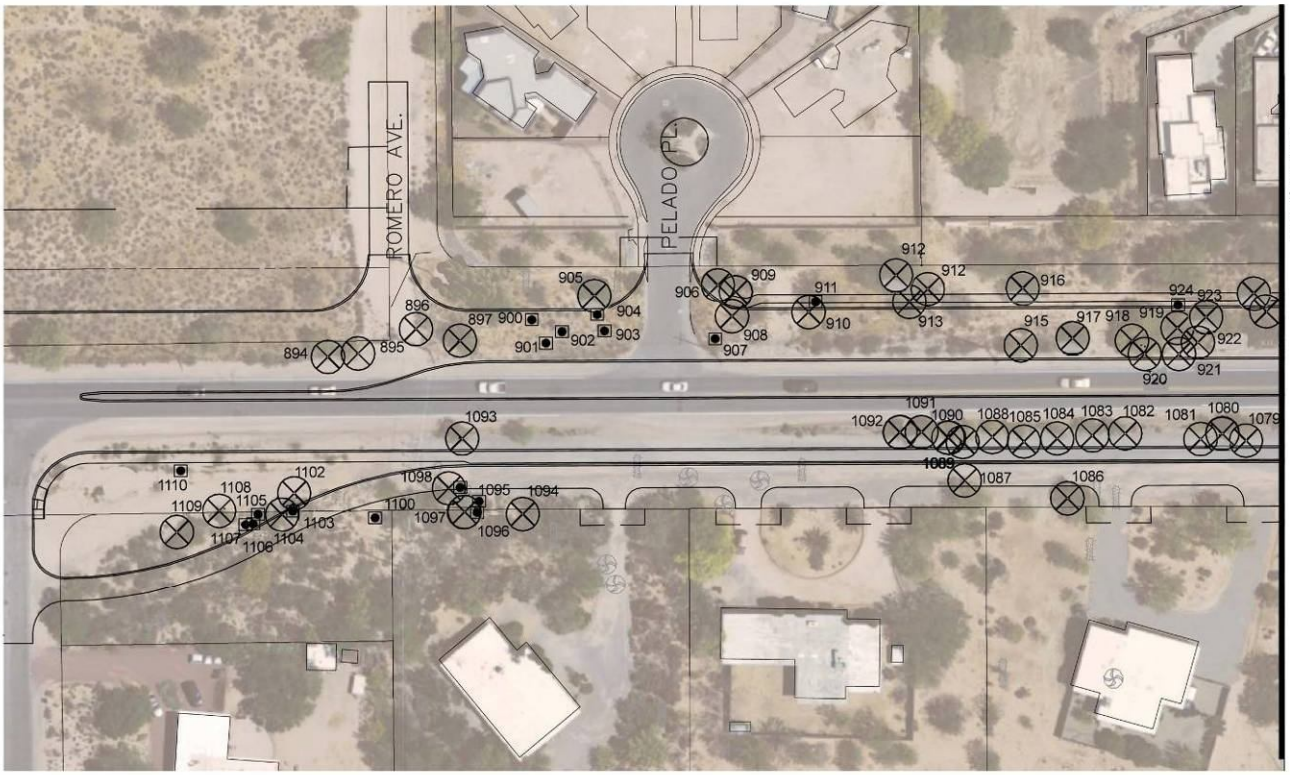
Notes:

- Only the species listed above are required to be inventoried and only the disturbed area needs to be inventoried.
- If the entire site happened to be inventoried including non-disturbed areas, the trees in the non-disturbed areas should not be included in the total caliper inches.

Assess and document the following for each tree:

1. Caliper
    - Measure 24" above ground with forestry caliper
    - For multi-trunked species, the largest 3 trunks are measured. The species is included if the sum of the trunks is greater than or equal to 3"
2. Location
    - Record GPS coordinate points for each tree and saguaro inventoried.
    - Locate trees and saguaros on air photo as shown in page 4.

STEP 1: INVENTORY OF PROTECTED PLANT SPECIES

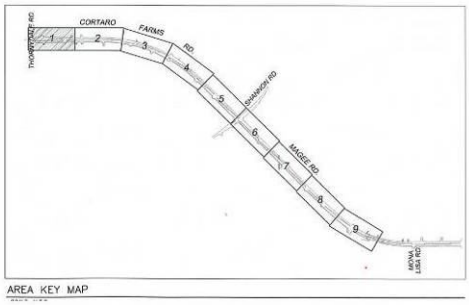


LEGEND

⊗ TREE (Number refers to inventory)

▣ SAGUARO (Number refers to inventory)

40' 0 40' 80'
SCALE: 1" = 40'



SAMPLE NATIVE PLANT INVENTORY PLAN SHEET

ID #	Scientific Name	Common Name	Caliper	Height
119	Parkinsonia microphyllum	Foothills Verde	5	
120	Parkinsonia microphyllum	Foothills Verde	4	
121	Parkinsonia microphyllum	Foothills Verde	13	
123	Carnegiea gigantea	Saguaro		7
125	Carnegiea gigantea	Saguaro		8
128	Chilopsis linearis	Desert Willow	12	
131	Olneya tesota	Ironwood	9	
134	Carnegiea gigantea	Saguaro		6

SAMPLE NATIVE PLANT INVENTORY

- **Tree: indicate caliper inches**
- **Saguaro: indicate heights**

STEP 1: INVENTORY OF PROTECTED PLANT SPECIES

C. Calculate mitigation requirements for protected trees and saguaros

Trees:

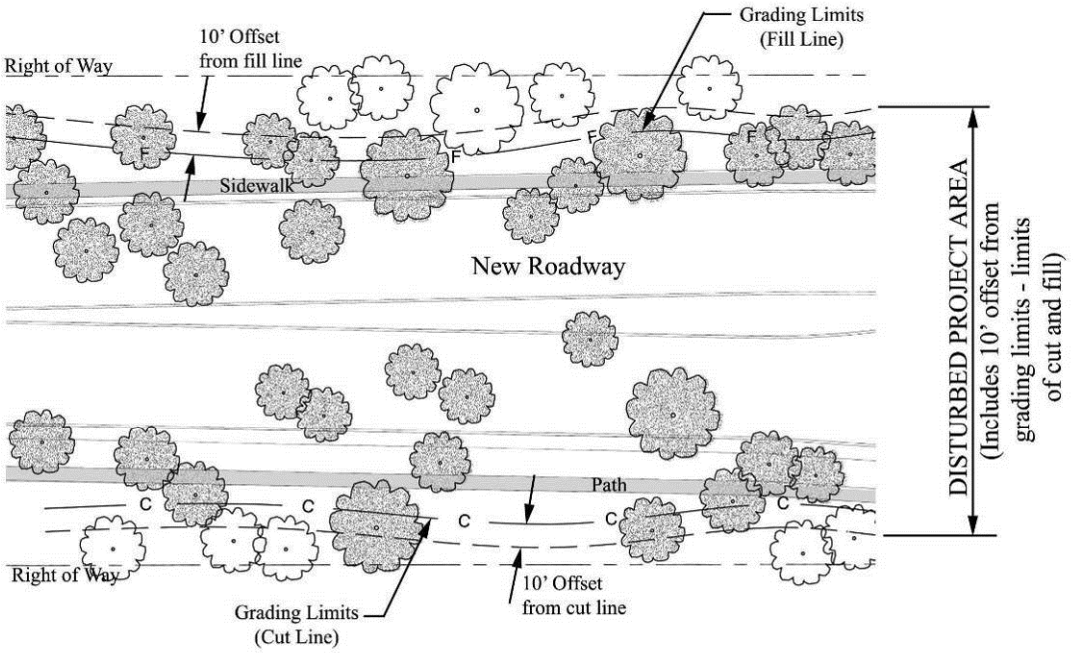
- Add up total caliper inches for each species of tree in the project area that will be disturbed only. Do not include caliper inches for trees in undisturbed areas that will not be impacted by development. (See Diagram Below)
- Mitigation/species = Total Caliper inches x 125% x ESR ratio

Example:

- 100 caliper inch of palo verde in a disturbed site area of 10 acres. (The overall project area r/w to r/w may be larger than these 10 acres, but **only** the caliper inches in the ***disturbed area*** are counted).
- Only 2.5 acres of the 10 acres are plantable (the rest is roadway, clear zone, drainage, etc.)

Result: 100 cal inch x 125% x ESR multiplier = 31.25 cal inches that must be replaced in the 2.5 acres of disturbed acres

NOTE: ESR Multiplier = Plantable Area/Disturbed Project Area or 2.5 acres/10 acres = 25%



Saguaro:

- Mitigate saguaros at 1:1
- Saguaros will be replaced with replacement saguaros that are as close in height to the original saguaro being removed up to an 8' maximum height for replacement saguaros.
- Replacement standards will be as follows:

Inventoried Saguaro	Minimum Replacement Size
0-2'	1-2'
2-4'	2-4'
4-6'	4-6'
6-8'	6-8'
Over 8'	8' maximum ht.

Example:

- Site contains 10 saguaros. See the table below for replacement sizes.

Inventoried Saguaros	Height of Inventoried Saguaros	Minimum Replacement Size
1	10'	8'
2	12'	8'
3	6'	4-6'
4	4'	4-6'
5	4'	4-6'
6	8'	6-8'
7	2'	2-4'
8	5'	4-6'
9	7'	6-8'
10	15'	8'

D. Convert Total Caliper Inches for Required Tree Mitigation

The final caliper inch value for protected tree species is to be distributed into appropriately sized trees to the extent possible, based on plant availability. A demonstrated effort must be made to mitigate using a variety of plant sizes.

Example:

For a given project, it is determined that 31.25" of caliper inches for Parkinsonia microphyllum, (Foothills Palo Verde) need to be replaced. The total inventoried plants = 100 caliper inches. They are originally distributed as follows:

STEP 1: INVENTORY OF PROTECTED PLANT SPECIES

ORIGINAL TREE INVENTORY

Tree #	Tree Species	Caliper Inches
1	Parkinsonia microphyllum	18
2	Parkinsonia microphyllum	16
3	Parkinsonia microphyllum	12
4	Parkinsonia microphyllum	9
5	Parkinsonia microphyllum	9
6	Parkinsonia microphyllum	8
7	Parkinsonia microphyllum	7
8	Parkinsonia microphyllum	6
9	Parkinsonia microphyllum	5
10	Parkinsonia microphyllum	4
11	Parkinsonia microphyllum	3
12	Parkinsonia microphyllum	3
Total Caliper Inches =		**100**

In order to distribute the replacement mitigation trees into a variety of sizes, determine the original distribution of sizes:

DISTRIBUTION OF TREE SIZES IN ORIGINAL INVENTORY

Size ranges	# of Trees	Percentage as Total # of Trees	Total # Required Caliper Inches
> 12"	2	2 trees/12 trees =**17%**	17% x 31.25 =**4.8**
8-12"	3	3 trees/12 trees =**25%**	25% x 31.25=**7.2**
6-8"	3	2 trees/12 trees = **25%**	25% x 31.25=**7.2**
< 6"	5	5 trees/12 trees = **42%**	42% x 31.25 =**12.0**
Totals		**100%**	**31.3**

The next step, once it is determined how many caliper inches are in each size range, is to translate these ratios into sizes of plants that are commercially available. The largest size container available is assumed to be 48" box, with (4) different sizes of plants to be used.

CALCULATING DISTRIBUTION OF TREE SIZES*

Original Caliper Size of Tree	Replacement Container Size	Caliper Inches per Container	Required Caliper Inches/Caliper Inches per Container	Actual # of Trees per each container size
>12".	48" Box	6	4.8/6=**.8**	**1**
8-12"	36" Box	4	7.2/4=**1.8**	**2**
6-8"	24" Box	2	7.2/2.5=**2.9**	**3**
<6"	15 Gal. or 24" tree pot	1	12/1=**12.0**	**12**

***The largest caliper tree sizes shall be planted 100' within either side of wash areas**

In the process of distributing the required caliper inches among container grown plants, use the standards specified below:

Container Size Tree	Caliper Inches per Container
15 Gal. or 24" tree pot	1
24"Box	2.5
36" Box	4
48" Box	6

This method assumes a variety of sizes is commercially available. In the event that the required tree species and saguaros cannot be found in the required sizes, the consultant shall proceed by doing the following:

1. Submit a list of nurseries contacted to Pima County's Landscape Architect.

2. Upon reviewing this list, the landscape architect may require additional plant sources be contacted

3. The County Landscape Architect will make a final determination that all possible tree sources have been contacted before allowing smaller tree sizes to be used to meet the ESR requirement or to allow substitution of tree species

4. It is recognized that plant availability may change between the time construction plans are done and the time the project is built. Therefore, if the tree species and sizes specified on the plans are not available at the start of construction, the contractor must verify this by submitting a list of nurseries contacted to the county landscape architect. The county landscape architect may advise one of the following:

   a) Require additional nurseries to be contacted

   b) Make an adjustment to the trees required based on caliper sizes available

   c) Allow alternate species to be used for tree mitigation. Under no circumstance will alternate species be allowed to be used to mitigate for ironwood trees (Olneya tesota).

E. Allow for Plant Salvage:

For plants in the right of way that will conflict with new construction, PCDOT is providing the opportunity for them to be salvaged by other government agencies and non-profit native plant organizations. Permits will be required from the Arizona Department of Agriculture for transplanting all plant material protected by the Arizona Native Plant Law. PCDOT Right of Way Use Permits will need to be obtained prior to any work being performed it the right of way.

STEP 2: COMPREHENSIVE PLANT SAMPLING – RELEVE PROCESS

The purpose of this second step is to establish a basis for all other planting (not included in Step 1), used to mitigate the impacts of roadway construction projects through revegetation.

The **Releve Method** is a technique that vegetation ecologists use to sample an area for such variables as species diversity, cover, density, and abundance. It attempts to document the entire biotic plant community in the project area prior to roadway construction, so that the disturbed areas can be restored to as close to original condition as possible post construction. Circular plots (releves) are used to inventory and record each species present. Information obtained is extrapolated from these representative samples and used throughout the entire project. Releve survey results shall be used to determine the following:

(1) Tree and shrub species to be planted with tree pots provided by the Pima County Native Plant Nursery
(2) Cacti and succulents to be planted from containers provided by the Pima County Native Plant Nursery
(3) Seed mixes

It is critical that the personnel conducting this method are highly skilled in plant identification, including annual species.

Follow these steps:

A. Conduct releve:

1. Determine number of vegetation entities:

Assess visually the number of *vegetation entities* (discrete assemblages of species) represented within a project area.

- Establish one (1) entity in areas with the same assemblage of species represented throughout.
- Establish two (2) or more entities for most roadway projects. Typical projects might include an upland community with a wash running though it, where the wash contains an assemblage of species distinct from the surrounding uplands. The upland community would be one entity, while the wash community is a second entity. Additionally, washes may contain more than one entity.

2. Determine the required number of releve plots:

Locate circular plots (releves) that are representative of the plant assemblages or communities. The appropriate number and size of these plots will depend upon the size and diversity of the project area.

- Relatively homogenous projects require fewer releves, while project areas having multiple vegetation entities require a greater number of releves.
- It is the responsibility of the project manager to meet with the Pima County DOT staff landscape architect to determine the number of releves required before the project scope is developed.

3. Locate releve plots

- Locate plots to be as representative of each vegetation entity as possible. Preliminary assessment of plots may be determined via MapGuide or other digital tools, but final locations require onsite field visits to be determined.
- Establish 20' radius plots as a general rule. Plot sizes may increase or decrease in size due to site specific circumstances with the approval of the Pima County DOT landscape architect.
- Locate plots in areas adjacent to the project, if limited vegetation is present within the project area due to prior site disturbance. Locate these offsite plots in undisturbed areas with similar topography.
- Define center of plot and plot boundaries with flagging. Document flagged areas with GPS or other means so that they can be re-established if flagging is removed prior to the second releve being done.
- Map releve locations and include this information in the releve submittal to the Pima County staff landscape architect.

MAP OF RELEVE LOCATIONS

STEP 2: COMPREHENSIVE PLANT SAMPLING – RELEVE PROCESS

5. **Collect releve data (See Column A in Table 1):**
   - Identify every species of a plant present within the releve, including annual species.
   - Collect unknown plants and bring to the University of Arizona Herbarium or to a qualified botanist for positive identification.
   - Include single species of plants that are not represented within the releve but fall within 10' of the releve boundary
   - If the releves are not capturing species that appear to be dominant in the landscape, then additional and/or larger releves are required.
   - Provide releve inventory data as illustrated in the columns labeled "A" in Table 1. The example shows five releves (five surveyed plots).
   - Indicate invasive species as shown in the sample provided in Table 1 (See Column C).

6. **Calculate average plant densities per releve (See column B in Table 2):**

Example:

Acacia constricta was inventoried in five separate releves. Total these five areas:

1 (Releve 1) + 0 (Releve 2) + 3 (Releve 3) + 1 (Releve 4) + 3 (Releve 5) = 8 plants

Next, calculate average density:

Total number of plants for each species / number of releves = Average density per releve

8 plants/5 releves =1.6 plants per releve

7. **Repeat entire inventory process two separate times:**
   - Measure the releve twice (spring and fall) to accurately capture the annual flora. On larger PCDOT projects there is typically sufficient design time to allow for two releves to occur.
   - It is recognized that it may not always be possible on smaller projects with shorter design timeframes to repeat the process two times.
   - It is recognized that there may not be signs of enough vegetative diversity to justify repeating the process twice. If this is the case, the reasoning why the releve was not repeated shall be documented.

STEP 2: COMPREHENSIVE PLANT SAMPLING – RELEVE PROCESS

TABLE 1

These five columns indicate the 5 releve plots. The number of columns will vary depending on the number of releves

	A					B	C
	Density (plants per 20' radius releve)					Average Density (per 20' radius releve)	Invasive (check box if applicable)
	Releve 1	**Releve 2**	**Releve 3**	**Releve 4**	**Releve 5**		
Large Shrubs and Trees							
Acacia constricta	1	0	3	1	3	**1.6**	
Larrea tridentata	6	2	4	3	5	**4**	
Parkinsonia microphylla	0	0	2	4	0	**1.2**	
Prosopis velutina	0	1	2	1	0	**0.8**	
Cacti/Succulents							
Carnegiea gigantea	0	2	0	1	0	**0.6**	
Echinocereus fasciculatus	3	2	0	6	1	**2.4**	
Ferocactus wislizeni	0	1	2	1	1	**1**	
Fouquieria splendens	1	0	2	0	1	**0.8**	
Mammillaria grahamii	4	5	8	0	5	**4.4**	
Opuntia engelmanii	1	2	1	0	1	**1**	
Opuntia versicolor	0	1	1	0	0	**0.4**	
Subshrubs, Forbs, and Grasses							
Abutilon incanum	0	1	4	0	3	**1.6**	
Ambrosia deltoidea	23	15	19	24	4	**17**	
Bouteloua aristidoides	4	6	9	5	1	**5**	
Encelia farinosa	9	17	2	8	6	**8.4**	
Erioneuron pulchellum	55	42	30	24	10	**32.2**	
Lesquerella gordonii	0	11	4	8	0	**4.6**	
Muhlenbergia porteri	5	1	7	4	0	**3.4**	
Pennisetum ciliare (Buffelgrass)	12	2	5	6	0	**5**	**x**
Psilostrophe cooperi	2	4	6	4	0	**3.2**	
Senna covesii	1	6	4	9	0	**4**	
Zinnia acerosa	16	22	16	30	24	**21.6**	
					total	**104.4**	

B. Calculate per acre replanting densities for tree pots and container plants

STEP 2: COMPREHENSIVE PLANT SAMPLING – RELEVE PROCESS

Per acre replanting densities are shown for the example of Ferocactus wislizenii (Barrel Cactus – highlighted in teal in Table 2 below)

Example: Calculate the replanting density for barrel cactus:

a. Convert the square foot (SF) area of the releve plot to acres:

- First, find the square foot (SF) area of the 20' radius releve

  Area of a circle = $\Pi \times r^2$

  $3.14 \times 20^2 = 1256$ SF

- Second, convert SF to acres. Area of 1 acre = 43,560 SF

  1256 SF / 43,560 SF = .029 acres

Replanting density for Ferocactus wislizeni =1 plants per releve/.029 acre =35 plants/acre

Table 2: Calculating Replanting Densities for Tree Pots and Container Plants

	Average (per 20'radius releve, 0.029 acre)	Replanting Density per acre
Trees/shrubs		
Acacia constricta	**1.6**	**55**
Parkinsonia microphylla	**1.2**	**42**
Prosopis velutina	**0.8**	**28**
Cacti/succulents		
Carnegiea gigantea	**0.6**	**21**
Echinocereus fasciculatus	**2.4**	**83**
Ferocactus wislizeni	**1**	**35**
Mammillaria grahamii	**4.4**	**152**
Fouquieria splendens	**0.8**	**28**
Opuntia engelmanii	**1**	**35**
Opuntia versicolor	**0.4**	**14**

Notes:
Species highlighted in yellow or green have mitigation requirements satisfied under Step 1. Landscape consultant may chose to add additional 5 gal. plants in these species, depending on the specific situation, but this is not required.

Numbers for replanting densities are recommended guidelines, not mandates. Use of plants depends on specific planting environment

C. Determine Seed Mix

The main goal for re-vegetation is to re-establish the plant community present before disturbance. This can prove challenging as the plant community existing on the site prior to construction may represent a late seral (successional) plant community with long-lived perennials. Disturbance of the soils provides an optimal environment for establishment of ruderals or weedy annual plants. Seed mixes attempting to immediately re-establish perennial grasses and shrubs may have a difficult time establishing in the newly-disturbed soils. These later successional plants may have difficulty competing with annual weedy species and aggressive exotics including buffelgrass and fountain grass.

STEP 2: COMPREHENSIVE PLANT SAMPLING – RELEVE PROCESS

The Natural Resources Conservation Service (NCRS) of the United States Department of Agriculture recommends that seed mixes intended for restoration should try to establish an early to mid-seral community of native annual forbs and grasses that can effectively compete with invasive exotic species and can set the stage for re-establishment of the original native late seral (and more perennial) plant community over time. If the seedbank in the project soil has not been removed or covered over during project grading, the original plant community will regenerate over time. The emphasis in the seed mix should be on native annual forbs and grasses that will germinate quickly and provide cover. Some perennial grasses and tree and shrub species should also be included.

1. **Determine relative percentages of plants not included in the container plantings**.

   The first step in selecting a seed mix is to take each native plant relative to the total number of plant species and determine its percentage relative to the total number of plant species. Do not include plant species represented in the container plantings.

Hypothetical Seed Mix – First Step

	Average (per 20' radius releve, 0.029 acre)	% of Seed Mix	Pure Live Seed per 20 Pounds per Acre	Availability
Trees/Shrubs				
Larrea tridentata	**4**	3.8	.76	Yes
Subshrubs, Forbs, and				
Abutilon incanum	1.6	1.5	.30	No
Ambrosia deltoidea	17	16.2	3.24	Yes
Encelia farinosa	8.4	8.0	1.6	Yes
Lesquerella gordonii	4.6	4.4	.88	Yes
Psilostrophe cooperi	3.2	3.0	.60	Yes
Senna covesii	4	3.8	.76	Yes
Zinnia acerosa	21.6	20.6	4.12	Yes
Grasses				
Bouteloua aristidoides	5	4.8	.96	Yes
Erioneuron pulchellum	32.2	30.7	6.14	Yes
Muhlenbergia porteri	3.4	3.2	.64	Yes
	104.4	**100%**	**20**	

Notes:
Trees and large shrubs are generally not included in the seed mix for roadway projects due to setback restrictions, clear zone issues, and site visibility triangles. In riparian areas where these don't apply, larger shrubs and trees are to be included.

Seed mixes are to be adjusted for seed availability.

2. **Select seed mix using first step for general guidance. A seed mix should be developed by the consultant using the following criteria:**

   - Provide 20 to 25# PLS (pure live seed)/acre depending on project conditions
   - Provide up to 50% of seed mix as native grasses depending on project conditions.
   - Include species that germinate in both the warm and cool weather

STEP 2: COMPREHENSIVE PLANT SAMPLING – RELEVE PROCESS

Hypothetical Seed Mix – Second Step

	Pure Live Seed per 20 Pounds per Acre	Comment
Trees/Shrubs		
Larrea tridentata	1	
Subshrubs, Forbs, and		
Abutilon incanum	1.0	
Ambrosia deltoidea	0.5	
Encelia farinosa	2.0	
Lesquerella gordonii	0.5	
Psilostrophe cooperi	1.0	
Senna covesii	1.0	
Zinnia acerosa	1.0	
Grasses		
Aristida purpurea	3.0	Added because germinates well and will help re-stabilize slopes
Bouteloua aristidoides	2.0	
Erioneuron pulchellum	6.0	
Muhlenbergia porteri	1.0	
	20.0	

Notes:
Trees and large shrubs are generally not included in the seed mix for roadway projects due to setback restrictions, clear zone issues, and site visibility triangles. In riparian areas where these don't apply, larger shrubs and trees are to be included.

Seed mixes are to be adjusted for seed availability.

Proposed seed mixes shall be submitted to the Pima County landscape architect, along with all the data documenting the consultant's work. The Pima County landscape architect will assist and advise the consultant as to the final composition of the seed mix, based on the additional following considerations:

- Are there steep slopes that will be subject to erosion?
- Is the soil sandy and subject to greater erosion?
- Is there buffelgrass in the area? (If so, the percentage of native grasses to force quick cover should be increased)
- What time of year will the project be seeded? If this is known, what will germinate the quickest?
- Is the seed mix in a riparian mitigation area? If so, RFCD staff may provide additional seed mix recommendations.