

MEMORANDUM

Date: July 21, 2003
Final Version

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From: Kevin Conner, RLA, C&B

Re: **SARIP – Assigning Manning’s “n” Values for Vegetation Associations**
Carter & Burgess Proj. No. 310145.013

This memorandum is intended to provide a general framework for the assignment of “n” values to general vegetative zones in the river improvement areas in order to provide clarity and coordinated for all the design teams. The zone descriptions are schematic in general and not intended to dictate rigid constraints in regard to vegetation types, spacings, or applications. It is the responsibility of the design teams to apply these guidelines as dictated by project requirements using the appropriate standard of care so that hydraulic performance for the final channel design correlates with the proposed planting plan.

Vegetation Assumptions

As the GRR and Unit 8-5-2 studies proceed toward completion, we need to assign or at least agree upon common “n” values (coefficients of channel roughness) for the different proposed vegetation densities that will be found in the Mission Reach and Museum Reach. Within the cross-sections for the hydraulic model, the vegetation zones can be shown by areas of different “n” values, which will then result in the model taking the channel roughness coefficients into account. This practice will result is an approximation of hydraulic behavior for the proposed SARIP conditions.

The Urban Segment of the Museum Reach is exempted from the conditions described by this memorandum, due to R.O.W. and hydraulic constraints, which are radically different than those in the Mission Reach and Unit 8-5-2.

The conditions described in this memorandum may generally apply to the rehabilitation of the Catalpa-Pershing Channel of the Museum Reach, although the proposed vegetation for that project may be less dense than those described below for the Mission Reach. The Museum Reach design team will document the application of these guidelines in the Museum Reach design report.

For the sake of record-keeping and clarity, below are the factors affecting the vegetation zones:

- ❖ There will be different vegetation zones within the project. Four were proposed in the Master Plan, and as a result of the concerns voiced at the October 17th O&M meeting for the Mission Reach, one category (Zone B) was dropped.

For the purposes of the following text, "understory" is defined as woody, perennial plants that form shrubs or small trees. While herbaceous plants and grasses can be found within this "understory," it is dominated by woody plants. By its nature, it impedes water flow, because the woody plants tend to resist the flow rather than bend with it. Plants with low or negligible hydraulic resistance in their juvenile and mature growth stages will not be considered "understory."

- Zone A is described in the Master Plan on page 60. Zone A consists of trees planted within the range of 10' to 25' on center (o.c.) with understory allowed and no minimum limb height in the mature condition, except in areas where pedestrians are present. If pedestrians are present, minimum branch height is 10' in the mature condition. The Master Plan intended that Zone A areas would be planted at the top of bank, above the 100 year floodplain. That is not feasible in most portions of the Mission Reach, because the 100 year floodplain rises to the top of bank or over the top of bank. For purposes of the initial H&H fatal flaw study, judgment calls were made on a cross-section by cross-section basis to establish how much of the planted area shown on the Master Plan was Zone A, C, etc.

Where the floodway conveyance is considerably increased, Zone A may extend down the floodway channel banks.

- Zone C is described in the Master Plan as trees planted 15' o.c. average with no understory allowed and a minimum limb height of 8' in the mature condition, except in areas where pedestrians are present. If pedestrians are present, minimum branch height is 10' in the mature condition. Due to O&M concerns and hydraulic concerns, these trees are now proposed to be planted within the range of 25' to 40' o.c. Some clumps of understory and/or understory with trees will be planted and designated as "no-mow" zones. Tree spacing may be altered in some instances to provide clumps of understory without trees. Clear compensatory conveyance areas will be located on each side of these understory clumps. The rest of the ground within Zone C will be planted with native grasses and forbs. This zone is to be installed top to toe of slope, and where hydraulically feasible the zone may extend to the flatter areas of the river. Floodwaters are expected to reach into the lower to middle portions of the canopies of these trees.
- Zone D is described in the Master Plan as trees planted 15' o.c. average with no understory. There is some confusion about this zone, as a note in the Hydraulics Summary Appendix on page 117 changes that to 30' on center. Further confusing the issue, the graphics in the Master Plan show a significantly different scenario with clusters of trees interspersed amongst large meadows. Again due to O&M concerns and hydraulic concerns, this needs to be isolated trees or clumps of trees within large native grass and forb meadows. The

amount of trees in this zone can be characterized as approximately 30 trees per acre, or roughly 40' o.c. or greater with a minimum limb height of 8' in the mature condition. However, these would be planted in clumps so that large grass and forb meadows surround the trees. These areas are to be planted in the flatter areas around the river, and floodwaters can be expected to reach far up into the canopies of these trees.

Tree spacing in this zone should be dependent upon the species height at maturity, as well. For example, trees between 30' to 60' height should be planted 40' on center average and greater, and larger trees should be planted on 40' to 60' centers average.

Careful consideration must be given to the species of trees within the floodway. Use of trees that are clump-forming or inclined to low-branching and easy suckering should be minimal.

Trees planted in Zone D are encouraged around the pilot channel to enhance the aquatic habitat, but should not be planted within 10' of armoring that the tree roots would damage in the future. Various revetment techniques are being considered, and tree roots will assist some types and damage others.

Further, the trees planted adjacent to the pilot channel should be species exemplary of a shaded riparian habitat, with the purpose of ultimately shading large portions of the water surface.

- Zone E, meadow areas without trees, was not described in the Master Plan, but are present in the current design. These meadow areas are comprised of native grasses and forbs. This zone may also include taller riparian herbaceous species along the riparian zone in certain areas.
 - The hike/bike trail is contained within a corridor that has specific maintenance requirements. On both sides of the trail, a 2' wide strip will be seeded with shorter native grasses and mowed/ maintained to a 6" maximum height. Outside of that 2' zone, a zone varying from 4' to 6' will be seeded with native grass that will allowed to reach 12" in height, and will be maintained consistent with Zone D. Isolated, infrequent trees are allowed within this 4'-6' zone to frame views, provide interest along the trail, etc. In a mature condition, the minimum limb height on these trees will be 10'. The use of native species is encouraged all along the hike/bike trail.
 - Tree planting near the pilot channel will be promoted as much as possible. Care will be taken to avoid regular, linear arrangements that appear artificial. Care will also be taken to not compromise diversity in vegetation location within the channel. The intent of this measure is to create more habitat potential at the water's edge and within the stream body.
- ❖ The various Zones are illustrated on the Vegetation Zone Concept plan attached to this memo. These vegetation zones can be hydraulically characterized by different "n" values for the hydraulic models.

- ❖ The O&M for the Zones will have a specific regimen intended to either be grown in a predictable fashion or be maintained in a particular state.
 - Zone A ($n \approx 0.150$) will be a "no-mow" zone. Plants can reseed themselves and the understory can grow denser. The maintenance agencies will periodically (every year to 2 years) remove excessive detritus and resolve objectionable areas, but overall, this area is intended to be a dense stand of vegetation.
 - Zone C ($n \approx 0.075 - 0.085$) will be mowed and maintained so that only the trees that were planted as part of the SARIP project or subsequent approved projects will be allowed to remain. These trees will be marked so that they are not damaged or removed accidentally. The groundcover will be native grasses and forbs that do not have to be mowed frequently, but rather can grow to a height of 12" to 24". No understory will be allowed to remain except in the "no-mow" clumps as described above.
 - Zone D ($n \approx 0.055$) will be maintained in the same manner as Zone C.
 - Zone E ($n \approx 0.035$) will be periodically mowed, but not as a manicured lawn. The frequency of mowing will be criteria determined by the habitat manager in coordination with the City of San Antonio's designated maintenance agency and deemed necessary to keep a healthy habitat, which includes aesthetics and safety to users and neighboring property owners. Mowing height is anticipated to be from 12" to 24" in height at 1-2 mowings per year.
 - The exception to the above would be areas adjacent to hike/bike trails or other publicly-used areas (highly used parks). In publicly-used areas, grasses may be mowed to a 6" maximum height. The use of low maintenance, short, native grasses is the preferred design approach.

Associated "n" Values

Each of these Zones can have an "n" value assigned to it, characterizing its hydraulic resistance. Over 40 years of professional engineering experience played a significant role in determining these values. Further, to back up the professional experience, two reference texts were consulted that are the considered by the engineering profession to be the standards:

- ❖ Open-Channel Hydraulics ("OCH")
Ven Te Chow, PhD, University of Illinois; McGraw-Hill Book Company, 1959
- ❖ Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains ("The Guide")
George J. Arcement, Jr., and Verne R. Schneider; U.S. Geological Survey Water-Supply Paper No. 2339;

The Guide applies primarily to overbank areas with a relatively low flow depth when compared to the conditions in the SARIP. Therefore, The Guide was used primarily for its representative photographs.

OCH provided some guiding principles in determining the "n" values for both channels and floodplains. These are found on pages 101 through 123.

Following is a discussion of the different vegetation zones and corresponding "n" values:

❖ Zone A

- Is characterized by "n" value of 0.150
- OCH provides a method of approximating "n" values for channels on page 109 by adding coefficients for factors of roughness within a channel. Below is a table describing the factors and chosen coefficients:

VARIABLE	FACTOR	VALUE
n ₀	Material Involved: Earth	.020
n ₁	Degree of Irregularity: Moderate	.005
n ₂	Variation of Channel Cross-Section: Alternating Occasionally	.005
n ₃	Relative effect of obstructions: Minor	.015
n ₄	Vegetation: Very High	.100
m ₅	Degree of Meandering: Minor	1.0

The equation for combining these values is:

"n" = (n₀+n₁+n₂+n₃+n₄)m₅ or in this case, "n" = 0.150 (rounded).

- OCH also provides a comparative table on pages 110 through 113. OCH provides in the table that the maximum value for a Major Stream with an irregular or rough section is 0.100. It is clear that the channels within the SARIP would be characterized as major streams, however, this value is clearly a composite "n" value applying to the entire channel rather than a vegetation zone within the channel. OCH and The Guide both support "n" values ranging from 0.100 to 0.200 for forested floodplain areas of varying densities. Therefore, since Zone A may be selected for use in the channel as well as other areas of the floodplain, a reasonably conservative Manning's "n" value of 0.150 for Zone A has been selected for use in the hydraulic modeling of this zone only where it is applied spatially within the floodplain.

❖ Zone C

- Is characterized by "n" value range of 0.075 to 0.085.
- Below is the table of factors and chosen coefficients, as described above:

VARIABLE	FACTOR	VALUE
n ₀	Material Involved: Earth	.020
n ₁	Degree of Irregularity: Moderate	.005
n ₂	Variation of Channel Cross-Section: Alternating Occasionally	.005
n ₃	Relative effect of obstructions: Minor	.010
n ₄	Vegetation: High	0.035 to 0.045
m ₅	Degree of Meandering: Minor	1.0

- From the OCH comparative table described above, there does not appear to be a good comparison, taking into account flow depth and vegetation. However, Zone C will generate less resistance than Zone A because the tree planting is not as dense and clear compensatory conveyance areas will be located on each side of the understory clumps. The 0.075 - 0.085 "n" value obtained through the factors chart therefore seems reasonable.
- The primary difference is the depth of inundation within the tree canopies. If it appears likely that the water surface elevations would reach the mature tree canopies, then the higher value ought to be used.

❖ Zone D

- Is characterized by "n" value of 0.055.
- Below is the table of factors and chosen coefficients, as described above:

VARIABLE	FACTOR	VALUE
n ₀	Material Involved: Earth	.020
n ₁	Degree of Irregularity: Moderate	.005
n ₂	Variation of Channel Cross-Section: Alternating Occasionally	.005
n ₃	Relative effect of obstructions: Negligible	.000
n ₄	Vegetation: Medium	.025
m ₅	Degree of Meandering: Minor	1.0

- From the OCH comparative table described above, there is not a match for isolated trees or clumps of trees within the channel. However, when one considers that Zone D trees will be planted farthest down in the channel with much of the tree canopies inundated, the result is very similar to brush in a proportionally smaller flow. The normal value for scattered brush and heavy weeds in a floodplain area is .050, which corresponds closely with the proposed Zone D value of .055.

❖ Zone E

- Is characterized by "n" value of 0.035.
- Below is the table of factors and chosen coefficients, as described above:

VARIABLE	FACTOR	VALUE
n ₀	Material Involved: Earth	.020
n ₁	Degree of Irregularity: Moderate	.005
n ₂	Variation of Channel Cross-Section: Alternating Occasionally	.005
n ₃	Relative effect of obstructions: Negligible	.000
n ₄	Vegetation: Medium	.005
m ₅	Degree of Meandering: Minor	1.0

- From the OCH comparative table described above, there is a close match for "Dense weeds or aquatic plants in deep channels," found on Page 112 of OCH. That value is 0.035 in the Normal range.

Correlation with the City of San Antonio Unified Development Code (UDC)

The City of San Antonio has established within its UDC a set of "n" values to be used in hydraulic calculations that are subject to regulatory review or for consulting services performed for the City. Those values listed below:

CHANNEL DESCRIPTION	MANNINGS "n" VALUE
Concrete Lined Channel	0.015
Grass Lined Channel with Regular Maintenance	0.035
Grass Lined Channel without Recent Maintenance	0.050
Vegetated Channel with Trees, little or no Underbrush	0.055
Natural Channel with Trees, moderate Underbrush	0.075
Natural Channel with Trees, dense Underbrush	0.090
Natural Channel with dense Trees and dense Underbrush	0.100

Zone A, as described above with an "n" value of 0.150, is to be applied as a component of an overall composite "n" value for the channel and agrees with the City of San Antonio UDC Manning's "n" value representing "Natural Channel with dense Trees and dense Underbrush." We believe that 0.150 appropriately represents this dense vegetation zone.

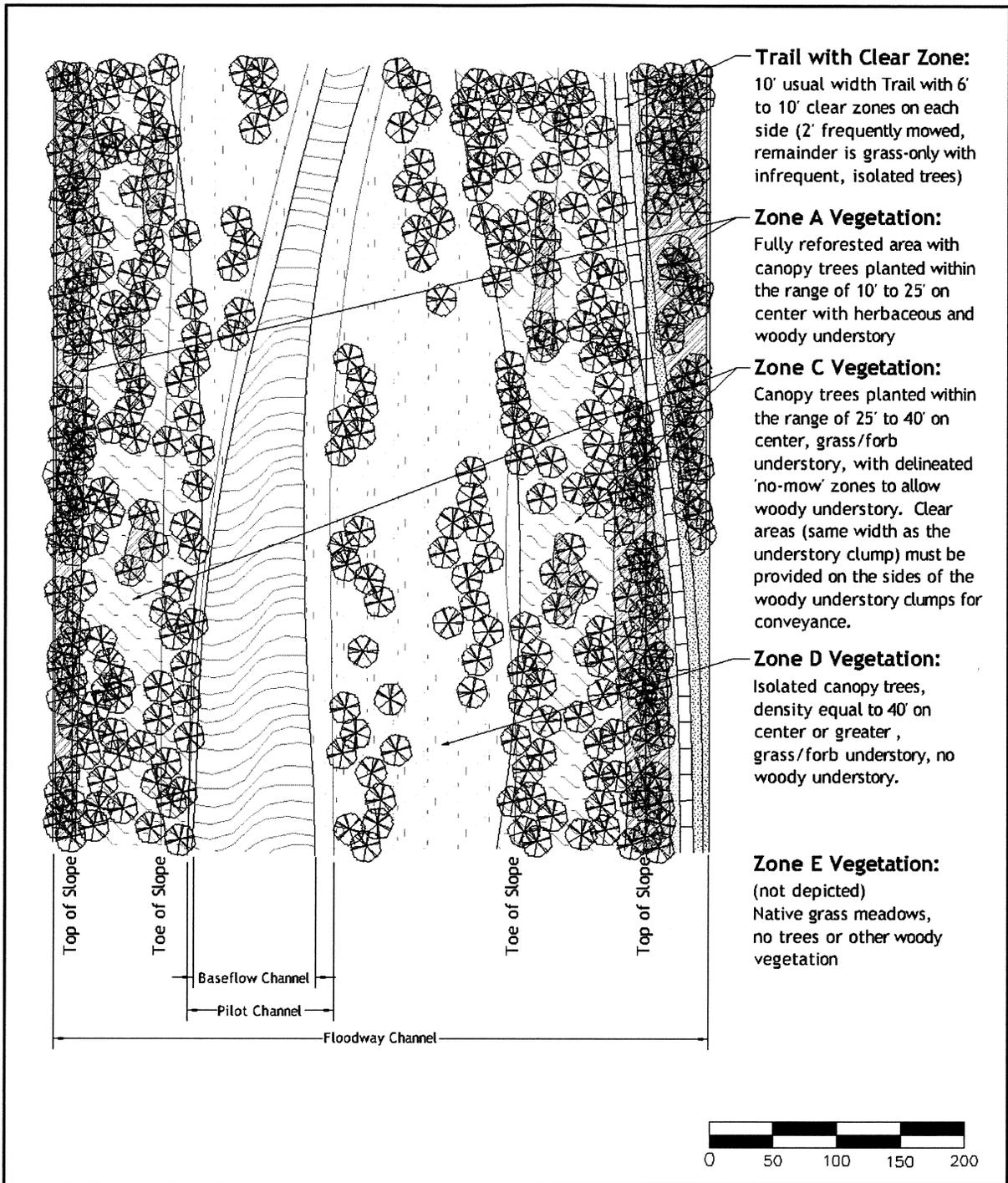
Zone C, as described above with an "n" value of .075 to .085, corresponds well to the "Natural Channel with Trees, moderate Underbrush," which has a .075 'n' value. The approach taken for the SARIP project is actually more conservative in this zone, because Zone C does not have any understory plantings at all, yet is calculated at a slightly higher "n" value. We believe this approach and corresponding value of .075 to .085 to be a valid and proper conservative approach, due to the potential of the water surface elevation to reach the tree canopies, depending upon channel depth. As mentioned above, if it appears likely that the water surface elevations would reach the mature tree canopies, then the higher value ought to be used.

Zone D, as described above with an "n" value of .055, corresponds well to the "Vegetated Channel with Trees, little or no Underbrush." Again, this approach is conservative compared to the UDC, as Zone D has trees in isolated motts or clusters.

Zone E has an assigned "n" value of 0.035, which corresponds well to the "Grass Lined Channel with Regular Maintenance," which has the same "n" value.

In conclusion, these above described vegetation zones will act as a guide for project development. Additional vegetation zones may be developed as additional constraints or habitat restoration opportunities are identified or as appropriate. The zones described in this memo and their corresponding "n" values provide a basis for the low, medium, and high ranges of vegetation plantings that will occur within this project.

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