Appendix C

AGFD DESIGN RECOMMENDATIONS

ATTACHMENT

ARIZONA GAME AND FISH DEPARTMENT RECOMMENDATIONS FOR THE SONORAN VALLEY PARKWAY - WILDLIFE MITIGATION STRATEGIES

Introduction

Wildlife move across the landscape to meet their basic survival needs. Anthropogenic barriers to wildlife movement, such as roads, pose a significant threat to the long-term persistence of wildlife populations worldwide by fragmenting habitat (Noss 1983, Wilcox and Murphy 1985, Noss 1987). The rapid expansion of the U.S. road system to approximately 3.9 million miles (Forman et al. 2003) has exacerbated the effect of habitat fragmentation on wildlife populations by creating barriers to movement (Noss and Cooperrider 1994, Forman and Alexander 1998). Other impacts of roads on wildlife populations include habitat loss within the road's physical footprint, reduced habitat quality adjacent to the roadway, increased exploitation of wildlife resources by human populations, direct mortality (i.e., road kill), pollution, establishment of invasive species, increased development, and reduced landscape connectivity (Spellerberg 1998, Tombulak and Frissell 2000, Foreman et al. 2003).

Wildlife crossing structures with funnel fencing have the potential to make roads safer for motorists and wildlife by reducing wildlife-vehicle collisions and maintaining landscape connectivity (i.e., the degree to which a landscape facilitates or impedes the movement of organisms among distinct resource patches; Taylor et al. 1993). From a wildlife conservation perspective, effective wildlife crossing structures can reduce the impacts of habitat fragmentation resulting from the isolation of core habitat (e.g., decreased population numbers, loss of genetic variation, loss of population viability, extirpation/extinction). Effectiveness is dictated by the assemblage of species present, the types of crossing structures installed, and the placement of those structures relative to animal movements.

The City of Goodyear has identified the need for a new parkway in the Rainbow Valley to service future development in and around Mobile, Arizona, which was annexed by the City of Goodyear. The Rainbow Valley, located between the Sierra Estrella Mountains and the Sonoran Desert National Monument (SDNM), functions as a critical link for a variety of sensitive wildlife species, including desert bighorn sheep (*Ovis canadensis nelsoni*), desert mule deer (*Odocoileus hemionus*), and desert tortoises (*Gopherus agasizzii*), and provides habitat for numerous other species such as the Western shovel-nosed snake (*Chionactis occipitalis*).

Given the awareness of the planned parkway's potential impacts on wildlife connectivity, a data-driven approach to maximizing the effectiveness of mitigation measures in terms of conservation benefit and financial resources is most desirable. A pilot-study was developed during July 2008 to provide preliminary information on wildlife movement across the El Paso Gas Pipeline Road. While this effort was brief, it indicated that wildlife move across the alignment in specific locations (Figure 1). This effort represents the only wildlife movement data available from Arizona Game and Fish Department (AGFD) in this area to date. Wildlife movement studies should be conducted to inform future design recommendations during parkway expansion projects that optimize wildlife passage, reduce wildlife/vehicle collisions and reduce wildlife mortality. Pre-construction and/or post-construction monitoring of wildlife movement across the 2 lane parkway and within recommended bridge and culvert crossing structures could inform future recommendations for additional design features such as funnel fencing and escape ramps. Funnel fencing is a critical component of crossing structure designs as traffic

volumes increase and the parkway is expanded to 6 lanes. Wildlife movement data should be incorporated into the pre-design phase of future expansion projects.

The recommended research approach includes road kill assessments, track surveys, and traffic volume analyses to finalize location and design of crossing structures and other fencing or flood control designs; followed by post-construction monitoring of crossing structures to evaluate effectiveness and apply adaptive management and design strategies if necessary.

At this time, the AGFD will not provide recommendations for locating wildlife crossing structures suitable for bighorn sheep as parkway mitigation. The modeled linkage design includes bighorn sheep. The only mitigation for Bighorn that will work is a wildlife overpass structure. However, AGFD does not believe we could accurately recommend siting for this mitigation without telemetry data to better understand movement patterns between suitable habitats in the mountainous terrain of the area. There is no source for telemetry research at this time. Therefore, AGFD is not recommending mitigation solutions for bighorn within the Linkage Zone at this time; however, we consider connectivity of bighorn sheep habitat between the Sierra Estrellas and Sonoran Desert National Monument (SDNM) a future priority that should be addressed prior to future interstate highway expansions in the area.

Mitigation Recommendations

The AGFD recommends construction of a series design features along the SVPP alignment that will facilitate wildlife movement within the Sierra Estrella-SDNM Linkage Zone (Maximum BLM alternative) and important natural wash movement corridors associated with Waterman Wash and larger tributaries. The overall connectivity goal is to provide multiple crossing structures, suitable for a variety of species (large and small mammals, reptiles and amphibians) and spaced at distances that accommodate species with small and large home range sizes, associated with washes and upland habitats. Decisions on the parkway alignment should strive to minimize the distance traversed across the Linkage Zone in such a way as to consolidate future transportation and utility corridor ROWs and avoid excessive fragmentation of the Linkage Zone, thereby minimizing the need for mitigation.

Design features identified in project planning mitigation discussions include a variety of solutions including: bridges or span arch culverts, box and pipe culverts, crossing structure funnel fencing, wildlife permeable flood control features, wildlife friendly Right-of-Way (ROW) fencing, and reptile exclusion fencing where necessary for reducing impacts to special status species. Recommendations for the locations of structures have not been finalized and are contingent on which alignment alternative is chosen for implementation. The AGFD recommends coordination during the parkway engineering and design phase to finalize site and design specifications of wildlife crossing structures. Recommendations will be based on findings from relevant wildlife research, site specific wildlife movement information, existing wildlife habitat values, field expertise from AGFD, wildlife habitat modeling and AGFD bridge, culvert and fence guidelines (http://www.azgfd.gov/hgis/guidelines.aspx) for wildlife passage. Considerations will include future land use plans within the City of Goodyear and Maricopa County Flood Control District plans for future flood control designs within the Rainbow Valley area. Design specifications for wildlife crossing structures should optimize the movement of wildlife while not impeding the management of flood water.

Wildlife mitigation recommendations are based on a phased implementation approach; tiered to the phased construction approach proposed by the City of Goodyear. Initial construction will be for a 2 lane road, with posted speeds of 55 mph, with plans for future expansion to a 6 lane parkway.

Design Recommendations for Large Sized Mammal (Mule Deer) Crossing Structures

AGFD research indicates that deer are very adverse or sensitive to crossing roadways and need the largest underpass as possible (bridges). There has been some deer passage documented through culverts, and it is possibly enough to maintain gene flow and functional genetic connectivity; but not true permeability in the sense that resident populations would have the ability to move through home ranges for feeding, breeding, dispersal and in response to climatic or episodic events. The best case scenario within the Linkage Zone would be a wildlife overpass (land bridge type structure) that does not arch but remains at natural grade; with a roadway that tunnels underneath; a structure such as this would accommodate all species including bighorn. Goodyear has stated this is not economically feasible.

The recommended solution is construction of multiple large arch span type culverts within the Linkage Zone and associated with priority wash corridors outside the linkage. Culverts should have clear visibility to the other side, large openness ratio, a 12 foot recommended minimum height to avoid a tunneling effect, and sloped walls as opposed to vertical. Wide cross-sectional areas should provide for out of channel wildlife movement when wash corridors are flowing, an important design consideration. Center grates on medians should be considered to enhance natural lighting.

This option should provide better passage than a box culvert 10x10 foot box type structure. Ongoing AGFD research in Twin Peaks, Arizona, to evaluate mule deer use of a 2-cell, 10’ high x 12’ wide x 130’ long culvert underpasses indicates deer come approach, but do not use it.

AGFD recommends a phased implementation approach, that utilizes designs that can be easily upgraded as opposed to reconstructed. There is potential to identify suitable locations within the Linkage Zone at the 2 lane phase. However, in a build out future, it may be best to site crossing structures towards the middle of the Linkage Zone away from the disturbances of the urban fringes, in addition/or in lieu of wash corridors. *AGFD recommends further analysis for timing and location of structures during the engineering and design phases of the project.* At a minimum, construction of large mammal crossing structures should occur when the parkway is expanded to 4 or 6 lanes, and when traffic volume across the linkage increases. It may not be cost effective for the 2-lane phase of the project.

AGFD recommends approaching bighorn sheep mitigations for the Linkage Zone as part of Phase 2 implementation of the project. This will require collaboration on bighorn sheep movement research with multiple stakeholders and project proponents including the Arizona Department of Transportation (ADOT); and in coordination with other local transporation projects including but not limited to the future SR 303, I-11 and/or Hassayampa freeway through the Linkage Zone.

Design Recommendations for Medium and Small Sized Wildlife Crossing Structures

AGFD recommends maximizing the number and size of medium and small sized culverts within the Linkage Zone; and as required for roadway design outside of the linkage. AGFD research has demonstrated that culverts are used by mountain lions, bobcat, javelina and other medium to small mammals, reptiles and amphibians for passage under roadways. A study funded by the Pima County Transportation Authority (Grandmaison 2012) provides background on passage rates for small vertebrates (i.e., lizards, snakes, small mammals, meso-carnivores). Similar to large mammals, small critter fencing (eg. Tortoise fencing) can be used to funnel movement and as an additional safe-guard for special status species such as Desert tortoise (see further discussion on tortoise fencing below).

Design culverts with at grade natural substrate bottoms and avoid use of large rip rap in front of or adjacent to culverts; and/or backfill with topsoil and stabilize with vegetation to optimize movement of barrier sensitive species such as Desert tortoise. Design culverts so as to avoid sharp drop offs and scour at the downstream end.

Structural dimensions for culverts suitable for medium sized wildlife should have *openness ratios >0.4 and heights of at least 3-6 feet*. Structures should be placed frequently (*every 500-1000 ft.)* to correspond with smaller home range sizes over roadway distances greater than ½ mile. For a six lane or larger roadway, *AGFD recommends a cross-sectional opening of >30 square feet for medium sized mammal culvert locations.* Installing a structure suitable for a six lane road will require little to no retro-fitting and reduce the need to fully reconstruct crossing structures when the parkway is expanded up to six lanes. Culverts should be easily accessible (at natural channel grade) with natural vegetation surrounding the approach and entrance. Avoid use of large rip rap at approach and entrance and/or design with ramps to facilitate movement if constructed above grade.

Small mammals, reptiles and amphibians will utilize small pipe, box culvert and/or pipe culvert designs. Structural dimensions should have smaller cross-sectional areas, 2-4 sq. feet, with heights of at least 1 foot.

Small Sized "Upland" Crossing Structures Suitable for Amphibians and Reptiles

There are several species of reptiles and amphibians that utilize habitat within the Rainbow Valley area. Small sized crossing structures (see above) in upland locations are suitable for these species and could be easily incorporated into parkway designs. AGFD recommends placing a few crossing structures for these species in *upland locations* to compliment the distribution of large, medium and small culverts and bridges within the Linkage Zone. However, additional structures would be beneficial further north, proximate to City of Goodyear open space plans, to maintain distribution and abundance of these species within open space areas fragmented by the parkway. Optimum placement is every 150-300 feet. Small pipes or box culverts with natural substrates should be fitted with grated open top designs or slotted drain culverts that are flush with roadways and allow natural light, air and rain to infiltrate without water pooling. Crossing structures outside of floodplains would provide safe passage for species that don't typically use wash habitats and/or have small home ranges. Funnel fencing will be an important design component for these passage structures. We recommend further discussion on how these features could be incorporated into a connectivity strategy within the Linkage Zone. (See also discussion on tortoise fencing below)

Funnel Fencing and ROW Fencing and Tortoise Fencing

AGFD strongly recommends funnel fencing at all wildlife crossing structures designed for wildlife mitigation to ensure they are effective; without funnel fencing research has shown wildlife will continue to cross the roadway at grade. Funnel fencing is a critical component of successful wildlife crossings. Fencing is generally placed to compliment natural topographic features and encourage wildlife to move through a crossing structure and to prevent entrapment along medians. Escape mechanisms (such as fencing that leads to a slope and allows an animal to jump down but not up) are often used to compliment funnel fencing objectives and prevent roadway entrapment. Fence heights will need to be a minimum of 7 ft. for deer and sheep and 3-6 ft. for medium to small mammals. Livestock can be excluded from funnel areas by placing ROW fencing across and setback from the funnel/wildlife crossing structure area.

AGFD recommends use of roadway exclusion fencing as an additional mitigation to minimize roadway mortality of Desert tortoise as a Linkage Zone design mitigation and outside the linkage where the parkway overlaps high quality Category I tortoise habitat identified in the EIS. Roads impede tortoise movements and have been identified as a significant threat to tortoise populations throughout their distribution (AGFD unpublished data, AIDTT 2000, Berry 1986a, Berry 1986b, Boarman 1991, Boarman et al. 1993, Nicholson 1979, von Seckendorff Hoff and Marlow 2002). Desert tortoises occur at relatively low density, have low reproductive rates, and low mobility, three characteristics that heighten their sensitivity to road-induced habitat loss (Trombulak and Frissell 2000, Gibbs and Shriver 2002). Exclusion fencing could be co-located with ROW fencing and funnel fencing associated with culverts, pipes and reptile/amphibian upland crossing structures. Exclusion fencing is typically not more than 3 feet in height and constructed of heavy gauge 1 x 2' horizontal welded wire; partially buried in the ground and with a angled lip at the top to prevent climbing (see *Recommended Specifications for Desert Tortoise Exclusion Fencing* September 2005, USFWS).

Results from future wildlife movement monitoring should be used to inform where other fencing needs might become critical to minimize wildlife/vehicle collisions, wildlife mortality and enhance the use of the constructed wildlife crossing structures. Due to the flat topography of the Rainbow Valley, it will be difficult to predict the extent and/or location of fencing without current wildlife movement data. It is feasible that the entire Linkage Zone may require funnel fencing at build out conditions to safely move wildlife through crossing structures due to expected high volumes of traffic. We anticipate that as development and traffic volumes increases in the Rainbow Valley there will be a greater need to construct funnel fencing and escape ramp features along all transportation corridors within the Linkage Zone. *AGFD recommends monitoring/research on wildlife movement within Rainbow Valley to provide information necessary for placement of funnel fencing. AGFD recommends interim strategies to design arch span culvert crossings with a limited amount of funnel fencing, and monitoring/research discussed below to evaluate additional needs at all wildlife crossing structure locations.*

ROW fencing becomes problematic to wildlife as a result of design and location. Wildlife friendly design recommendations (http://www.azgfd.gov/hgis/pdfs/FencingGuidelines.pdf) should be used for all ROW fencing. AGFD recommends ROW fences be setback as far from the roadway as practicable. Where ROW fences cross drainages and parallel wildlife crossing structures, fences should be set back as far as practical, but at least 50 yards from the entrance of the structure and retrofitted with PVC or alternate materials to create "jumps".
Fence design recommendations for this area should meet requirements for desert bighorn:

- 3-strand barbed and barbless wire
- Bottom strand 20" from ground; middle 15" from bottom strand; top strand 4" above middle strand
- Maximum height of 39" with minimum of 18-20 inches ground clearance on bottom wire; top and bottom wire barbless and middle strands barbed
- T-posts should be space 20-25" apart and at least 3 stays equally space between

Vegetation and Crossing Structure Design Recommendations

Maintaining natural vegetation along the approach and exits of structures and natural substrates through culverts has demonstrated increased wildlife use. Vegetation provides wildlife with security cover. *AGFD recommends a non-clear cut approach to wash habitats during construction and post-construction restoration.*

Scouring is common on the downstream side of concrete or pipe culverts along washes. The changes in elevation from floodway bottom to culvert/pipe bottom often compromise wildlife access through the culverts/pipe. Tortoise have been shown to be particularly sensitive to this situation on Highway 87. *AGFD recommends design solutions that prevent scour and promote access and safe passage by small mammals, reptiles and amphibians.*

Wildlife Monitoring/research Recommendations for Project Implementation

AGFD recommends research on wildlife movement to optimize design and placement of crossing structures that fit the need of the local wildlife and their movement patterns and reduce impact to and address human health and safety issues; as part of the phased implementation approach to the project. Further evaluation is imperative to identify hotspots for roadway mortality and to evaluate if construction and future expansion of the parkway and increasing traffic volumes merit the need for additional mitigation measures, what types and where; in order to be successful.

Evaluation of crossing structure utilization is critical to determine effectiveness and to identify if there are any design modifications that would increase the effectiveness, and suitability as a future mitigation measure for roadway expansions and new projects.

Information gained from evaluation should be used to help decide timing and future steps towards mitigating increasing levels of development and traffic volume in the planning area as it relates to managing the Linkage Zone for the long-term. There are several approaches that should be explored and partnerships should be developed to find the resources to accomplish through shared commitments.

Approaches to consider:

- Track, Scat and Roadkill surveys to identify “hot spots” for mortality and vehicle collisions
- Wildlife movement studies (telemetry) to identify movement patterns
- Traffic Volume using traffic counters to examine the potential influence of traffic volume on wildlife movement and mortality across the parkway and in response to phase implementation of wildlife crossing structures
- Post-construction monitor of crossing structures using digital cameras and/or track plates to evaluate success and/or need for adaptive management measures.

Mitigation for Loss of Water Sources

Local wildlife is extremely dependent on stock tanks in the area as an ephemeral and/or semi-permanent source of water. If parkway construction will eliminate existing stock tanks along the project alignment we recommend replacement of in-kind values and redevelopment at the nearest alternate location.

Roadway Grading

Research suggests that roadkill of small terrestrial vertebrate species decreased by 93% on roads raised on embankments compared to roads at natural grades (Clevenger et al. 2003). This roadway design may be beneficial to small mammals, reptiles and amphibians throughout Rainbow Valley and through the Linkage Zone. Used in combination with wildlife friendly bridge and culvert designs, this design strategy may be an effective way to minimize impacts, while enhancing permeability.

Literature Cited

Arizona Interagency Desert Tortoise Team. 2000. Averill-Murray, R.C., (ed.). Status of the Sonoran population of the desert tortoise in Arizona: an update. Arizona Interagency Desert Tortoise Team and Arizona Game and Fish Department, Phoenix, AZ, USA.

Berry, K.H. 1986a. Desert tortoise (Gopherus agassizii) research in California. Herpetologica 42:62-67.

Berry, K.H. 1986b. Desert tortoise (Gopherus agassizii) relocation: implications of social behavior and movements. Herpetologica 42:113-125.

Boarman, W.I. 1991. Effectiveness of fences and culverts for protecting desert tortoises along California State Highway 58: final report on study design. California Energy Commission Contract No. 700-89-007.

Boarman, W.I., M. Sazaki, K.H. Berry, G.O. Goodlett, W.B. Jennings, and A.P. Woodman. 1993. Measuring the effectiveness of a tortoise-proof fence and culverts: status report from the first field season. Proceedings of the Desert Tortoise Council Symposium 1992:126-142.

Clevenger, A.P., B. Chruszcz, and K.E. Gunson. 2003. Spatial patterns and factors influencing small vertebrate fauna road-kill aggregations. Biological Conservation 109:15-26.

Forman, R.T.T., and L.E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207-231.

Forman, R.T.T., D. Sperling, J.A. Bissonette, A.P. Clevenger, C.D. Cutshall, V.H. Dale, and L. Fahrig. 2003. Road Ecology: Science and Solutions. Island Press, Washington, DC, USA.

Gibbs, J.P., and W.G. Shriver. 2002. Estimating the effects of road mortality on turtle populations.

Grandmaison, D. 2012. Wildlife Linkage Research in Pima County – Crossing structures and fencing to reduce wildlife mortality. Arizona Game and Fish Department, Phoenix, Arizona.

Nicholson, L. 1979. The effects of roads on desert tortoise populations. Proceedings of the Desert Tortoise Council Symposium 1978:127-129. Conservation Biology 16:1647-1652.

Noss, R.F. 1983. A regional landscape approach to maintain diversity. BioScience 33:700-706.

Noss, R.F. 1987. Protecting natural areas in fragmented landscapes. Natural Areas Journal 7:2-13.

Noss, R.F., and A.Y. Cooperrider. 1994. Saving Nature's Legacy: Protecting and Restoring Biodiversity. Island Press, Washington, D.C., USA.

Spellerberg, I.F. 1998. Ecological effects of roads and traffic: a literature review. Global Ecology and Biogeography Letters 7:317-333.

Taylor, P.D., L. Fahrig, K. Henein, and G. Merriam. 1993. Connectivity is a vital element of landscape structure. Oikos 68:571-573.

Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

von Seckendorff Hoff, K., and R.W. Marlow. 2002. Impacts of vehicle road traffic on desert tortoise populations with consideration of conservation of tortoise habitat in southern Nevada. Chelonian Conservation and Biology 4:449-456.

Wilcox, B.A., and D.D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. American Naturalist 125:879-887. References: