Innovative Funding for Sign Sheeting Upgrades and Sign Management System in Phoenix, Arizona

Jenny L. Grote, P.E., PTOE, Srinivas Goundla, P.E., PTOE, Ryan T. Cook

ABSTRACT

The Federal Highway Administration (FHWA) changes in the 2009 Manual on Uniform Traffic Control Devices (MUTCD) require new minimum sign retroreflectivity standards and subsequently, require public agencies to replace non-compliant signs and shall use a sign assessment or management method designed to maintain sign retroreflectivity at or above the minimum levels. This appears a daunting task since the City of Phoenix covers more than 517 square miles and is the fifth largest U.S. city in population with 1.5 million residents.

The City of Phoenix Street Transportation Department plans to meet the minimum retroreflectivity levels by using two of the five assessments or management methods; the Blanket Replacement Method and the Expected Sign Life Method. The intent of this project is to comply with the 2009 MUTCD regulations by developing a traffic sign inventory and replacing signs along 215 miles of major arterial streets, and removed sign blanks refurbished and returned to inventory.

To meet the mandate, the Department applied for funds available through the American Recovery and Reinvestment Act (ARRA) of 2009. The successful application and approval provided $3.0M to fund a Sign Management System during a fiscally conservative time when only essential maintenance can be funded. Phase I, the “design phase,” will cost $0.5M and include a field inventory of all signs on 215 miles of major arterials. Phase II, the “construction phase,” for fabrication, installation and refurbishment, will cost $2.5M. ARRA funds allocated to this project will allow the City to meet the Federal mandates for sign sheeting upgrades, along with a way to manage thousands of street signs which ultimately will improve mobility on Phoenix streets.

PROJECT BACKGROUND

Traffic signs are the principal medium by which highway agencies communicate regulatory, warning, guidance or other information to road users. Therefore, traffic signs must be detectable, legible, and comprehensible to users at a distance commensurate with their purpose. Traffic signs are designed to satisfy these requirements by selection of sign size and color, the size and style of letters and numerals and application of symbols, with retroreflective materials used for the background and legend. As signs age and become less retroreflective, their effectiveness in communicating information to road users diminishes to the point that they cannot be seen or read in time for a driver to react, especially at nighttime. Thus, to maintain their effectiveness, signs must be replaced before they lose their retroreflectivity.

An effective sign management system is crucial for efficient management of the thousands of signs installed by a large city. A sign inventory system provides benefits including: tracking installation, inspection and maintenance dates; orderly processing of work orders for maintenance activities; tracking information for customer service; documented information for tort liability claims, and; tracking ages of signs for replacement at the end of their expected life.

The Federal Highway Administration (FHWA) 2009 Manual on Uniform Traffic Control Devices (MUTCD) requires public agencies to create or enhance their sign asset management system for orderly management of their signs. The FHWA developed retroreflectivity maintenance strategies to provide public agencies with adaptable implementation options to comply with the standards. The FHWA retroreflectivity maintenance strategies can be divided into two main groups--assessment methods and management methods:

- Assessment Methods
  - Visual Nighttime Inspection, and
  - Measured Retroreflectivity
- Management Methods
  - Expected Sign Life
  - Blanket Replacement, and
  - Control Sign

The City of Phoenix Street Transportation Department has an existing asset management system that records all stop and yield signs currently installed within the City. This asset management system does not contain the records of regulatory (other than stop and yield signs), warning, or guide signs currently installed on any of the roadways. The City of Phoenix is committed to replacing signs on more than 200 miles of its 750 miles of arterial streets to comply with the FHWA mandates to meet new minimum sign retroreflectivity standards and expand the sign management system to maintain sign retroreflectivity at or above the minimum levels.

The City initiated a sign inventory to collect sign data for stop and yield signs installed in the field and a plan for a replacement method. The American Recovery and Reinvestment Act 2009 (ARRA) provided an excellent opportunity to fund the development of an expanded sign inventory system and replace signs on selected arterial corridors. The “Blanket Replacement Method” was the preferred method instead of either performing visual night time inspections or recording retroreflectivity readings on thousands of signs. The City further plans to use "Expected Sign Life" to manage the replaced signs. The selected arterial street corridors accounted for approximately 31 percent (215 centerline miles) of the total 750 centerline miles of arterial streets in the city. Since these routes were not inventoried prior to this project, it was unknown how many signs existed.

The project will be completed in two phases with phase one focusing on field inventory and development of project plans and specifications. Phase one is complete and now the second phase is in process with a contractor recently procured to fabricate and replace the identified signs in accordance with project plans and specifications. In addition, a portion of the existing signs to be removed from the 215 miles of arterial streets will be refurbished with hydro-blasting and returned to the Sign Shop's inventory of aluminum sign blanks. This process is likely to become permanent and used citywide for all signs needing replacement, as a cost saving measure instead of buying all new sign blanks for sign fabrication.

DATA COLLECTION AND POST-PROCESSING

The data collection effort consisted of four key components: Global Positioning System (GPS); hardware; software, and; technical staff. Parsons Brinckerhoff (PB) partnered with 3M to complete the sign inventory utilizing the innovative "GPS Mobile Capture System." The mobile GPS captured photographs of the signs to a photo database as a vehicle/van drove at posted speeds along the roadway segments. The location of vehicle and photo were saved in the database with a time stamp. A post-processing team in the office reviewed the photo database (photolog) to extract sign attributes and GPS coordinates for each sign. This GPS application was chosen for its efficiency in time and cost savings when compared to traditional "manual data collection" that includes walking or driving to each sign to collect the sign attributes. The project team had multiple meetings with City staff to discuss inventory methodologies. The team identified six primary attributes required for the sign inventory. The primary sign attributes were:

- MUTCD designation
- Sign size
- Latitude and longitude coordinates
- Street address
- Sign orientation
- Post type
- Side street
- Photograph of sign

These attributes ensured compatibility with the existing inventory system and provided essential details for sign replacement. In addition, secondary sign attributes were post-processed to develop project plans and specifications.

Mobile GPS & Hardware

Positional accuracy of a street sign is of primary importance when creating a sign inventory, as it provides the information about the physical location of the sign. The innovative "GPS Mobile Capture System" (System) was used for the field inventory of the traffic signs. The System included two 1280 X 960 resolution cameras roof-mounted on a van. The cameras were connected by Firewire to a computer in the vehicle. Each camera captured five photographs per second (sign photolog). Simultaneously, GPS location coordinates of the van, accurate to within one horizontal meter, were recorded. The photolog and location coordinates were stored in a connected computer in the vehicle. The vehicle driver was provided with real time feedback of the picture quality.

The System was portable and installation was less than an hour. Figure 1 shows the GPS Mobile Capture System installed on a vehicle.

Figure 1 GPS Mobile Capture System mounted on a vehicle (Source: 3M)

The first camera was oriented to capture right-side curb and shoulder-mounted signs, and the second camera was positioned to capture overhead and median-installed signs in the direction of travel, as shown in Figure 2. The vehicle drove in the curb lane at the posted speed limit. The sign inventory was completed in both directions along the 215 miles in three days. The data was reviewed for quality control and approximately 13 miles (6 percent) of the roadways were re-driven to capture signs that were missed due to lighting conditions including reflection, glare, shadows or obstructions.

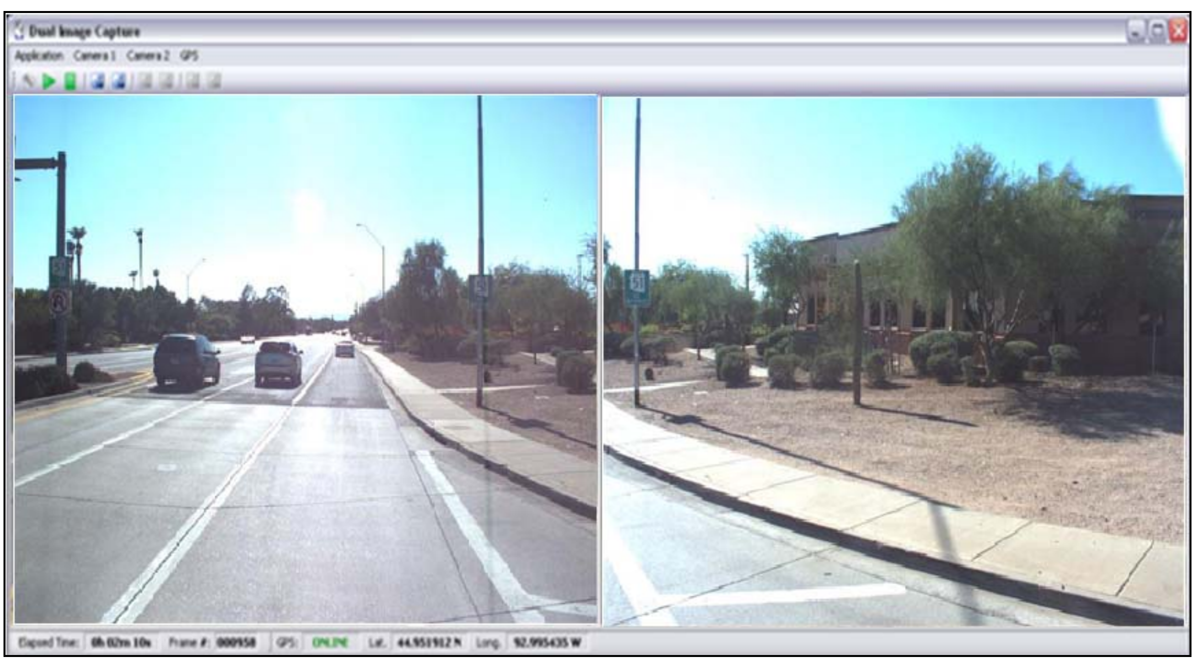


Figure 2 Images captured using the GPS Mobile System (Source: 3M)

Software

Field hardware recorded the photos and GPS coordinates of the vehicle as it was driven at posted speeds along the street. The photolog was post-processed to collect the required sign attributes to populate the database. An ArcGIS Personal Geodatabase was designed to record sign attributes from the field inventory and geographic coordinates in one data record. The City provided ancillary reference data included street centerline files and sub-foot accurate orthorectified aerial imagery. 3M developed customized tools to populate the sign database with sign attributes. The customized tool “GPS Video Sync” provided an animation of the field inventory photolog, combined with the location (GPS) coordinates of the vehicle along the project corridors. Figure 3 shows the screenshot of GPS Video Sync. Each sign’s GPS coordinates and sign attributes were then recorded by a trained post-processing team member.

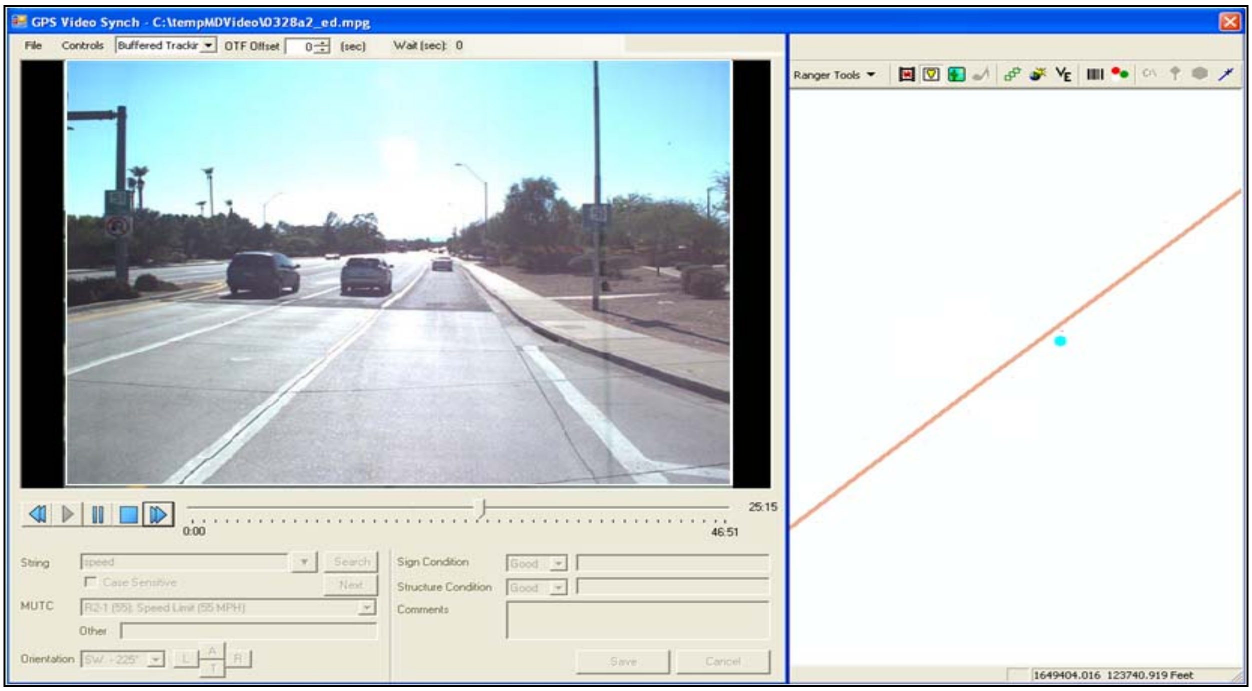


Figure 3 GPS Video Sync Screenshot (Source: 3M)

ArcGIS geodatabase architecture was designed to store sign attributes. ArcGIS spatially stores sign data within the geodatabase and enables seamless usage of powerful query tools available within ArcGIS ArcMap. The query tools within ArcGIS ArcMap aided the development of project plans. The cohesive system of high quality photography, high accuracy location coordinates and high accuracy ancillary references enabled overall quality and accuracy of the sign inventory.

Technical Staff

The project team consisted of members from PB, 3M and the City's Street Transportation Department/Traffic Services Division/Sign Shop and IT Division staff from the beginning of the project to development of project plans and specifications.

The input and knowledge from the Sign Shop foremen was very helpful in completing the project on time. The post-processing team members were educated about project specifics such as identifying signs on side streets, private signs, non- City of Phoenix signs, and other issues to achieve uniform sign data collection. Custom templates were developed for post-processing.

Post-processing the field photolog was completed by trained staff in approximately sixty calendar days with iterative review and quality oversight. Also, additional sign attributes were collected during the post-processing to support development of project plans and control the exclusion of signs that were not to be replaced with this project.

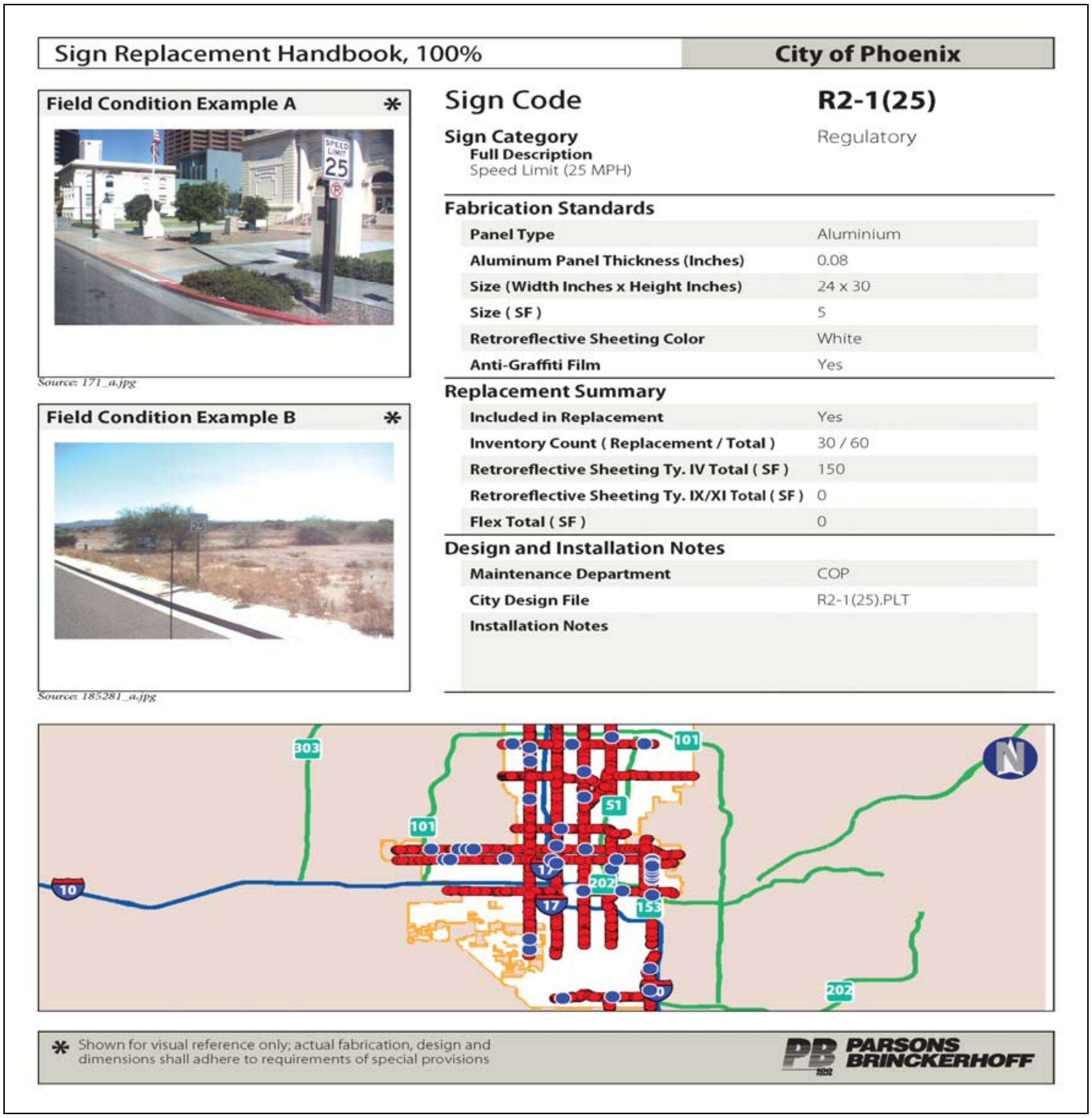
DESIGN PLANS AND SPECIFICATIONS

Post-processed data was reviewed for accuracy using ArcGIS query tools. A quality control methodology was developed to include quality assurance checks on each sign attribute data collected. The quality control reviews included checks on sign attributes, sign types, identifying the typical number of speed limit signs and/ or parking signs installed on arterials, review of all school signs, sign posts, city limits and custom signs. A Sign Handbook (Figure 4) was developed from the database for review of the sign attributes. This Handbook was a consolidated catalogue of sign types with details such as: sign panel type; sheeting type; sign size, and; replacement quantities. This tool was very helpful for City staff to be able to review and comment. Figure 4 shows a sample page from the Sign Handbook.

Project plans were developed and listed approximately 17,000 signs that would be replaced of the 28,000 signs that were inventoried. Custom program codes were written in Microsoft VBA to sort and list the signs by Project Corridor. The custom programming scripts calculated quantities by plan sheet and arterial corridor. Formatting of the projects plans, individual sign listings, used Adobe InDesign to produce the plan in a digital and hard copy format. Special provisions were completed to specify the sign panels; retroreflective sheeting; anti-graffiti film; adhesives; bar code requirements; fabrication requirements; construction methods; recycling and salvaging the removed signs, and; traffic control requirements during installation.

CHALLENGES

Some of the challenges experienced during the project included classification of the regulatory and warning signs. The City of Phoenix, like other public agencies, has modified regulatory and warning signs to provide for specific requests based on need. Additional sign type classifications were created using the current MUTCD designations. Figure 5 shows examples of a variation in the most common sign post type and modified standard signs, such as the plethora of custom “No Parking” signs.



Sign Replacement Handbook, 100% | City of Phoenix

Field Condition Example A *

Source: 171_a.jpg

Field Condition Example B *

Source: 185281_a.jpg

Sign Code	**R2-1(25)**
Sign Category	Regulatory
Full Description	
Speed Limit (25 MPH)	
Fabrication Standards	
Panel Type	Aluminium
Aluminum Panel Thickness (Inches)	0.08
Size (Width Inches x Height Inches)	24 x 30
Size (SF)	5
Retroreflective Sheeting Color	White
Anti-Graffiti Film	Yes
Replacement Summary	
Included in Replacement	Yes
Inventory Count (Replacement / Total)	30 / 60
Retroreflective Sheeting Ty. IV Total (SF)	150
Retroreflective Sheeting Ty. IX/XI Total (SF)	0
Flex Total (SF)	0
Design and Installation Notes	
Maintenance Department	COP
City Design File	R2-1(25).PLT
Installation Notes	

* Shown for visual reference only; actual fabrication, design and dimensions shall adhere to requirements of special provisions

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Figure 4 Sign Handbook excerpt

- Private signs, neighborhood association signs, and signs maintained by the State (Arizona Department of Transportation) and other adjacent cities were identified and classified as "out of scope" for the replacement (construction) phase.
- Sign post types were categorized to identify sign panel and sheeting types (e.g. some parking restriction signs are made of flexible material on utility poles and overhead signs are made with Type XI or equivalent sheeting).
- Small signs captured by the Mobile GPS had lower resolution, making it difficult to extract the legend (i.e. - time restrictions on parking signs). Special Provisions were written to direct the contractor to field check these signs prior to sign fabrication.

Figure 5 Examples of variations in sign post types and in No Parking signs

BENEFITS

Implementation of the mobile GPS application resulted in significant savings in project cost and time. Before this project began, the City conducted a sample field inventory of a mile corridor along an arterial roadway with the Sign Shop crews. The data for 230 signs was collected by one staff member on a mile-long sample corridor within one working day using a handheld GPS device, collecting sign attributes and photographs. The trial data collection included either walking from one sign post to other sign post and/or driving in a vehicle and stopping at each sign to collect the data. The estimated labor to complete the sign inventory, using this method, for all 215 miles was 1,750 labor-hours with additional time to download the data into the database and prepare the final project plans and specifications. Two employees working full time would have taken approximately **six months** to complete the field inventory. The field inventory time was reduced to **three days,** with field inventory and post-processing of sign data completed from September through October 2009 (sixty days). The project plans and specifications for sign replacement were completed by December 2009 - in time to meet the deadline to apply for ARRA funds.

The additional benefits included:

- Recording inventory of signs and the accuracy of the sign type and location checked. (eliminated need to return to the specific sign location)
- Enhanced accuracy of GPS coordinates. (accuracy of post location was within two feet compared to the project-required three-meter accuracy tolerance)
- Eliminated exposure of City sign crews to vehicular traffic and exposure to high seasonal temperatures.
- Less fuel consumption with reduced time completing field inventory.

The project is currently in the second phase of hiring a contractor to fabricate and replace 17,000 signs. The project was advertised for bid in March 2010 and a contractor is expected to begin the sign replacements in early June 2010. If a second phase of ARRA funding becomes available, the logical addition to this project would add street name signs. They were not included in the original scope since the 2009 MUTCD had not yet been approved. Now that it is approved, the City will need to increase the size of the street name letter size and blank size. The estimated cost for this extra sign type is approximately $0.5M. If even more funds become available, additional arterial street corridors would be inventoried, at a minimum, and ultimately signs replaced with upgraded sheeting.

CONCLUSIONS

With accurate information about sign data, the City of Phoenix is better equipped to manage its inventory for maintenance. Using mobile GPS equipment was instrumental in expeditiously collecting a significant amount of data and integrating it with a sign management system. The goal of this ARRA-funded project is to conduct a 'blanket replacement' and upgrade sign sheeting for better retroreflectivity of 17,000 of the City's traffic signs. In addition, a more effective maintenance/sign replacement program will allow for more efficiency and timeliness of maintaining hundreds of thousands of signs on more than 5,000 miles of Phoenix streets resulting in safer travels for all road users.

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AUTHORS

Jenny L. Grote, P.E., PTOE
Traffic Engineering Supervisor
City of Phoenix
Street Transportation Department
200 W. Washington Street, 6th Floor
Phoenix, AZ 85003
Ph: (602) 262-7217
Fax: (602) 495-0336
jenny.grote@phoenix.gov

Srinivas Goundla, PE, PTOE
Lead Traffic Engineer
Parsons Brinckerhoff, Inc.
1501 W. Fountainhead Parkway, Suite 400
Tempe, AZ 85282
Ph: (480) 921-6865
Fax: (480) 966-9234
goundla@pbworld.com

Ryan T. Cook
Transportation Planner
Parsons Brinckerhoff, Inc.
1501 W. Fountainhead Parkway, Suite 400
Tempe, AZ 85282
Ph: (480) 449-4609
Fax: (480) 966-9234
cookry@pbworld.com

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