APPENDIX G

Laser Profiler Recommendation

URS Corporation provides the following updated recommendation for purchase of laser profiling equipment by MDOT as part of research study OR10-048 "Re-Examination of the 1994 and Subsequent Sewer and Culvert Installations". This supersedes the original recommendation dated August 05, 2011 and is based upon comparative analysis of available laser profiler equipment and vendor demonstrations and information collected during the ongoing research. This revision includes information learned after the submittal of the original recommendation, much of which was precipitated by MDOT questions with vendor answers included as Appendix A.

The following laser vendors were considered:

- Cues, Inc. of Orlando, Florida (demonstrated/tested on June 13, 2011)
- Rausch Electronics USA, LLC of Chambersburg, PA (demonstrated/tested on June 14, 2011)
- RS Technical Services, Inc. of Petaluma, CA (demonstrated/tested on June 14, 2011)
- IBAK Helmut Hunger GmbH & Co./Rapidview, LLC of Rochester, Indiana (demonstrated/tested on June 15, 2011)
- Aries Industries, Inc. of Waukesha, Wisconsin (invited, but decided not to demonstrate/test, has similar laser equipment as RS Technical Services, Inc.)
- Envirosight, LLC of Randolph, New Jersey (invited, but decided not to demonstrate/test, has similar laser equipment as Cues, Inc. and IBAK Helmut Hunger GmbH & Co./Rapidview, LLC)

The following basic criteria considerations were included in the comparative analysis:

- Ability to measure pipe diameter deviations, pipe cracks and other pipe anomalies
- Quality and expediency of results/reports, quality of analog CCTV
- Precision and necessary calibrations
- Laser device technology, field operation procedures and safety issues
- Resolving laser profiling issues related to presence of pipe corrugations
- Pipe size ranges and approximate no-laser data zones at end of pipe runs
- Measuring slope with inclinometer and option for documenting speed when laser profiling
- Equipment pricing and possibility for upgrade to digital camera

The following criteria from the current MDOT Special Provision 03DS401(D305) *"Laser Inspection of Sewer and Culvert Pipe"* were considered:

- Optical zoom (min 10:1) and combined digital/optical zoom (min 40:1)
- Adjustable transporter speed and adjustable camera height
- Distance counter
- Inclinometer
- CCTV Camera capable to rotate 360 degrees and to pan and tilt 90 degrees
- Camera ability to pan and zoom 360 degrees at every joint and pipe anomaly
- Minimal size of cracks to be measured (0.01")
- Profiler accuracy (0.5%)
- Profiler repeatability (0.12%)

Some, but not all criteria parameters were checked at the demonstration tests. Some, but not all of the demonstration tests gave satisfactory results. Some of the equipment capabilities were not possible to verify,

but were taken as true from statements by the laser vendors. The Aries Industries, Inc. laser profiling equipment is assumed to have similar characteristics as RS Technical Services, Inc. because both companies use the same laser profiler system under license by C-Tec of Laval, Quebec, Canada.

Based on the above listed criteria URS Corporation recommends that MDOT purchase laser profiler equipment from Rausch Electronics USA, LLC of Chambersburg, Pennsylvania. The recommendation is based on the following:

- Performance at the June 14, 2011 demonstrations/tests
- Ability to quickly provide basic data in compact and understandable form
- Limited or no "shadow effect" due to minimized offset between camera and laser
- Ability to increase longitudinal accuracy by lowering laser transporter speed, this can substantially improve measuring pipe diameter deviations when laser profiling in corrugated pipe
- Self-contained combined CCTV & laser device unit, easy to operate, uses seamless software package
- Limited or no need for field calibrations, lower risk for calibration operator errors
- Access from one side of pipe increases safety, accessibility and ease of operation
- Minimized size of no-laser data zones at end of pipes because of single unit performing camera work and laser profiling
- Ability to measure cracks and pipe slopes
- Stated (but not demonstrated in June 2011) ability to display transporter speed when laser profiling on monitor screen in feet per minute
- Covered basic requirements of current MDOT special provision 03DS401(D305) *"Laser Inspection of Sewer and Culvert Pipe"*
- Crane use allows one or two man operation without operator entry in manholes, option for less expensive floor mounted crane (swivel instead of telescopic) lowers price to within budget
- Ability to prove that diameter measurements are accurate and repeatable
- Ability to include nominal diameter when calculating diameter deviations, option (included in the quote) to add more diameter deviation graph planes to the reports (presently the reports have only two planes – horizontal and vertical; the minimum should be six planes that are equally spaced around the clock positions, therefore corresponding to a virtual 12 edge mandrel)
- Ability to measure 12" to 48" culverts and sewers (vendor stated that 48" is maximum; operator at demonstration/test stated that larger culverts are possible to laser profile)
- Included in the quote: laser & analog CCTV assemblies, micrometer, POSM software, spare parts kit, inclinometer, floor mounted crane, 2 each O&M manuals with option for more, training of up to 10 MDOT staff for 2 days - one day on the field, and one day in the office
- Generator, Air Conditioner and trailer with accessories to be provided by MDOT, installation at vendor's shop is included in an updated quote

The Rausch laser uses "spinning laser" technology instead of "continuous laser ring" technology used by the other vendors. When the laser profiling speed is lowered to 1 fpm (full spin every 0.16") to 5 fpm (full spin every 0.80"), the "spinning laser" technology measurement intensity along the length of the pipe is comparable to the "continuous laser ring" technology using 30 fpm (one frame every 0.20"). In our opinion, the "spinning laser" has the advantage over the "continuous laser ring" because it measures the pipe diameter and deviations from that pipe diameter almost perpendicular to the pipe walls; whereas the "continuous laser ring" is not perpendicular and therefore is impacted by "shadow effects" caused by pipe corrugations or other pipe anomalies. When used at 30 fpm, the Rausch "spinning laser" measures pipe diameter in a 4.8" inch long spiral. In our opinion, even this measurement frequency produces enough pipe diameter data for practical pipe evaluation.

The Rausch circumferential measurement intensity of 20 points can be compared to a 20 point virtual mandrel. While the "spinning laser" circumferential data points are substantially less than the "continuous laser ring" circumferential data points (360 to >1000 in recent upgrades), in our opinion they appear to provide adequate and more accurate diameter information. This is because in our opinion both the laser and camera are located on the same vehicle and camera/laser head and therefore are almost perpendicular to the pipe walls and experience less data fluctuation.

In our opinion, the "continuous laser ring" technology appears to have significant data fluctuation caused by laser and camera vibrations induced by their respective independent transporter movements. The fluctuations are likely lower at reduced speeds (<30 fpm) but in our opinion may still be significant enough to necessitate substantial data filtering during data post processing.

Cues and Aries represent the two "continuous laser ring" technologies currently available on the market – Cleanflow and Coolvision.

We note, in comparing Cues and Aries that the "continuous laser ring" fluctuations discussed earlier may be more pronounced with the current Cues, Inc. system. This is because Cues uses two transporters when laser profiling, whereas the Aries/C-Tech system uses just one transporter (the fluctuations are still an issue in this system, in our opinion, because the laser and the camera are still offset from each other and are above different wheel axels).