



5th Quarterly Progress Report

Ohio DOT Research

Fifth Quarter Ended on March 31, 2019

“Quarterly Report: State Job #135417”



AMERICAN
STRUCTUREPOINT
INC.



LEO Consulting, LLC





For Quarter Ending:	March 31, 2019
Date Submitted:	April 30, 2019

Project Title:	Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits		
Research Agency:	CUIRE/The University of Texas at Arlington		
Principal Investigator(s):	PI: Mohammad Najafi, Ph.D., P.E., F. ASCE, Professor and Director, CUIRE Co-PI: Xinbao Yu, Ph.D., P.E., Associate Professor		
State Job Number:	5501.03	Agreement Number:	31347
Project Start Date:	20 December 2017	Contract Funds Approved:	25 September 2017
Project Completion Date:	20 December 2019	Spent to Date:	\$317,875.51
% Funds Expended:	80%	% Work Done:	55%
		% Time Expired:	63%

List the ODOT Technical Liaisons and other individuals who should receive a copy of this report:

1. Jeffrey E. Syer, P.E. – Ohio DOT
2. Brian R. Carmody, P.E. – NYSDOT
3. Matthew S. Lauffer, P.E. and Charles Smith P.E. – NCDOT
4. Paul Rowekamp and Aislyn Ryan – MnDOT
5. Sheri Little – PennDOT
6. Carlton Spirio – FDOT
7. Jonathan Karam and Nicholas Dean – DelDOT



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**Schedule of Research Activities Tied to
Each Task Defined in the Proposal
and Percentage Completion
of the Research**



Table 2: Completion Percentage of SAPL Research Project Tasks over the 1st, 2nd, 3rd, 4th and 5th Quarters

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits						
						
Task Number	Task Description	Percentage Completed by the end of:				
		1 st Quarter	2 nd Quarter	3 rd Quarter	4 th Quarter	5 th Quarter
		<i>Dec 2017 through Mar 2018</i>	<i>Apr 2018 through Jun 2018</i>	<i>Jul 2018 through Sep 2018</i>	<i>Oct 2018 through Dec 2018</i>	<i>Jan 2019 through Mar 2019</i>
1	Survey of US DOT's and Canadian Agencies	29%	71%	100%	100%	100%
2	Literature Search/Participation Material Vendors	57%	100%	100%	100%	100%
3	Additional Reinforcement	0%	67%	95%	100%	100%
4	Evaluation if Corrugations Needed to be Completely Filled by the Spray Applied Liner as Part of the Structural Design	0%	67%	90%	100%	100%
5	Life Cycle Cost Analysis	0%	0%	0%	0%	35%
6	Review the Cured in Place (CIPP) Design Equations	0%	0%	67%	80%	100%
7	Field Data Collection and Assistance from DOT Partners	0%	40%	100%	100%	100%
8	Develop a Recommended Structural Design Equations	0%	0%	0%	20%	30%
9	Develop Performance Construction Specification	0%	0%	0%	0%	30%
10	Computational Modeling	19%	38%	57%	60%	65%
11	Lab Testing	19%	38%	43%	45%	50%
12	QA/QC	17%	29%	38%	54%	65%



**Comparative Status of Actual Versus
Estimated Expenditures**



Table 3: The 5th Quarterly Progress Work of SAPL Research Project

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits								
Task Number	Task Description	Total Duration (Months)	Duration Completed (Months)	Budgeted Amount (\$)	Percentage of Completion Based on Schedule (%)	Percentage of Total Budget (%)	Percentage Completed This Quarter (%)	Actual Amount Completed this Quarter (\$)
1	Survey of US DOT's and Canadian Agencies	7	7	\$25,751	100	6.44	0	0
2	Literature Search/Participation Material Vendors	7	7	\$21,875	100	5.47	0	0
3	Additional Reinforcement	3	3	\$2,100	100	0.52	0	0
4	Evaluation if Corrugations Needed to be Completely Filled by the Spray Applied Liner as Part of the Structural Design	4	4	\$3,900	100	0.97	0	0
5	Life Cycle Cost Analysis	8	3	\$29,123	37	7.28	37	\$10,775.51
6	Review the Cured in Place (CIPP) Design Equations	5	6	\$13,751	100	3.44	67	9,213
7	Field Data Collection and Assistance from DOT Partners	5	5	\$26,752	100	6.69	0	0
8	Develop a Recommended Structural Design Equations	10	5	\$34,081	50	8.52	30	\$10,224.3
9	Develop Performance Construction Specification	11	6	\$27,392	55	6.85	27	\$7,395.84
10	Computational Modeling	20	15	\$52,039	75	13	15	\$7,805.85
11	Lab Testing	20	15	\$67,001	75	16.75	15	\$10,050.15
12	QA/QC	24	15	\$8,000	63	2.00	13	\$1,040
13	Draft Final Report and Fact Sheet	7	Not Started	\$88,270	0	22.07	0	0
14	Final Report and Presentation	3	Not Started					
Total				\$400,034	-	100	-	\$49,584.65



Table 4: Expenditures Summary of SAPL Research Project in the 5th Quarter

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits	
Summary of Expenditures for the 5 th Quarter (January through March 2019)	
Description	Sum Amount
Salaries and Benefits	
Students Salaries and Benefits	\$15,016.04
Faculty Salaries will be Paid During Summer Months	-
Subtotal	\$15,016.04
Partner Companies	
American Structurepoint, Inc.	\$7,398.59 (Pending)
Rehabilitation Resource Solutions	\$7,500.00 (Pending)
LEO Consulting	\$400.00
Subtotal	\$15,298.59
Other Indirect Costs	
Indirect Costs	\$7,265.85
Total	\$37,580.48



**Brief Description of the Activities Accomplished by
Each Member of the Research Team as
Listed in the Project Budget**



Principal Investigator: Dr. Mohammad Najafi

Task 11: Laboratory Testing

Soil Box Testing

- Completed the steel frame installation.
- Completed the MTS actuator installation.
- Completed the MTS hydraulic pump installation.
- Completed the grouting below the steel frame to fill the gaps.
 - Grout was donated by Madewell Company.
- Held a training meeting with MTS representative and calibration of MTS actuator.
- Designed partition walls and channels.
- Designed, ordered and purchased load pads.
- Performed literature search and study on load rate for the purpose of loading CMPs with MTS actuator.

Instrumentation

- Purchased connectors for strain gages.
- Held a workshop from Micro-Measurement at CUIRE/UTA to educate students the installation of strain gages.

Task 5: Life Cycle Cost Analysis

- Performed literature review of life-cycle cost analysis.
- Identified the major components of life-cycle cost for the SAPL.
- Prepared a draft survey to collect data of the life-cycle cost of the SAPL projects.
- Performed interview with some of the SAPL vendors at NASTT No-dig Show, March 17-21, 2019, Chicago, Illinois.

Participation in the Meetings during Conferences, Internal Meetings, Progress Meetings

- Attended three monthly progress meetings with DOTs.
- Held a meeting with Mr. Chip Johnson from Sprayroq and discussed the soil box testing and the schedule in details.
- Held internal meetings with CUIRE team research partners (Xinbao Yu and Firat Sever).
- Presented at the NASTT No-dig Show, March 17-21, 2019, Chicago, Illinois (oral presentation and poster presentation).
- Submitted ASCE papers and received the acceptance for all of them.
- Held discussions on soil box testing with Dr. Royer from Milliken at the NASTT No-dig Show, March 17-21, 2019, Chicago, Illinois.



- Held a meeting with Madewell Company at the NASTT No-dig Show, March 17-21, 2019, Chicago, Illinois.
- Held a meeting with project partners Ed Kampbell, Firat Sever and Lynn Osborn in conjunction with UCT in Fort Worth, January 30, 2019.



Co-Principal Investigator: Dr. Xinbao Yu

The following are the tasks performed this quarter:

Soil Box Tests**a) Soil Box Test Plan**

- Performed sieve analysis and standard Proctor compaction test on concrete sand samples obtained from Big Tex Stone.
- Presented test results to the CURIE research team
 - The soil sample was classified as poorly graded sand (SP).
 - The compaction curve showed that there is no clear optimum moisture content for concrete sand.
 - Performed a literature review to find a theoretical basis for the compaction curve of sands. Similar compaction curves were found in previous compaction studies of sands.
- Rearranged CUIRE shed and stored equipment from past projects.
- Prepared laboratory for actuator installation.

b) Instrumentation

- Tested the data acquisition (DAQ) system for strain gauges purchased for this project.
- Obtained quotes for screw adapter terminals to facilitate strain gauge installation.
- Participated in strain gauges training offered by micro measurements.
- Obtained quotes for aluminum foil tapes to use as mechanical protection for strain gauges.

FEM Modeling

- Finalized CMP corrugation geometry according to ASTM A796.
- Completed the modeling of the intact CMP pipe with corrugated geometry.
- Compared the intact actual geometry CMP model with intact equivalent plane geometry model.
- Obtained bending moment for intact actual and intact equivalent model and compared the results. The pipe deflections and bending moments resulted from the two models have a reasonable agreement.
- Created a model for an invert cut CMP with corrugated geometry.



**Subcontractor: Mr. Ed Kampbell
Rehabilitation Resource Solutions, LLC**

Task 3 – Review of Additional Reinforcement

We received comments from the NY DOT regarding their review of the task 3 report on additional reinforcement on March 26th. I will await any additional reviews by the stakeholders on this report. If no other reviews are received by June 1, I will make the necessary changes at that time.

Task 4 – Evaluation if Corrugations needed to be Completely Filled by the SAPL as Part of the Structural Design

The comments received from the DOT partners were reviewed and appropriate edits were made to the report. This report was finalized and transmitted to the CUIRE on February 12, 2019. Subsequent to that we received the ODOT review of that submittal on February 22 and the NY DOT review of that submittal on March 26th. We have since been waiting to see if we receive any additional comments from any of the other stakeholders before making any changes warranted by their reviews. If no additional reviews are received by June 1, I will make the necessary changes at that time.

Task 6 – Review the Cured in Place (CIPP) Design Equations

This task was completed on February 10 and transmitted to the CUIRE on February 12, 2019. To date we have received only one review of that report. It was from the ODOT and was transmitted on February 22. If no additional reviews are received by June 1, I will make the necessary changes at that time.

Task 9 – Develop Performance Construction Specifications

This task has been started and per our discussion on the last team conference call I have been awaiting Structurepoint drafts of the specifications to add my input.



**Subcontractor: Dr. Firat Sever
American Structurepoint, Inc. (ASI)**

Subcontractor American Structurepoint, Inc. /Dr. Firat Sever has performed the following tasks in the 5th quarter:

- Presented at February 2019 monthly meeting with the CUIRE and DOTs.
- Finalized base design equations for polymeric and cementitious SAPLs.
- Completed the outline for performance technical specifications (one for polymeric and one for cementitious SAPL).
- Continued researching QA/QC procedures for testing liner application and thickness.
- Reviewed the CIPP equations analysis by Ed Kampbell.



**Subcontractor: Mr. Lynn Osborn
LEO Consulting, LLC**

Task 12. QA/QC

As QA/QC Reviewer, much of my work depends upon the work and progress of other team members and items that require quality checks.

Activities for Q5 include:

- Update meeting with Dr. Najafi, Ed Kampbell, Firat Sever and others – January 30, 2019.
- Reviewed and commented on Task 6 (CIPP Design Equations). Document produced by Ed Kampbell. February 24-25, 2019.



Proposed Work for New Quarter



Table 5: SAPL Research Project Tasks for 6th Quarter (April 1 through June 30, 2019)

Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits					
Task Number	Responsibility	Task Description	Percentage of Work to be Completed by the end of 6 th Quarter		
			April 1 st through June 30 st		
			April	May	June
5	Dr. Mo Najafi	Life Cycle Cost Analysis	To be Continued		
8	Dr. Firat Sever	Develop a Recommended Structural Design Equations	To be Continued		
9	Dr. Firat Sever Mr. Ed Kampbell	Develop Performance Construction Specification	To be Continued		
10	Dr. Xinabo Yu	Computational Modeling	To be Continued		
11	Dr. Mo Najafi Dr. Xinbao Yu	Lab Testing	Control Test to be Completed		
12	Mr. Lynn Osborn	QA/QC	To be Continued		



Principal Investigator: Dr. Mohammad Najafi

Task 5: Life Cycle Cost Analysis

- Perform a literature review of life-cycle cost of trenchless and open-cut methods for comparison with SAPL method.
- Finalize survey to collect the data for life-cycle cost of the SAPL and other trenchless and open-cut methods.
- Determine elements which can be identified, collected, and quantified for the environmental and social costs of the SAPL and other trenchless and open-cut projects.
- Collect data from DOTs regarding environmental and social cost elements of SAPL and other trenchless and open-cut projects.

Task 11: Soil Box Testing

- Purchase embedment soil.
- Soil box testing of control test:
 - Installation of channels and partition walls.
 - Placing foundation, bedding and embedment.
 - Placing the CMPs inside the soil box.
 - Instrumentation of CMPs (strain gages and earth pressure cells).
 - Backfilling the CMPs.
 - Compaction and measurement.
 - Loading.
 - Monitoring and analysis.



Co-Principal Investigator: Dr. Xinbao Yu

Planned Task for the Next Quarter

Following are the tasks planned for the coming quarter:

- Complete laboratory setup for soil box test.
- Perform sieve analysis, standard proctor compaction, and triaxial tests on the purchased sand samples.
- Install channel section and partition wall in the soil box.
- Perform control tests on bare intact and invert-cut CMPs.
- Perform FEM modeling of bare and lined invert-cut circular CMP.



**Subcontractor: Mr. Ed Kampbell
Rehabilitation Resource Solutions, LLC**

Task 3 – Review of Additional Reinforcement

Update the report based on the additional comments received from DOTs.

Task 4 – Evaluation if Corrugations needed to be Completely Filled by the SAPL as Part of the Structural Design

Update the report based on the additional comments received from DOTs.

Task 6 – Review the Cured in Place (CIPP) Design Equations

Update the report based on the additional comments received from DOTs.

Task 9 – Develop Performance Construction Specifications

This task has been started and per our discussion on the last team conference call I have been awaiting Structurepoint drafts of the specifications to add my input.



**Subcontractor: Dr. Firat Sever
American Structurepoint, Inc. (ASI)**

The following tasks are to be performed by American Structurepoint/Firat Sever in the next quarter:

- Modify the current base equations based on experimental data and computational modeling with FEA being performed by CUIRE.
- Communicate with FDOT and others on the team and develop an approach for internal pressure (submerged) condition. Factor it into the design equations.
- Improve the draft specifications, particularly with respect to developing procedures for QA/QC.
- Attend periodic team conference calls as requested.
- Review any interim work and reports.



**Subcontractor: Mr. Lynn Osborn
LEO Consulting, LLC**

Task 12. QA/QC.

QA/QC reviews will continue on design and development planning, inputs and control. This will include general project oversight as required.



Implementation (if any):

N/A

Problems & Recommended Solutions (if applicable):

Request for additional time and fund has been submitted due to changes from service load to ultimate load conditions in the soil box testing and additional field inspection costs.

Equipment Purchased (if any):

N/A



Contacts and Meetings



Progress Meeting

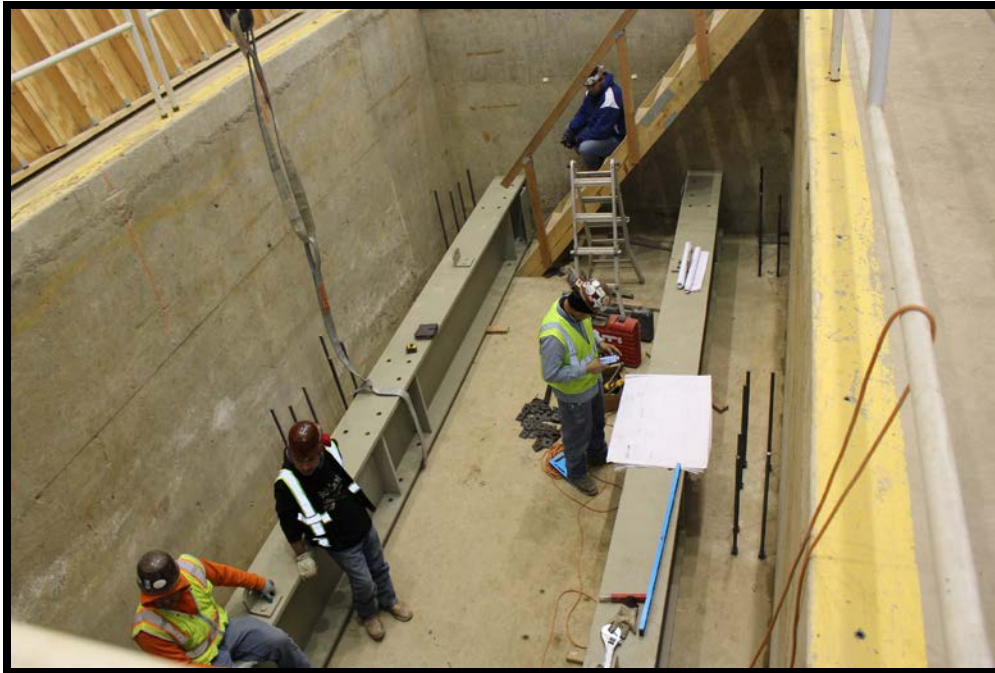
**Table 6: SAPL Progress Meeting during the 5th Quarter
January 1 through March 31**

No.	Progress Meeting Agenda	Date
12	<ul style="list-style-type: none"> • Schedule Update • CMP Delivery (Wednesday, Dec 26, 2018) • Preliminary Review of Design Equations (Presented by Dr. Sever) • Task 3 - Draft Report on Additional Reinforcement 	January 8, 2019
13	<ul style="list-style-type: none"> • Schedule Update • Steel Frame Installation (Photos) • Task 4 - Evaluation if Corrugations Needed to be Completely Filled by the Spray Applied Liner as Part of the Structural Design, Presented by Mr. Ed Kampbell • Task 6 - Review the Cured in Place (CIPP) Design Equations, Presented by Mr. Ed Kampbell 	February 12, 2019
14	<ul style="list-style-type: none"> • Schedule Update • Steel Frame Installation (90% Completion) • Planning Meeting with Mr. Johnson for SprayWall installation into the Soil Box • Needs Feedback from all DOTs on: <ul style="list-style-type: none"> ○ Task 3 – Additional Reinforcement ○ Task 4 - Evaluation if Corrugations Needed to be Completely Filled by the Spray Applied Liner as Part of the Structural Design ○ Task 6 - Review the Cured in Place (CIPP) Design Equations • Task 5 - Plan for Life Cycle Cost Analysis • FEM Update - Comparison of Equivalent with CMP 	March 14, 2019



Appendix A

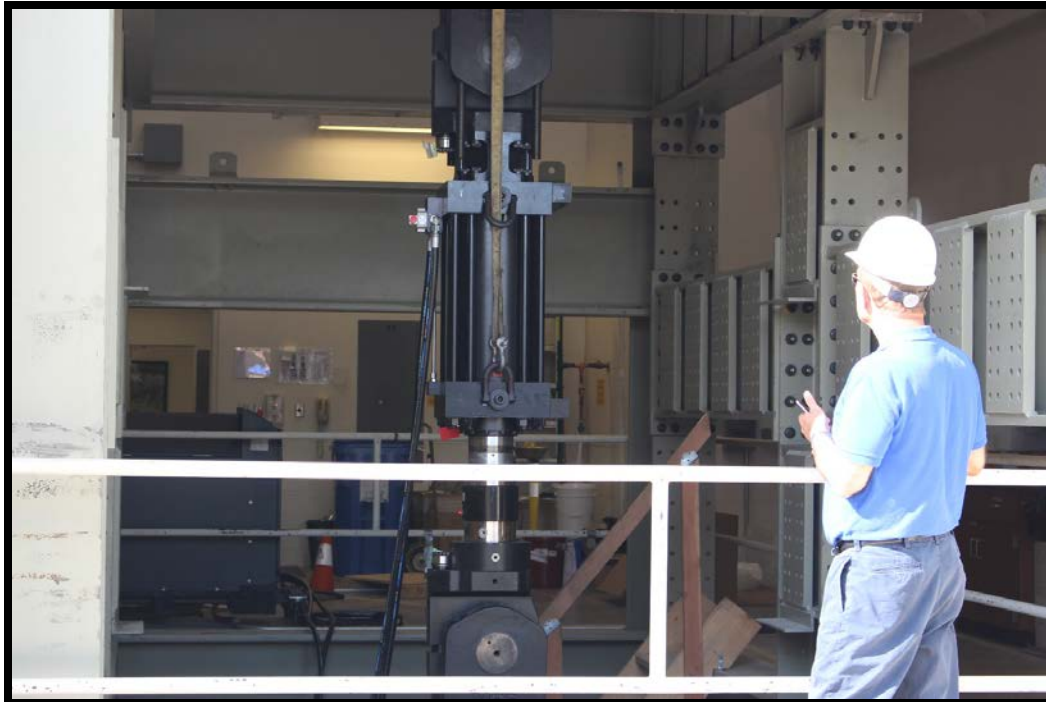
(Steel Frame and Actuator Installation Photos)



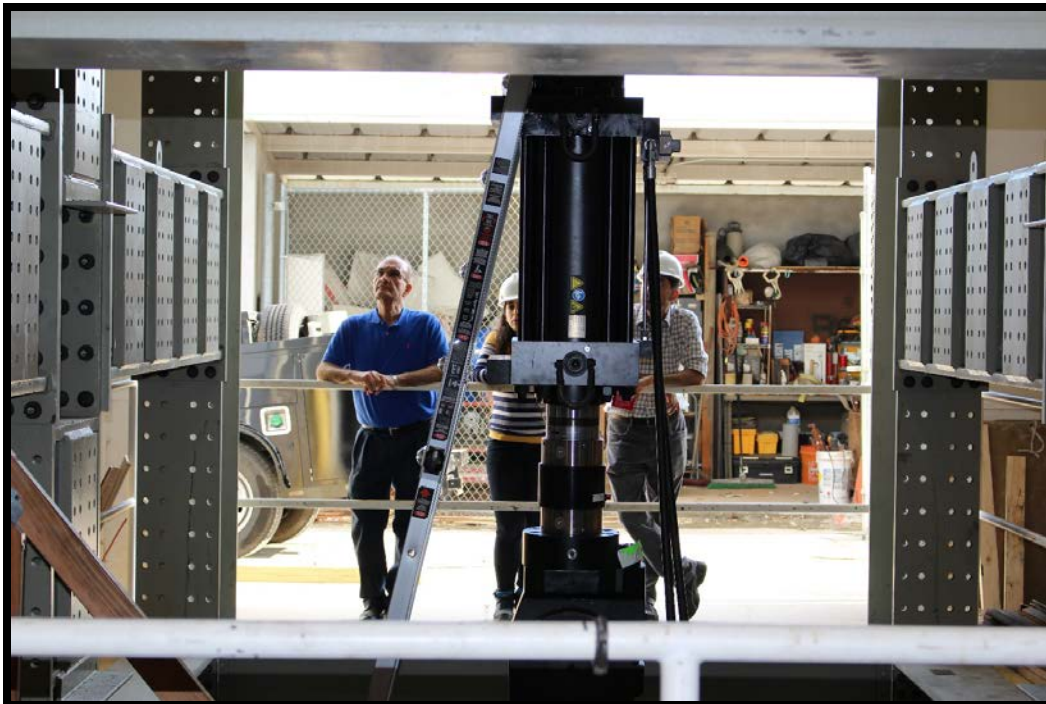
(a)



(b)



(c)



(d)



(e)



(f)



(g)

Figure A1, (a) to (g): Installation of Steel Frame and Actuator in CUIRE/UTA.



Appendix B

(SAPL Revised Schedule for Time Extension Request)



Ohio Department of Transportation
Structural Design Methodology for Spray Applied Pipe Liners in Gravity Storm Water Conveyance Conduits

Project Schedule Sorted by Start date (Extended Schedule End by December 20, 2020)

Task	Responsibility	Description	Completion in 2017 & 2018	2019												2020															
				Current Quarter				Q1				Q2				Q3				Q4				Q1				Q2			
				Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec				
2	Dr. Mike Nagel	Literature Search/Participation Materials Vendors	Delivered																												
13	Dr. Mike Nagel	Lab Testing	In progress																												
10	Dr. Shihua Ye	Computational Modeling	In progress																												
3	Dr. Mike Nagel	Survey of US DOT's and Canadian Agencies	Delivered																												
7	Mr. Bill Bergquist	Half-Dome Collection and Assistance from DOT Partners	Delivered																												
8	Mr. Bill Bergquist	Additional Reinforcement	Delivered																												
5	Mr. Bill Bergquist	Revision of Computations Needed for the Composite Pipe for the Storm Applied Load as Part of the Structural Design	Delivered																												
6	Mr. Bill Bergquist	Review the Code in Place (CIP) Design Equations	Delivered																												
8	Dr. Pratik Senar	Develop a Recommended Structural Design Equations	In progress																												
9	Dr. Pratik Senar	Develop Performance Construction Specifications	In progress																												
9	Dr. Mike Nagel	Life Cycle Cost Analysis	In progress																												
14	Dr. Mike Nagel	Draft Final Report and Fact Sheet																													
14	Dr. Mike Nagel	Final Report and Presentation																													
12	Mr. Lynn DeBore	GD/CC																													

* Milestone

Task	Deliverables
1	Identify use and locations where spray applied linings have been installed.
2	Obtain and review of existing methodologies.
8	Literature review to investigate the benefits of incorporating non-metallic tensile reinforcement.
4	Provide a Report for Structural Capacity of Spray Applied Liner Pipes for Congested Road.
9	Provide life cycle cost analysis with considering durability of material.
6	A review of ASTM F1228 and the new AASHTO design concept for flexible liners including design spreadsheets.
7	To measure and evaluate the in-situ deflections, the bonding, spalling, cracks and holes, corrosion, pavement surface settlements and cracks for spray applied liners to validate how the structure is performing in agreement with the design it was built.
8	Two design procedures, one for polymeric flexible liners, and the other for nonrigid composite liners including tensile spreadsheet for structural design of spray applied pipe liners in gravity storm water conveyance conduits.
9	Design equations for structural design equations for spray applied pipe liners to gravity storm water conveyance conduits that allow the users to modify based on project objectives.
10	A report documenting the mathematical modeling of soft structure system used to validate the proposed design methodologies presented in Task 8.
11	A report documenting the qualifications based type testing to validate the results from the task 8 computational modeling that was used to validate the proposed concrete liner design equations of task 8.
12	Monitor the progress and GD/CC of the project and developing inspection protocols for spray applied lining.
12A	Design & Development / Planning Design & Development Inputs, Design & Development Control, Design & Development Output, General Project Oversight.
12B	Recommendations for GD/CC procedures when installing spray applied liners.
13	Submit draft report and fact sheet.
14	Conduct presentations to DOT as well as at statewide and national conferences.

