SHARP AVENUE
2018 ANNUAL PERFORMANCE REPORT

Sharp Avenue from Pearl to Dakota streets is a pilot project for the City of Spokane to evaluate the effectiveness of permeable pavements in stormwater management and treatment. The project satisfies a permit condition of the City's Eastern Washington Phase II Municipal Stormwater permit (Permit) to select, propose, develop, and conduct Ecology-approved studies to monitor the effectiveness of stormwater management program activities and best management practices. While the effectiveness study is primarily focused on water quality, the City is also interested in learning the pavement durability and maintenance requirements for permeable pavements.

Construction of the project was completed in 2018 and includes both pervious concrete (PC) and Porous Hot Mix Asphalt (PHMA). The list below describes the locations where pavements were placed.

- Pervious concrete (PC): Full lane width (25 feet wide) on the north side from Lidgerwood Street to Astor Street.
- Pervious concrete (PC): Parking and bike lane (14 feet wide) with 11 feet of run-on on the south side from Lidgerwood Street to Astor Street.
- Pervious concrete (PC): Full intersection at Astor Street.
- Porous Hot Mix Asphalt (PHMA): Full lane width (25 feet wide) on both sides of the median between Addison Street to Dakota Street.
- Porous Hot Mix Asphalt (PHMA): Full intersection at Standard Street.

A steering committee was established in 2017 for this project to provide support, guidance, and oversight of progress as well as to determine the measures of success. Committee members included Raylene Gennett, Wastewater Superintendent; Cadie Olsen, Director of Sustainability; Dan Kegley, Director of Water and Wastewater Collections; Katherine Miller, Director of Integrated Capital Programs (ICM); Adrianne Pierson, Stormwater Permit Coordinator; and Marcia Davis, Principal Engineer in ICM. The overall goal of the project was to design, construct, maintain, and evaluate a minor arterial with permeable pavement and to assess the effectiveness of permeable pavement regarding durability, water quality, and infiltration for effectiveness under the Stormwater permit. From this overarching goal, specific goals were identified to measure success before the start of construction. Metrics were created for seven specific goals, and these are described in detail on the following pages. Status of each goal is noted as achieved, under way (meaning it has started, but the work is not completed), or not started.

Each goal is described with the status or achievements of 2018.

GOAL 1: CITY STAFF IS COMMITTED TO THE PROJECT'S SUCCESS.

STATUS: Under Way

This goal identified that staff would need to work cross-departmentally and to collaborate on the changes and results. During 2017 and 2018, staff from Engineering, ICM, Streets Wastewater Collections, and the Riverside Park Water Reclamation Facility (RPWRF) collaborated during the design and construction phases of this project. More collaboration is expected to continue during the monitoring phase.

GOAL 2: POLLUTED RUNOFF WITHIN SHARP AVENUE RIGHT-OF-WAY WILL BE SEPARATED FROM THE MUNICIPAL SEPARATED STORM SEWER SYSTEM (MS4) OUTFALLS THAT DRAIN DIRECTLY TO THE SPOKANE RIVER.

STATUS: Under Way

The runoff within the project area of Sharp Avenue that is managed by center bioretention or permeable pavements has been separated from the MS4. The areas that are being monitored are lined and have underdrains; the runoff from these areas is currently going to the Spokane River with the ability to divert to a drywell. After data is collected that shows water quality is sufficient to infiltrate, the underdrains will be diverted to drywells.

For this goal to be successful, the scope needs to be constructable and fit the existing conditions. Also, the construction documents need to achieve the project scope. Both of these goals were achieved.

GOAL 3: PERMEABLE PAVEMENT IS DESIGNED, CONSTRUCTED, AND MAINTAINED TO MEET NATIONAL AND / OR INDUSTRY STANDARDS.

This goal is divided into 3 sections: design, construction, and maintenance.

DESIGN STATUS: ACHIEVED

For the project to be constructed successfully, the construction documents needed to clearly specify the requirements of the project. The concerns that design needed to address were as follows:

1. Permeable pavements infiltration rate. A high infiltration rate is necessary when the project is constructed for continued functioning and account for possible clogging. An infiltration rate of 100 inches/hour was specified for both PHMA and PC.
2. Permeable pavements design elements. Particular attention needs to be given the design elements that are different from standard pavement design. The City contracted with Robin Kirschbaum of RKI (memo dated 01/19/2018) for review of the design. The recommendations that were incorporated into the design documents include requiring the contractor to have training for installation of PC, washing the aggregates, preparing a jointing plan, and subsurface barriers between conventional and permeable pavements. The specifications for PHMA and PC were updated with the current standards from WSDOT and local experience.
3. Collection of stormwater for monitoring. The project team was concerned about capturing enough water to monitor and sample. Special attention was given to the liner and underdrain pipe. Slotted pipe was specified (as recommended by Robin Kirschbaum) for improved capture

of runoff in the underdrain. The liner needed to be welded or without seams to minimize water loss. Local suppliers were contacted to verify that design requirements could be met by local suppliers. Testing for underdrains and liners was specified make sure they operated correctly before being covered.

CONSTRUCTION STATUS: ACHIEVED

For the project to be constructed successfully, the construction management and inspections needed to make sure the contractor followed the contract documents. The concerns that were addressed are:

1. Staff and contractor are properly trained. Construction Management (CM) staff was trained on installation of PC. The contractor had a subcontractor that was trained and had experience in permeable pavements.
2. Pavement installation meets specifications requirements. The construction work was inspected to meet design requirements. Infiltration rates were tested per the specification to achieve 100 inches/ hour rate. The 51 test locations were identified and tested on 10/08/2018 using ASTM C1701 Standard Test Method for Infiltration Rate of In-Place Pervious Concrete. The same method was used for both PC and PHMA. These locations were recorded so the same locations can be evaluated in the future. The results of the testing are in Table 1; the results have a wide range, but all were above the minimum of 100 inches/ hour. The detailed data is in the Appendix A.
3. Runoff can be captured. The underdrains and liners were tested before being covered. The system was tested at the end of construction. The testing requirements of the specifications were followed and completed.
4. The design can be constructed within one construction season. Because this project was complicated and fairly long, there was a concern that construction methods to install would be difficult and the work could not be completed in one construction season. The project was constructed per plan and within the time allotted.

Table 1-Infiltration Testing Results from 10/08/2018

Pavement Type	Number of Locations Tested	Minimum Infiltration Rate (in/hr)	Maximum Infiltration Rate (in/hr)	Average Infiltration Rate (in/hr)
PC	39	101	1762	907
PHMA	12	518	1762	397

MAINTENANCE STATUS: Under Way

Proper maintenance of this project is needed for stormwater to be managed appropriately. Maintenance strategies have been identified based on current City resources. Street sweeping will be performed using City owned regenerative sweeps quarterly, the same as other arterial streets. Leaf pick-up will occur annually, but the method has been modified, as discussed in Goal 4.

Modifications to the frequency and type of maintenance will be evaluated based on the changes of infiltration rates. If infiltration rates are reduced to 50 inches/hour or less, additional maintenance, or the type of maintenance, will be prescribed to improve infiltration. The initial rate of 50 inches per hour has been selected to represent a 50% reduction the infiltration rate, yet high enough to avoid concerns of flooding. Infiltration rate testing will be performed before and after street sweeping, approximately quarterly for the next 5 years at 16 of the 52 locations done initially. These 16 locations have been identified both by GPS and offset measurements and will be the basis for future infiltration tests.

GOAL 4: INFORMATION IS COLLECTED TO CREATE METRICS TO DETERMINE LIFE CYCLE COSTS. THESE METRICS INCLUDE MAINTENANCE, CONSTRUCTION, AND DURABILITY.

This goal is divided into 3 sections: maintenance, construction, and durability.

MAINTENANCE STATUS: Under Way

Street maintenance will include street sweeping, leaf removal, and snow removal. Street sweeping and leaf removal are needed to prevent clogging of the permeable pavements. In addition, snow plowing is necessary for vehicle travel. De-icing chemicals will not be applied directly to the permeable pavements to this section of Sharp Avenue. Employees will need to be trained in different methods for leaf pickup, snow plowing, and de-icing on this portion of Sharp Avenue. An Operations and Maintenance Plan will be developed to provide guidance to the City of Spokane (City) departments tasked with performing maintenance activities as well as to ensure maintenance approaches are documented.

The City plans to perform maintenance activities using equipment per normal operations whenever possible. Infiltration testing and durability information will be collected to determine if the maintenance requirements of permeable pavements need to be modified. Adjustments may be necessary based on the data collected to include power washing or purchasing specialty equipment.

1. Street sweeping-No street sweeping was performed after construction in 2018. The next sweeping will be in the spring 2019. In the future, sweeping is planned for two times each year using Tymco 435 regenerative air system vacuum sweepers.
2. Leaf removal was performed on November 23, 2018, (the Friday after the Thanksgiving Holiday). Tymco 435 regenerative air system vacuum sweepers were used. Normally 10-wheel dump trucks with front-end scoops or rubber-bladed tractors are used, but there was concern this operation could pack leaf debris in the permeable pavements. The leaves were wet, but not frozen. Because this was a holiday weekend, fewer cars were parked along the street and there was low traffic volume allowing for more efficient operation of the vacuum sweepers. The same process is planned for 2019.
3. Snow plowing was done in December 2018. The City's Street Department bought a rubber plow front-end attachment and attached it to a pick-up truck. An employee was available to operate this pick-up truck, but in the future a standard plow may be used. The rubber attachment will cause less abrasion on the street surface. In the future, the decision may be made to use a steel plow to evaluate the wear to the surface. Plowing to the middle of the street is working as expected.
4. Deice: The City did not use deicer on Sharp. Evidence of deicer as well as ice melt on the crosswalk was noted from possible track-on.

CONSTRUCTION STATUS: ACHIEVED

Standard construction practices are important to be able estimate costs accurately and to stay within budget. The time it takes to construct a project affects the cost of labor and time-sensitive rentals as well as any seasonal and weather-related constraints. Material costs will also impact overall project cost. Permeable pavement is included with the cost of the stormwater system.

1. Installation time-The permeable pavements installation did not take extra time, but the excavation of the several different roadway sections and subgrade elevations specific to this project was complicated and time-consuming. The extra depth for ballast necessary for runoff storage took more time because there is more volume.
2. Material costs-It is difficult to assess the material costs of this project because there are several unique features: inverted crown; multiple street sections; monitoring considerations. Also, general construction costs have increased since the City first installed permeable pavement.

   PHMA cost $71.00 per square yard, compared to $50.00 to $76.40 per square yard for recent City projects. PC cost $170.00 per square yard compared to $75.00 to $150 per square yard for recent City projects. Permeable ballast cost $16.71 (PHMA) and $18.00 (PC) per square yard compared to $24.50 to $27.25 per square yard for recent City projects.

Sharp Avenue was not constructed in a manner that will be typical for construction projects in the future. The information gathered on costs will be useful in the future to estimate construction of permeable pavements.

DURABILITY STATUS: Under Way

Durability of the street surface will be measured using the City's Standard Pavement Condition Index (PCI), based on the ASTM D6433-11: Standard Practice for Road and Parking Lots Pavements Condition Index Surveys. The PCI assigns a numerical value from 0 to 100; new pavement is scored 100. The pavement distress observed for several factors including cracking, bumps, swelling, bleeding, and raveling.

Inspections are done on sunny days with dry pavement to have a consistent measurement. Each pavement type will be observed two times per year and a new PCI assessed starting in the spring and planned to be measured twice a year.

In addition, Etonis Polymer, a strengthening agent, was added to the PC in locations. Performance will be measured in comparison to the rest of the PC.

GOAL 5: TREATED STORMWATER RUNOFF IS CAPTURED IN SAMPLING EQUIPMENT, AND THEN THE WATER QUALITY IS ANALYZED AND EVALUATED.

This goal is divided into 3 sections: capture, water quality sampling, and analysis and evaluation

CAPTURE STATUS: Underway

Difficulty in capturing enough effluent to test was a concern in prior projects. For Sharp Avenue, the specifications were written to have incremental tests to ensure stormwater will reach the sampling station. The system was tested in incremental steps during installation to evaluate each component of the design as part of quality assurance. Water was also captured after construction at an celebration of completion with the Mayor, Gonzaga University officials, and use of a firehose after installation.

1. Liner was tested during construction to make sure it did not have leaks. The contract elected to purchase a one piece liner without seams. The contractor thought the installation was easy rather than seaming.

2. The drains were tested before being buried. Water flowed to the monitoring stations.
3. The work by the contract passed the inspection and testing.

The ability to capture runoff will be determined by future storms.

SAMPLING STATUS: Started

The manholes and connecting pipes were installed by the contractor for the 3 sampling stations. Sampling equipment was ordered and the interior piping was installed in 2018. The Wastewater Instrumentation Electrical and Data Collection section of RPWRF purchased the equipment and will install it in 2019. Leaks were repaired at the sampling station. RPWRF Lab staff will be sampling and performing lab tests.

The sampling will follow the procedure outlined in the QAPP.

ANALSYS STATUS: Not Started

No samples were collected in 2018, and therefore, no lab analysis could be performed. Samples collection and analysis will follow protocols in the QAPP. RPWRF Lab staff will be sampling and performing lab tests.

EVALUATION STATUS: Not Started

Data validation will be performed in accordance with the Ecology approved QAPP.

GOAL 6: THE PROJECT'S PURPOSE IS COMMUNICATED INSIDE AND OUTSIDE THE CITY.

STATUS: Started

Information about this project has been communicated both inside the City and with interested outside parties. A Steering Committee was established in January 2017 to determine the goals of the Sharp Avenue Pilot Project. The Steering Committee met 10 times between January 2017 and December 2018.

An external stakeholders meeting was created with Dan Sander, PE, Sander Enterprises Training and Environmental Consulting, as the facilitator. Two meetings were held during 2018. The first meeting described the project goals, general design elements, and schedule. The second meeting reviewed the 60 percent design plans. Emails were sent to the Stakeholders of the final plans as new content became available. The stakeholder members were:

- Mike Petersen, Executive Director, The Lands Council
- Art Jenkins, PE, Stormwater Engineer, City of Spokane Valley
- Chad Phillips, PE, Stormwater Engineer City of Spokane Valley
- BiJay Adams, General Manager, Liberty Lake Water & Sewer
- Jeremy Jenkins, Environmental Manager, Liberty Lake Water & Sewer
- Ben Brattebo, PE, Water Resource Specialist, Spokane County
- Jake Saxon, PE, Project Engineer, Spokane County
- Kelly Williquette, General Manager, Spokane Water District #3

Sharp Avenue Stakeholders Kickoff Meeting was held 01/11/2018 for City staff. The project background, goals, and information to be gather was shared. Roles and responsibilities, potential obstacles, and monitoring was discussed.

In the next years, communication will continue on the City project webpage. The Sharp Avenue Effectiveness Study Annual Report required by the Phase II permit will be submitted to Ecology as an attachment to the Annual Stormwater Report. Both the Effectiveness Study and Performance Annual Reports will be uploaded to the City's web site and notification sent to Stakeholders. An email list of Stakeholders, internal and external, will be created. The sampling information may be added to the International Stormwater BMP database.

GOAL 7: INFORMATION GATHERED IS DOCUMENTED AND USED FOR DECISION-MAKING.

STATUS: ACHIEVED

This annual performance report was written to document the progress of the evaluation of Sharp Avenue and lessons learned. A performance report will written annually for 5 years to continue to document information gather and lessons learns.

LESSONS LEARNED

1. Selecting an appropriate location is essential.
    a. The location and geology of the project area were very favorable for the pilot elements of the project.
    b. The project was scoped well enough to know the subsurface soils would drain well, the depth to aquifer was over 70 feet, and there were few utility conflicts.
    c. Having one adjacent property owner (Gonzaga University) with multiple entrance/exit points and few dry utility (communications or power) connections simplified construction. A maintenance plan with GU was developed before construction was completed; this informed the maintenance staffs of the required maintenance and desired frequencies so they could be better prepared.
2. Staff needs to share a common goal to effectively work together and be creative to find solutions.
    a. The success of the project to date is due to City staff being committed to deliver a high quality product.
    b. Staff worked interdepartmentally to achieve the best outcomes.
    c. The design team researched construction materials and methods to ensure the project was constructable. The pavement layout capitalized on the best way to use the permeable materials as well as locations for sampling stations.
    d. Street Department operations used a non-standard method for leaf removal to avoid clogging the pavement. This method appears to work.
3. Construction costs were evaluated and compared to other projects, but this project is unique in the variety of pavement and stormwater management strategies applied. The costs of this project

can be used for future stormwater project costs. A baseline for durability was established. Things to keep in mind in considering costs for permeable pavement:

- One section and type of permeable pavement would be best to simply construction and reduce cost;
- Because the depth of the section, dry utilities and gas lines are more impacted;
- Road closures are important to keep traffic off the subgrade and ballast that is not compacted as much until the pavement is installed.
- Costs should be compared to alternative stormwater management system because permeable pavements are used for stormwater management.

Appendix A

Test #	Date	Station	Location	Polymer	Pre-soak	Pounds H2O	Infill. Sec.	Inches Per Hour	Material
IT-1	10/3/2018	13+36	9.0' (S) of(N) Curb	4%	9 Sec.	40	31	1,136.80	PC
IT-2	10/3/2018	13+56	2.5' (S) of(N) Curb	4%	15 Sec.	40	52	677.7	PC
IT-3	10/3/2018	13+77	8.0' (S) of(N) Curb	4%	16 Sec.	40	69	510.7	PC
IT-4	10/3/2018	14+01	7.0' (S) of(N) Curb	4%	21 Sec.	40	85	414.6	PC
IT-5	10/3/2018	14+34	3.0' (S) of(N) Curb	0%	11 Sec.	40	33	1,067.90	PC
IT-6	10/3/2018	14+61	10.0' (S) of(N) Curb	0%	11 Sec.	40	30	1,174.70	PC
IT-7	10/3/2018	14+88	5.0' (S) of(N) Curb	0%	17 Sec.	40	58	607.6	PC
IT-8	10/3/2018	15+19	7.0' (S) of(N) Curb	0%	20 Sec.	40	80	440.5	PC
IT-9	10/5/2018	13+00 lot 3	10.0' (N) of (S) Curb	2%	10 Sec.	40	48	734.20	PC
IT-10	10/5/2018	13+36 lot 3	8.0' (N) of (S) Curb	2%	12 Sec.	40	31	1,136.80	PC
IT-11	10/5/2018	13+57 lot 3	6.0' (N) of (S) Curb	2%	8 Sec.	40	36	978.9	PC
IT-12	10/5/2018	13+77 lot 3	3.0' (N) of (S) Curb	2%	8 Sec.	40	30	1,174.70	PC
IT-13	10/5/2018	14+01 lot 3	4.0' (N) of (S) Curb	2%	8 Sec.	40	30	1,174.70	PC
IT-14	10/5/2018	14+34 lot 4	6.0' (N) of (S) Curb	2%	10 Sec.	40	41	859.60	PC
IT-15	10/5/2018	14+61 lot4	8.0' (N) of (S) Curb	2%	7 Sec.	40	28	1,258.60	PC
IT-16	10/5/2018	14+88 lot 4	10.0' (N) of (S) Curb	2%	26 Sec.	40	124	284.2	PC
IT-17	10/5/2018	15+19 lot 4	12.0' (N) of (S) Curb	2%	52 Sec.	8	70	100.7	PC
IT-18	10/8/2018		88.0' East of South East Curb Line Addison, 11.5' (N) of (S) Curb E/B		50 Sec.	8	65	108.40	PHMA
IT-19	10/8/2018		170.0' East of South East Curb Line Addison, 5.0' (N) of (S) Median E/B		34 Sec.	8	50	141.00	PHMA
IT-20	10/8/2018		47.0' West of South West Curb Line Standard, 7.5' (N) of (S) Median E/B		22 Sec.	40	120	293.7	PHMA
IT-21	10/8/2018		51.0' East of South East Curb Line Standard, 13.5' (N) of (S) Median E/B		18Sec.	40	94	374.90	PHMA
IT-22	10/8/2018		146.0' East of South East Curb Line Standard, 5.5' (N) of (S) Median E/B		13 Sec.	40	88	1,762.00	PHMA
IT-23	10/8/2018		298.0' East of South East Curb Line Standard, 16.5' (N) of (S) Median E/B		62 Sec.	8	88	80.10	PHMA
IT-24	10/8/2018		52.0' East of North East Curb Line Addison, 16.5' (S) of (N) Curb W/B		15 Sec.	40	51	691.00	PHMA
IT-25	10/8/2018		156.0' East of North East Curb Line Addison, 6.5' (S) of (N) Curb W/B		31 Sec.	8	44	160.2	PHMA
IT-26	10/8/2018		317.0' East of North East Curb Line Addison, 15.0' (S) of (N) Curb W/B		115.0 Sec.	8	136	51.8	PHMA
IT-27	10/8/2018		298.0' East of South East Curb Line Standard, 15.0' (S) of (N) Curb W/B		88 Sec.	8	121	58.3	PHMA
IT-28	10/8/2018		146.0' East of South East Curb Line Standard, 6.5' (S) of (N) Curb W/B		13.0 Sec.	40	53	664.9	PHMA
IT-29	10/8/2018		57.0' East of South East Curb Line Standard, 20.0' (S) of (N) Curb W/B		15.0 Sec.	40	94	374.9	PHMA
IT-30	10/8/2018	13+25 lot 5	4.0' (N) of (S) Median	2%	11 Sec.	40	43	819.6	PC
IT-31	10/8/2018	13+60 lot 5	6.0' (N) of (S) Median	2%	10 Sec.	40	35	1006.9	PC
IT-32	10/8/2018	13+90 lot 5	8.0' (N) of (S) Median	2%	31 Sec.	8	42	167.8	PC
IT-33	10/8/2018	14+20 lot 5	10.0' (N) of (S) Median	2%	7 Sec.	40	23	1532.2	PC
IT-34	10/8/2018	14+50 lot 6	12.0' (N) of (S) Median	0%	6 Sec.	40	20	1762	PC
IT-35	10/8/2018	14+80 lot 6	3.0' (N) of (S) Median	0%	7 Sec.	40	26	1355.4	PC
IT-36	10/8/2018	15+00 lot 6	7.0' (N) of (S) Median	0%	6 Sec.	40	23	1532.2	PC
IT-37	10/8/2018	15+25 lot 6	3.0' (N) of (S) Median	0%	8 Sec.	40	42	839.1	PC
IT-38	10/16/2018		5.0 (S) of (N) curb Astor CL & 16.0(W) of E curb CL ramp	4%	9 Sec.	40	26	1,355.40	PC
IT-39	10/16/2018		15.0 (N) of (S) curb Astor CL Southside	4%	11 Sec.	40	38	927.4	PC
IT-40	10/16/2018		7.0 (N) of (S) curb Sharp & 8.0(E) of W CL ADA ramp S/W	4%	7 Sec.	40	25	1409.7	PC
IT-41	10/16/2018		7.0 (N) of (S) curb & 6.0(W) of E curb CL ramp S/E	4%	9 Sec.	40	26	1355.4	PC
IT-42	10/16/2018		13.0 (S) of CL Storm Man Hole Astor & Sharp	4%	7 Sec.	40	32	1,101.30	PC
IT-43	10/16/2018		7.0 (E) of (W) curb Sharp & 15.0(N) of (S) CL ramp S/W	4%	12 Sec.	40	50	704.8	PC
IT-44	10/16/2018		24.0 (N) of (S) ER S/W & 15.0(E) of W curb	4%	10 Sec.	40	44	800.9	PC
IT-45	10/16/2018		21.0 (N) of (S) curb Sharp CL ADA Ramp & 6.0(W) of E CL Median Sharp	4%	32 Sec.	8	40	176.2	PC
IT-46	10/16/2018		23.0 (S) of (N) curb (E) ER & 15.0(W) of E curb Sharp	4%	16 Sec.	40	75	469.9	PC
IT-47	10/16/2018		5.4 (N) of (S) CL Storm Man Hole Astor And Sharp	4%	5 Min.	8	N/A	N/A	PC
IT-48	10/16/2018		12.0 (S) of (N) curb Sharp on E curb line Astor & 17.0(W) of E curb Sharp	4%	48 Sec.	8	60	117.5	PC
IT-49	10/16/2018		13.0 (S) of (N) curb Sharp on W curb line Astor & 10.5 (E) of CL ramp N/W	4%	9 Sec.	40	34	1036.5	PC
IT-50	10/16/2018		6.0 (S) of (N) curb Astor & 6.0(E) of CL ramp N/W	4%	10 Sec.	40	31	1136.8	PC
IT-51	10/16/2018		6.5 (S) of (N) curb Astor &7.0(W) of E CL ramp N/E	4%	8 Sec.	40	31	1136.8	PC