DESIGNING A LITTER TRACKING METHOD FOR WORCESTER, MA: SUPPLEMENTAL MATERIALS

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APPENDICES

Appendix A: Worcester Officials Interview Questions

We used these questions or similar ones for interviews with George Russell, Matthew Wally, Jeff Tomaino, Jay Fink, and Eric Batista.

1. I saw that you have been representing District 3 since 2012. What made you run for office?
2. What has been your proudest achievement?
3. Have you worked with other WPI students on their projects in Worcester?
4. What role does the Public Works Committee play when it comes to addressing trash and cleaning up the city?
    a. What are some challenges that the committee runs into
5. What do you think contributes to the amount of trash in the streets and parks?
6. Do you think the issue has been getting better?
7. I saw that you support street sweeping and keeping recycling free. Are there other efforts being made to clean up the city further?
    a. Why do you think these are important?
8. Have you encountered a lot of residents that feel strongly about cleaning up the city?
    a. What have you found to be the best way to communicate with residents of Worcester?
9. What would be your ideal trash collection and anti littering campaign?
    a. Do you think aspects of that are attainable?
10. Does the city have a trash/litter tracking program in use?
    a. Do you think that having some kind of trash/litter tracking program aids/would aid the city's cleanup efforts?
        i. If so, what might be some of those ways?
11. What do you think are the most important features of a potential tracking tool?
12. We have reached out to REC Worcester about the Annual Earth Day Clean Up. Are there any other organizations that you work with to address trash or plan clean ups?
13. Do you think clean ups are an effective way to address litter?
    a. Do you think a different method that focused on prevention could work?

Appendix B: Steve Fischer Interview Questions

1. What do you think Worcester could improve to prevent trash on the streets? (signage, policy, more trash bins, etc.)
2. What do the sponsors of this event do to contribute to the cleanup, e.g National Grid?
3. Do you think there is a good volunteer base that is interested and engaged in cleaning up Worcester?
4. Has the number of sites and/or amount of litter being cleaned up changed very much over the years excluding last year and this year due to the pandemic? (i.e. the litter situation in Worcester improving, deteriorating, or staying the same)
5. With the pandemic causing a smaller event this year, what are some ways the REC is trying to have the same level of cleanup volume of litter as previous years?
6. How will you choose which sites are cleaned up this year?
7. Do you record what types of litter come from the various sites?

Appendix C: Mary Tilton Interview Questions

1. Let's start by having you tell us a bit of background about yourself and how you got into your career as the Keep Bamberg County Beautiful Coordinator
2. Since taking on this role, what has been your proudest achievement? What do you hope to accomplish in the future?
3. How are the roads selected each year? Do the same people conduct the assessments annually?
4. Is there any training required in order to use the ranking scale? If so, what is the process and timeline of said training?
5. What is done to ensure that the data collected is precise and accurate across evaluations?
6. Is there a lot of variation between the 3-5 people that conduct the assessments?
7. How is the data analyzed and what has been the community impact from this program?
8. In addition to the ranking system, are there any other programs that aim to address littering in Bamberg? If so, what are they and how successful have they been?
    a. Did you look at other tracking methods before settling on a litter index?
9. In what ways does the Keep America Beautiful program provide support to Bamberg County?
10. If you were to choose one area to improve on the litter index, what would it be, why and what would be your ideal solution?

Appendix D: Interview Analysis Table

Name	Title/position	Main points	other
Matthew Wally	District 5 councilor	• Proper funding to parks • Education of youth on litter issues • More funding towards litter clean up programs such as clean worcester • Illegal dumping in parks • Covered trash and recycling can be helpful • Pictures useful in trash tracking	• The mindset of the people can greatly affect litter
George Russell	District 3 Councilor	• Supportive of a municipal app • Thinks a picture submissions for citizen reporting could be useful • Some trash in parks is household garbage • Thinks lack of education is a large contributing factor	• Strong opinions about curbside pickup (doesn't like plastic bags for recyclables)
Jeff Tomaino	Parks and recreation coordinator	• Parks have problem with dumping household trash • Ease of use and accessibility very important for program • Trash generated by homeless/during relocation of homeless • Outreach through social media, park friends groups, sports organizations • Work to educate youth • Track tonnage of trash removed on quarterly basis	• Have tested various trash can designs • ~2 employees that go around to collect trash from bins in parks • Youth program over summer to assist with litter problems • East park and university park are high litter areas • Some parks have foremen to manage them • Needles can be mixed in with litter (drugs)
		• Supports education, just not sure how to do it	litter
Steve Fischer	REC Worcester	• Organizes annually earth day clean up • Scale of impact is limited by covid • Last year cleaned over 100 sites and had 1200 volunteers participate	

Eric Batista	Director of the office of urban innovation	• Better communication between DPW and residents • Specific types of litter may need specific solutions • Big belly bins and more drop off times could help • Behavior is a problem • Yellow bag program works and has been improved over time • Supports clean ups • App needs before and after images	• Advocates for bigger bins and more cleaning to reduce the visual trash and show a place is cleaner, leading to people littering less • Need a mix of reactive and proactive strategies against litter
Jay Fink	DPW commissioner	• Advocates for better street cleaners • More clean ups and more workers • Didn't notice much trash in parks, noticed it on highways • Supports yellow bag program, encourages recycling • Not sure big belly useful in worcester • Supports education, just not sure how to do it	• Important to identify where litter is coming from to reduce it at its source • Not sure how to combat sources of litter
Steve Fischer	REC Worcester	• Organizes annually earth day clean up • Scale of impact is limited by covid • Last year cleaned over 100 sites and had 1200 volunteers participate	

Appendix E: Example Informed Consent Preamble

This, or similar preambles were given to interviewees prior to the beginning of the interviews.

We are a group of students from Worcester Polytechnic Institute in Worcester, MA. We are conducting interviews of organizations in Worcester to learn more about litter tracking and the cause of litter in Worcester. We believe this research will enhance the management of litter and the long-term success and sustainability of the environment within the city. Your participation in this interview is completely voluntary and you may choose to not answer any or all of our questions. Please remember that your answers may not remain completely confidential. Identifying information may appear on the questionnaires or in any of the project reports or publications. Additionally the name of the organization you are representing may be used. You will be contacted for permission to use identifying information before it appears in the report via email or a phone call. This is a collaborative project between the Worcester DPW&P and WPI. If you would like to speak to our faculty advisors, you may email them: Corey Dehner (cdehner@wpi.edu) and Gillian Smith (gmsmith@wpi.edu). If interested, a copy of our results can be provided at the conclusion of the study, simply email us or our faculty advisor.Thank you, your participation is greatly appreciated.

Appendix F: Park and City Data Table

City	Resources (excluding the method of tracking)	Amount of Green Space	# Annual cleanups	Recycling programs	Curbside Pickup	Public Maintenance Schedule
Worcester, MA	-clean city program -park friends groups -REC worcester cleanups	~1300 acres of parks	REC annual earth day cleanups	Free pickup	Yellow Bag Program	2 employees go around parks to empty trash cans daily
Philadelphia, PA	-Strong community involvement (park friends, neighborhood groups, citizen action toolkit) -zero waste partnership program -organized website including all resources in one spot -trashcan partnership (community cans) -mobile app (philly 311) -illegal dumping enforcement -affiliated with Keep America Beautiful	9463 acres of parks		-strong recycling and education program		-volunteer based park cleanups (responsible for cleaning park or neighborhood) -increased number of trashcans because reduce litter and time spent cleaning (conducted study)

Lafayette, LA	illegal dumping enforcement;	~1500 acres of parks	annual "trash bash" cleanup event	curbside or drop off recycling		Volunteer cleanups
Bamberg County, SC	-keep Bamberg County Beautiful annual litter index -volunteers and KBCB board members -drive by observations and notes taken -map of the county showing district scores from previous years -affiliated with Keep America Beautiful	395 square miles	does multiple volunteer based clean ups	-tire recycling -scrap metal processing -white goods recycling	does not provide residential garbage collection instead has 8 waste disposal locations	has roadside volunteer based clean ups through KBCB
cambridge, MA	"Get Rid Of It Right" Tool and App; zero waste master plan; curbside pickup of compost	~464.65 acres of parks and open spaces	several neighborhood and business associations do annual neighborhood cleanups; annual earth day charles river cleanup	free curbside pickup;	weekly pickup of trash, recycling (free) and compost	residents can call in to report issues in public spaces to relevant department
newton, MA	"Recycle Right Newton" app; Recreation & Open Space Plan;	541.02 acres of parks and playgrounds	keep mass/newton beautiful organizes cleanups; annual earth day charles river cleanup	curbside or drop off recycling	curbside trash and recycling pickup	have installed bigbelly smart trash cans

Appendix G: Litter Tracking Programs Data Table

City/program	Method	Duration	Area covered	technology used (mapping, pictures, ranking system etc)	type of people involved (volunteer vs trained employee)	drawbacks or weakness of method (time, subjectivity, training requirements, etc)	Strengths of method (time, subjectivity, training requirements etc)
Philadelphia, PA	Interactive mapping and informational hub,	2017-Present	9463 acres of parks	employees rank sites on 1-4 scale and fill out a survey which is mapped using geographical data, submitting a picture is optional. rating matrix used by surveyors is based off of estimates	-employees surveys sites	ranking can only be carried out by trained employees, the matrix would be too vague for volunteers because it could be very subjective	surveys/ estimates are quicker than counting
Lafayette, LA	log data w/ "Survey123" app then upload to "Storymaps" to analyze + illustrate findings	not entirely sure, few months in late 2019/early 2020?	Carencro High campus (maybe more since article was written; planning visits to library, parks and recreation facilities, and other public facilities)		4 students + teacher		each instance of data collection was under an hour in length
cambridge, ma	hub for information about the city including trash collection and street sweeping schedules		entire cambridge area	used ArcGis data for mapping	any resident	not specifically used for litter tracking	organized information with positive reviews from the community

newton, ma	Recycle right now app		newton, ma	mobile app	any resident	not specifically used for litter tracking	educates and reminders residents about proper trash disposal, recycling and methods to cut down on waste
pothole.info	residents report potholes to maintenance crews	2010-present	national website	mobile app that accepts picture submissions and descriptive notes	any resident	overwhelmed cities when it first came out because there was a lot of responses evened out over time	increases efficiency of response teams by providing relevant info such as city vs rurals roads for maintenance crews
rubbish.love	use app w/ grabber arm ("rubbish beam") to categorize litter as it is collected		pilot cleanup programs, etc, in and around San Francisco CA area	rubbish app, "rubbish beam" grabber arm	people with the app and grabber arm	needs (?) rubbish beam to work (must be bought)	aims to make process fun, litter collected along with data, categorization of litter can be delayed to speed up litter collection

Bamberg County, SC	3-5 .5-1 mile long sections of randomly selected roads in each of the 7 districts of the county are surveyed each year by car. The surveyors score the sections of road based on how much litter is there visually, how easy the litter is to be cleaned up, and how easy the site is to clean. The road scores are averaged into a district score, then the district scores are averaged into a county score.	2015-present, 3 days each year	21-35, .5-1 mile sections of road	manual data entry through observation, notes, and surveying by car	a team of 6 people made up of employees and volunteers	not many people. could use more volunteers to survey more streets, thereby increasing the accuracy. only once every year. inefficient manual data entry	has been done for numerous years. simple method. gives a detailed annual report that includes a table of streets surveyed and GIS map of litter rating by location. gives qualitative and quantitative analysis of litter in a location with index score

Appendix H: SWOT Analysis of Litter Tracking Tools

	Internal: attributes of the method		External: attribute of the execution	
Methods	Strengths	Weakness	Opportunities (improvements)	Threat (challenges)
Philadelphia, PA Litter Index: Interactive map	-Shows the data visually -Organizes info by location on map -Quadrant organization Link: https://www.arcgis.com/apps/View/index.html?appid=4856a523514c4c02ba0e28e6a0e8c42c	-Needs a platform and accurate geographic data -Does not count or sort litter	-Could be an informational hub -Could provide waste management information by neighborhood like trash days	-Coding/creating a w page or app
Pothole.info: Residential Reporting App	-Widely used -Ease of use -Provided additional data so maintenance crews could be more efficient -Collected photos and reports	-Overwhelmed maintenance crews with volume of requests at first -User needs a smartphone	-Could be used to organize clean ups in areas with a lot of requests -Public access to the data could result in motivation for citizen organized clean ups -Could be used with ranking system to prioritize requests (this could be a motivator)	-Developing app -Raising awareness among users -Organizes all of the requests in one format
REC Worcester: Trash bag metrics	-Could use either number of bags or weight of the bags -Two uniform objective metrics for each site	-Does not provide info about trash break down such as composition and specific location within a site	-Cleans up an area while collecting tracking information -Does not require development of a platform/ specific methodology	-Needs organized events in order to execute
Debris Tracker: mobile app	-Easy to use -Collects metadata like time and location -Photos or data entry -Sorts data by litter categories such as plastic vs metal	-Data entry could be very tedious -Categories need to be very clear for data accuracies but breaking categories down too much will slow down efficiency	-Could be an informational hub -Could provide waste management information by neighborhood like trash days -Public access to the data could result in motivation for citizen organized clean ups	-Developing app -Raising awareness among users -Organizes all of the requests in one format

Picture Post: Photo submission	-Easy to use -Provides images that would clearly show change overtime	-Needs an actual picture post at each location -Would only provide a snapshot of an indicator location within a site	-Could be used to track other visual changes in ecology -Could submit pictures from Worcester posts to the nation map created by the organization	-Large volume of pictures would need to be organized in order for them to be useful
Rubbish.love: mobile app	-Easy to use -Collects metadata like time and location -Sorts data by litter categories	-Needs "rubbish beam" grabber arm to work; phone connects via bluetooth	-Could be informational hub -Could provide waste management	-Developing app -Raising awareness among users
	-Maps data to find trends -Cleans up an area while collecting tracking information	-User needs smartphone	information by neighborhood like trash days	
Lafayette, LA: photo submission (not government program; teacher and 4 students)	-Easy to use -Collects metadata like time and location -Sorts data by litter categories -Record distance from nearest trash can	-User needs smartphone -Individual data collection may be tedious	-Article doesn't specify what litter categories are; could be specified	-Raising awareness among users -Uses separate platforms to collect and display data
StormX Netting Trash Trap	-Easy to use -Cost efficient -Collects litter down to 5mm in diameter -Great for "first flush" -Easily collectable and interchangeable -Collects organic matter to reduce algae blooms	-Limited to waterway collection and needs current -May need crane for removal	-Could be ways to collect large amounts of waterway litter to be analyzed and categorized	-Such large volumes may be tedious to sort -Limited heavy machinery may cause removal issues -Cost may not suit budget

Appendix I: SWOT Analysis of People Participating in Litter Tracking Programs

	Internal: attributes of the method		External: attribute of the execution	
Methods	Strengths	Weakness	Opportunities (improvements)	Threat (challenges)
Philadelphia, PA Litter Index: surveyors using a ranking system	-Quick and can be done by a single person	-May take training so that everyone is on the same page with the different ranking classes -Keeping track of data/ organization of submissions	-Use concrete language and examples -Buddy system for new surveyors -Supplemental picture submissions	-Scale could be subjective and yield inconsistent results with volunteers
Pothole.info: Residential Reporting App	-Anyone can download from the app store and use it -Great for citizen reporting/ science	-Could potentially receive spam	-Concept could be expanded outside of litter tracking -Improves communication between city government and residents	-Data quality may vary such as a blurry photo and report that filled out incorrectly -DPW employees would end up submitting work orders to their own office?
REC Worcester: trash bag metrics	-Can be executed by anyone because there are no specialized skills or judgement	-Could take a very long time if there's a small turn out/ highly littered area -Little to no data analysis needed to quantify the amount of trash removed	-Opportunity for community involvement -Could be carried out independently by neighborhood groups -creates pride in the community which also discourages littering behavior	-May have to supply volunteers with gloves, trash pickers or other sanitary measures- (budget?) -May be hard to generate sustained interest/ involvement
Debris Tracker: mobile app	-Anyone can download from the app store and use it -Great for citizen reporting/ science -Little to no subjectivity	-Volunteers could lose interest quickly because it could be tedious and time consuming	-Making the platform fun and interactive -Could add incentives such as recognizing the top contributor of the week or giving users feedback on the impact they have had -Could organize group tracking days so one person does not need to log every single piece of litter independently Ex. Start at opposite sides	-Likely that one person will not track one location in it entirety so there could be gaps in data collected and duplicates in areas such as the park entrance (metadata could prevent duplicates) -DPW employees may have to go to different areas to fill in gaps
Picture Post: Photo submission	-Could be used by citizens and employees -Pictures can convey a strong method and show results in a concrete way instead of numerically	-Photo quality could vary across submissions -Needs high quality cameras and adequate lighting in order to see litter	-Could be decorated and flashy to provoke interest Ex. community could decorate/paint the post -Would focus on indicator locations only which cuts down the amount of ground that needs to be cover	-Would require a lot of photo analysis which could be time consuming -Uploading multiple pictures at one time may difficult in areas with bad service

Rubbish.love: mobile app	-Anyone can download from the app store -Great for citizen reporting/ science -Categories reduce subjectivity -Has type of rewards program -Categorization of litter can be delayed to speed up litter collection	-Categorization with individual pickup can be very tedious and time consuming -Not something that can just be started randomly, needs "rubbish beam" and bag/bucket for trash collection	-Categories could be made more specific to reduce subjectivity -Community statistics in more cities -311 integration for more cities	-requires(?) sign in/up before starting -People may cover entire areas, may leave gaps in data
Bamberg County Litter Index	-Small crew of employees and volunteers -Has been done annually for 5 years -Produces GIS map of litter ratings using randomly sampled roads evenly distributed around the county -Provides qualitative and quantitative data	-Does not categorize trash -Only once a year -Only visual inspection from curbside	-Could include pictures and categorizing of litter in locations -More volunteers would mean more streets observed -Change from 3 days to 5 days for observers to cross check	-Could be hard to scale without significantly more people -Could be gaps in data with highly littered roads not getting observerved
StormX Netting Trash Trap	-Can be purchased and setup by almost anyone	-Fittings on pipes may need to be custom fit	-Workers who routinely empty trash in parks could change and empty smaller nets	-Nets that require cranes need special personnel to operate the heavy machinery
Lafayette, LA: photo submission (not government program)	-Small group of people collecting data (1 teacher + 4 students) -Instances of data collection were less than 1 hour in duration -Great for citizen reporting/ science	-Small numbers of data collectors limits area of coverage	-Method could be used on larger scale with residents and/or volunteers -Categories could be made more specific to reduce subjectivity	-People may cover entire areas, may leave gaps in data -Potentially time consuming data collection may discourage some people from participating

Appendix J: Tracking Method Attribute Table summarizing the SWOT analysis used for comparison of methods.

Table Legend	
Color	Meaning
✓	Meets criteria
X	Does not meet criteria
🔍	Requires further research

Method	Efficient	Photo Submissions	Ranking System	Citizen science friendly	Quantitative	Mapping feature	Needs a platform
1.Litter Index: Interactive map	✓	🔍	✓	X	X	✓	✓
2.Pothole.info : Residential Reporting App	✓	✓	X	✓	🔍	🔍	✓
3. REC Worcester: Trash bag metrics	✓	X	🔍	✓	✓	🔍	X
4. Debris Tracker: mobile app	X	X	X	✓	✓	X	✓
5. Picture Post: Photo submission	🔍	✓	X	✓	✓	✓	X
6. Rubbish.love: mobile app	X	✓	X	✓	✓	✓	✓
7. Bamberg County Litter Index	X	X	✓	X	✓	✓	X
8. StormX Netting Trash Trap	✓	X	X	X	✓	X	X
9. Lafayette, LA		✓		✓	✓	✓	Y

Appendix K: Initial Park Visit Data Table

park	location	Trash types	Trash cans	Type of space	surroundings	No littering signs
Bell pond	Off of Belmont street	Bottles, food wrappers, glass, bags, cigar/cigarette butts, recreational, small pieces	2, 1 at each parking lot	Water with wooded trail around the bank. 1 small beach. Road along 1 side	Multifamily residential	2, 1 on each trash can
Coes pond, big beach	Off mill street	Bottles, glass, food wrappers, junk	3 trash cans, 1 missing	Road along 1 side, woods and water on other sides	Woods and run down businesses	3, 1 on each trash can
Coes pond park	Off coes street	junk, bottles, glass, food wrappers, small pieces, cigar/cigarette butts	4 trash cans, not very spread out	Small secluded beach, rocky bank, brush along stream, playground	Single family residential buildings and multifamily residential	4, 1 on each trash can
Colombo park	Off east park terrace	Cups, glass, cigar/cigarette butts	7 trash cans, 1 missing, mostly clumps	Mostly recreational fields and amphitheater	Businesses and single family homes	0
University park	Off crystal street	Bottles, glass, recreational, small pieces, food wrappers	5 trash cans spread out	Playground and small pond	Clark university and single/multifamily houses	4 no littering signs
Elm park	Off russell street	Bottles, food wrappers, glass, recreational	Numerous trash cans around the park	Playground and big pond with paths around	Businesses and single family housing	No do not litter signs
Indian lake	Off shore drive	Glass, food wrappers, cups, bottles, recreational,	4 trash cans clumped together by entrance	Parking lot area that is roped off and beach	Single family housing	2 do not litter signs

Appendix L: Litter Category Table with Examples

Category	Examples
Bottles	Water bottles, gatorade bottles
Plastic cups	Dunkin cups, red solo cups,
Glass	Glass shards, liquor bottles
Bags	Disposable plastic bags
Food packaging and containers	Plastic Utensils, take out containers, sauce packets, food wrappers
Tobacco products	Empty cigarette boxes, lighters, cigar packages
Recreational/toys	Balls, sand bucket, rusted bicycle
Textiles/clothing	Hair ties, socks, shoes, jackets, pieces of linen, masks
Junk: Items that cannot be disposed of in a trash bag	Rusted bicycle, tires, pieces of wood (2x4), siding, large styrofoam packaging
Small items	bottle caps, soda can tabs, wrappers, or labels