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## A Mobile Initiative for Waste Disposal in Bringing Awareness to the Damage Littering Behavior Has on Storm Drains

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## ABSTRACT

### A MOBILE INITIATIVE FOR WASTE DISPOSAL IN BRINGING AWARENESS TO THE DAMAGE LITTERING BEHAVIOR HAS ON STORM DRAINS

by

KIMBERLY W. HUNG

APRIL 23, 2018

Irresponsible dumping of wastes into sewage processes and unmaintained areas not intended for waste processing negatively impacts the surrounding environment and ecosystem homeostasis of the dumpsite. Perhaps one of the most concerning aspects of waste dumping is when the waste, that is improperly disposed as litter, begins to disrupt its local environment, and thus negatively impacting the health of everyone and everything in the relative environment. The overall objective of this capstone project was to develop a user-friendly platform that serves as an educational tool for the public to further improve understanding of waste disposal practices and encourage individuals to work with their communities to take simple steps to establish clean practices in their communities. The project, titled TrashCache, focuses on littering behavior as it contributes to storm drains, which flow directly into waterways. Due to increased popularity in using mobile devices, a mobile approach was produced as a method for distributing the educational material through a mobile-friendly website and social media campaign. A prototype of a mobile application was also developed, which would provide its users with easy access to the educational material, regardless of geographical location and internet availability. Perception of littering behavior was recorded through questionnaires. As a result, the mobile-friendly website and social media campaign were widely accepted and reached over 900 page views, reaching nearly 200 individuals around the United States within a 4 week period. The ever-growing problem of irresponsible waste disposal practice will continue to negatively influence the environment, unless there is more public awareness about this issue.

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IN BRINGING AWARENESS TO THE DAMAGE  
LITTERING BEHAVIOR HAS ON STORM DRAINS

by

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A Capstone Submitted to the Graduate Faculty  
of Georgia State University  
in Partial Fulfillment of the  
Requirements for the Degree

MASTER OF PUBLIC HEALTH

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APPROVAL PAGE

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by

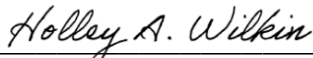
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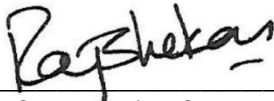
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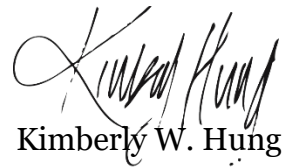
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Kimberly W. Hung

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## INTRODUCTION

Wastes are a requisite outcome of human life. Various types of refuse come from not only human activity, but also settlements, industries, hospitals, and commercial activities. Each of these waste sources must be carefully taken care of in order to maintain safe living environments.

Irresponsible dumping of wastes into sewage processes and unmaintained areas not intended for waste processing negatively impacts the surrounding environment and natural ecosystem of the dump site. Sewage systems are designed to process and filter piped wastes so that water can eventually be returned to a natural water source without disturbing its natural flora and fauna. When wastes are externally dumped into the drains as water is lead back to a natural water source, the resulting consequences on the environment are grave.

Problematic wastes are introduced into the sewage system in various ways. To have a better understanding of these variations, refer to figure 1. In an ongoing waste campaign in King County, Washington, this infographic was created to illustrate how wastes can be introduced to the sewage drains. Modern day pumping systems allows for raw sewage to be transferred out of homes and other buildings and enter a process that biodegrades the wastes safely back into the environment. When this process is fully functional, there is minimal environmental footprint. However, there is another aspect to the sewage process. Storm drains are made to be accessible at multiple points underground and eventually leads to a larger waterway such as a river, lake, or the ocean. These storm drains do not go through a filtration system before the water, and anything else in the drains, is returned

to the natural water source. Therefore, anything that is dumped here essentially gets dumped in to the ocean and affects the environment in the vicinity.

After storms, it is understandable to find an increase in plant debris in storm drains. Plant debris consists of organic matter that is able to decompose eventually with minimal impacts on the environment. The problem at hand is the collection of human-produced wastes, such as plastic packaging, glass, metals, and textiles in drains as the water in the drains flow to larger bodies of water, such as rivers, lakes, and oceans.

Public understanding of the sewage process needs improvement so that wastes are no longer disposed of irresponsibly. Storm drain littering is a behavioral issue with environmental consequences that needs to be addressed. The purpose of this capstone project was to develop a user-friendly platform that serves as an educational tool for the public to improve understanding of waste disposal practices. It also hopes to encourage individuals to take simple steps to establish clean practices in their communities. The audience of focus was Americans with social media accounts, around the age range of 18-34. Because of increased popularity in using mobile devices, a mobile approach was produced as a method for distributing the educational material through a mobile-friendly website and social media campaign. This project includes a social media campaign, functional website, and mobile application prototype that educates its users on the appropriate practices for waste disposal. If improper waste disposal continues, natural water sources and sewage systems will increasingly become negatively impacted by the presence of waste releasing persistent organic pollutants into the environment. Additionally, the project will raise awareness on the importance of waste disposal

practices and will be accessible to users of all ages and backgrounds in the state of Georgia, with the hopes of expanding the project to a regional, and then national level.

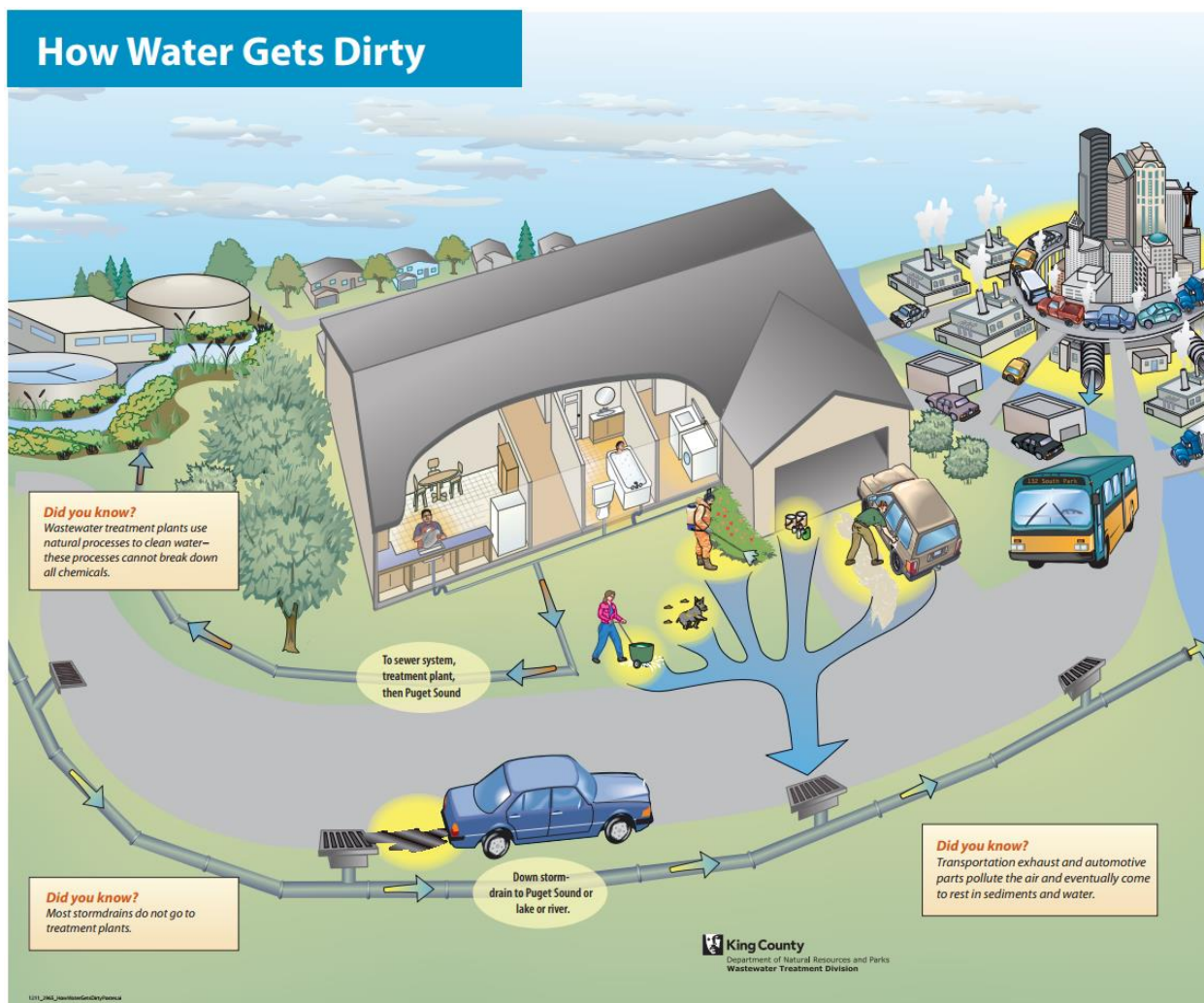


Figure 1 Infographic on water sewage process in King County, WA. From "How Water Gets Dirty," by King County Wastewater Treatment Division, 2016, [https://www.kingcounty.gov/~media/services/environment/wastewater/education/docs/12\\_howWaterGetsDirtyPoster.aspx?la=en](https://www.kingcounty.gov/~media/services/environment/wastewater/education/docs/12_howWaterGetsDirtyPoster.aspx?la=en).

## REVIEW OF THE LITERATURE

Wastes, which are an unavoidable byproduct of human life, have become an issue around the world, and particularly in recreational areas, due to the practice of irresponsible waste disposal. This issue falls under waste management, yet is dependent on social societal perceptions of littering (Beeharry et al., 2017). Awareness of environmental impacts have shown to influence littering dynamics, but knowledge of these impacts is generally low (Campbell et al., 2014). It is imperative to continue sharing on impacts of irresponsible waste disposal and littering behavior.

Waste dumping has become a growing global concern in environmental health in recent years. Perhaps one of the most concerning aspects of waste dumping is when the waste that is improperly disposed as litter, it begins to disrupt its local environment, and thus negatively impacting the health of everyone and everything in the relative environment. This is most evident in rural settings, where five thousand tons of garbage are put in open dump sites daily (Hafeez et al., 2016). Urban settings tend to have piping systems so that wastes are more controlled, yet these settings still suffer from urban environmental hazards due to improper waste disposal. Findings on the impact of dumping irresponsibly have reported that waste dumping has a significant impact on the presence of persistent organic pollutants found in surrounding air, dust, soil, and water of popular waste dumping sites (Ali, Pervaiz, Afzal, Hamid, & Yasmin 2013). Dumpsites are wherever there is a trash buildup, like in the storm drains, or in the stream and ocean where the storm drains lead to.

The Clean Water Act of 1948 established regulatory standards for surface water, and under this Act, the Environmental Protection Agency has implemented numerous

programs relating to controlling pollution in water. One such program is the National Pollution Discharge Elimination System (NPDES) Stormwater Permits for Trash, which allow municipalities to enforce regulations on the amount of trash that flow into storm drains (Environmental Protection Agency). The goal of the NPDES is to have a substantial impact in reducing the influx of wastes from reaching waterways due to runoff.



Figure 2 Infographic on waterway littering in Santa Clara Valley, CA. From "How Trash Gets into Creeks," by Santa Clara Valley Urban Runoff Pollution Prevention Program, 2017, <https://www.epa.gov/trash-free-waters/clean-water-act-and-trash-free-waters>.

While the most common contributors to the issue of waste dumping is open human refuse, other common wastes noted as potential sources of potential organic pollutants include plastics, electronics, paper, glass, metals, and textiles (Hafeez, Mahmood, Syed, Ali, Malik, & Zhang 2016). For dumping sites near recreational marine areas, wastes also

include batteries, fishing lines, and fish carcasses (Baasel-Tillis & Tucker-Carver, 1998). Traces of pharmaceuticals, such as antibiotics, have been found in water sources such as rivers, lakes, and oceans. The continuous release of pharmaceutical products into water systems without filtration are believed to have effects on marine animals, which can eventually therefore have an influence in fishing markets (Zorpas et al., 2017). Developments in technology have changed packaging design in consumer products to include more plastics than ever before. Figure 2 illustrates how trash from daily activities may inadvertently get into waterways, such as creeks. Nearly 80% of our trash is form of plastics, and when plastics break up in the ocean, they become microplastics (LeGuern, 2018). In a study by Karami et al. (2017), small traces of microplastics have been found in commercial sea salt products and will probably be increasingly found in other products from aquatic environments.

This issue is present, not only in America, but also around the world. In Pakistan, studies on unmanaged wastes have found that little has been done to alleviate these concerns, despite compelling evidence showing contaminants from wastes have the ability to alter soil chemistry (Ali et al. 2013). When unmanaged wastes impact the surrounding soil chemistry, adverse impacts on the surrounding plant life can subsequently damage the local ecology. In Nigeria, it has been found that improper waste disposal contributes to a number of environmental concerns, including air pollution, underground water contamination, land degradation, soil contamination, and habitat deterioration (Ezechi, Nwabuko, Enyinnaya, & Babington 2017). According to Ezechi et al. (2017), environments near dumpsites also contain a heightened risk of infections and the spread of various diseases, such as cholera. While dependent on the types and quantity

of wastes distributed into the environment, introducing organic waste pollutants into an ecosystem produces environmental risks that can be avoided with responsible disposal of wastes.

In a study on sustaining anti-littering behavior, Beeharry et al. identified essential variables that influence littering behavior, and also contributing factors regarding the behavior (2017). The variables identified include the society, and its overall acceptance of littering, as well as individual behavior towards the practice. Through a social survey, questions regarding perception, actions, and potential solutions were assessed. Participants of this survey generally agreed upon societal level impacts on their littering behavior, such as the absence of bins and omnipresence of plastic packaging. These findings directly coincide with a high intention and morale in responsible waste disposal behavior among those educated on the environmental impacts, which has been identified in several studies (Akulume & Kiwanuka, 2016; Cottrell & Graefe, 1997).

Education on the impact of wastes in the open environment has often been limited to the general understanding of maintaining a natural environment. It is common acceptance that litter in nature diminishes the aesthetic appeal of the area, so the behavior behind recreational littering is poorly understood. The built environment should be considered a challenge to this behavior change because even with education on littering practices, excess plastic packaging and the absence of trash bins remain an issue. Littering in storm drains not only poses a threat to human safety and health, but also impacts wildlife and tourism (Eastman et al., 2013; Beeharry et al. 2017).

While the issue of irresponsible waste disposal, especially in recreational areas, is not a new phenomenon, it has not been until recent years that environmentalists have

increasingly shown interest in the environmental impact of open wastes. A framework for environmental behavior was examined by Cottrell & Graefe (1997), which demonstrates the multivariate conditions in which responsible environmental behavior is subject to. Currently, several studies have used the Theory of Planned Behavior to identify the dynamics of this behavior, and to our knowledge, there have not been any other examinations using Cottrell & Graefe's methods in combining the Theory of Planned Behavior and the General Responsible Environmental Framework. Additionally, studies are often conducted at the site of interest, where there are evident high levels of irresponsible waste disposal behavior.

According to Gordon's statistics on social media usage in the US, Americans who use social media are generally in the age range of 18-34 and the most widely used social media outlets in America are Facebook, YouTube, and Twitter. Almost half of registered Facebook users use the platform to learn about new products (Gordon). A mobile initiative for waste disposal will focus on providing this audience with the education material needed to learn about the sewage system, the issue of waste dumping, and how to become part of the solution towards promoting a cleaner environment, rather than continuing to pollute it. Prior research using the General Responsible Environmental Behavior model has shown that a multi-level approach is necessary for effective behavior changes regarding environmental responsibility (Cottrell & Graefe 1997). The General Responsible Environmental Behavior model stems at the belief that as people become more knowledgeable about environmental issues, people will become more motivated to interact with the environment more responsibility (1997). However, even when people understand the impacts on these actions towards the environment, responsible behavior

also depends on the availability of resources required to act responsibly. For example, studies have found that even when recreational boaters are knowledgeable about the environmental influence imposed when wastes are pumped overboard, recreational boaters are given little choice to do otherwise when marinas do not offer or have inoperable pump-out stations that can responsibly contain various wastes from vessels (Baasel-Tillis & Tucker-Carver 1998; Cottrell & Graefe 1997). Perhaps with more individuals aware about the impacts of littering behavior, communities can engage in providing more resources to promote better decision making regarding irresponsible waste disposal.

In order to provide mobile application users with optimal resources, and to promote positive environmental behavior, the application features two main functions:

The first function of the application will be educational material focused on environmental health promotion. Core lessons on American sewage systems and the issue of waste dumping will feature interactive infographics that will appeal to every type of learner by including visual, audio, and written information. When the Public Health in the Parks Grants Initiative began, parks received an overwhelmingly positive response to environmental health lessons that engaged its audience (Wong and Higgins 2010). These lessons will also be available on the mobile-friendly website for those who do not have the application on their mobile devices.

The second function of the application will apply the lessons and promote responsible environmental health behavior by locating areas for appropriate disposal of wastes. This portion of the application ties into the technological availability of mobile devices containing a Global Positioning System (GPS). Mobile devices today—cellphones,

laptops, and tablets—contain a GPS already built into the device for a multitude of different purposes. Applications have the opportunity to use this built-in feature to allow the user to have a more personalized experience of the application by applying relevant local or regional information into the application. The proposed application will use the device's GPS to find the user's nearest recycling facility, junkyard, or landfill specific to the type of waste that needs to be disposed.

Currently, there is only one other similar application on the Google Play Store, named Trash-It-Right. The application aims to aid in environmental responsibility by assisting users on properly sorting and organizing trash (GRAS tech 2017). The application also provides a list of waste disposal centers available in all the cities in the state of California. However, since this application is unreleased, it is not available for widespread use. Even so, Trash-It-Right does not address the issue of waste dumping into storm drains along the sewage system. While there are mobile applications available in both the Google Play Store and the Apple App store that promote responsible recycling habits, each application is made specifically for a local city or state. No application is available for the nation as a whole, which may be the cause of the limited use of these apps, as irresponsible waste disposal practices from recreational activities are likely actions from visitors rather than residents.



*Figure 3 Fulton County Drain Marker*



*Figure 4 Dunwoody Drain Marker*

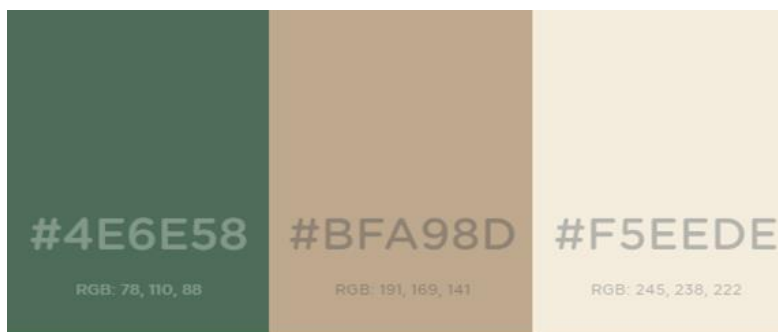
Specific to Georgia residents, there is one known related campaign for citizens of Fulton County. The campaign, “Storm Drain Marking & Adopt-A-Drain,” began as an initiative to inform residents that storm drains eventually flow into a waterway without first being treated (Fulton County, n.d). The campaign motions citizens to clean drains, and to keep them clear of trash, so that trash does not accumulate and cause obstructions that prevent storm drains from operating efficiently. After volunteers mark storm drains with colorful decals provided from the Fulton County Public Works, the Adopt-A-Drain portion of the campaign focuses on promoting the aesthetic appeal of maintaining open, unclogged, storm drains in neighborhoods. The city of Dunwoody also has similar markers on many of their storm drains, however no documentation on the program was able to be found for this research.

## METHODOLOGY

The overall objective of this capstone project was to develop a user-friendly platform that serves as an educational tool for the public to further improve understanding of waste disposal practices and encourage individuals to work with their communities to take simple steps to establish clean practices in their communities. This platform will include messaging through developing a brand, a social media campaign, graphics, web design, and mobile app development.

### 3.1 Branding

In order to establish a platform for the messaging on waste disposal practices, it was imperative to establish a presence by developing a brand. In order for a brand, whether it be an app, website, or business, to be successful, it must gain momentum and recognition by maintaining a consistent message and image. For this project, a memorable name, meaningful logo, standardized color palette, descriptive catch phrase, and clear mission were created to build the brand.



**#CLEARTHECACHE**

*Figure 5 Trash Cache Branding*

The project's name, Trash Cache, was developed as a memorable name, although the word cache can have several meanings, as with computing and geocaching. For the purpose of this project the name uses the definition that a cache is a collection of items in an inaccessible place, such as storm drains. The design of the logo uses the initials of the project name to form a storm drain. The colors were chosen because trash is generally associated with the color green, tan was added as a complementary color, and an off-white beige rather than white, which indicates cleanliness. The catchphrase, which doubles as a hashtag: #ClearTheCache, shares the idea about TrashCache while indicating the issue of the collection of trash in storm drains. The mission created for Trash Cache is as follows: "Here at TrashCache, we are working towards a brighter and cleaner future by reducing the amount of trash found in streets and waterways. We believe that if everyone does their part, there can be an end to this litter pollution."

### 3.2 Coding Elements

Through the development process of building a mobile application, the associated coding languages for applications specific to mobile device operating systems and web development were used. This particular application will be first made available as a standalone website on the World Wide Web, and then subsequently, using available frameworks, made for the Android Operating System, because of the widespread use and availability of mobile devices that use Android.

To develop the website, Mobirise, which is a bootstrap based web builder, with added extensions to customize HTML, was used. The site is hosted on GitHub Pages. The domain name TrashCache.org was bought through Google Domains. The website

incorporates a pre- and post- questionnaire to survey users on their perception of trash and littering in storm drains.

The app was built with the React Native framework, which allows deployment to the Android operating system and iOS. GitHub is a service that offers repositories, like folders, to store code and manage version control, in which this project is stored. Web technologies such as HTML, CSS, and JavaScript were used to create the mobile and web component of the application, utilizing the underlying React Native framework to render it, adhering to visual standards of each operating system.

### 3.2 Education Promotion

The learning portion of the application and website also serves as an environmental health promotion campaign that will motivate users to participate in making the environment cleaner. The purpose of these infographics and social media cards will be to not only invite the public to learn about TrashCache, but also learn about waste disposal, and simple steps that can be done to promote good practices, through this campaign.

In addition, social media presence is an important part of building a brand and becoming relevant to the public, since nearly 80% of the US population has a social media profile. Messages on littering affects will be cross-posted on Facebook and Twitter through a social media campaign.

### 3.3 Volunteer Recruitment

After the coding of the website and mobile application is complete, it will be tested among colleagues for any bugs or other issues that may occur because of the variations in mobile devices and web browsers. The mobile application will eventually be available on online stores for mobile applications. Once the mobile application is available to the public, a

larger pool of volunteer users will be found to test the application's ease of use, the geolocation services reliability, and change in knowledge of environmental health literacy.

### 3.4 Data Analysis

The effectiveness of this mobile application to educate users on waste disposal practices will be measured through the preliminary and post-questionnaires using Qualtrics, in which the change in responses will indicate an influential or non-influential effect of the mobile application.

## RESULTS

### 4.1 Social Media Campaign

The goal of the social media campaign was to bring awareness to the issue of littering in storm drains, and also to promote TrashCache.org. The hashtags #clearthecache and #ProjectTrashCache were used in association with Earth Day hashtags, #EarthDay2018 #EndPlasticPollution #LessPlastic, to gain viewership. Figures 6 through 19 display the social media campaign as seen on Facebook. A fourteen-day series of posts were created to build momentum for Trash Cache, along with Earth Day 2018. For eight of these posts, social media cards were used to visualize the text in the posts. Graphics were made using a mixture of Photoshop and Canva.com, which is an online-based graphic design tool.

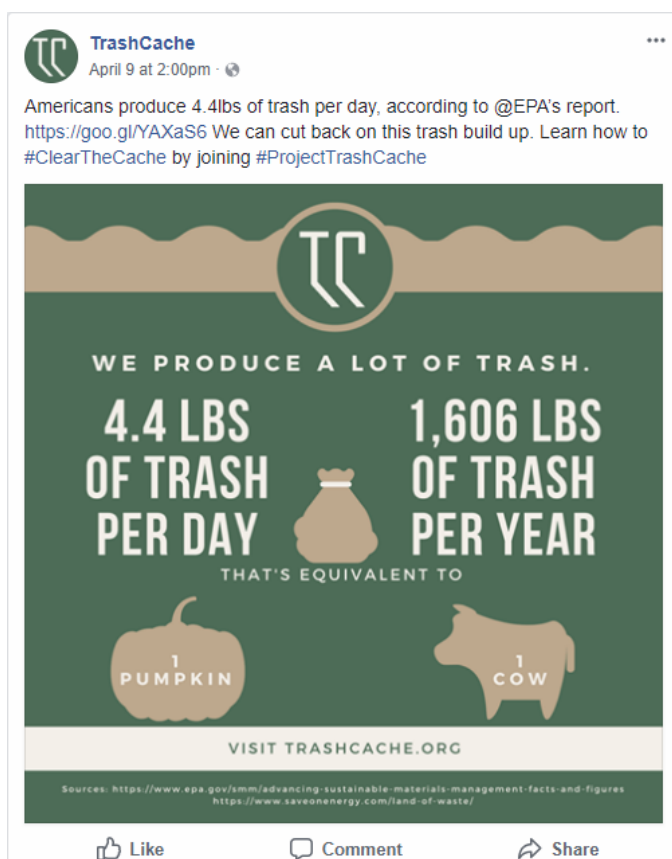



Figure 6 Facebook Post for April 9




Figure 7 Facebook Post for April 10



Figure 8 Facebook Post for April 11


 **TrashCache**  
April 12 at 9:00am · 🌐

Make for a better tomorrow by throwing your trash away in the appropriate places. Not in the street, not in the drains. #ClearTheCache with #ProjectTrashCache




Like Comment Share

Figure 9 Facebook Post for April 12

 **TrashCache**  
April 13 at 9:00am · 🌐

When trash goes into storm drains, the trash goes directly into our rivers and ocean. Discover more about how you can help reduce trash build up and #ClearTheCache by joining #ProjectTrashCache at [trashcache.org](http://trashcache.org)



Like Comment Share

Figure 10 Facebook Post for April 13

 **TrashCache**  
April 14 at 9:00am · 🌐

Trash has a habit of collecting in storm drains, and they don't filter out. Clogged drains flood streets. Prevent litter from trashing our drains and #ClearTheCache with #ProjectTrashCache!



Like Comment Share

2 Shares

Figure 12 Facebook Post for April 14

 **TrashCache**  
April 15 at 9:00am · 🌐

Have you noticed these on the storm drains in your neighborhood? Be part of the solution to #ClearTheCache and find out how to mark your storm drains from your local government. #ProjectTrashCache <https://goo.gl/MSNLHK>



Like Comment Share

Figure 11 Facebook Post for April 15



Figure 13 Facebook Post for April 16



Figure 15 Facebook Post for April 17



Figure 14 Facebook Post for April 18



Figure 16 Facebook Post for April 19

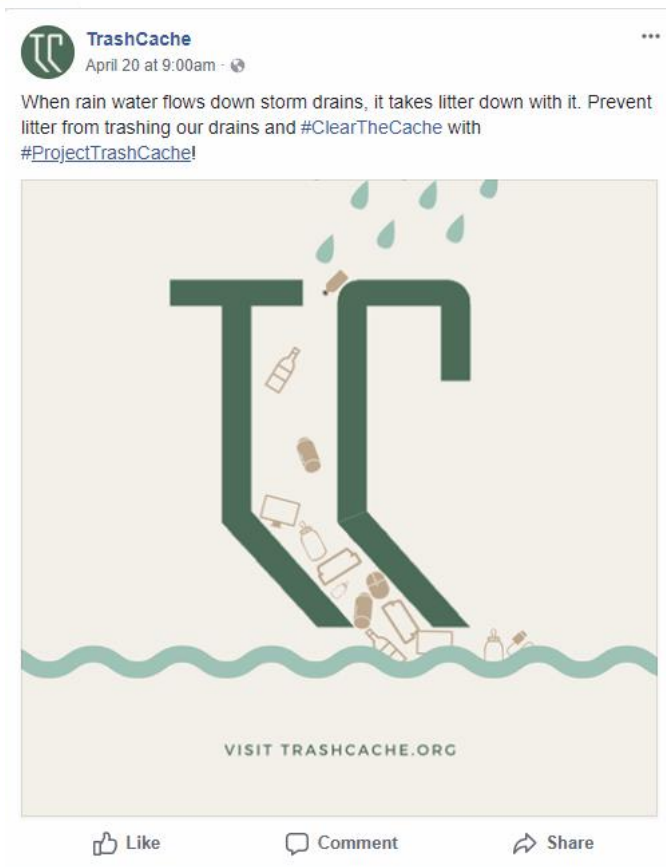


Figure 17 Facebook Post for April 20



Figure 18 Facebook Post for April 21



Figure 19 Facebook Post for April 22

## 4.2 Organization of the Website

The website, trashcache.org, contains four pages and two questionnaires. The homepage provides a brief overview of the mission and objective of Project Trash Cache. Then visitors are directed to the preliminary questionnaire, which contains four questions about trash perceptions. After completing the preliminary questionnaire, visitors can visit Wasteway Academy to learn about the impacts of littering, watch the infographic video, and if they want to learn more about the issue of littering, there are select videos available. There is a link to a post questionnaire with four questions similar to the preliminary questionnaire after viewing the infographic video. After completing the post-questionnaire, visitors can view the resources available to spread the word about Trash Cache. The social media cards, infographic, video, and pamphlet are available for download on the resources page. See Figures 20 and 21 for the infographic and pamphlet. The video is publicly available on YouTube at <https://youtu.be/48mKjaJTIZY>. There is also a page to locate local programs and interventions involving littering in storm drains, which lists programs by region. Figures 22 through 28 are screenshots of the website.

we've got trash, but

# WHAT'S THE CACHE?

**cache** [kaSH]  
NOUN  
a collection of items in an inaccessible place






## TRASH CACHE

IS A MOVEMENT THAT AIMS TO

**empower everyone to make a difference**

in reducing trash in storm drains.

IN AMERICA, WE EACH MAKE

**4.4** lbs of trash PER DAY



THAT'S

**1,606** POUNDS PER PERSON, PER YEAR.

TRASHCACHE.ORG  
 @ProjTrashCache  
 /ProjTrashCache

Figure 20 TrashCache Pamphlet

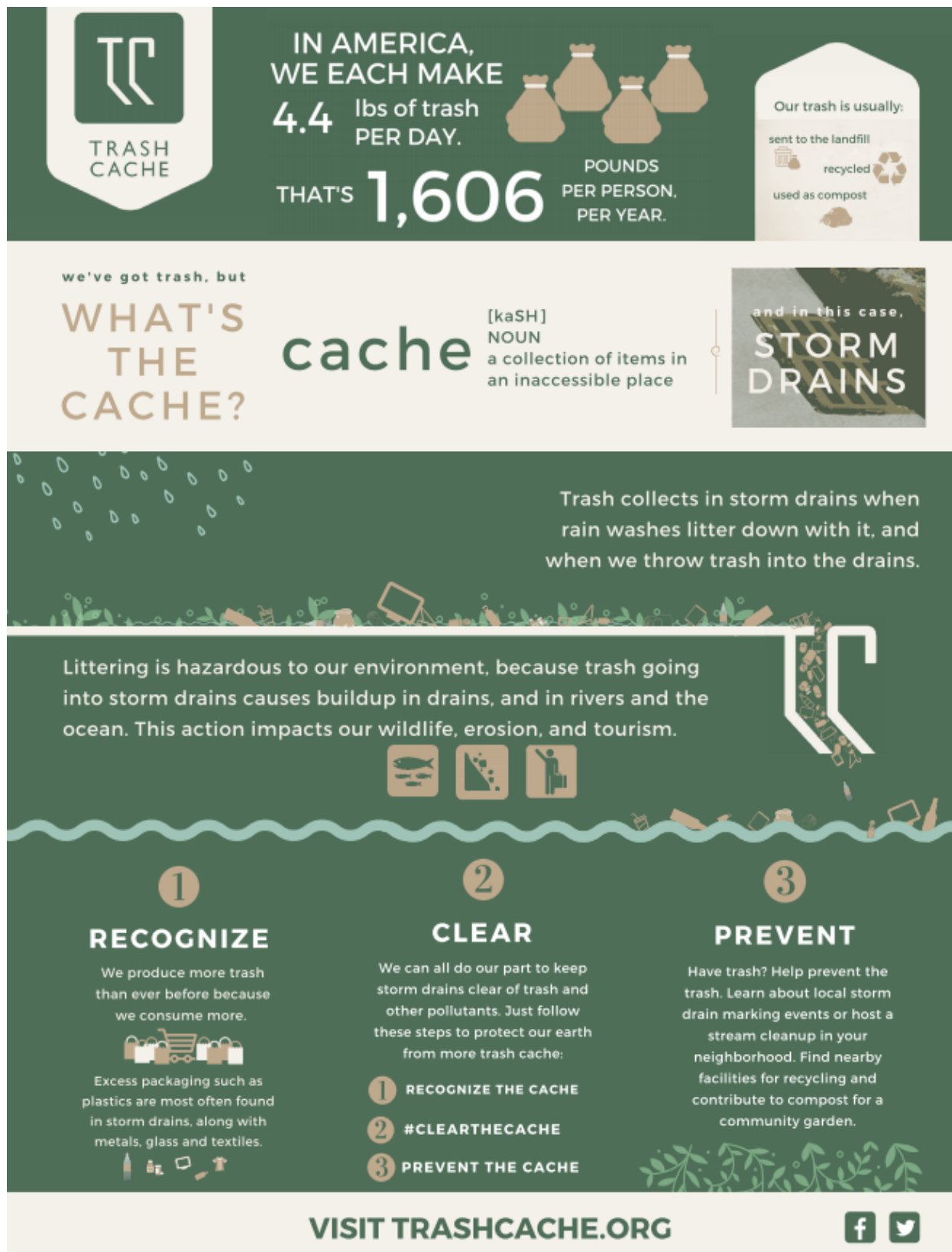


Figure 21 TrashCache Infographic

TRASHCACHE.ORG

Learn Try It Now!

## Welcome to Trash Cache

Here at TrashCache, we are working towards a brighter and cleaner future by reducing the amount of trash found in streets and waterways.

We believe that if everyone does their part, there can be an end to this litter pollution. There are three simple steps to #ClearTheCache:

- 1 RECOGNIZE THE CACHE** - Storm drains were never meant to be trashcans. Next time you see trash that "accidentally" missed the trashcan, or see miscellaneous items along the curb, take a moment to imagine where that trash would flow during the next rain storm.
- 2 CLEAR THE CACHE** - Be an active part in protecting our environment by picking up litter and throwing the trash away.
- 3 PREVENT THE CACHE** - Stop trash from becoming cache in storm drains by making sure all your trash is thrown away properly. Reduce the amount of trash you have by recycling eligible trash items.

Think you already know all there is about TrashCache?

TEST YOUR TRASH CACHE KNOWLEDGE

TRASH CACHE

LEARN LOCATE RESOURCES

Figure 22 TrashCache.org homepage

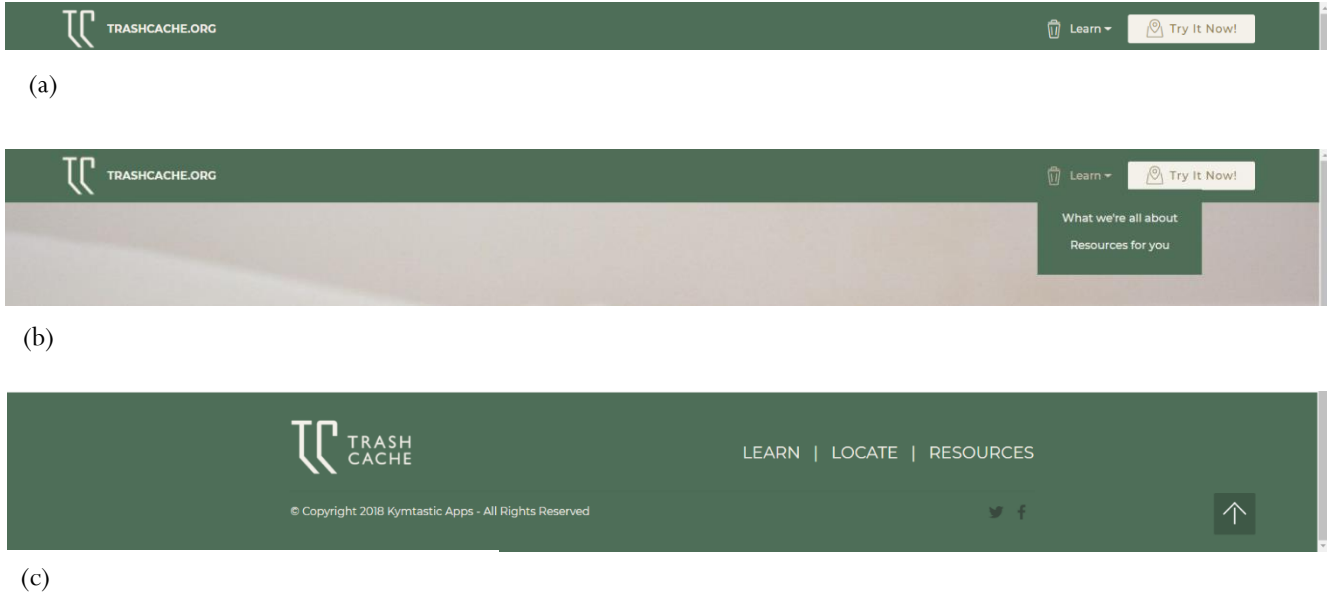


Figure 23 TrashCache.org header and footer features. (a) Header as it is seen on each page (b) Header when dropdown menu is selected (c) Footer containing sitemap

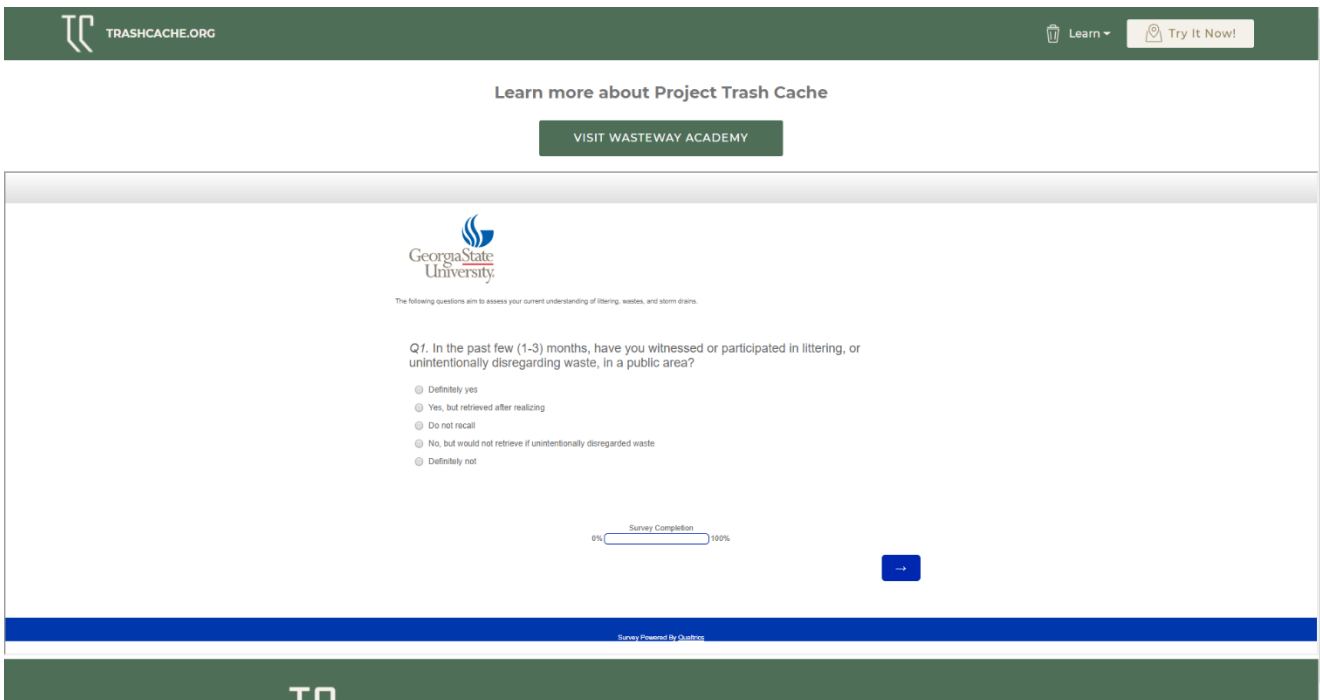


Figure 24 Trashcache.org Preliminary Questionnaire

TRASHCACHE.ORG Learn Try It Now!


# TRASH CACHE

Now that you've been briefed on Project Trash Cache,


LET US KNOW WHAT YOU'VE LEARNED

Still want to learn more?  
View these videos to see what others are doing to make a difference.


Special Edition:  
The Plastic Cyre



The Face of Litter:  
changing the way we see  
litter



The Ocean Cleanup  
Research team's mapping  
effort to locate garbage in  
the Pacific Ocean.



TRASH CACHE LEARN | LOCATE | RESOURCES

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Figure 25 TrashCache.org Wasteway Academy

TRASHCACHE.ORG Learn Try it Now!

# RESOURCES

Want to spread the word to help #ClearTheCache in storm drains?  
Visit our Facebook and Twitter pages and share these resources!

[t](#) [f](#)

**TAKE TRASHCACHE WITH YOU**  
SPREAD #CLEARTHECACHE WITH THE MOBILE APP

TRASH CACHE LEARN LOCATE RESOURCES

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Figure 26 TrashCache.org Resources page

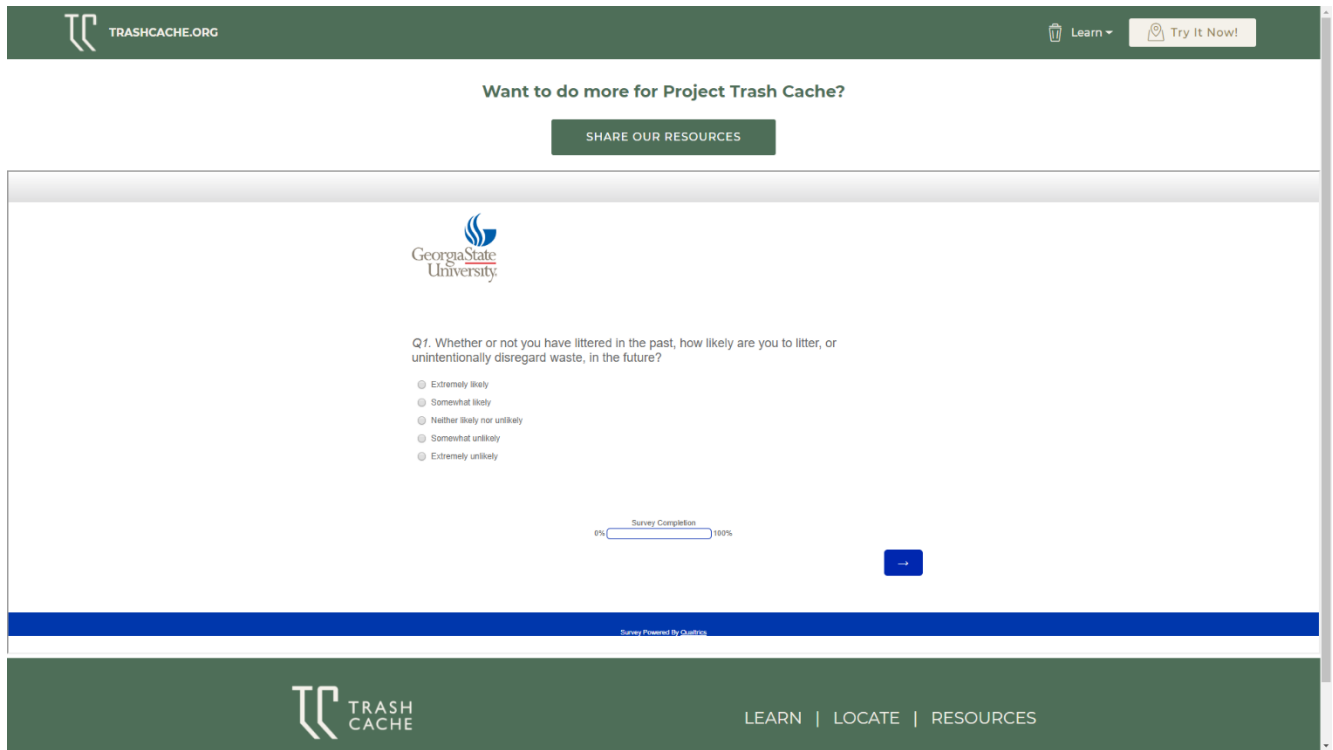


Figure 27 TrashCache.org Post Questionnaire

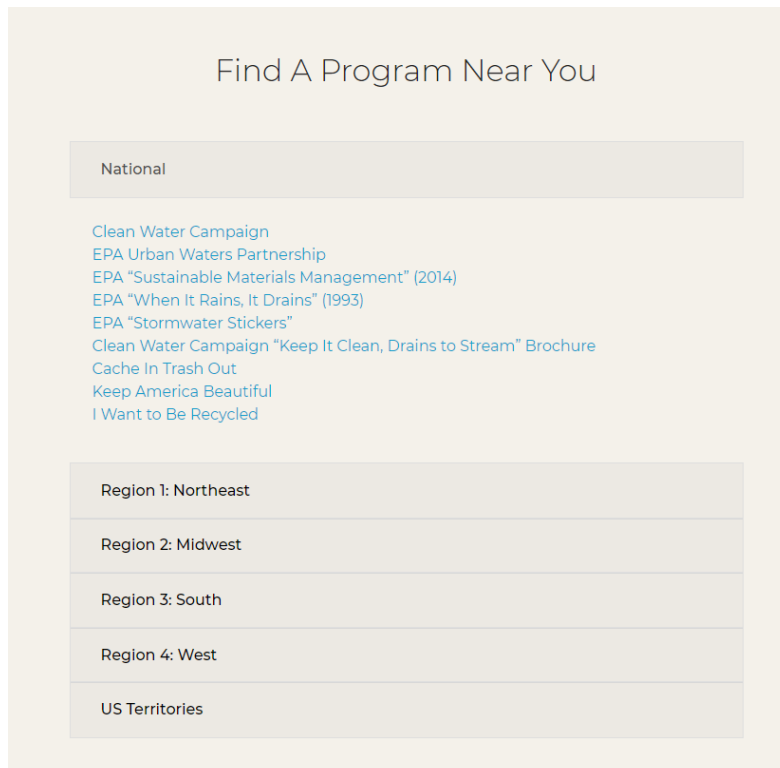


Figure 28 TrashCache.org Program Locator accordion menu

### 4.3 Architecture of the Application

Though the application has not been completed, Figures 29, 30, and 31 display what is currently working on the application. The application will eventually mirror the website. Currently there is the homepage, information page, and a map locator.

Change in knowledge of environmental health literacy will be recorded through short questionnaires of before and after mobile application use. The application will have a preliminary questionnaire upon first use of the mobile application, and after the completion of learning from the provided infographics on proper waste disposal, the user will be directed to take a post-questionnaire to determine any changes in environmental health literacy. The functions of the mobile application will remain available to users regardless of whether these questionnaires have been completed, however, incentives such as the ability to save favorite disposal sites, will be unlock-only features after the questionnaires have been completed.

As the application's objective is to educate its users on proper disposal of wastes, and to assist in locating the nearest disposal location, the mobile application will have two main features: in order to educate users on the proper disposal of wastes, infographics developed will help users identify impact littering behavior has on the environment; the second feature of this mobile application will use geolocation software to provide users with the nearest waste disposal location for larger, or more specific, wastes that cannot be placed in a regular waste bin.



Figure 29 Android Application Homepage

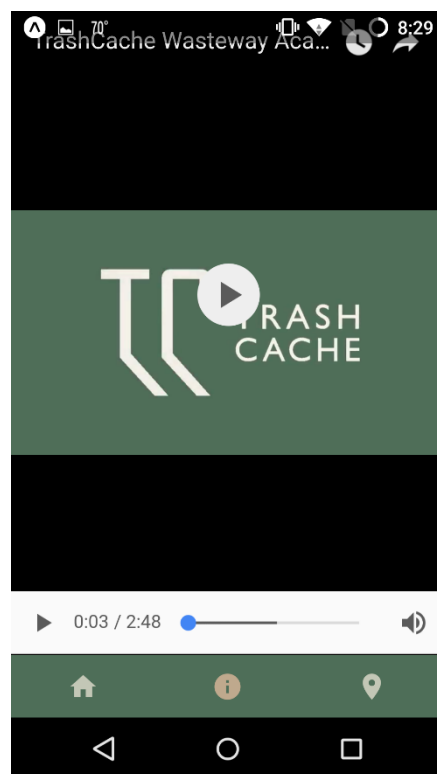


Figure 30 Android Application Information Page

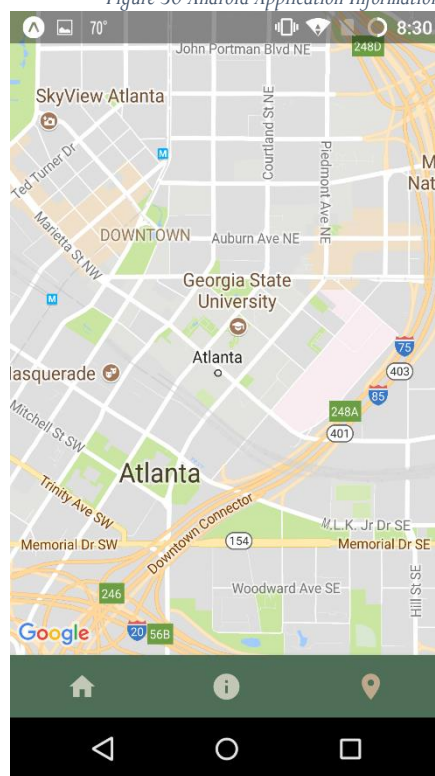


Figure 31 Android Application Map Page

### 4.4 Analytics of Website and Social Media Reach

Utilizing Google Analytics software, website traffic was recorded over a 4-week period from trashcache.org’s initial launch date. During this time frame, the website gathered a 1,012 page views with 157 individual users. Of these users, 53% accessed the site from a mobile device and 40.76% accessed the site from a desktop or laptop. With the social media campaign, the twitter posts gathered over 200 impressions. Similarly, the Facebook posts reached nearly 200 individuals. There was an organic share of a Facebook post by the Kearny Department of Public Health in New Jersey, which means the Public Health Department in Kearny reposted information about TrashCache onto their own social media page.

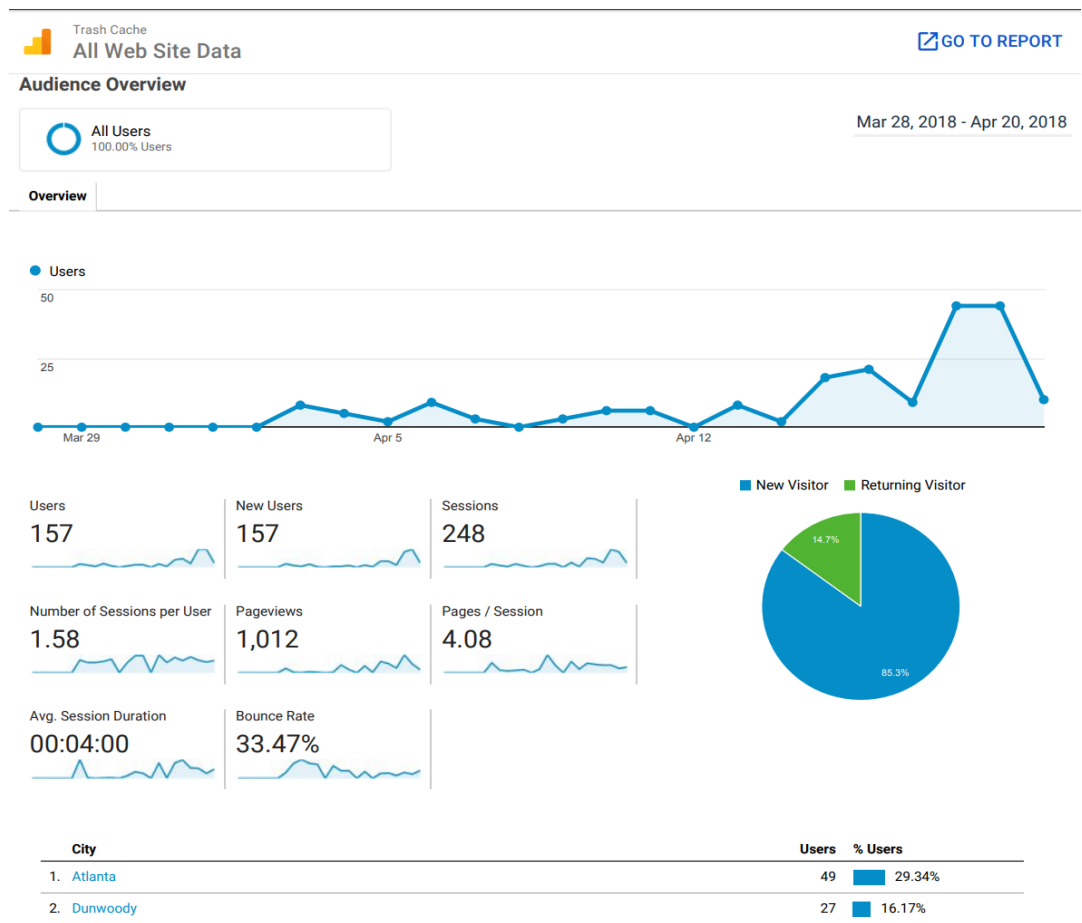


Figure 32 TrashCache.org 4 week viewership analytics

Device Category	Acquisition		
	Users	New Users	Sessions
	157 % of Total: 100.00% (157)	157 % of Total: 100.00% (157)	248 % of Total: 100.00% (248)
1. mobile	84 (53.50%)	84 (53.50%)	118 (47.58%)
2. desktop	64 (40.76%)	64 (40.76%)	116 (46.77%)
3. tablet	9 (5.73%)	9 (5.73%)	14 (5.65%)

Figure 33 TrashCache.org 4 week device usage

The screenshot shows the Facebook page for the Kearny Department of Public Health. The page layout includes a top navigation bar with the Facebook logo and search bar, and a right-hand sidebar with a 'Call Now' button and sections for 'Community' (54 likes, 54 followers) and 'About' (645 Kearny Ave., Kearny, New Jersey 07032). The main content area features a shared post from TrashCache.org, dated April 14 at 9:00am. The post includes a graphic with the text 'PREVENT STREETS FROM FLOODING. DON'T LITTER OUR STORM DRAINS.' and the website 'VISIT TRASHCACHE.ORG'. Below the graphic, the post text reads: 'Trash has a habit of collecting in storm drains, and they don't filter out. Clogged drains flood streets. Prevent litter from trashing our drains and #ClearTheCache with #ProjectTrashCache!'. The post has 1 like, 0 comments, and 0 shares. The page also shows a 'Home' navigation menu on the left and a 'Create a Page' button.

Figure 34 Kearny Department of Public Health Facebook page with shared TrashCache post

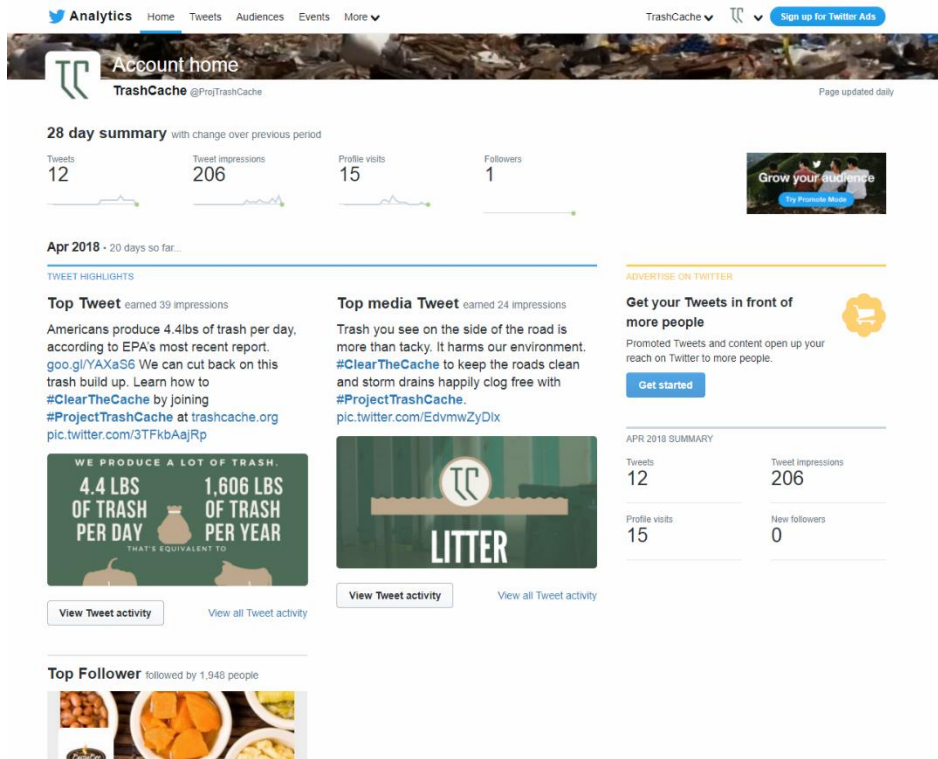


Figure 35 TrashCache Twitter viewership analytics

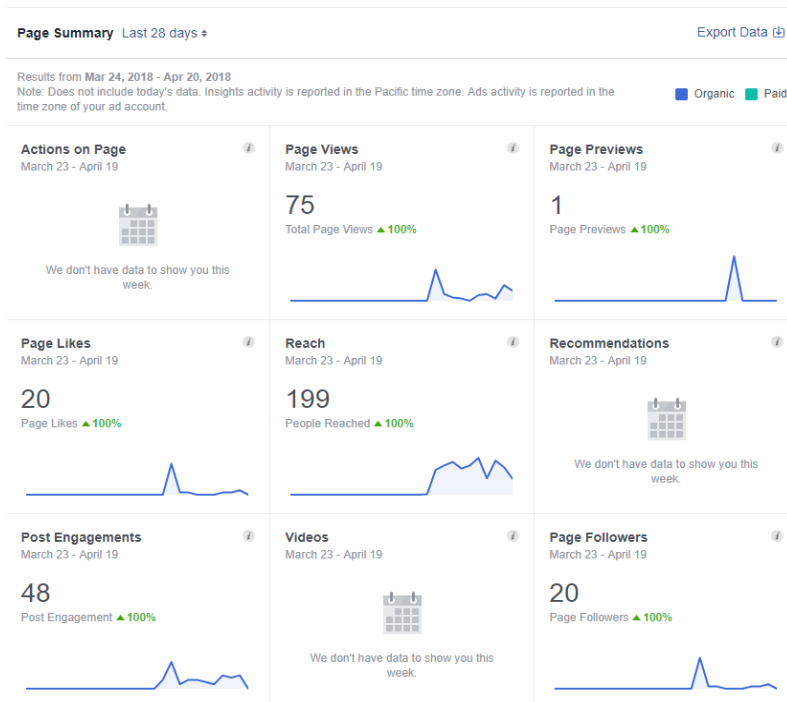


Figure 36 TrashCache Facebook viewership analytics

#### 4.5 Questionnaire Response

Four questions were developed for both the preliminary questionnaire and the post questionnaire. Figures 37 through 40 display the results of the questionnaires. The post questionnaire was intended to be taken after the infographic video was viewed, and when the user has had the opportunity to learn about the importance of proper waste disposal when it comes to littering into storm drains. There were 86 responses for the preliminary questionnaire and 29 for the post questionnaire. The first question asked whether or not the individual would participate in littering, but wording was changed for the post questionnaire to reflect future intentions of littering behavior and cannot be directly compared with the corresponding preliminary responses. The other three questions remained the same. The second question was: Do you feel knowledgeable about where your waste goes after it is removed from trash bins? For both Pre-and Post, most respondents felt somewhat knowledgeable. Question three asked: Based on your current knowledge, what happens to trash in storm drains? The answer choices were: Trash is removed at city sanitation facility, trash is released into major waterway, river, or ocean, trash is collected in the drain and contributes to flooding in streets, trash decomposes and eventually liquifies before reaching the river or ocean, and trash remains in the storm drain until it decomposes. Respondents were allowed to pick multiple answers for this question, but the overall perceptions remained the same. For the final question, respondents were asked based on your current knowledge, what is the most commonly littered item? And the choices, metals, electronics, plastics, textiles, or glass. Plastics, by far, are known as the most littered item.

**Q1 - In the past few (1-3) months, have you witnessed or participated in littering, or unintentionally disregarding waste, in a public area?**

**Q1 - Whether or not you have littered in the past, how likely are you to litter, or unintentionally disregard waste, in the future?**

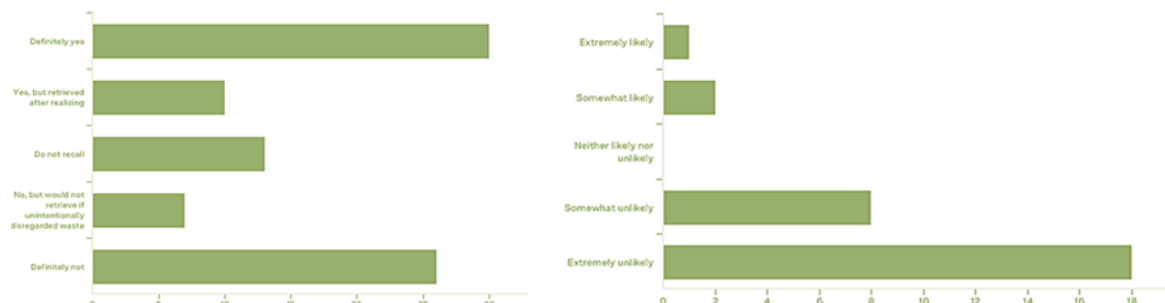


Figure 37 Questionnaire responses to Question 1. Left is the preliminary question and to the right is the post question responses.

**Q2 - Do you feel knowledgeable about where your waste goes, after it is removed from trash bins?**

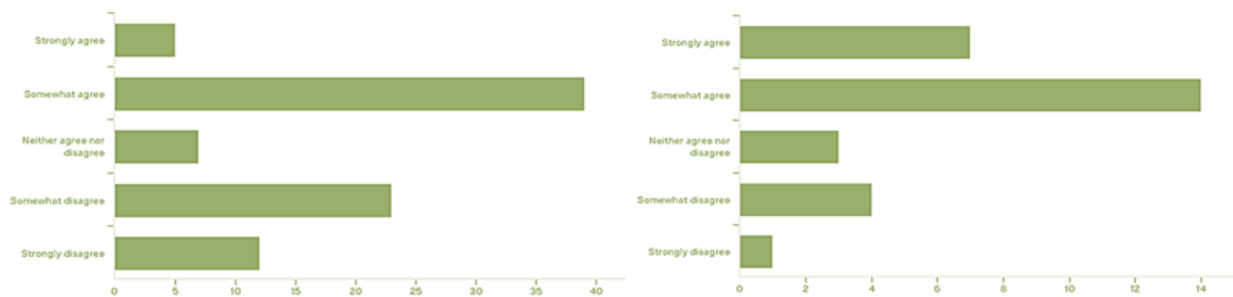


Figure 38 Questionnaire responses to Question 2. Left is the preliminary question and to the right are the post questionnaire responses.

**Q3 - Based on your current knowledge, what happens to trash in storm drains?**

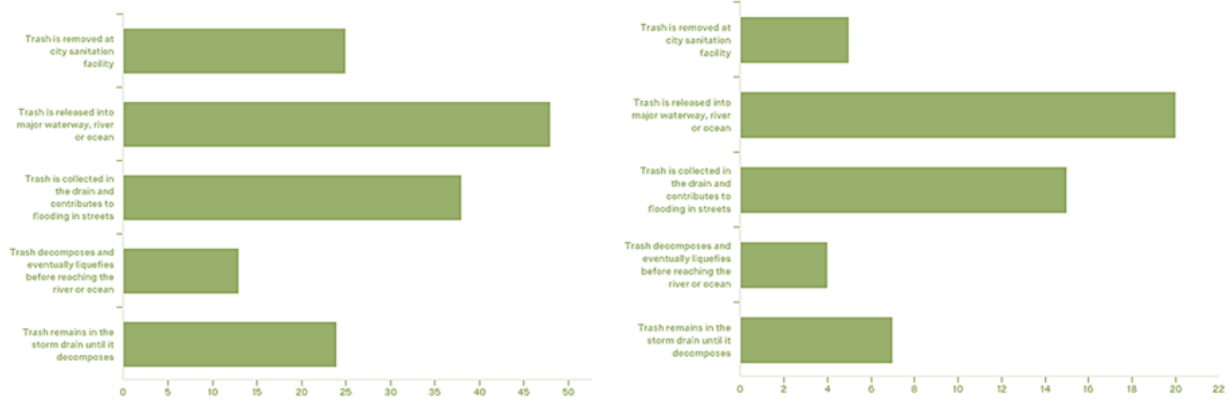


Figure 39 Questionnaire responses to Question 3. Left is the preliminary question and to the right are the post questionnaire responses.

**Q4 - Based on your current knowledge, what is the most commonly littered item?**

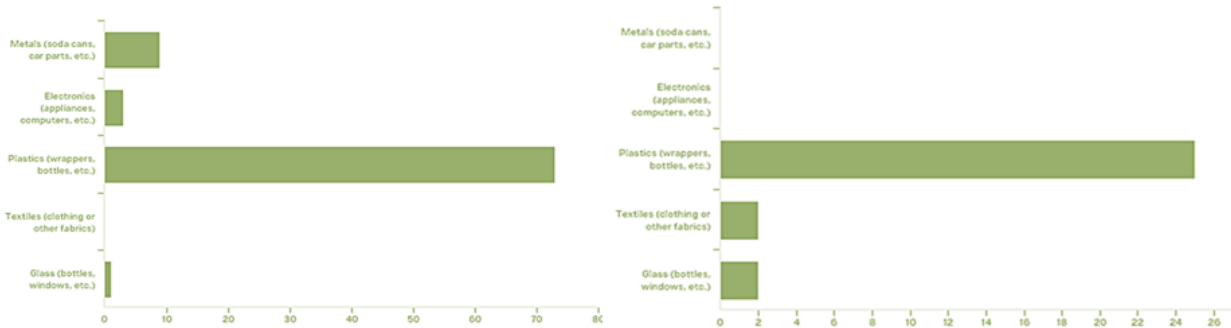


Figure 40 Questionnaire responses to Question 4. Left is the preliminary question and to the right are the post questionnaire responses.

## DISCUSSION

### 5.1 Discussion of Results

The project, titled TrashCache, focused on littering behavior as it contributes to storm drains, which flow directly into waterways. Due to increased popularity in using mobile devices, a mobile approach was produced as a method for distributing the educational material through a mobile-friendly website and social media campaign. A prototype of a mobile application was also developed, which would provide its users with easy access to the educational material, regardless of geographical location and internet availability. Perception of littering behavior was recorded through questionnaires. As a result, the mobile-friendly website and social media campaign were widely accepted and reached over 900 page views, reaching nearly 200 individuals around the United States within a 4 week period. The ever-growing problem of irresponsible waste disposal practice will continue to negatively influence the environment, unless there is more public awareness about this issue.

### 5.2 Limitations

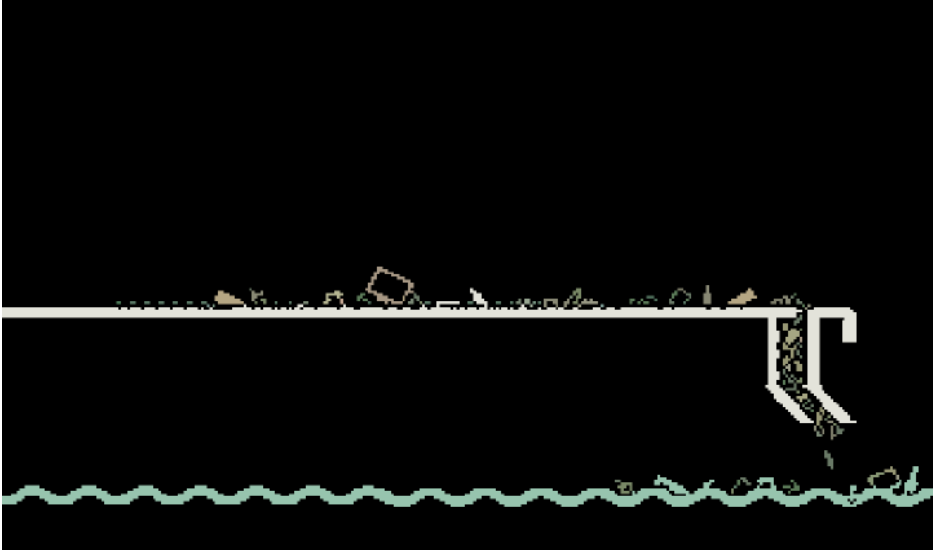
Even with the 1000 pageviews on trashcache.org, only 86 responses to the preliminary questionnaire and 29 post questionnaires responses were gathered. Without investing in advertisement boosts, the audience was limited to personal social media networks and colleges. Because the post questionnaire got significantly less responses, this probably was not visible enough on the website. Also, with how the website is currently set up, it is difficult to measure behavior change. Project Trash Cache may only be useful for bring littering behavior back into the conversation and relevant on social media.

### 5.3 Conclusions

The use of social media to share about Trash Cache had a positive effect in promoting more sustainable littering behaviors. Through the questionnaire, it was found that the perceptions of trash and littering varied, but users generally understood that there is a negative impact on storm drains and that plastics are the most common in our trash. If the issue of littering behavior can become relevant in social media, this can influence communities to engage in more positive health campaigns such as storm drain marking events and regular stream clean ups.

### 5.4 Future Directions

Project Trash Cache will be continued through regular social media posts to bring the discussion of littering practices relevant in social media, and to get #clearthecache trending. Search engine optimization and marketing will help make TrashCache.org easier to find online and have a stronger presence as an organization. A completed mobile application will also allow more users to learn about TrashCache. In the future, an added gaming feature will also broaden the appeal of reducing littering behavior to a wider audience.



*Figure 41 Design idea for an 8-bit styled TrashCache game*

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