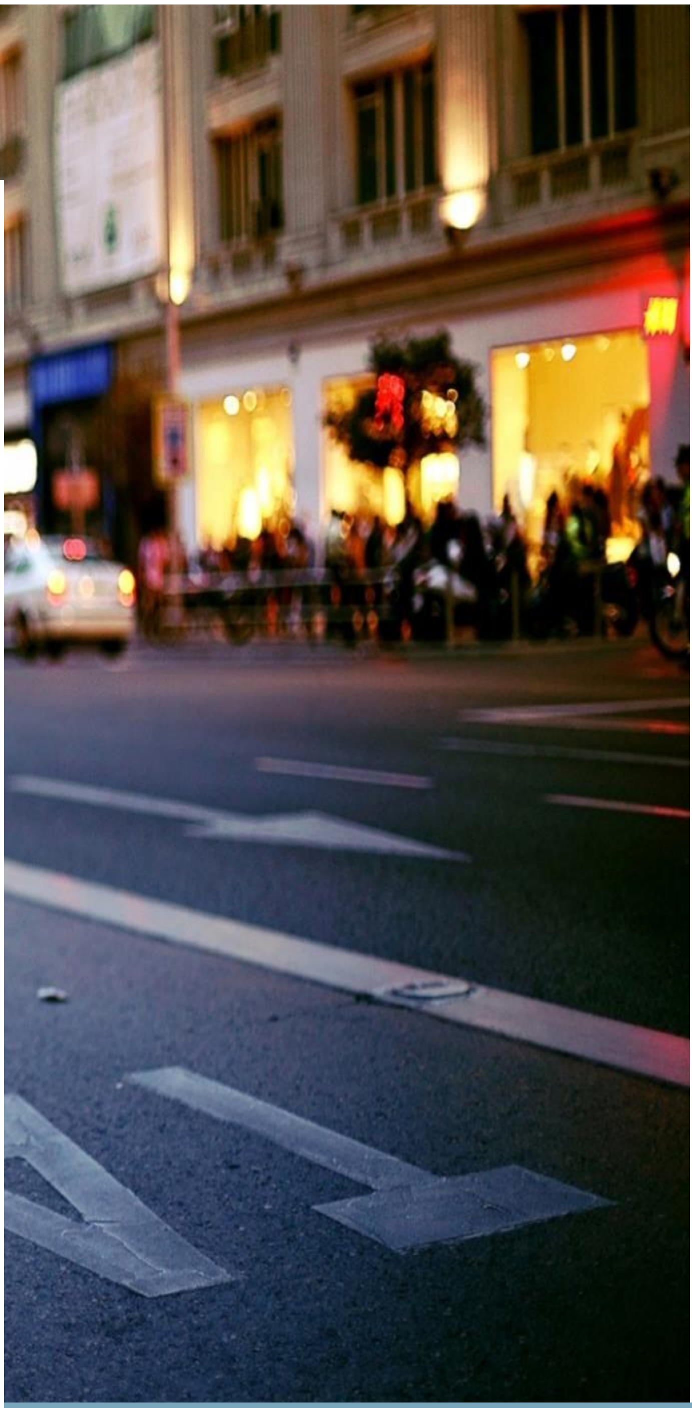
Beneath the Streets: New Tools for Managing Degrading Sewer Infrastructure

Final Report



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List of Acronyms and Terms

BMP	Best management practices
EPA	Environmental Protection Agency
FOG	Fats, oils, and grease
FSE	Food service establishment
GTAP	Grease Trap Assistance Program
IAP	Infrastructure Assistance Program
SSO	Sanitary sewer overflow
TGC	Tempe Grease Cooperative
WCED	World Commission on Environment and Development
WWTP	Wastewater treatment plant

Abstract

Infrastructure degradation is a chronic problem for fats, oils, and grease (FOG) pretreatment programs at wastewater utilities, which can lead to harmful bypass and high loss of a renewable energy feedstock. Not only does this exacerbate the potential for environmental harm, but not taking advantage of this resource leaves most FOG anaerobic digestion programs non-resilient and non-scalable. It is vital that there are strategies utilizing a sustainability perspective and integration of hard and soft infrastructure management principles to address this infrastructure degradation issue before there can be fully implemented zero-waste, FOG resource recovery initiatives. This applied project sought to answer the question, "How can municipalities sustainability manage the issue of degrading FOG pretreatment infrastructure?" with an emphasis on providing an applied example where a sustainability approach can mitigate complex, infrastructure problems. In partnership with the City of Tempe's Environmental Services Section, this project addressed the issue of degrading infrastructure by crafting and implementing a comprehensive Infrastructure Assistance Program (IAP). Designed to assist food service establishments (FSEs) and wastewater utilities, the IAP provides pathways for preventing FOG infrastructure degradation through initiatives that bolster hard and soft infrastructure to support a more efficient means of achieving compliance and local goals for resource recovery and renewable energy.

Introduction

In the City of Tempe, Arizona there are 1000 food service establishments (FSE's) ranging from local and small restaurants to national hotel and fast food chains. Residents, students, faculty, business-owners, and tourists visit these community landmarks throughout Tempe every day, unknowingly contributing to a major environmental and community pollution issue. Every FSE discharges a pollutant known as fats, oils, and grease (FOG). FOG is found in almost all the foods we eat; from the obvious greasy burger and fries to our morning coffee and everything in between. As this pollutant builds-up in private sewer lines, it can create blockages, private kitchen backups, and odors in the establishment. In the worst-case scenario, when this pollutant is discharged unchecked into public sewer systems, it can result in blockages which can cause sanitary sewer overflows (SSOs). These expensive and harmful backups are typically prevented by capturing FOG at the restaurant in pretreatment devices known as grease traps or grease interceptors. Capturing this pollutant not only minimizes the risk for backups but FOG is also an energy-rich resource which can recovered for local renewable energy solutions. Unlike other organic bio-stocks, FOG contains a high lipid content; due to this feature, not only can FOG be converted independently as bio-fuel but is also the most efficient feedstock blend component for all other organic fuels, leading to higher conversion efficiency coefficients and a more stable bio-fuel generation process (Skaggs, 2018). Traditional models of wastewater pretreatment manage FOG only as a waste product, and rarely consider its potential as a resource. This perspective perpetuates a linear model of enforcement and disposal, with an emphasis on a cradle-to-grave life cycle, which is a wasted opportunity for a sustainability outcome. By looking at FOG from the perspective of resource recovery, emphasizing a circular, cradle-to-cradle life cycle, the model of FOG management could take a systems-thinking approach to align infrastructure with resource recovery.

Every municipality adopts plumbing codes that are maintained by the utility that dictate the service frequency and cleaning procedure requirements to be followed by restaurants and the companies that service them. In the traditional FOG pretreatment model, the burden of maintaining compliance rests on the ability of restaurant owners to monitor and assess the quality of third-party services, most important of which are those services related to pumping out the contents of the grease trap or interceptor. If these services are not performed correctly, the responsibility of addressing environmental enforcement from the city is tied to the restaurant owner, usually at their expense. In addition, municipalities and their wastewater pretreatment programs dedicate enormous amounts of time and resources to inspecting the FOG infrastructure at each individual FSE to monitor the device condition and potential for FOG bypass, unfortunately with limited success. Often, there are more FSE's than city resources and inspection staff, which can lead to low compliance rates and FOG bypass. The EPA estimates that only 30% of FSEs across the country are in compliance with FOG regulations (Environmental Protection Agency, 2017), which is consistent with observed compliance rates in Tempe. Higher rates of non-compliant FSEs means more FOG is bypassed to sewer, which can increase the likelihood of downstream backups. The other concern is the high loss of FOG resource from device failure and infrastructure degradation due to improper maintenance procedures at the restaurant premise.

The gaps in the current state of FOG management called for an adaptation of the principles around sewer management, environmental regulation, and resource recovery. In this vein of thinking, the City of Tempe, designed and implemented a new model of FOG management, called the Grease Cooperative to address some of these wide-spread problems. While the Tempe Grease Cooperative (TGC) has had success in addressing some of the historical concerns with traditional FOG management, there are limitations to the program that hinder the long-term goal of recovering FOG as a resource. Furthermore, the TGC has unintentionally led to unforeseen consequences and new challenges, specifically related to infrastructure which now need to be mitigated. This project will seek to address these limitations and unforeseen consequences by applying a sustainability approach to the question of infrastructure.

Context

Though the Tempe Grease Cooperative (TGC), the burden of monitoring and assessing the quality of utility-mandated, third-party pumping services has become the responsibility of the utility. Restaurants and other FSEs can voluntarily enroll and purchase "grease compliance" (Figure 1). The goal of the TGC is to act as a business advocate rather than as traditional regulator. The TGC assures proper maintenance of the device, establishes hauler accountability, allows restaurants to focus on their business, and ensures the city to own the FOG waste for maximum collection and potential for reuse as a renewable energy feedstock. The Tempe Grease

Cooperative has reframed the relationship between public and private institutions and solved many of the problems associated with traditional FOG pretreatment models.

After four years of implementation, one-fifth of the city's FSEs, approximately 200 establishments, have voluntarily enrolled into the TGC. In the last year alone, the city collected and assumed ownership of approximately 600,000 gallons of waste, which, if it were to be used for energy generation has the potential to create 4.8 million cubic feet of renewable natural gas, based on EPA estimates (Environmental Protection Agency, 2017). The bulk purchasing discounts achieved through the TGC have saved participating restaurants over $92,000 in service costs compared to standard market pricing. Used fryer oil collected for biodiesel production in 2017 provided an additional $16,000 in credit back to participating restaurants. The city estimates a savings of over $250,000 per year in treatment costs to the regional wastewater treatment plant, with most of that cost savings related to energy consumption, resulting in a reduction in Tempe's carbon footprint.

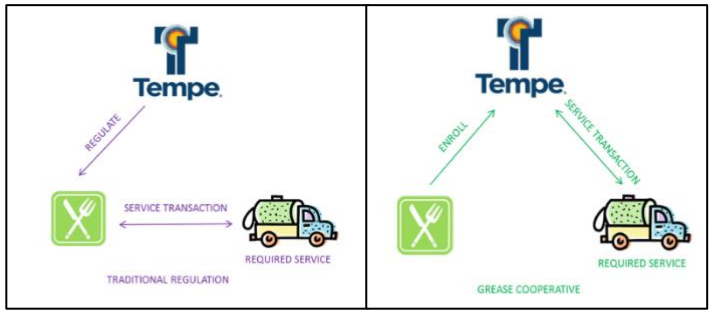

Figure 1: Traditional model of FOG compliance (left) and the TGC model of FOG compliance (right).

Like many other sustainability solutions, the Tempe Grease Cooperative recently underwent a period of reflection to identify opportunities of growth within the program itself, which eventually evolved into the TGC's 5-Year Strategic Plan (City of Tempe Environmental Services, 2017). The Strategic Plan identified several opportunities for the program to continue improving. First, a software solution was needed in order to expand the program and its membership further as existing administrative staff and resources were already operating at full capacity. Second, pretreatment devices naturally degrade even with the proper maintenance frequencies and proper cleaning procedures. It has been observed in some new, metal devices that they experience complete device-breakdown within two to three years, instead of the expected five or six years, which then requires a costly, full-trap replacement. Third, TGC members face increased scrutiny when it comes to repairs and compliance. When a device begins to degrade, it often does not cause a sudden problem; rather, it is a chronic issue that builds-up over time. Through the TGC, the pumpers perform a device health check at each service, which is dictated by the plumbing ordinance. A monthly device check is performed at every indoor, grease trap pumping service and members with larger devices, such as outdoor grease interceptors, have their device checks at each quarterly service. Pumpers become an asset rather than a liability to city staff as they have similar technical expertise as the inspection staff to be another pair of eyes diagnosing device degradation. This benefits the city and the restaurant because inspection staff can be notified of these issues before they become a costly expense. However, since utility resource constraints often result in inspections for non-TGC members as infrequent as once every seven years, device degradation and the accumulation of FOG bypass have the potential to build up to a much more serious and expensive problem. Timely identification of degrading infrastructure and possible FOG bypass issues has long term benefits for the city, the sewer infrastructure, and the restaurant. However, the relatively smaller upfront cost is difficult for local restaurants to absorb. This system has inadvertently created a financial and regulatory inequity between TGC and non-TGC restaurants. Finally, estimates from the EPA illustrate that up to 17,000 pounds of FOG are bypassed from each failing device in a restaurant annually to the public sewer system (Environmental Protection Agency, 2007), which is a hinderance to successfully implementing the FOG-to-Fuel model.

Infrastructure degradation has been identified as a major problem for all FOG pretreatment programs and is not exclusive to the TGC or the City of Tempe. Previously, the TGC utilized the traditional enforcement model to address infrastructure issues, but this strategy lacked a critical holistic, systems thinking perspective. This approach contradicted the sustainability-focus of the business advocacy and regulatory partnership that is foundational to the TGC's success. In an effort to improve upon this issue and others, Tempe's Environmental Services drafted measurable long-term strategic goals to reach the future vision of this program. The goals are to (1) establish a project-specific plan for 100% recovery of diverted FOG by 2022, and to (2) achieve

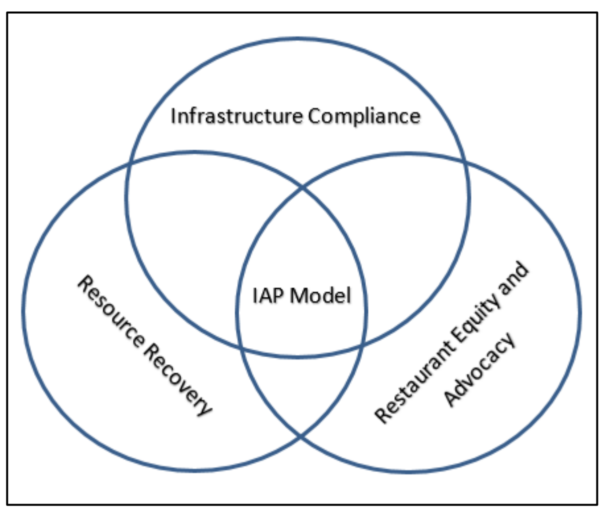

Figure 2: The intersection of the infrastructure degradation influencing factors and the IAP Model's connection.

85% compliance-assurance for restaurants by 2023 (City of Tempe Environmental Services, 2017). Through the desired future-state vision, it quickly became clear that a sustainable approach to infrastructure management, both within and outside the TGC, was necessary to achieve these long-term strategic goals. The method to achieve these strategic goals was to identify an intervention point at the intersection of infrastructure compliance, restaurant equity and advocacy, and resource recovery (Figure 2).

This project tackled the degrading infrastructure issue by applying sustainability competencies and strategies for an innovative, alternative methodology and outcome to manage infrastructure rather than continuing to use the inefficient and unsuccessful, business-as-usual enforcement strategies. The Infrastructure Assistance Program (IAP) assists FSEs and wastewater utilities alike by providing pathways for preventing and managing FOG infrastructure degradation to support higher levels of resource recovery. This project has identified and addressed the gaps in the existing FOG program and has answered the following question:

How can municipalities sustainably manage the issue of degrading FOG pretreatment infrastructure?

Literature Review

SANITARY SEWER OVERFLOWS AND PRETREATMENT TECHNOLOGY

The EPA estimates that 23,000 – 75,000 sanitary sewer overflows (SSOs) occur each year throughout the United States which results in billions of gallons of untreated sewage entering the environment and surrounding waters (Environmental Protection Agency, 2017; Environmental Protection Agency Office of Wastewater Management, 1996). An SSO is an event where untreated sewage waste is discharged into the environment prior to reaching treatment facilities; and this can have profound consequences regarding environmental and human health as well as a high financial cost to the community. Untreated, raw sewage can carry microbial pathogens that can cause mild illness, such as gastroenteritis, to more serious illnesses, such as cholera and dysentery (Environmental Protection Agency Office of Wastewater Management, 1996; Environmental Protection Agency, 2017). Any untreated sewage can have serious pollution impacts to local waters in addition to causing thousands of illnesses each year (Environmental Protection Agency, 2017).

There are numerous causes of SSO events related to the integrity of the sewer infrastructure. However, the most common cause of SSO events is pipe blockage which is usually a result of fat, oil, and grease (FOG) build-up in sewer lines (Environmental Protection Agency Office of Wastewater Management, 1996). Food service establishments (FSEs) discharge FOG, as a result of preparing and serving food. The utility requires restaurants to install and maintain FOG interceptor devices to prevent this commercial waste from entering the wastewater collection system (Washington Suburban Sanitary Commission, 2016; Environmental Protection Agency Office of Wastewater Management, 1996). Without these devices, or if these devices are improperly maintained, FOG can build-up in sewer lines and lead to pipe blockages, private backups, and SSOs. Both indoor and outdoor grease interceptors utilize gravity to separate the FOG and solid particles in a large, underground "bin" from the rest of the wastewater leaving the FSE (Figure 3). However, traditional FOG interceptor technology is outdated and inefficient. The conditions inside these devices can be corrosive due to bacteria build-up and decomposing organic material, which will very quickly destroy the metal structure used in traditional grease interceptor design (Loucks, 2017). Higher levels of corrosion can result from infrequent cleaning services, improperly managed repairs, acidity of food waste, poor kitchen management practices, or any combination of these factors (Environmental Protection Agency, 2017; Atlantic Pit Service Inc., 2009). Municipalities manage this problem through regulatory compliance, but the lack of accountability and enforceability makes the infrastructure management issue and higher compliance rates a challenge.

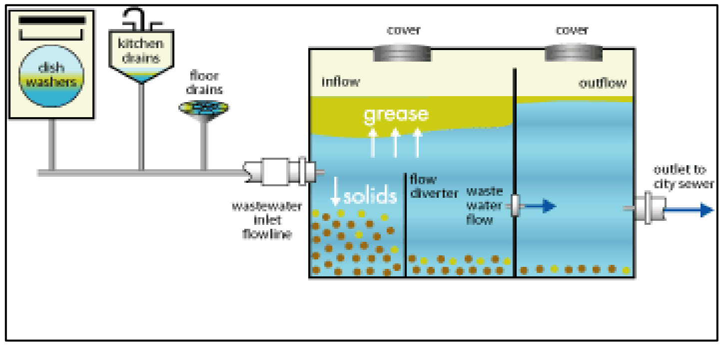

Figure 3: Design of outdoor gravity grease interceptors.

There are new, emerging technologies in grease trap and interceptor design, such as epoxy-resin coatings, polyethylene "plastic" construction materials, and redesigns of the structure of the device to increase grease capacity and reduce size (Loucks, 2017). These new technologies can solve many of the hard infrastructure problems of pretreatment programs, such as frequent structure degradation, corrosion, and FOG bypass prevention (Loucks, 2017). However, there is misinformation and confusion in the marketplace of these new technologies, making it difficult for restaurant owners to accurately select the proper device regardless of building materials (Loucks, 2017). Furthermore, municipalities struggle with soft infrastructure management strategies to incorporate these technologies into their plumbing codes, ordinances, and practice. The limitations of municipalities lie in the inability to make formal recommendations on commercial products, and this requires a reexamination of the intersection of hard and soft infrastructure management.

HARD AND SOFT INFRASTRUCTURE MANAGEMENT

Hard infrastructure includes anything related to physical infrastructure, such as roads or sewer pipes, in contrast to soft infrastructure which relates to human capital or institutions which create non-tangible, program-related "infrastructure" (Portugal-Perez, 2012). The physical integrity of our sewers is closely linked to the health of our local environment, the people who live and work in our communities, and the local values. Management of these physical systems traditionally is established through regulatory mandates from the local government. Commercial businesses play a role in contributing to this classic example of "The Tragedy of the Commons", often unknowingly contributing to sewer degradation and resource loss due to misinformation, competing economic interests, and individuals maximizing their individual benefits (Hardin, 1968). Even at the time of Hardin's "Tragedy of the Commons" fifty years ago, the conclusion was similar to the sustainability principles of today; that a purely technical solution to the complex problems associated with the commons would not be successful. According to Hardin, addressing "The Tragedy of the Commons" requires "a fundamental extension of morality" and a shifting of paradigms to include management philosophies and education of the users (Hardin, 1968). Following Hardin's connection between the commons and global infrastructure, the World Commission on Environment and Development (WCED) further evolved this idea of hard and soft infrastructure integration in the report titled *Our Common Future* (Mei, 2009; World Commission on Environment and Development, 1987). In this report, the idea of sustainable development was combined with the concepts of hard and soft infrastructure to not only develop technical solutions, but to also provide long-term, resilient management solutions (World

Commission on Environment and Development, 1987). This set the stage for the future development of integrated management and technical sustainability solutions, but a present-day focus on solely hard infrastructure projects has left gaps in the literature of sustainable infrastructure management.

Much of the literature agrees that infrastructure, both hard and soft, plays a critical role in short-term and long-term economic development, human living standards, distribution of public services, and environmental stewardship (Mei, 2009; Portugal-Perez, 2012; Ugwu, 2005; Sterling, 2012). In addition, there is strong statistical evidence that supports the interconnectedness of hard and soft infrastructure; that both the physical solutions influence the success of the managerial solutions and vice versa (Portugal-Perez, 2012). However, there is limited literature available that seeks to provide frameworks, or even examples, of successful infrastructure management projects that incorporate elements of hard and soft infrastructure. Many focus on a top-down, engineering-focused approach that continuously has limited the associated frameworks because it doesn't incorporate concepts such as equity, future-thinking, and social context (Kibert, 2007). Challenges to this approach include measuring sustainability, monitoring infrastructure and sustainability criteria, integrating practical solutions with morality, maintaining market competitiveness, and aligning stakeholders to common outcomes (Sahely, 2005). From the perspective of a global environment, finding solutions to these challenges is key to evolving the literature on infrastructure management. The current literature fails to consider the success of local-level interventions on both hard and soft infrastructure, and how the sustainability frameworks can play a role in developing new infrastructure management frameworks that incorporate both hard and soft infrastructure principles. This project fills an important gap in the sustainable development literature by providing a concrete example where hard and soft infrastructure can be combined to achieve community sustainability, infrastructure compliance, institutional resilience, and business equity.

RESOURCE RECOVERY

Wastewater management has historically used a "take, make, waste" approach to the management of wastewater, water resources, and the associated waste byproducts (Glen, 2009). In this approach, urban water management is perpetuating the unsustainable practice of a cradle-to-grave resource life cycle. Limitations of this linear system approach include water resource stress, unsustainable resource consumption, environmental dispersion of highly concentrated nutrients such as phosphorus, loss of energy rich waste resources, and financially unstable utilities (Glen, 2009). Within the global energy context, limited resource availability has shifted economic and societal systems to explore other options of renewable energy generation. This includes the current push to include byproducts of the wastewater treatment process, including FOG from pretreatment and sludge residuals from post-treatment, into the biotechnological process of anaerobic co-digestion (Puyol, 2017).

Anaerobic co-digestion provides numerous opportunities and benefits for wastewater treatment plants (WWTPs), such as reducing energy needs, diverting waste from landfill, reductive detoxification of wastewater, water resource recovery from dewatered sludge, and nutrient recovery (Jensen, 2017; Mata-Alverez, 2014; van Lier, 2008;). The feasibility of utilizing FOG as an anaerobic co-digestion substrate is well documented at the WWTP in Garching, Germany. The inclusion of FOG into the anaerobic co-digestion process increased the efficiency of food waste digestion while lowering the cost of feedstock blending components (Puyol, 2017). Externally from the digestors themselves, the cost of treatment savings from FOG waste diversion greatly lowered the financial risk of the Garching WWTP utility (Puyol, 2017; Mata-Alverez, 2014).

The biotechnologies to achieve this energy generation through waste digestion are available to use and a lack of technological innovation is not the limitation to this systems intervention (Puyol, 2017). Instead, the major challenge to this sustainability solution comes from resource availability which stems from a variety of institutional barriers such as existing infrastructure, utility governance, utility values, public and private infrastructure costs, enforcement structures, and resource management (Glen, 2009; van Lier, 2008). Opportunities to improve institutional infrastructure management directly connect to the ability of wastewater treatment plants and their associated jurisdictions to overcome the barriers to anaerobic co-digestion and energy sustainability.

Infrastructure and Sustainability

This project's defining characteristic was its application of sustainability theories, perspectives, and techniques to a complex, multi-stakeholder, infrastructure challenge. The importance of this project comes from identifying new, alternative pathways within wastewater and extending the sustainability knowledge related to infrastructure management beyond that of traditional regulatory models. Other sustainability research has not only identified infrastructure as both a top issue related to global environmental progress and knowledge generation, but also the most underutilized area for a sustainability approach (Mei, 2009; Sterling, 2012). While there are frameworks and processes designed for engineers and by engineers regarding building-specific sustainable infrastructure, there are very few tools and examples for how to *manage* the infrastructure from a regulatory perspective (Sahely, 2005; Ugwu, 2005). A more holistic approach to infrastructure management would fill a global gap in the sustainability literature by illustrating that sustainability principles can be applied to a local infrastructure challenge in order to achieve a successful outcome. This project serves as an example within the sustainable infrastructure literature that the sustainability competencies can identify, measure, and mitigate the challenges associated with the intersection of environmental, social, and economic pressures.

A sustainability project is defined as integrating five core competencies: systems thinking, anticipatory thinking, strategic thinking, normative thinking, and collaborative thinking (School of Sustainability, 2017; Wiek, 2011). This project utilized these competencies to create a comprehensive strategy for infrastructure management described below.

SYSTEMS THINKING

Traditional FOG infrastructure management involves an enforcement strategy that focuses on the singular goal of replacing degraded infrastructure. There are missed opportunities to engage businesses, community stakeholders, waste haulers, and local governments to create an infrastructure system that is both practical and resilient. This project utilized a series of stakeholder interviews and literature reviews to understand the indicators, stakeholders, and variables that are most important in a sustainable infrastructure program. For example, the inconsistency with waste hauler language disrupts the process of the system by creating uncertainty in identifying the repairs and the associated urgency. This can cause delays, wrongful repairs or replacements, unnecessary costs, and ultimately bypass and resource loss due to the device not operating as designed. Identifying this systematic issue as an intervention point was critical in creating the new Repairs and Compliance Program.

The experiences of outside agencies as well as the internal experience of Tempe informed this project on the best possible intervention strategy that could both work locally and can be scaled up to other municipalities and applied to other sustainability initiatives. For example, the financial assistance portion of this project was developed specifically for grease trap replacements. However, the program structure was created with application to other sustainability initiatives in mind, such as solar, grey water recovery, and low-use irrigation systems. The "sustainability buy-in" model, where businesses or individuals must front costs to participate in a sustainability solution, can be a barrier to most infrastructure-related challenges, and this financial assistance model is intentionally applicable beyond just the TGC system.

ANTICIPATORY THINKING

Many of the TGC's sub-programs required extensive future scenario planning to identify any major unforeseen consequences that could disrupt or derail the resource recovery goal. For example, the Vendor Registry was initially designed with the intention of being a subjective evaluation process looking for exemplary service quality, business sustainability, and customer service philosophy. This was to ensure that vendors would be vetted along the lines of sustainability and business advocacy, with the intention of maintaining the trust between the local government and the business members.

However, in the long-term this approach had the potential to incur great liability on the part of the municipality that could result in the dismantling of the Vendor Registry and tarnish the reputation of the TGC as a FOG management program. This would completely undermine the FOG-to-Fuel model as the goal. Therefore, the future scenario planning process required that the Vendor Registry take a more objective approach in the vetting process to minimize the city's risk. With this in mind, the objectiveness of the registry application was designed in a way that sought the same principles of service quality, business sustainability, and customer service by strategically asking specific questions and defining what would be the acceptable response or responses. Another intervention point was to include a method by which member restaurants could file incident reports in the event that a vendor demonstrated a failure to uphold the principles of this program, which they agreed to as they joined. Through these methods, the project was adjusted to the anticipation of possible negative future outcomes by designing more strategic interventions today.

STRATEGIC THINKING

The gaps in infrastructure management stated previously are problems found in the majority of wastewater pretreatment programs. By creating a new model for infrastructure management that uses a holistic approach a more sustainable future can be achieved.

For this project specifically, the use of knowledge gained during the process was used to alter the final result to assure a more effective outcome from the proposed intervention strategies. Originally, the idea was to create a Repair program for non-TGC members adapted from the TGC Repairs and Compliance Program. However, the interviews with key stakeholders made it clear that this intervention would have no effect on the outcome of infrastructure management due to the nature of the inspection process. As mentioned before, non-TGC restaurants are usually inspected once every seven years which means that any failing device discovered usually requires a full replacement, and not just a simple repair. The intervention was redesigned to reflect the needs and experiences of the stakeholders and to create a strategic solution that would better suit their needs when replacing infrastructure: the FOG Resource Packet. It combined hard infrastructure replacement processes with the educational strategies of the TGC to ultimately created a positive outcome aligning with the overall sustainability vision.

NORMATIVE THINKING

As stated previously, the traditional infrastructure management model comes from a linear perspective where FOG is considered a waste and infrastructure as merely a replaceable part. Little emphasis is placed on the value of FOG as a resource, the importance of infrastructure in its collection, and the partnership between business and government for the common goal of environmental stewardship.

This project specifically has contributed to evolving this perspective in numerous ways. First, the Infrastructure Assistance Program is the first of its kind to offer a financial assistance package from a municipality that leverages the sustainable investment of city-allocated funds to directly maintain the infrastructure of a waste resource for recovery efforts. In this way, the program has eliminated the “sustainability buy-in” barrier to better align the values of businesses and their regulators. This is the first step in changing the larger picture of environmental regulation from an enforcement perspective to a partnership perspective. Secondly, the FOG Resource Packet ties into changing the perspective of the enforcement process. By clearly illustrating through targeted education the importance of "The Commons" related to sewer and the infrastructure maintenance processes, business values will shift to encompass a future-thinking strategy of a public good rather than the limited viewpoint of their own economic bottom-line. Finally, in a more general sense, the very idea of putting emphasis on the importance of infrastructure for resource recovery completely changes the role of a municipal government. Instead of following the current paradigm of reactionary regulation, the role of local government takes on a preventative strategy to advocate for private business infrastructure protection to maximize collection of a resource. This changes the future of the environmental regulation perspective to encompass greater sustainability ideals such as protecting the future ability for communities to enjoy the benefits of clean water and clean communities.

Collaborative Thinking

Part of creating a successful sustainability project is the ability to communicate the end-goal across a variety of audiences and differing values. This project has relied heavily on the ability to demonstrate the need for sustainability strategies within a political climate focused on economic development. Specifically, there was an extensive review process across several different departments and workgroups to integrate the proper language, philosophy, perspective, and mindset into the programs; including Legal, Financial Services, Procurement, and Public Works. Many of the concepts within the Infrastructure Assistance Program are subjective in nature and follow a sustainability philosophy, such as service quality, equity, community building, and future thinking. While these more subjective concepts work well in purely a sustainability environment, the concepts needed adaptation with relevant city stakeholders in order to communicate the outcomes and provide relevance to a broader audience. The goal became to transform many of the program components to incorporate objectivity in the language, such as defining a "TGC Vendor", providing financial justification for the Grease Trap Assistance Program, and incorporating the long-term goals of the Public Works Department.

In addition to the inter-department collaboration, this project required creating arguments for sustainability to stakeholders focused almost exclusively on the economics. The importance of reducing costs and increasing business value was critical to convincing the restaurant community in Tempe that these programs not only accomplish city goals of sustainability but also values their bottom-line requirements. For example, the development of the Repairs and

Compliance Program relied heavily on the previous data from vendor repairs and conversations with current vendors and compliance staff to determine the course of action, urgency, and on-site management of repairs. Additionally, with the Grease Trap Assistance Program, conversations with restaurant stakeholders were vital to creating the program design and justification for allocation of city funds.

Applied Project Methodology

As mentioned above, the defining characteristic of this project is the application of a sustainability perspective to a complex social, economic, and environmental problem. In this type of project, the methods deviate from the traditional sense of an academic project to develop pragmatic and relevant solutions for the stakeholders. The National Research Council has defined applied projects methods as outside the normal methodology frameworks of experimental or theory-seeking projects (National Academy of Science, 1983). Their definition includes the importance of context-specific analysis in human-technology systems to optimize the capabilities and performance of the system beyond the current state (National Academy of Science, 1983). The limitations of applied methods include time, financial resources, and freedom of action, which indicates that traditional experimental or theory-seeking projects frameworks and methods do not have the suitable structures to answer the pertinent questions within systems development (National Academy of Science, 1983). The significance of this approach to the project methodologies is that this framework connects specific actions and pathways with their critical context and application. Due to the dynamic nature of applied

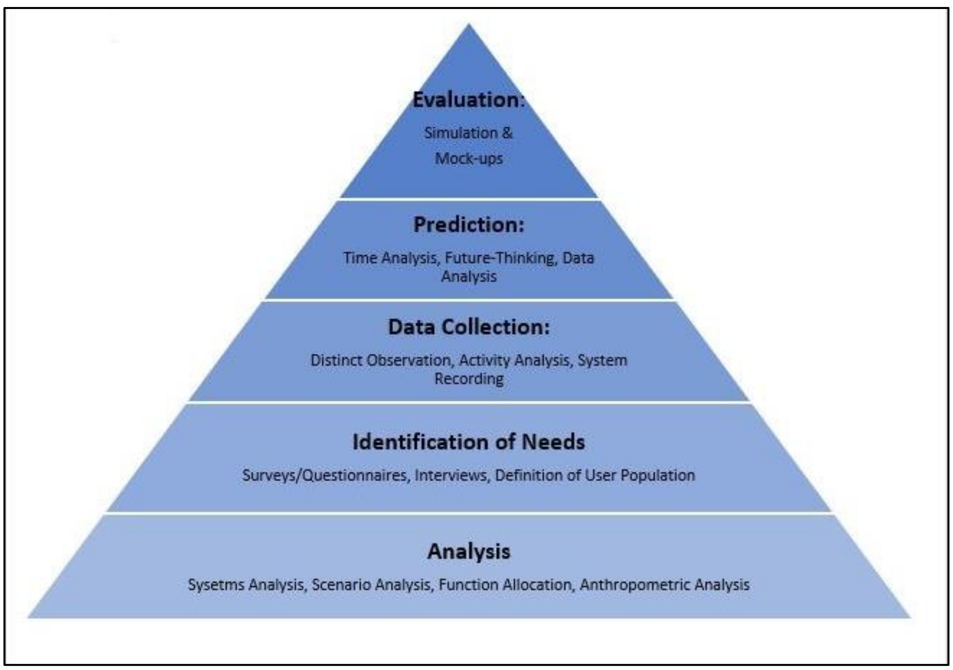

Figure 4: Illustration of the applied project methods design, showcasing how each part builds-on the next step in the process.

projects, parsing out a context-free methodology limits the understanding of the processes, challenges, and alterations inherent to a long-term project (National Academy of Science, 1983). Finally, this project needed to be adaptable to other utilities and their specific contexts. For this reason, it was important to utilize a methodology that applied easy-to-follow steps and a narrative of the entire process, including critical decision-making context. This was more important to the project success than following a traditional, academic methodology.

In the original project charter, the methodology outlined a five-phase process centered around deliverable development. However, this format did not accurately portray the methods and their context for a holistic understanding of the project's development. Instead, this project followed more closely the methods of the National Research Council's approach to applied methodology, which are categorized into five distinctive, steps (Figure 4): analysis, identification of needs, data collection, prediction, and evaluation (National Academy of Science, 1983).

ANALYSIS

Analysis, under Applied Project Methodology, is the stage to gather information on the current state by performing information and system analysis (National Academy of Science, 1983). The analysis section of this project derived from the use of an extensive literature review of the current state. This included an examination of literature related to pretreatment regulation, pretreatment technology, FOG, resource recovery, and infrastructure management. Finally, a literature review of other municipal aid programs related to FOG and infrastructure was conducted to identify the limitations of other attempts to address this problem. This included reviewing preferred pumping programs, financial assistance models, and vendor vetting processes. The major limitations of these programs, which sparked the conceptualization of the Infrastructure Assistance Program model, were narrowness in scope, minimized equity, long-procurement timelines, and little to no emphasis on restaurant education.

The second-portion of this literature review sought to understand the current state specific to the TGC and City of Tempe Environmental Services as part of a Function or Task Analysis defined by the Applied Project Methodologies (National Academy of Science, 1983). In this portion, informal conversations with Environmental Services staff, vendors, and restaurants in addition to workflow examinations, operations observations, and on-site experiences began to identify the current state of the existing soft infrastructure.

IDENTIFICATION OF NEEDS

In the Identification of Needs step, the researcher uses an interview or survey method to gather information about stakeholder needs and relevant intervention points (National Academy of Science, 1983). The methods used for the Identification of Needs utilized the approach of developing a stakeholder survey and interview process. A questionnaire asking strategic questions regarding hard and soft infrastructure management was created to be distributed to key Environmental Services staff, this built-upon the information gathered during the Analysis step. The questionnaire asked questions related to organizational structure, institutional relations, workflow data, and program recommendations. Participants could opt-in to have the questionnaire asked in an interview process with the default process being to individually fill-out the questionnaire. The information was collected after a two-week period and compiled into a matrix that disassociated the identities of the participants from their answers. Each participant was given a randomized number assigned with their answers for the remainder of the project. After the data collection and compiling it into the response matrix, key concepts, phrases, and trends were identified.

DATA COLLECTION

Data Collection refers to the compiling of information from the previous two stages and an application of the knowledge, trends, or models developed thus far (National Academy of Science, 1983). Information from the Analysis stage and the Identification of Needs stage was organized to understand the stakeholder needs for the new Repairs and Compliance Program. Interview information, previous repair data, vendor stakeholder conversations, and restaurant owner feedback were integrated into the model following a common-repair list. In this redesign, a list of the most frequent “common” FOG device repairs were compiled. Then, based on vendor recommendations, each repair related to the proper urgency, response time, and repair technique. After a review process by Environmental Service Compliance Staff and TGC vendors, the new Repairs and Compliance Program underwent an Activity Analysis (National Academy of

Science, 1983), or beta-testing, to test the new intervention as a coupled soft-hard infrastructure process.

The original drafts of the Vendor Registry and Grease Trap Assistance Program (GTAP) programs developed before the drafting of this project scope. These drafts were reexamined with the objective to look for opportunities to create intervention points to address gaps identified in the previous steps. After identifying the first two categories of vendors that would be on the registry, industry-specific qualifications were identified through a review of FOG technology requirements, business certifications, and industry expert knowledge.

PREDICTION

The Prediction stage takes the previous step's application and uses future-scenario planning tools to consider any risks or unforeseen consequences with the interventions (National Academy of Science, 1983). Next, the new Vendor Registry applications were drafted to include the subjective processes from other preferred pumper programs, although modified for two specific vendor categories: (1) Manufacturers of devices and (2) vendors capable of making the necessary repairs or installing new devices. These documents underwent an extensive legal review process to transform much of the subjective structure to a more objective process, such as language, application questions, and program expectations. This process highlighted the areas where the Vendor Registry did not align with the future-state or potentially could lead to unforeseen consequences in the future state.

The GTAP program design was developed during this time to incorporate different aspects of other FOG financial assistance programs and the stakeholder needs of the TGC. GTAP also underwent extensive internal review process and was altered to reduce future risk. GTAP funding opportunities were explored and these included non-profit grant programs, federal funding grants, city budget supplementals, and city award funds. Federal funding, which was the preferred choice, was not available given the administration's priorities and legislation. Ultimately, both a city budget supplemental and an application for a city-funded innovation grant were submitted.

Interview data from stakeholders in the Analysis step altered the course of the deliverables and process in this portion of the project. Stakeholder information illustrated a need for more restaurant outreach and education strategies rather than another infrastructure replacement process. Outreach strategies from TGC experience, staff recommendations, and restaurant requests were combined into a FOG Resource Packet designed to educate restaurants on the infrastructure replacement process. Additionally, based on literature review findings and stakeholder interviews, two program recommendations were drafted for Environmental Services and TGC managerial staff. These included future-vision methodologies based on current intervention needs outside the original scope of the project, which were the incentivization of plastic trap materials and automatic enrollment of new-build restaurants into the TGC.

EVALUATION

A defining feature of the Applied Projects Methodology is its consideration for the on-going evaluation and improvement process in the application of information and processes to systems interventions (National Academy of Science, 1983). This allowed the room for growth within this project as it worked through the drawn-out process of government review. This project conducted its own Evaluation process through the reviews and expertise of the Public Works, Legal, Financial, and Procurement city departments. Through their feedback and industry knowledge, adjustments were made to the project deliverables to encompass a more thorough checklist of stakeholder needs. Additionally, test plans for the Vendor Registry and GTAP were crafted upon the completion of the review process and approval of key Tempe personnel.

Finally, all documentation relevant to software development and the Infrastructure Assistance Program were compiled and given to the software development team. This included standardizing formatting to ensure the best assimilation into the future software automation of components of the Infrastructure Assistance Program. There were several meetings with the software vendor to ensure that the needs of the Infrastructure Assistance Program and TGC were aligned with the visioning of the software program.

Findings

CURRENT STATE LIMITATIONS

From the questionnaires, interviews, and research, three main gaps were identified in the existing program, which were organized into a project approach that consisted of three combined deliverable phases, respectively. The first gap identified is that there was a concern from TGC staff regarding the equity of TGC members in comparison to non-TGC restaurants when replacing or repairing FOG infrastructure. While there is some leniency in the timing requirements for TGC members to get their traps repaired or replaced if it does appear to cause significant harm to the sewer or operational issues within the restaurant, there is no ability to show discretion and provide leniency to let a failing device be unaddressed indefinitely. As a result of this, it became clear that the intervention point would have to instead ease the process for TGC members and provide a clearer internal process for city staff to enforce quickly with restaurant advocacy in mind. This resulted in the conceptualization of a multi-faceted Infrastructure Assistance Program that would both ease the process from a technical, financial, sustainability perspective (See Figure 5).

The second gap identified was that the existing workflow for identifying repairs in TGC members was inconsistent, inefficient, and did not value the partnership approach that is core to the TGCs foundation. Additionally, the previous workflow was time consuming, lacked concrete accountability, and did not coordinate with the stakeholders of the TGC. The intervention point at this gap was to reconstruct the existing workflow into a comprehensive Repairs and Compliance Program of the TGC that was both fair to the members, and efficient and effective for city staff. Additionally, it had to ensure that repairs and replacements would happen as quickly as possible.

The third gap identified was that the repair and replacement process for non-TGC members was not reflective of stakeholder needs, including education and advocacy. The existing process was slow, sometimes taking up to a year or two to replace a failing device, inconsistent, and errors due to miscommunications were common which led to

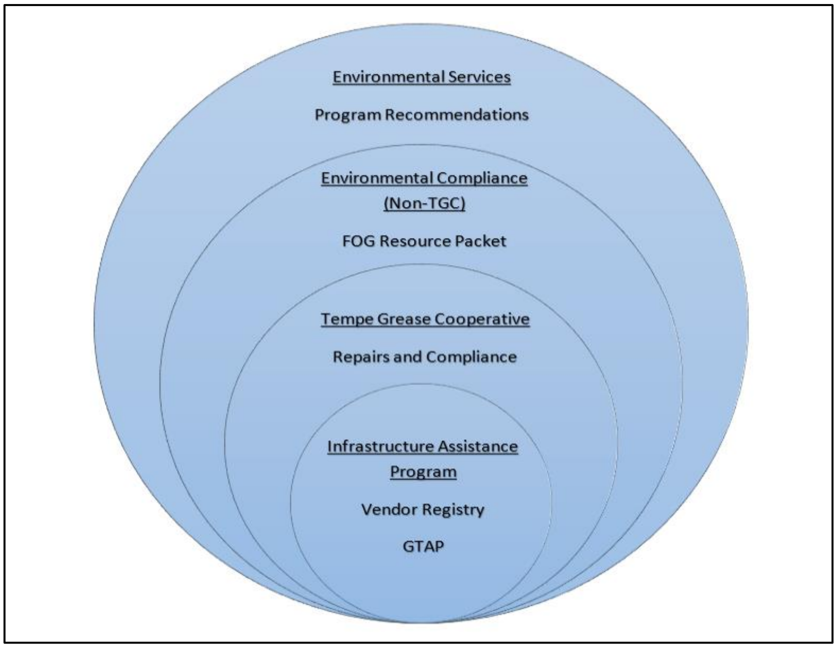

Figure 5: Representation of the new Infrastructure Assistance Program structure within the Tempe regulatory model with the associated sub-

restaurants once again replacing infrastructure at their expense. It was determined that the most efficient intervention point to address this gap was to create an education document to assist business-owners through the replacement process.

PROJECT DELIVERABLES

The findings of the literature review and research resulted in a series of deliverables that make up the various intervention points determined to help the program reach its future vision. Below is a list of the deliverables, as well as the definition, objective, and outcome or outcomes of each.

Program Recommendations

DEFINITION: The Program Recommendations is a memorandum document written to Environmental Services managerial staff to provide two additional intervention points that align with the future-vision and strategic priorities outside the scope of this project: the institutional incentivization of plastic devices and the automatic enrollment of new-build restaurants into the TGC.

OBJECTIVE: The objective of this deliverable is to provide all possible intervention points to the client that address the hard and soft infrastructure gaps identified during the Analysis. The recommendations were crafted based on the literature review of gaps in the larger industry so as to better contribute to the scalability of this project and the program.

OUTCOMES: The outcome of this deliverable is to provide a recommendation for future strategies to continue to evolve the IAP and TGC vision to better align with the sustainability goals.

FOG Resource Packet

DEFINITION: The FOG Resource Packet is a document utilizing educational strategies to outline the FOG infrastructure replacement process for restaurants and to educate owners on FOG management through a Best Management Practices (BMP) strategy.

OBJECTIVE: The objective of this document is to provide a comprehensive, educational tool for restaurant owners, both TGC and non-TGC, to better understand the replacement process.

Additionally, it continues to support the public-private-partnership model of creating new municipal relations with private businesses and promoting an understanding across the common goal of environmental stewardship. The other objective is providing Environmental Compliance Staff with a single point-of-information about device replacement, rather than the current, piece-meal process.

OUTCOMES: The outcome of this deliverable is to streamline the restaurant communication process by incorporating principles of education, advocacy, and partnership. In conjunction with this, the outcome to reduce inspection staff time spent reexplaining the replacement process to restaurants or fixing incorrectly permitted, sized, and/or installed devices.

Repairs and Compliance

DEFINITION: The Repairs and Compliance Program is a sub-program of the TGC that encompasses monitoring device condition, coordinating repair vendors, communicating infrastructure needs to member restaurants, and providing compliance assurance with city plumbing code.

OBJECTIVE: The objective of this program and its new workflow process is to provide long-term resilience to the intersection of TGC advocacy principles and Tempe compliance requirements to model a hard and soft infrastructure approach. More specifically, this includes reducing the extra time spent by inspection staff tracking down repairs and replacements, confusion in the communication between Tempe and its vendors, and better outlining the pathways towards compliance for restaurants.

OUTCOMES: The outcome of this sub-program redesign is a more comprehensive internal compliance process for the TGC that encompasses principles of hard and soft infrastructure management. The future-vision of maintaining infrastructure sustainability for the goal of resource recovery and better soft infrastructure management strategies is best encapsulated in the use of the industry-standardized common repair list in this new program design.

Vendor Registry

DEFINITION: The Vendor Registry is a list of non-contractual, grease-related services and vendors selected by and exclusively for the TGC as a resource for members to address issues outside the normal pumping and cleaning. This includes a set of applications based on chosen vendor categories, objective vetting processes based on application responses, and the online access for member restaurants to find high-quality, consistent grease-related services.

OBJECTIVE: The objective of the Vendor Registry is to provide an alternative pathway for vendor procurement that does not rely on the traditional, contracted procurement processes. This better aligns the TGC processes with the service of member restaurants to find high-performance vendors to repair, upgrade, or replace their plumbing infrastructure. The Vendor Registry is one of the two components of the Infrastructure Assistance Program, which has the overall objective of addressing the inequity associated with current TGC infrastructure repairs and replacements.

OUTCOMES: The outcomes of the Vendor Registry build upon the need to incorporate hard and soft infrastructure strategies. From a hard infrastructure perspective, this program provides access to the vendors who will perform the repairs, upgrades, and replacements properly and in compliance with city-code. From a soft infrastructure perspective, the Vendor Registry continues to utilize the strong relationships with Tempe and vendors to achieve common goals related to infrastructure and environmental stewardship.

Grease Trap Assistance Program (GTAP)

DEFINITION: The Grease Trap Assistance Program (GTAP) is a revolving fund to help credit-worthy businesses spread the cost of grease trap upgrades over one or two years by offering zero-percent interest loans at the same rate that previous loans are paid back to the city. This utilizes a revolving fund model to more sustainably leverage a one-time investment of $60,000 in city funds to pilot this project.

OBJECTIVE: The objective of GTAP is to balance the inequities between TGC and non-TGC members due to higher levels of scrutiny which create a higher frequency of repairs and replacements for TGC members. Currently, there are 10% - 15% of restaurants that require full trap replacements which would not have been identified outside the TGC. GTAP is the other component of the Infrastructure Assistance Program, which has the overall objective of addressing the inequity associated with current TGC infrastructure repairs and replacements.

OUTCOMES: The outcomes of GTAP are estimated to be the disbursement of $4,000 in new loans each month which could replace one to two grease traps per month with approximately a minimum balance $10,000 sustained in the fund account. With these estimates, GTAP could replace 20 failing grease traps per year and encourage more enrollment in the TGC by removing the cost barrier to restaurants with degraded infrastructure.

Overcoming Project Challenges

Throughout this project, there have been a few challenges to the original design of the Infrastructure Assistance Program that required different solutions to overcome. First, funding for GTAP was originally going to come from federal grant money through EPA Region IX. However, due to uncertain Congressional funding for the EPA grant programs and government shutdown in January, this path was no longer feasible within the scope of the project. Next, the client and myself decided to fund the program through a City budget supplemental rather than wait for federal funding to become available. This led to another set of reviews highlighting a need for a smaller scoped program pilot before more money would be set aside. Therefore, a new funding source was recommended to myself which was The Innovation Fund Award. As part of the client deliverables, the program was designed for the Innovation Fund Award application and submitted to City Council. The new amount we asked for was $60,000 to start the pilot program.

Second, the governmental review process became one of the major limitations to project implementation. The research, design, and content creation of the project moved with ease during the beginning phases of the project. However, including collaboration across several different city departments proved to greatly slow down the project momentum and delay program implementation. The best approach to overcoming this challenge was to remain strategic, persistent, and patient in instituting the changes of the various stakeholders. For example, the internal review process proved to be longer than previously determined and prevented the original timeline for implementation. To overcome this, the core evaluation metrics for vendor quality were kept constant but the strategy (i.e. subjective versus objective) by which the program sought that information was altered to satisfy the requirements of city programs.

Third, the methods by which gaps in the program were identified was altered from the original design of the project charter. Originally, the intended model was to utilize an Institutional Analysis of internal processes to illustrate where deficiencies in the current system may arise. This proved to not be a good fit for the nature of the stakeholder feedback and system representation. Instead, the better model became a Trend Analysis (National Academy of Science, 1983) to highlight the key concepts, gaps, limitations, and stakeholder needs from both the literature review and the interviews. This better demonstrated the critical external system context while not limiting the internal needs of relevant stakeholders. For example, the FOG Resource Packet was a direct result of the Trend Analysis approach. Stakeholders identified that non-TGC device maintenance could rarely encompass a repair process due to the lengthy re-inspection process. The best option by the time failing non-TGC devices are discovered is to replace the entire device. Stakeholders explicitly identified a need for restaurant education strategies and not a repair program for restaurants outside the TGC. Due to this measurable data trend of non-TGC device failure and stakeholder knowledge, which could not accurately be represented in the graphical approach of an Institutional Analysis, the FOG Resource Packet was developed utilizing TGC educational strategies around FOG, device replacement, and infrastructure maintenance.

Conclusions

The health of our sewer systems is rarely a component of sustainability that comes to mind when discussing environmental, human, and economic longevity. We often take for granted the infrastructure, resources, and people that spend their time working to make sure our communities are clean and free from contaminants. When infrastructure degrades, not only is harmful bypass affecting our environment but we are also losing a resource that has the potential to change local renewable energy solutions. Degrading wastewater infrastructure will always be a problem that requires a more comprehensive solution than merely replacing pipes and fighting the never-ending battles of traditional enforcement. This project has illustrated that by providing the tools to restaurants and local businesses, FOG resource recovery and higher compliance rates are possible through a sustainability model.

By providing the tools for community businesses to maintain their infrastructure long-term, the issue of infrastructure degradation can be addressed with both a hard and soft infrastructure approach which fulfills a gap in the current sustainable infrastructure literature. Through a comprehensive approach to infrastructure assistance, including internal administration, funding, and external partner messaging, this program can cultivate a community where sewer health, environmental longevity, and resource recovery are local values and shift the paradigm from enforcement to partnership.

Future Directions

Future students have many opportunities for further exploring the gaps in the sustainability literature related to infrastructure and infrastructure management solutions, such as: How can local infrastructure management solutions be scalable? What are the challenges and limitations to the regionalization of both hard and soft infrastructure sustainability?

Additionally, with a specific focus on FOG, more attention needs to be paid to the physical design of grease traps and interceptors. This could include a comprehensive review of certification requirements and the subsequent inconsistencies in this current model. Students should focus on questions such as: How can hard infrastructure code be standardized across neighboring municipalities and even regions? What changes to grease trap and interceptor design would best support resource recovery, keeping in mind the issue of degradation?

References

Atlantic Pit Service Inc. (2009). Commercial Grease Services. Retrieved from Atlantic Pit Service Inc. Disposal Solutions.

City of Tempe. (2017). *Tempe Grease Cooeprative*.

City of Tempe Environmental Services. (2017). *Tempe Grease Cooperative 5-Year Strategic Plan.* Tempe: City of Tempe.

Department of Civil, Construction and Environmental Engineering. (2013). Mechanisms of fat, oil, and grease (FOG) deposit formation in sewer lines. *Water Restoration*, 4451-4459.

Environmental Protection Agency. (2017). Renewable Natural Gas: Driving Value for the Natural Gas and Biogas Sectors. *Natural Gas STAR Program.* Broomfield, CO: EPA.

Environmental Protection Agency. (2017). *Sanitary Sewer Overflows*. Retrieved from National Pollutant Discharge Elimination System (NPDES): /www.epa.gov/npdes/sanitary-sewer-overflows-ssos

Environmental Protection Agency Office of Wastewater Management. (1996). *Sanitary Sewer Overflows.* Washington DC: Environmental Protection Agency.

Glen, D. (2009). Evolving Urban Water and Residuals Management Paradigms: Water Reclamation and Reuse, Decentralization, and Resource Recovery. *Water Environment Research*, 809-823.

Hamutuk, L. (n.d.). Civil Society Comments on Infrastructure Strategic Sector.

Hardin, G. (1968). The Tragedy of the Commons. *Science*, 1243-1248.

Jensen, P. A. (2017). Anaerobic codigestion of sewage sludge and glycerol, focusing on process kinetics, microbial dynamics and sludge dewaterability. *Water Resources,* 355-366.

Kibert, C. J. (2007). The next generation of sustainable construction. *Building Research and Information*, 595-601.

Loucks, K. (2017). *Hydromechanical Grease Interceptor Product Review and Recommendations.* IW Consulting.

Mata-Alverez, J. D.-G. (2014). A critical review on anaerobic co-digestion achievements between 2010 and 2013. *Renewable Sutainability Energy Review*, 412-427.

Mei, Y. Y. (2009). A Knowledge Management Framework to Promote Infrastructure Project Sustainability. *Proceedings of the 15th International Symposium on Construction Management*.

National Academy of Science. (1983). Applied Methods. In C. B. Education, *Research Needs for Human Factors* (pp. 140-163). Washington D.C.: National Academy of Sciences Press.

Portugal-Perez, A. W. (2012). Export Performance and Trade Facilitation Reform: Hard and Soft Infrastructure. *World Development*, 1295-1307.

Puyol, D. B. (2017). Resource Recovery from Wastewater by Biological Technologies: Opportunities, Challenges, and Prospects. *Microbiotechnology, Ecotoxicology, and Bioremediation*.

Sahely, H. K. (2005). Developing sustainability criteria for urban infrastructure systems. *Canadian Journal of Civil Engineering*, 72-85.

School of Sustainability. (2017). MSUS Culminating Experience Guide. Tempe: Arizona State University.

Skaggs, R. C. (2018). Waste-to-Energy biofuel production potential for selected feedstocks in conterminous United States. *Renewable and Sustainable Energy Reviews*, 2640-2651.

Sterling, R. A. (2012). Sustianability issues for undergrond space in urban areas. *Proceedings of the Institution of Civil Engineers - Urban Design and Planning.*, 241-254.

Ugwu, O. H. (2005). Key performance indicators and assessment methods for infrastructure sustainability - a South African construction industry perspective. *Building and Environment*, 665-680.

van Lier, J. (2008). High-rate anaerobic wastewater treatment: diversifying from end-of-the-pipe treatment to resource-oriented converstion techniques. *Water, Science, and Technology*, 1137-1148.

Washington Suburban Sanitary Commission. (2016). *Fats, Oils, and Grease*. Retrieved from WSSC: www.wsscwater.com/FOG

Water, E. P. (2007). *Controlling Fats, Oils, and Grease Discharges from Food Service Establishments.* Washington, DC: EPA.

Wiek, A. W. (2011). Key competencies in sustainability: a reference framework for academic program development. *Integrated Research System for Sustainability Science*, 203-218.

World Commission on Environment and Development. (1987). *Our Common Future.* United Nations.

Photo References

Figure 1: (City of Tempe, 2017)

Figure 3: (Atlantic Pit Service Inc., 2009)

Figure 4: (National Academy of Science, 1983)

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