

PLAY SUSTAINABALL AN ENVIRONMENTAL FOOTPRINT FOR AN MLB TEAM SEASON

BREN SCHOOL GROUP PROJECT FINAL REPORT

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Signature Page

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The Group Project is required of all students in the Master of Environmental Science and Management (MESM) Program. The project is a year-long activity in which small groups of students conduct focused, interdisciplinary research on the scientific, management, and policy dimensions of a specific environmental issue.

This Group Project Final Report is authored by MESM students and has been reviewed and approved by:

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1. Project Objectives

1. Develop an analytical framework for quantifying specific environmental impacts (greenhouse gas emissions and onsite water usage) of an MLB team over a season.
2. Identify environmental impact hotspot areas to focus sustainability and determine actions most likely to deliver the greatest benefits.
3. Recommend interventions and/or management strategies that address identified hotspots and client interests that are:
 - 1) Existing industry initiatives; or,
 - 2) Potential new initiatives determined from literature review

2. Significance

Major League Baseball (MLB) stadiums have been reported to use upwards of ten million gallons of water per year, have monthly energy needs the size of a small city, and generate over a ton of waste per game. To put that number in perspective, each American produces less than a ton of waste in an entire year (Colker and Gutierrez, 2017; Hershkowitz et al., 2012; Turrentine, 2019). The league and teams are interested in making their operations more sustainable –all 30 MLB teams have established environmental initiatives, seven MLB stadiums are now LEED certified, and MLB was the first professional sports league to endorse all of its clubs as members of the Green Sports Alliance (GSA), an organization recognized for its promotion of sustainability in sports (MLB, 2020). In addition to team-specific environmental initiatives, league-wide initiatives like the MLB Green Glove Award demonstrate a growing movement towards sustainable practices in baseball. While many teams have made strides in recent years to lessen their environmental impacts, no organization has a public-facing, comprehensive quantification of a stadium and/or team’s environmental footprint. Two existing efforts seeking to assess a teams’ environmental impact, the GSA PLAY campaign and Honeycomb Strategies’ Sustainable Sport Index (SSI), are in their early stages (Green Sports Alliance, 2022; “Sustainable Sport Index,” 2022). These initiatives, aimed at benchmarking, provide evidence that there is a need to address industry-wide gaps in baseline environmental impact assessment in professional sports. This gap was confirmed by project clients Gary Goldring, partial owner of the Tampa Bay Rays MLB team, and Chris Dickerson, co-founder of Players for the Planet, a nonprofit focused on uniting athletes to create positive change for our environment.

Providing a foundational understanding of a team’s environmental impacts is pivotal for creating action to reduce emissions. A comprehensive model that quantifies the environmental impacts of team operations at both the stadium and clubhouse level is a necessary first step in establishing best management practices (BMPs) applicable league-wide. Without baseline quantification, environmental improvements incurred from the implementation of BMPs cannot be accurately understood or communicated. Furthermore, identifying key hotspots will help to prioritize potential interventions to target areas of highest impact and inform better decision-making, as

data will provide insights into areas where reductions will yield the highest benefit. Thus, the results of this project can serve to guide sustainability efforts across facilities and organizations alike.

Lastly, as highly visible and influential organizations, club-level environmental action has the potential to educate and spark environmental stewardship across a broader audience; this idea is aligned with the goals of our client Players for the Planet, who uses the influence of professional athletes to create action around specific environmental goals. Former GSA President, Dr. Allen Hershkowitz, also spoke on the far-reaching influence of the sports industry, stating: “Perhaps no other industry is as well suited to confirm that environmental stewardship has become a mainstream, nonpartisan issue ... While only 13% of Americans say they follow science, 61% identify themselves as sports fans” (Waste Management, n.d.). Hershkowitz's sentiment was echoed by MLB Senior Director of Operations and Sustainability Paul Hanlon, who said “All of our 30 ballparks are prioritizing environmental stewardship...hopefully it translates over to fans watching at home, fans coming to the game. They look and say, “Oh look, our club is doing this every night. Why can’t I make these changes in my daily life? Why can’t I prioritize recycling in my home?” (Ladson, 2021). Our clients also understand that environmental stewardship not only benefits the club itself but also demonstrates leadership for the broader American public to support environmental issues.

3. Background

While there is minimal public reporting of stadiums’ environmental impacts, the information available paints a picture of professional arenas consuming enormous amounts of natural resources; for example, game-day peak energy demand is estimated to be ten MW of electricity, meaning that a 3.5 hour game has the same electricity needs as that of the average American household over the course of a year (“FAQ’s - U.S. EIA,” 2021; Mason, 2016). In addition, the average MLB stadium is estimated to use upwards of 12 million gallons of water per year (Grant, 2014). Furthermore, the EPA estimates that attendees at sporting events generate about 39 million pounds of trash each year and estimates for the Seattle Mariners alone is approximately 2.8 million pounds of trash per year (Grant, 2014).

In addition to high utility consumption and large waste production, sporting events and stadium operations contribute to climate change via generation of thousands of tons of greenhouse gas (GHG) emissions per year. Based on available research, fan transportation to and from events represents the largest source of GHG emissions of sporting events (Dolf, 2012; Edwards et al., 2016; Hershkowitz et al., 2012; Waste Management, 2021, n.d.). The Portland Trail Blazers are one team that have taken steps to quantify the environmental impact of fan transportation, but there has been minimal investigation by the MLB or other leagues into data collection and mitigation efforts in this area (“Live Greener,” n.d.). On average, 28,000 fans flock to their favorite stadiums on a MLB game day, presenting opportunities to reduce GHG emissions from fan transportation, by encouraging shifts to public transportation, bikes, or carpools (Dosumu et al., 2017; Hershkowitz et al., 2012). Focusing on this large GHG-emitting activity presents a greater overall GHG reduction potential. Conversations with MLB staff, including Senior

Director of Ballpark Operations and Sustainability, Paul Hanlon, revealed that fan transportation is an area MLB would also like to better understand.

There have been some environmental footprinting and Life Cycle Assessment (LCA) efforts undertaken by various teams assessing individual components of sporting events' environmental impacts. LCA and environmental footprinting are methodologies that can be used to quantify environmental impacts. LCAs look at the entire life cycle of a product or service and assess the environmental impacts of each stage of the life cycle. This includes everything from material extraction, to use of the product, to the impacts of end-of-life management of the product, often described as "cradle-to-grave" impacts (Čuček et al., 2015). The LCA process is a structured and standardized process for quantifying environmental impacts. Environmental footprinting is a more general term that describes the quantification of the appropriations of natural resources by humans and the burdens and impacts of these appropriations on the global environment. Carbon footprints quantify the GHG emissions of human activities and water footprints quantify the water consumption required to sustain human activities (Čuček et al., 2015).

Components of team operations assessed in prior environmental research include a carbon footprint of team and fan travel (Dosumu et al., 2017), a carbon footprint of stadium baseload operations (Hedayati et al., 2014), water footprints comparing natural grass and synthetic turf (Adachi et al., 2016; Itten et al., 2020), and waste footprints from various collegiate and professional sporting events (Costello et al., 2017; Edwards et al., 2016). Despite finding literature evaluating individual components of team operations, we only found one publicly-available LCA that comprehensively looked at every aspect of a team's season, conducted for the University of British Columbia (UBC) Thunderbirds Department of Recreation (Dolf, 2012). This LCA assessed the following activities: baseload operations of venues; travel and accommodation impacts of both team and fans; all goods and services purchased to facilitate team operations; consumption of resources such as food at sporting events and the end-of-life impacts of generated waste. The results of the study showed that 72-86% of all environmental impacts measured were from venue operation, followed by combined team and fan transportation travel (Dolf, 2012). Notably, this study evaluated impacts for an entire year for every single sports team at the university level, and evaluated 24 university teams, so there was a very different total number of athletes and spectators relative to a typical MLB stadium and season (Dolf, 2012).

Other universities have conducted carbon footprints or LCA studies for both seasons and individual events, revealing numerous environmental "hotspots" throughout college sports (Cooper, 2020; Costello et al., 2017; Edwards et al., 2016). The University of Missouri analyzed waste from seven football games using the EPA WARM model and found food waste was the largest component of this waste-specific GHG footprint (Costello et al., 2017) and the University of Arizona conducted an LCA for two homecoming football games and found that fan travel had by far the biggest impact of their GHG footprint (Edwards et al., 2016). It is important to note that while these studies provide useful initial insights into potential environmental "hotspots," university-level stadium operations can be assumed to be quite different from professional sports stadiums.

Turning to professional sports, several teams have conducted LCAs or carbon footprints (Collins and Flynn, 2008; NHL, 2018; Pereira et al., 2019; Waste Management, 2021). The National Hockey League (NHL) and the Waste Management Phoenix Open, a zero-waste golf tournament, have both conducted publicly available carbon footprints (NHL, 2018; Waste Management, 2021). Still, other teams and organizations have advertised their greening efforts without clear insights into the total environmental improvement they represent; for example, the MLB reports that 12 teams have their own gardens used for concession stands and ballpark restaurants, but a quantification of the environmental impact reduction of such activity is missing, exposing the teams to the risk of having their initiatives called greenwashing (MLB, 2020, p. 100).

While there are several reported metrics in individual operational areas, and some professional sports organizations have performed environmental impact quantification, there is no public-facing comprehensive footprint or LCA on environmental impacts in a professional sports setting; Trendafilova and McCullough evaluated 84 peer-reviewed journal articles, as well as GSA reports, and concluded that clear metrics to measure and communicate success are needed in the field of sports management (Trendafilova and McCullough, 2018). Industry foci and client interest in impact quantification is primarily in understanding emissions generation and water consumption, thus we opted to complete a carbon footprint and analysis of onsite water consumed for this project.

While our initial literature review did show that many MLB teams have sustainability initiatives in place, and have reported reductions of energy and water usage and increases in waste diversion, our project clients and MLB sustainability staff confirmed that season-long studies have not been undertaken by the league or any of its 30 clubs. A baseline assessment of environmental impacts is a critical foundation needed before BMPs and other recommendations can be identified and evaluated for their effectiveness in impact reduction. Without initial analysis outlining a team's total estimated carbon footprint and water usage, including percent breakdown by activity area (i.e., percentage of GHG emissions attributed to concessions or percentage of water used for restrooms), statements touting absolute numerical reductions from environmental initiatives are less powerful since the actual percent reductions relative to the baseline are not understood.

Furthermore, research in corporate environmental reporting demonstrates that when more comprehensive environmental reporting is made public, and established goals and interventions are revealed and quantified, an organization's legitimacy and public trust is enhanced (Aerts and Cormier, 2009; Obermiller, 2013). Outlining environmental successes and interventions without a more comprehensive analysis, such as an LCA or carbon footprint analysis, is less effective in building stakeholder trust and engagement (McCullough et al., 2020). Furthermore, robust reporting and communication not only builds a stronger public image, but also can have a direct financial impact on an organization's bottom line (Robinson et al., 2011). Quantifying environmental impacts and improvements can translate into increased fan engagement and spending. To illustrate, Casper et al. found that fan-team identity was strengthened when quantifiable environmental performance and initiatives were communicated. Consequently, fans attended more games, purchased more merchandise, and followed the team through media (Casper et al., 2019, 2017).

Incorporating sustainability into stadium operations and fan campaigns is also an opportunity to achieve significant impact beyond the stadium (Waste Management, n.d.). A Nielsen report revealed that 48% of U.S. consumers say they would be likely to adjust their consumption habits in order to reduce environmental impacts (Nielsen, 2018). Therefore, raising awareness of stadium impacts may catalyze sports fans to change their behavior. In the stadium, leveraging fan identification (how an individual's fandom or experience at a stadium connects to a sense of place and contributes to team loyalty) serves to increase participation in environmental sustainability initiatives at and around sporting events (McCullough and Kellison, 2016). These stadium-based behavioral changes can translate into changes in their everyday lives; fans may even advocate for sustainable policy changes in their local communities to reflect what they experienced at sporting events (Casper et al., 2019), such as taking public transportation or converting to other low-carbon transportation modes. Players for the Planet, a client and organization dedicated to the preservation and protection of our planet, recognizes the power sports have to invoke broader environmental stewardship and believes that small changes, made by many, can make a large impact; as such, they are building a coalition of professional athletes that use their influence to inspire environmentally friendly behavior change in followers and fans alike.

Our clients recognize the importance of measuring a stadium's carbon footprint and water consumption and understand the potential for lasting and influential change in stadium operations. In particular, the Tampa Bay Rays have expressed interest in furthering sustainability at their current stadium, as well as preparing for the construction of their new stadium. The Rays have already begun making strides to improve sustainability efforts at their stadium, Tropicana Field, in St. Petersburg, Florida. The Rays have retrofitted 95% of all lights throughout the stadium to energy-saving LEDs, shifted to non-toxic cleaning supplies, and in 2021 the organization created a sustainability committee to further additional efforts. Tropicana Field is distinct from other stadiums, thus quantification of the Rays' carbon footprint and onsite water use likely differs from an MLB team with typical stadium features. As a result, some recommendations for the Rays are unique to their facility. For example, Tropicana Field is one of five MLB stadiums that utilize an artificial turf field, and is the only MLB stadium with a non-retractable roof; these specificities translate to atypical water and energy consumption. Additionally, Tropicana Field has a smaller than average capacity due to a closure of the upper deck level in 2019, which reduced the number of seats from 42,735 to 25,025 (Ballparks of Baseball, n.d.); we anticipate this also affects consumption and emissions specific to areas of the Rays operations that vary as a function of attendance.

Understanding that there are two environmental impact models currently in creation, the GSA PLAY campaign and the SSI, we believe the best approach to achieving our objectives and meeting client needs is to create a framework to quantify a carbon footprint (including fan transportation) and evaluate onsite water usage and develop a robust repository of BMPs to address identified hotspot areas quantified in our analysis. Although our initial research showed that fan transportation is likely a major emissions contributor, (Dolf, 2012; Edwards et al., 2016; Hershkowitz et al., 2012; Waste Management, 2021) GSA Director of Sustainable Events & Analytics, Brett Blumberg, told us that the PLAY campaign does not address fan transportation; therefore, our study provides unique insights by taking a deeper look at this activity. In early March 2022, the SSI released their first report, the 2021 Benchmarking Report, which confirmed

that quantification is lacking. The SSI report found that only 16.67% of teams surveyed track carbon emissions (“Sustainable Sport Index,” 2022); although this report was released after our footprints had been completed, it still provided a useful comparison, which is outlined in our discussion.

By developing an analytical framework that quantifies two specific and high priority environmental impacts of an MLB team, this project will enable team executives and stadium managers to incorporate energy, carbon, and water sustainability into their operations more effectively. In particular, the identification of BMPs in key hotspot areas will allow for the implementation of actions that deliver greater return on investment (environmentally speaking), by focusing effort on areas of greatest opportunity. This quantification effort can also lead to broader fan engagement, communication, and public trust-building. Lastly, the incorporation of fan transportation emissions within a broader MLB team’s carbon footprint distinguishes this project from other existing efforts and provides new insight into a major contributor of GHG emissions.

4. Footprinting Goal and Scope

As part of our analytical framework, our project quantifies the carbon footprint and onsite water usage for the Tampa Bay Rays over one full MLB season. We quantify these using an LCA approach. As highlighted in Section 3, there are numerous and diverse activities that go into facilitating professional sporting events. Assessing the environmental impacts of such events in sufficient detail is an enormous undertaking, as every aspect of the operation produces environmental impacts, albeit to greater or lesser extents. Further, operations upstream and downstream of the stadium itself, as required by an LCA, or “cradle-to-grave” approach, can be large components of any organization’s environmental footprint (Barrow et al., n.d.). Best practice LCA requires establishing a clear functional unit and system boundary for our analysis that allows us to be explicit in defining which activities we included (and excluded) to calculate our carbon footprint and water consumption analysis.

4.1 Functional Unit

Here, we define a functional unit to contextualize the quantified impacts relative to a specified output of products and services. In LCA, a functional unit is a quantifiable description of the performance of a product (in our case, an MLB team) that serves as a reference point for all environmental impact calculations (Arzoumanidis et al., 2020). For our project, we adopted a functional unit of facilitating one full MLB season (excluding spring training and playoffs) and related activities for a single team (Tampa Bay Rays). We constitute April 1 through September 30, inclusive, as the boundary for one full season, for simplification. This period included 158 of the 162 total games that the Rays played in 2019, and 77 of the 81 home games played at Tropicana Field. The related activities of the team that are included in our functional unit are those over which the Rays have direct control; for example, natural gas consumption and team travel, and activities for which the Rays have the ability to influence such as concessions purchasing and fan transportation via information campaigns and behavioral change incentives. Our functional unit does not include activities the Rays have minimal ability to influence; for

example, accommodations associated with fan transportation, or away games outside of team hotel accommodations.

In light of the COVID-19 disruptions to the MLB in 2020 and 2021, we primarily used 2019 season data as the applicable year for our functional unit; in some cases, where 2019 data was not available, we used 2021 data. We opted to use the season-only boundary, as opposed to quantifying the carbon footprint and onsite water usage over an entire year, because we were primarily interested in the impacts of the Tampa Bay Rays and wanted to minimize the contribution of events held at Tropicana Field that were not hosted by the Rays. All events hosted between April 1 and September 30, 2019, at Tropicana Field, regardless of whether or not the Rays hosted them, are included in our quantification. However, through conversations with Tropicana Field staff, it is our understanding that the vast majority of events hosted at Tropicana Field in this time period are hosted by the Rays. Further, the vast majority of events held at Tropicana Field that are not hosted by the Rays, such as Enchant Christmas, are held between October 1 and March 31.

4.2 System Boundary

Our system boundary included GHG-emitting activities occurring onsite at Tropicana Field as well as upstream and downstream GHG emissions-producing activities and all onsite water-consuming activities (**Figure 1**). We utilized the GHG Protocol's framework that divides GHG emissions into Scope 1, Scope 2, and Scope 3 emissions as a way to categorize the evaluation of GHG emissions. Scope 1 emissions are defined as "direct" GHG emissions, or emissions from sources that are owned or controlled by "the company," or, in our case, occurring at Tropicana Field (Ranganathan et al., n.d.). For a facility like a stadium, this is primarily any onsite fossil fuel combustion. Scope 2 is defined as the "indirect" GHG emissions associated with purchased electricity consumed onsite at Tropicana Field. **Figure 1** shows Scope 1 and Scope 2 emissions as they relate to other activities included in our study. Scope 3 is defined as all other indirect GHG emissions that are a consequence of the activities of the company, in our case the Tampa Bay Rays, but occur from sources not owned or controlled by the company. For example, the Rays' Scope 3 emissions include emissions from food production for concessions sold onsite or emissions from fans traveling to the stadium, among other things (Ranganathan et al., n.d.). The Scope 3 activities included in our study are all blue-oval activities in **Figure 1** that are not labeled as Scope 1 or Scope 2. The dashed box indicates the stadium boundary and the solid box indicates the system boundary with upstream and downstream activities included in the system boundary. Activities listed outside of the system boundary are notable exclusions from our study.

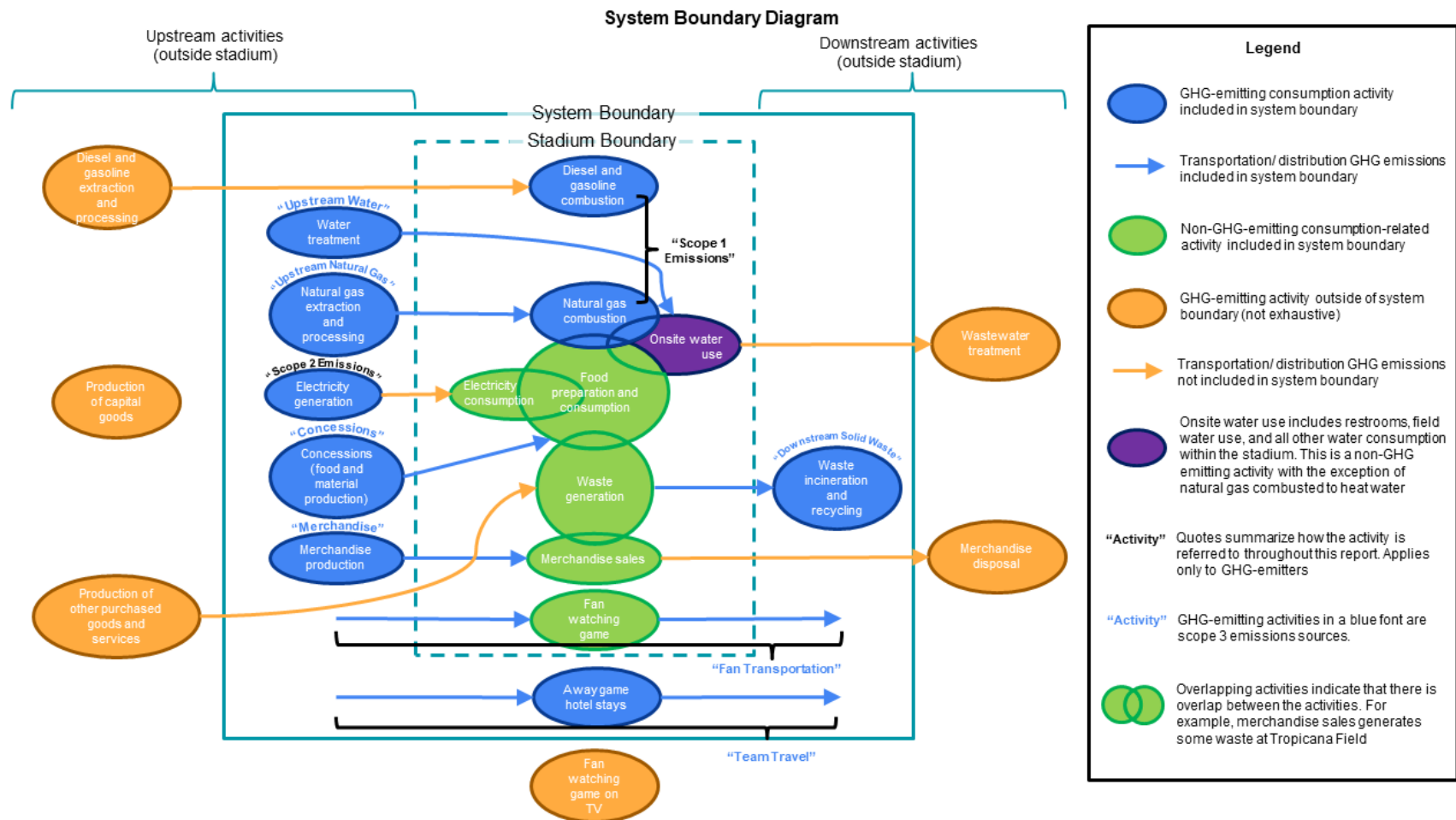


Figure 1: System boundary visualization. Diagram shows activities relevant to calculating a carbon footprint and onsite water use for one season for one MLB team. Includes activities upstream of the stadium (left-hand side of diagram) and activities downstream of the stadium (right-hand side). Relationships between activities are shown with arrows and overlapping bubbles. All upstream and downstream activities have a corresponding activity within the stadium boundary (dashed line box), although the onsite activity itself may or may not be a GHG-emitting activity. Color and system boundary (solid line box) delineates whether or not the activity was evaluated as part of our study

As outlined in the system boundary visualization (**Figure 1**), our carbon footprint comprises nine activities: Scope 1 emissions, Scope 2 emissions, upstream natural gas, upstream water, fan transportation, team travel, concessions, merchandise, and downstream solid waste. Our analysis of onsite water is “water consumption.” These activities were selected based on what we anticipated to be large emission drivers for the Rays based on our literature review and data availability from the Rays. Further explanation of chosen activities is below:

- *Scope 1 emissions* include onsite combustion of natural gas, diesel, and gasoline for activities including water heating, cooking, powering onsite vehicles, generators, and gas- or diesel-powered maintenance equipment. Food preparation requires natural gas to both heat water and fuel cooking appliances (see overlap in **Figure 1**).
- *Scope 2 emissions* refer to electricity delivered to the stadium by the local utility. Onsite consumption of electricity does not emit GHGs. Transmission and distribution losses are not included in Scope 2 emissions.
- *Upstream natural gas* refers to the emissions generated from the processes of extracting, processing, and delivering natural gas to the stadium.
- *Upstream water* links water usage to emissions for treating the water and delivering it to the stadium.
- *Fan transportation* includes emissions associated with all methods fans used to travel to and from Rays home games.
- *Team travel* refers to emissions associated with travel to and from other MLB stadiums across the country as well as staying in hotels for away games.
- *Concessions* refers to GHG emissions associated with growing, producing, processing, and transporting food, beverages, and miscellaneous kitchen supplies to the stadium. This evaluation is considered cradle-to-gate, meaning it includes all upstream GHG emissions associated with product manufacturing, including packaging, shipping, but excludes use and end-of-life phases.
- *Merchandise* sold at Tropicana Field refers to cradle-to-gate GHG emissions associated with the production of merchandise for sale.
- *Downstream solid waste* refers to GHG emissions from the disposal phase of a product's life cycle and includes all waste produced at the stadium including recyclables; sorted recyclables are diverted to material recovery facilities and all remaining waste is sent to a waste-to-energy facility for incineration and disposal.
- *Water consumption* refers to the total water used onsite at Tropicana Field and excludes any upstream or downstream indirect water consumption associated with other goods or services used at Tropicana Field. Our study included water consumption from restrooms, field irrigation, and all other sources at the stadium.

The Rays provided our team with numerous datasets related to the activities described above. Examples include utility bills, purchasing records, and fan survey results. Descriptions of data provided and how we used the data to quantify GHG emissions and water consumption are provided in Section 5.

4.3 Excluded Data

Notable exclusions in our system boundary included GHG emissions from diesel and gasoline extraction/processing/distribution, purchased goods and services outside of concessions and merchandise (which would include much of the impact of clubhouse operations and front office work), capital goods/stadium construction, GHG emissions from fans watching the game not at the stadium (i.e. on TV, radio, at a bar, etc.), merchandise disposal, wastewater treatment, and off-site (indirect) water consumption (**Figure 1**). Exclusion of these activities related to a lack of data availability from the Rays, a lack of emissions factors available, and time constraints.

By defining our functional unit as one season, as opposed to one year, as explained in Section 4.1, we excluded data from the Rays related to utility usage from January 1 - March 31, 2019, and October 1 - December 31, 2019. As noted in Section 4.1, we believed that the majority of the Tampa Bay Rays operations occurred from April 1 - September 30, 2019, and that this period incorporated minimal impact from events not hosted by the Rays. Using these dates to define one Rays season, we find that the 2019 season used between 60-80% of each utility used over the entire calendar year, with the exception of diesel (31%) (**Table 1**).

Table 1. Percentage of total year-long utilities/services used or disposed of during the 2019 season, separated by utility/service type

| Utility/Service | Percent of all 2019 usage included in our boundary (i.e. Percent of 2019 consumption/disposal that took place between Apr-Sept. 2019) |
|------------------|---|
| Natural Gas | 61.0% |
| Diesel | 30.6% |
| Gasoline | 60.7% |
| Electricity | 61.7% |
| Water | 81.2% |
| Solid Waste Haul | 68.4% |

5. Methods

5.1 Carbon Footprint Methodology Overview

As described in Section 4.2, our team opted to evaluate onsite GHG and water impacts, and upstream and downstream GHG impacts, from one Tampa Bay Rays season. This functional unit is defined as the nine blue-oval categories in **Figure 1**, and onsite water usage.

The carbon footprint of these nine categories were individually calculated with their own methodology to determine the mass of GHG emissions during the time period defined by our functional unit. A detailed description of each individual methodology is contained in Section 10.1. However, in general, the process can be described by multiplying activity consumption data from the Rays by the GHG emission factor associated with that activity (**Equation 5.1A**). Activity consumption data are quantities of resources associated with the activity, such as gallons of gasoline combusted, dollars spent on foods for concessions stands, or miles traveled by fans to the stadium. The GHG emission factor, which describes the mass of a particular GHG per unit of activity data (also known as emissions intensity), comes from numerous sources such as the U.S. EPA and other research institutions that have quantified the emissions intensity of certain activities. Multiplying the activity consumption data with the GHG emission factor returns the mass of GHGs associated with the activity (**Equation 5.1A**).

The mass of GHG emissions were calculated by type of GHG. We calculated emissions of carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) for all GHG-emitting activities. Emissions for the concessions and merchandise activities also included estimates of “other GHGs” as defined by the emission factor source. It is common practice to normalize the total mass of emissions in terms of CO₂, referred to as carbon dioxide-equivalents (CO₂e) (**Equation 5.1A**). This is done using 100-year global warming potentials (GWPs), which measure the heat absorbed by an individual GHG as a multiple of the heat that would be absorbed by the same mass of CO₂ (U.S. EPA, 2016a). This study used GWPs from the IPCC AR6 report (Smith and Nicholls, 2021, p. 6). However, for some activities, the only available emission factor data was already in units of CO₂e with an unspecified GWP time horizon and IPCC cycle data.

Equation 5.1A:

$$GHG \text{ Emissions per Activity (in CO}_2\text{e)} = \text{Activity Consumption Data} \times \sum (\text{Activity Emission Factor}_{GHG} \times GWP_{GHG}),$$

where GHG is CO₂, CH₄ and N₂O.

Once GHG emissions for all eight GHG-emitting activities included in our system boundary were calculated, we summed all eight of those totals together to get a complete carbon footprint for one full Rays season (**Equation 5.1A**). Further details on the methods and data used for the quantification of the estimated carbon footprint are below.

5.1.1 Scope 1

Through facility operator interviews and an onsite internship at Tropicana Field, it was determined that Scope 1 emissions for our functional unit were from:

- Natural gas combusted for water heating and cooking appliances;
- Diesel combusted by an onsite emergency generator, handheld lawn care equipment, and off-road vehicles used on the field; and
- Gasoline combusted by the Rays’ fleet of light-duty trucks

It is also likely that there are direct emissions of hydrofluorocarbons (HFCs), another GHG, at Tropicana Field from the use of refrigeration and air conditioning equipment. These were not

calculated because we had no access to Rays-specific data on refrigeration equipment or coolants.

Scope 1 emissions were calculated based on purchased quantities of fossil fuels for Tropicana Field during the time period contained within the functional unit. Exact quantity purchased was determined from natural gas utility invoices and receipts for diesel and gasoline. Direct emissions were calculated using emission factors from the GHG Emissions Calculations Tool from the GHG Protocol (“The GHG Emissions Calculation Tool | Greenhouse Gas Protocol,” n.d.). Further detail on direct emissions calculations and methods of percent breakdown of each fossil fuel type by activity is provided in Section 10.1.1.

5.1.2 Scope 2

Similar to Scope 1 emissions, utility invoices were used to determine electricity consumed. Emission factors from eGRID 2019 data for the Florida Reliability Coordinating Council (FRCC) subregion, which covers most of the state of Florida, were used to quantify Scope 2 emissions based on the quantity of electricity consumed.. eGRID is an inventory of environmental attributes of electric power systems that pulls data from the Energy Information Administration (EIA) and EPA’s Clean Air Markets Program Data (Rothschild et al., 2009). The resource grid mix for the FRCC subregion is dominated by natural gas, generating 74.5% of the total electricity in the subregion. Nuclear power generation accounts for 12.4% of electricity and coal accounts for 7.9%. The emissions intensity of the FRCC grid mix is 392 g CO₂e/kWh. Section 10.1.2 provides the detailed methodology for calculation of GHG emissions associated with purchased electricity consumed onsite. Our evaluation of Scope 2 emissions does not include losses associated with transmission and distribution of electricity.

5.1.3 Scope 3

Scope 3 is defined as all other indirect GHG emissions that are a consequence of the activities of the company. Calculating other indirect emissions associated with our functional unit required more varied sources of data and multiple calculation methodologies. The GHG Protocol acknowledges this and thus categorizes GHG emissions for Scope 3 into 15 different categories that, when evaluated in their entirety, provide a thorough and holistic description of upstream and downstream emissions sources for a company. As noted in our literature review, we anticipated that fan transportation, team travel, and emissions associated with concessions would be large components of the carbon footprint, so we prioritized evaluating these GHG emissions sources. **Table 2** discusses the categories of Scope 3 emissions included in our carbon footprint.

Table 2. Categories of Scope 3 emissions included in our study carbon footprint

| Scope 3 Category | Description of Included Activities |
|---|---|
| 1: Purchased Goods and Services | Evaluated emissions from food and materials purchased for concessions operation and merchandise purchased and then re-sold to fans (onsite only). Also evaluated emissions associated with purchase of water from the local water utility (i.e. energy required to treat water) |
| 3: Fuel- and Energy-Related Activities Not Included in Scope 1 or Scope 2 | Evaluated emissions associated with extraction and production of methane distributed by the natural gas utility. This does not include emissions associated with natural gas-powered electricity generation in the FRCC subregion |
| 4: Upstream Transportation and Distribution | Included (as Category 1) - Emission factors used to evaluate emissions from materials purchased for concessions and merchandise included transportation and distribution associated with those purchased goods |
| 5: Waste Generated in Operations | Evaluated emissions associated with management of waste from Tropicana Field, which consist primarily of emissions associated with a waste-to-energy facility |
| 6: Business Travel | Evaluated emissions from team transportation to and from away games and associated emissions from accommodation |
| 9: Downstream Transportation and Distribution | Evaluated emissions from fan transportation to and from home games at Tropicana Field |

Once activities to assess were picked, we worked with the Rays to acquire data related to the activities identified above. Based on the available data, we consulted the GHG Protocol to determine a calculation methodology for GHG emissions. The calculation methodologies can be summarized as follows:

- **Spend-based method:** estimates emissions associated with the production and distribution of goods and services by collecting data on the economic value of goods and services purchased and multiplying it by relevant secondary (e.g., industry average) emission factors (e.g., average emissions per monetary value of goods).
- **Supplier-specific method:** collects product-level cradle-to-gate GHG inventory data from goods or services suppliers.
- **Average-data method:** estimates emissions for goods and services by collecting data on the mass (e.g., kilograms or pounds), or other relevant mass units of goods or services purchased and multiplying by the relevant secondary (e.g., industry average) emission factors (e.g., average emissions per unit of good or service).

- **Distance-based method:** The distance-based method involves multiplying activity data (i.e., vehicle-miles or person-miles traveled by vehicle type) by emission factors (typically default national emission factors by vehicle type). Vehicle types include all categories of aircraft, rail, subway, bus, automobile, etc. (Barrow et al., n.d.).

Table 3 describes how we evaluated emissions for each activity included within our carbon footprint. Further information including detailed descriptions of calculations is included in Section 10.1.

Table 3. A summary of data sources, GHG Protocol methodology used, and emission factor sources used

| Emissions Activity Description | Activity/ Consumption Data Used | Activity/ Consumption Data Units | GHG Protocol Calculation Methodology Used | Emission Factor Data Source | Emission Factor Units | Supplemental Information with Detailed Methodology |
|---|---|---|--|---|-------------------------------------|---|
| Concessions | Purchasing records | 2021 USD | Spend-based method | U.S. EPA's Supply Chain Emission Factors for U.S. Industries and Commodities dataset | g CO ₂ e/ 2018 USD | 10.1.7 |
| Merchandise | Sales records from the Tampa Bay Rays | 2019 USD | Spend-based method | U.S. EPA's Supply Chain Emission Factors for U.S. Industries and Commodities dataset | g CO ₂ e/ 2018 USD | 10.1.8 |
| Upstream Water | Water utility invoices | gal | Supplier- specific method | Zaribaf's (Georgia Institute of Technology) application of Water-Energy Sustainability Tool (WEST) from UC-Berkeley | g CO ₂ e/ m ³ | 10.1.3 |
| Upstream Natural Gas | Natural gas utility invoices | therms | Average-data method | U.S. DOE and Argonne National Laboratory's GREET Model | g CO ₂ e/ mmbtu | 10.1.3 |
| Downstream Solid Waste | Waste and recycling hauler invoices | pounds | Average-data method | U.S. EPA's Waste Reduction Model (WARM) ^a | g CO ₂ e/ short ton | 10.1.4 |
| Team Travel - Air Travel | Tampa Bay Rays 2019 Season Game Schedule | miles | Distance- based method | EPA 2021 GHG Emission Inventory Factors | g CO ₂ e/ mile | 10.1.6 |
| Team Travel - Other Travel Methods and Accommodations | With a lack of available data from the Rays, we used a GHG emissions analysis from the New York Mets as a proxy for the Tampa Bay Rays. Given available data, it is assumed that the Mets used the average-data method to evaluate emissions. | | | | | 10.1.6 |
| Fan Transportation | Results of 2021 MLB Post-Game Survey distributed to fans | miles | Distance- based method | EPA 2021 GHG Emission Inventory Factors | g CO ₂ e/ mile | 10.1.5 |

^aThe U.S. EPA's Waste Reduction Model includes negative emission factors, i.e. GHG emissions credits, for both recycling processes and waste-to-energy processes. A credit is given when recycling processes are less carbon intensive than virgin material production processes. For waste-to-energy processes, a credit is given when electricity generation from the facility is less carbon intensive than the regional electricity grid mix. See Supplemental Information 10.1.4 for further detail.

5.2 Onsite Water Use

Monthly water utility bills from 2019 were provided from the Rays; bill information was recorded to calculate total monthly water usage (in gallons). Water utility bills were not sub-divided between onsite uses, thus specific information about service areas was not available; usage is therefore assumed to be inclusive of entire stadium operations. Monthly usages between April and September (inclusive) were summed to calculate the 2019 season total. End uses were identified as restrooms (urinals, toilets, sinks), water fountains, kitchen/cooking sinks, janitorial uses, cooling towers, clubhouse operations, leaks, and maintenance of the field. Sufficient information was only available for restrooms, and field maintenance, thus our estimations of onsite water use were broken down into just three categories: restrooms, field use, and other (**Equation 5.2A**).

Stadium personnel provided flow rates for restroom fixtures. Stadium personnel also supplied information related to water consumption for the cooling tower based on a contractor's estimate. The other category includes water consumed by water fountains, janitorial uses, cooling towers, clubhouse operations, leaks, and field maintenance (**Equation 5.2B**).

In order to glean insights into the contribution of the various "other" end uses to the total seasonal water use, literature was used to conduct "back-of-the-envelope" calculations for water fountains, janitorial uses, clubhouse operations, and leaks. See Section 10.2 for methodologies specific to each end use. From the cooling tower usage estimate, it is reasonable to assume the majority of the "other" category is related to cooling tower water use, thus the remaining water consumed was allocated to the cooling towers; this notion is discussed further in Section 6.2. Kitchen water consumption was excluded from the onsite water use breakdown due to an absence of literature estimates; janitorial uses were also simplified to washing the grandstand, and clubhouse operations were simplified to only include clubhouse showers and washing machines. Since the total water consumed during the 2019 season is known and top water-consuming activities are included in our calculation, these exclusions do not prevent us from meeting project goals of: quantifying onsite water consumed, identifying hotspots, and establishing reduction strategies for key hotspot areas. To calculate onsite water consumption, we sum each water consumption category (**Equations 5.2A and 5.2B**).

Equation 5.2A:

$$\textit{Onsite Water Consumption (gal)} = \textit{Restroom Water} + \textit{Field Maintenance Water} + \textit{Other Water}$$

Equation 5.2B:

$$\textit{Other Water (gal)} = \textit{Cooling Tower} + \textit{Water Fountains} + \textit{Grandstand Washing} + \textit{Clubhouse Showers} + \textit{Washing Machines} + \textit{Leaks}$$

6. Results

6.1 Carbon Footprint Results

The estimated carbon footprint for one full Tampa Bay Rays season is largely attributed to fan transportation (70.5%), followed by concessions (15.4%) and Scope 2 emissions (9.2%) (**Table 4, Figure 2**). As noted in **Table 3**, downstream solid waste management practices can generate a potential GHG emissions credit from recycling and waste-to-energy facilities offsetting electric grid emissions. The emissions credit associated with downstream solid waste is negligible (-0.39%). CO₂ is the GHG contributing the vast majority of emissions to the Rays' carbon footprint (**Figure 2**). Because total emissions are dominated by fan transportation, contributions of smaller sources of emissions are more easily comparable when compared without fan transportation (**Figure 3**). Emissions totaled just under 36,000 metric tonnes CO₂e over the entire season (**Table 4**).

Emissions can also be assessed on a per fan basis. With a total home attendance of 1,178,735 fans during the 2019 regular season (Bergin, 2019), approximately 30.6 kg CO₂e can be attributed to each Tampa Bay Rays fan. This is the same quantity of GHGs emitted from driving an average passenger vehicle approximately 89 miles (calculated using U.S. EPA 2021 Emission Factors for Greenhouse Gas Inventories; (U.S. EPA, 2021)).

Table 4. Mass and percent GHG emissions breakdown by activity of the Rays 2019 season (April-September) in CO₂e and respective GHGs (CO₂, CH₄, N₂O)

| Activity Description | CO ₂ (kg) | CH ₄ (kg) | N ₂ O (kg) | Other GHGs (CO ₂ e) | CO ₂ e (kg) | Percent of Total Footprint |
|---|----------------------|----------------------|-----------------------|--------------------------------|------------------------|----------------------------|
| Scope 1 Emissions | 224,000 | 4.1 | 0.4 | NA | 225,000 | 0.63% |
| Scope 2 Emissions | 3,310,000 | 210 | 27 | NA | 3,320,000 | 9.26% |
| Upstream Natural Gas and Upstream Water | 26,300 | 852 | 5.6 | NA | 51,700 | 0.14% |
| Downstream Solid Waste | NA | NA | NA | NA | -139,000 | -0.39% |
| Concessions | 25,800,000 | 68,400 | 3,600 | 62,900 | 5,540,000 | 15.5% |
| Merchandise | 372,000 | 1,960 | 0.0 | 1,400 | 428,000 | 1.19% |
| Fan Transportation | 25,100,000 | 529 | 620 | NA | 25,300,000 | 70.5% |
| Team Travel | 1,150,000 | NA | NA | NA | 1,150,000 | 3.22% |
| Total | 56,000,000 | 72,000 | 4,260 | 64,300 | 35,900,000 | 100.0% |

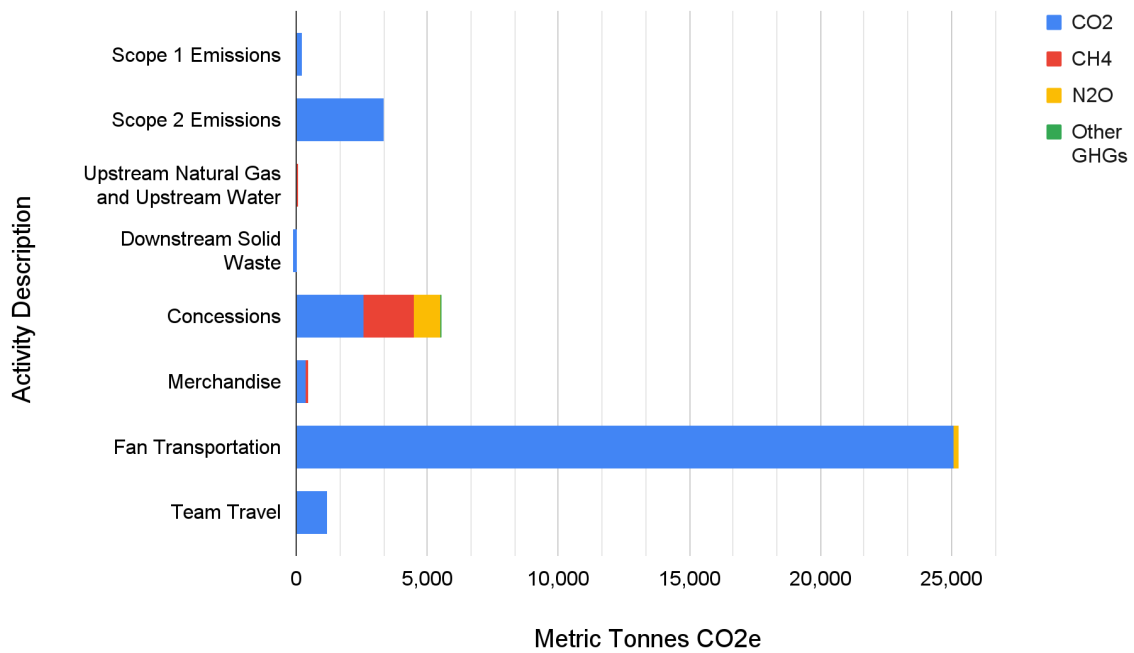


Figure 2: Total emissions of the Rays 2019 season by individual GHG and activity

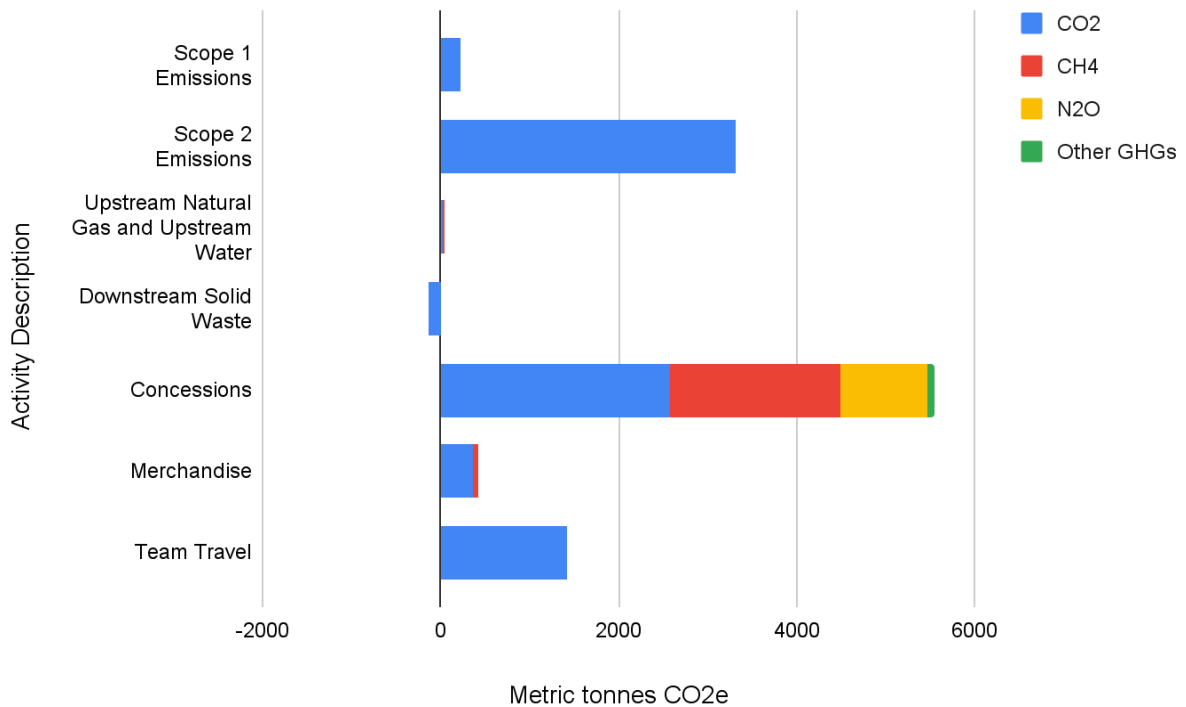


Figure 3: Total emissions of the Rays 2019 season by individual GHG and activity (excluding fan transportation)

6.1.1 Carbon Footprint: Activity Hotspots

The subsections below provide more granular detail on GHG emissions results for each GHG-emitting activity evaluated as part of the Rays’ carbon footprint. Most areas evaluated have one or more “hotspots” responsible for a majority of emissions associated with the category, listed in **Table 5**.

Table 5. Identified hotspots by activity evaluated for carbon footprint

| Activity | Hotspot |
|---|---|
| Scope 1 Emissions | Natural gas |
| Scope 2 Emissions | Electricity generation from fossil fuels |
| Upstream natural gas and upstream water | Natural gas |
| Downstream solid waste | PET combustion |
| Fan transportation | Travel by car/personal vehicles |
| Team travel | Airplane travel from coast to coast |
| Concessions | Meat products |
| Merchandise | Mystery grab bags and commemorative jerseys |

6.1.1.1 Scope 1 Emissions

Scope 1 emissions at Tropicana Field accounted for 0.63% of the Rays’ estimated carbon footprint. The breakdown of GHG emissions by fossil fuel type is shown in **Table 6**. Combustion of natural gas accounts for 93% of emissions from Scope 1 emissions. Natural gas is used at Tropicana Field for both water heating and kitchen appliances. The Tampa Bay Rays do not have natural gas sub-meters to indicate what proportion of natural gas usage goes towards heating versus kitchen. However, for reference, Citi Field, home of the New York Mets MLB team, uses 75% of their natural gas for water heating and 25% with kitchen appliances. Therefore, we assume that the majority of the Tampa Bay Rays Scope 1 emissions can be attributed to the Rays’ water heating system.

Table 6. Scope 1 emissions by fossil fuel type

| Fuel | CO2 (kg) | CH4 (kg) | N2O (kg) | CO2e (kg) | Percent of Scope 1 CO2e | Emission Factor (kg CO2e/unit) | Units |
|--------------|----------|----------|----------|-----------|-------------------------|--------------------------------|-------|
| Natural Gas | 209,000 | 4 | 0.39 | 209,000 | 93% | 53.1 | MMBtu |
| Diesel | 3,670 | 0 | 0.03 | 3,680 | 2% | 42.2 | gal |
| Gasoline | 11,600 | 0 | 0 | 11,600 | 5% | 8.78 | gal |
| Total | 224,000 | 4 | 0.42 | 225,000 | 100% | | |

6.1.1.2 Scope 2 Emissions

Scope 2 emissions accounted for 9.26% of the Rays’ estimated carbon footprint. Total Scope 2 emissions were calculated for each GHG (**Table 7**). As described in Section 10.1.2, emissions were calculated using U.S. EPA eGRID emission factors for 2019 data, published in 2021, for the FRCC subregion. The resource grid mix for the FRCC subregion is dominated by natural gas,

generating 74.5% of the total electricity in the subregion. Nuclear power generation accounts for 12.4% of electricity and coal accounts for 7.9%. All other sources of power are less than 3% of total generation (**Figure 4**). Note that the fossil fuel-heavy make-up of the electric grid accounts for the majority of Scope 2 emissions. FRCC subregion eGRID data indicates that 80% of CO₂e emissions are from natural gas-fired power plants, followed by 16% from coal-fired plants, 1% from oil, and 2% from all other electricity sources (U.S. EPA, 2020).

Table 7. Scope 2 emissions (GHG emissions from electricity generation)

| Activity Description | CO ₂ (kg) | CH ₄ (kg) | N ₂ O (kg) | Other GHGs (CO ₂ e) | CO ₂ e (kg) | Percent of Total Rays Footprint | Emission Factor (kg CO ₂ e/kWh) |
|----------------------|----------------------|----------------------|-----------------------|--------------------------------|------------------------|---------------------------------|--|
| Electricity | 331,000 | 211 | 27 | NA | 3,320,000 | 13.2% | 0.39 |

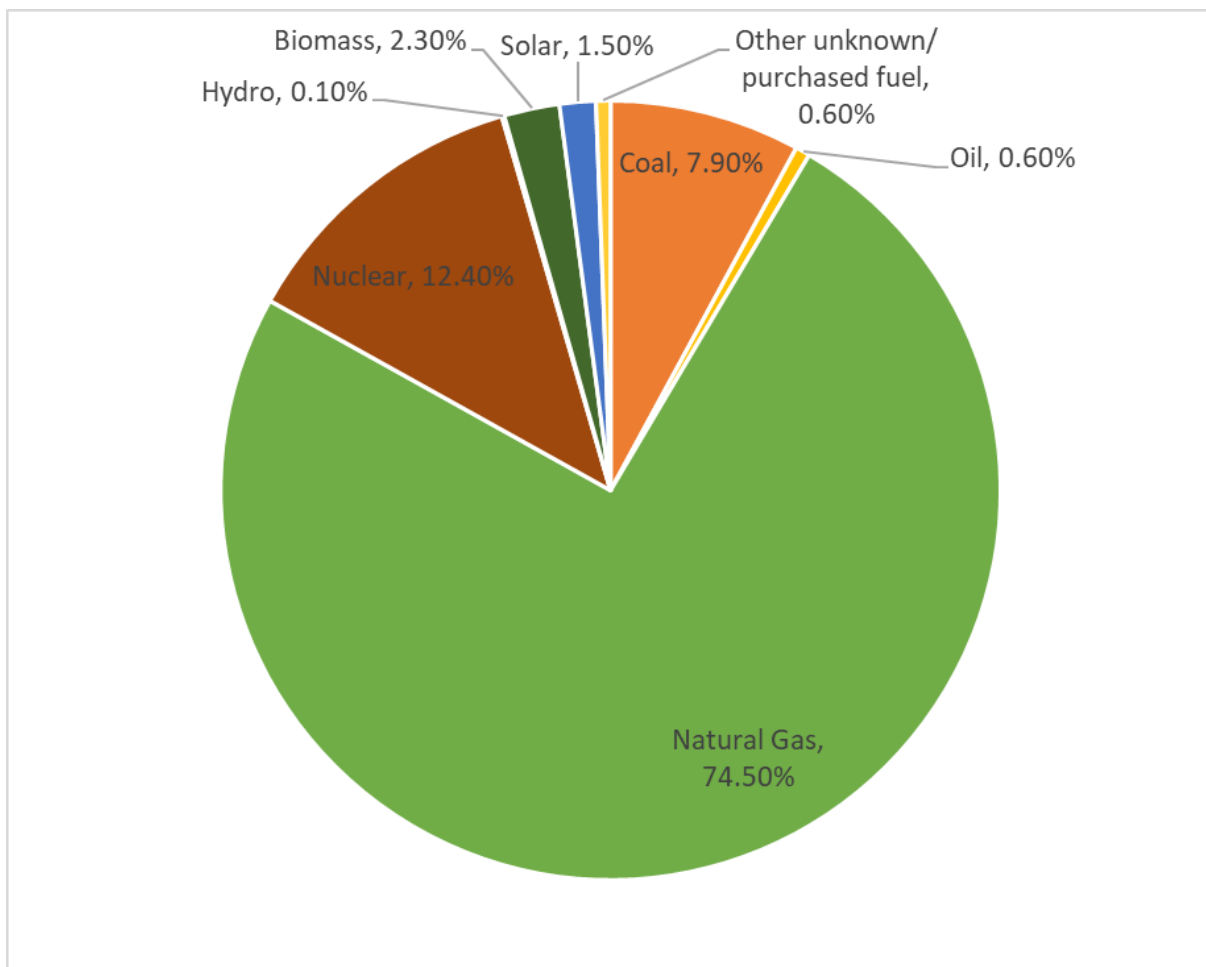


Figure 4: Florida Reliability Coordinating Council (FRCC) subregion resource grid mix. Not shown in figure is that 0% of the electricity generated in the FRCC subregion comes from wind energy, geothermal energy, or other fossil fuels such as other gasses besides natural gas. Source: eGRID 2019 Summary Tables (U.S. EPA, 2021b)

6.1.1.3 Upstream Natural Gas and Upstream Water

We calculated GHG emissions from upstream activities associated with water purchased from the local water utility and natural gas purchased from the local natural gas utility, i.e. emissions associated with natural gas extraction, processing, and distribution prior to onsite combustion (**Table 8**). Overall, this category comprises 0.14% of the Rays’ entire carbon footprint estimate. Within the category, 96% of emissions are associated with upstream natural gas as opposed to upstream water treatment (4%).

Table 8. Upstream GHG emissions by utility

| Utility | CO2 (kg) | CH4 (kg) | N2O (kg) | CO2e (kg) | Percent of Activity Footprint | Emission factor (kg CO2e/unit) | Units |
|-----------------|----------|----------|----------|-----------|-------------------------------|--------------------------------|----------------|
| Natural Gas | 24,200 | 852 | 5.59 | 49,600 | 96% | 12.6 | MMBtu |
| Water Treatment | NA | NA | NA | 2,080 | 4% | 0.05 | m ³ |
| Total | 24,200 | 852 | 5.59 | 516,700 | 100% | | |

6.1.1.4 Downstream Solid Waste

Our analysis found that management of waste from Tropicana Field resulted in an overall GHG emissions credit that reduced the Rays’ estimated carbon footprint by 0.39%. The U.S. EPA WARM output calculating GHG emissions from the Rays’ waste indicates that the team has earned a GHG emissions credit of nearly 139 metric tons of CO2e based on the different material streams present at Tropicana Field and managed offsite at the waste-to-energy (WTE) and recycling facilities (**Table 9**). Our analysis required understanding the material composition of waste streams at Tropicana Field. The Rays have not performed a waste audit at Tropicana Field to determine material composition of waste streams; we thus drew from the results of a publicly available waste audit for the Seattle Mariners MLB team (Hershkowitz et al., 2012). For more detailed information on the WARM analysis, see Section 10.1.4. Recycling generates GHG emission credits when the recycling process emits fewer GHGs than virgin material production. Combustion generates a GHG emissions credit when the GHG emissions from burning material for electricity production are less than the GHG emissions from the regional electrical grid. The largest credit comes from recycling corrugated containers followed by combusting mixed recyclables. Combusting polyethylene (PET), a plastic that is typically recyclable, produces the largest GHG emissions associated with this category followed by combustion of general municipal solid waste (MSW) (**Figure 5**).

Table 9. WARM GHG emissions waste management analysis

| Material Stream | Emission Factor (MTCO₂e per short ton recycling) | Emission Factor (MTCO₂e per short ton combusted) | Total Tons Recycled | Total Tons Combusted | Total GHGs from Recycling (MTCO₂e) | Total GHGs from Combustion (MTCO₂e) | Total GHGs from Waste Management (CO₂e) |
|------------------------|--|--|----------------------------|-----------------------------|--|---|---|
| Corrugated Containers | -3.14 | -0.47 | 26.0 | 16.3 | -81.5 | -7.7 | -89.2 |
| Office Paper | -2.86 | -0.45 | 0.4 | 41.8 | -1.2 | -19.0 | -20.2 |
| Food Waste | NA | -0.13 | NA | 287.4 | NA | -36.9 | -36.9 |
| PET | -1.04 | 1.27 | 0.4 | 42.3 | -0.4 | 53.6 | 53.2 |
| Mixed Electronics | -0.79 | 0.39 | 1.6 | - | -1.2 | 0.0 | -1.2 |
| Aluminum Cans | -9.13 | 0.03 | 0.4 | - | -3.7 | 0.0 | -3.7 |
| Mixed Recyclables | -2.85 | -0.41 | - | 107.5 | 0.0 | -43.9 | -43.9 |
| Mixed MSW | NA | 0.02 | NA | 143.7 | NA | 3.1 | 3.1 |
| Total | | | 28.8 | 638.9 | -88.0 | -50.9 | -138.9 |

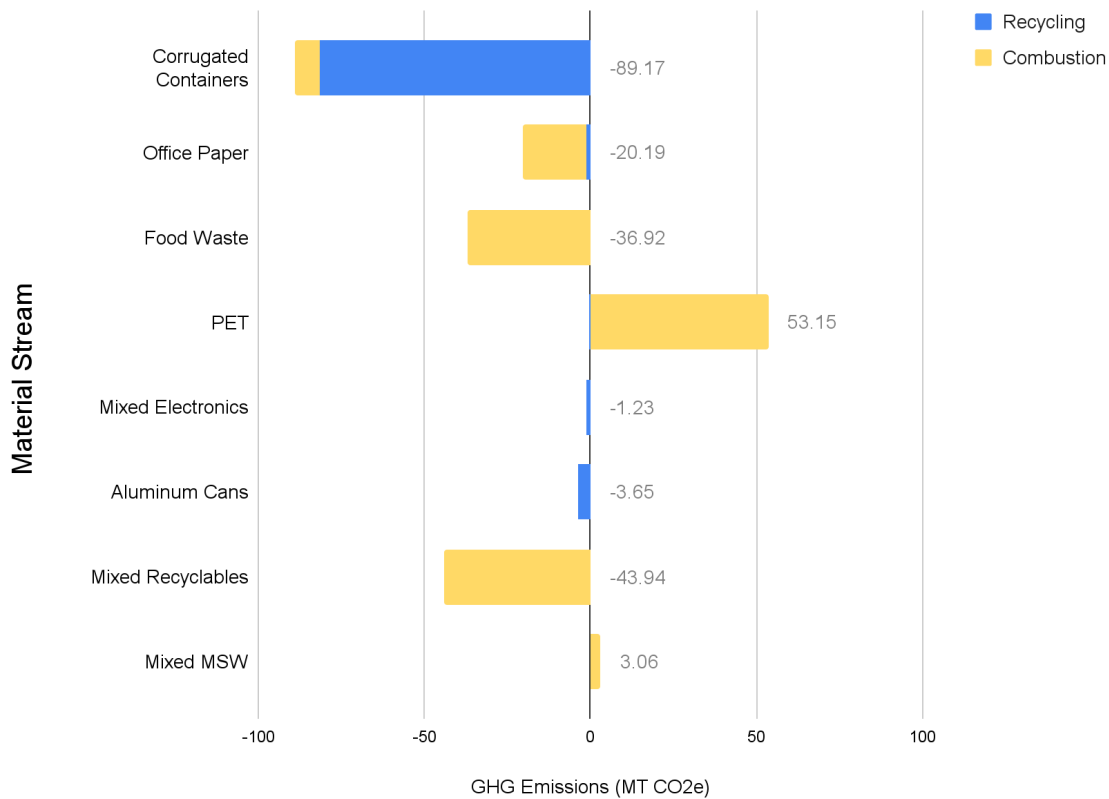


Figure 5: End-of-life emissions by solid waste material generated at Tropicana Field during the Rays 2019 season. Waste generated at Tropicana Field is recovered at a recycling facility or combusted at a WTE facility

6.1.1.5 Fan Transportation

GHG emissions from fan transportation account for 70.5% of the Rays’ estimated carbon footprint. Emissions are a function of transportation mode (and the corresponding emissions intensity of that mode) and distance traveled. Transportation mode and distance traveled for all fans was estimated using fan survey responses and scaled to total season attendance. Various efforts to clean data are detailed in Section 10.1.5.2 but, critically, the survey did not provide “airplane” as an option for travel mode. Our team assumed that fans traveling beyond 450 miles one-way to the stadium flew. **Figure 6** and **Table 10** show the percentages from air travel in addition to all modes included in the survey, according to our assumptions. It is likely that some fans used multiple transportation modes to get to the game, particularly if they used a mode that would not have taken them all the way to the stadium (i.e. airplane or train); however, due to limited survey data, we assumed all travel was by the single mode indicated on the survey (or assumed). For more details on methodological assumptions, see Section 10.1.5.6.

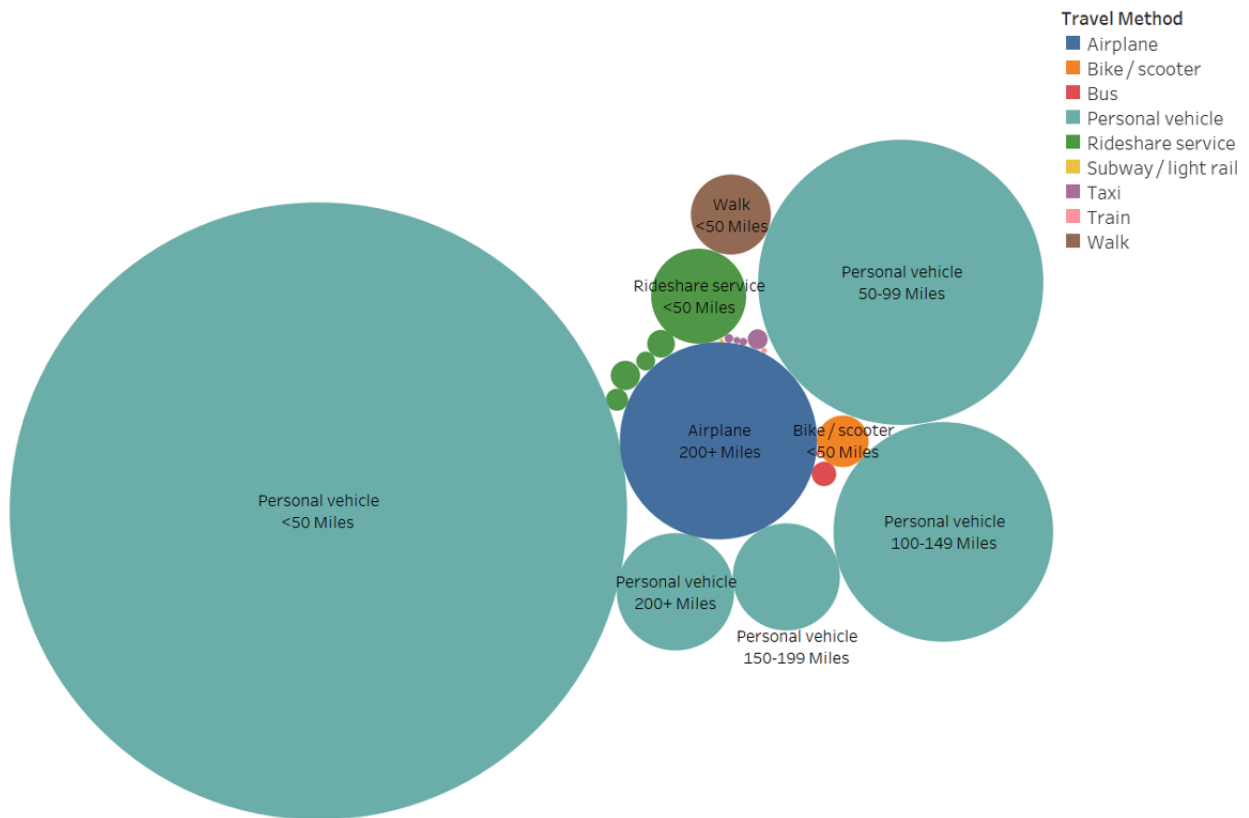


Figure 6: Distribution of fan transportation modes used, separated by distance traveled (<50 miles, 50-99 miles, 100-149 miles, 150-199 miles, and 200+ miles). Each color corresponds to a different travel mode. Bubble size corresponds to the relative number of fans that utilized that transportation mode. The largest combinations of transportation mode and distance are labeled

We estimated that 90% of fans (more than one million people when scaled up from survey responses) traveled to Tropicana Field by personal car (**Table 10**); as a result, 74% of the estimated GHG emissions from fan transportation are believed to be due to driving personal vehicles to the stadium. While only a small percentage of fans are estimated to travel via airplane (6.5%), this has an outsized impact on GHG emissions mostly due to the long distance of airplane trips, accounting for 24% of the footprint (**Table 10**). The remaining modes of transportation are used by very few fans to get to Tropicana Field and, as such, total emissions from those are miniscule by comparison.

Table 10. Summary fan transportation statistics and emissions. Includes attendee modes of transport (by percent), total attendees by mode, average trip length, and GHG emissions by mode

| Mode of Transport | Percent of Attendees Using Mode | Attendees | Average Roundtrip (Miles) | Emission Factor (kg CO2e/unit) | Units | CO2e (kg) | Percent of Activity Footprint |
|-------------------------------------|---------------------------------|------------------|---------------------------|--------------------------------|-------|-------------------|-------------------------------|
| Airplane | 6.5% | 76,800 | 590 | 0.13 | p-m | 5,970,000 | 23.6% |
| Car / personal vehicle | 89.8% | 1,060,000 | 97 | 0.41 | v-m | 18,600,000 | 73.6% |
| Rideshare service (e.g. Uber, Lyft) | 1.9% | 22,700 | 96 | 0.58 | v-m | 592,000 | 2.3% |
| Bus | 0.1% | 1,200 | 27 | 0.05 | p-m | 1,780 | 0.0% |
| Taxi | 0.1% | 1,150 | 87 | 1.62 | v-m | 85,600 | 0.3% |
| Train | 0.0% | 60 | 2080 | 0.15 | p-m | 19,000 | 0.1% |
| Subway / light rail | 0.0% | 30 | 35 | 0.11 | p-m | 113 | 0.0% |
| Bike / scooter | 0.4% | 5,240 | 4 | 0.00 | p-m | 0 | 0.0% |
| Walk | 1.1% | 12,600 | 2 | 0.00 | p-m | 0 | 0.0% |
| Total | 100.0% | 1,178,735 | 78 | 0.00 | | 25,300,000 | 100.0% |

Note: the number of attendees for each mode (scaled from survey response) does not add to total season attendance due to rounding

In **Table 10**, units for emission factors are kg CO2e/p-m (passenger-mile) and kg CO2e/v-m (vehicle-mile). Vehicle-miles refer to the number of miles the vehicle travels while passenger-miles refer to the number of miles each passenger travels; for example, a train carrying two passengers a total distance of one mile has traveled one vehicle-mile or two passenger-miles. Emissions from mass transportation modes are expressed per passenger-mile so the emissions can be evenly distributed between passengers based on average occupancy rates. Average mileage for airplane travel is the average attributable to the Tampa Bay Rays when factoring in multi-day stays in the region. The actual airplane travel mileage was higher. As described in Section 10.1.5, Fan Transportation Detailed Methodology, average stays in the region are 3.5 days. Therefore, we allocated emissions equivalent to 1 day out of 3.5 days, or 28.6%, of total emissions associated with air travel to the Rays. Section 10.1.5 also describes how emission factors were derived for the car/personal vehicle, rideshare service, and taxi modes. The average mileage for train travel comes from a single data point, the only survey response that selected the train as the transportation method.

GHG emissions from cars and personal vehicles alone account for nearly 52% of the season’s total footprint, more than triple any other activity area (**Figure 7**). Likewise, the portion of fan airplane-related emissions attributed to the Rays’ games account for almost 17% of the season’s total footprint, making it the second-largest emissions driver for the Rays overall (**Figure 7**).

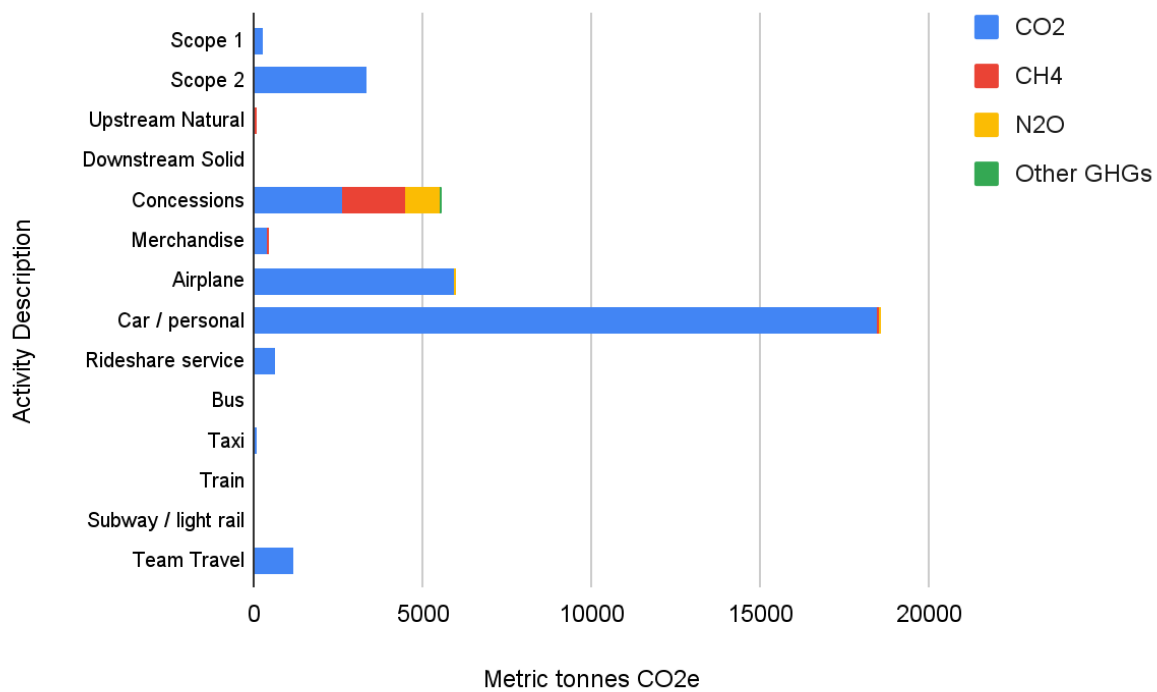


Figure 7: Emissions from fan transportation modes compared to other activity areas. Bike/scooter and walk modes are excluded because they are assumed to generate zero emissions (see Section 10.1.5.6 for details)

As expected, different transportation modes and distances traveled resulted in different roundtrip emissions per person (**Figure 8**). 67% of fans visiting Tropicana Field travel less than 50 miles (one-way), but only produce 26% of total emissions from their trips. The 33% of fans that travel over 50 miles (one-way) to the stadium are responsible for 74% of emissions from fan transportation (**Figure 8**). Thus, the distance traveled has a strong influence over emissions generated.

The survey responses revealed that most fans traveled to the stadium with friends, family, or colleagues. However, the survey data did not explicitly indicate the *number* of people traveling together, so we assumed one additional passenger per category selected (for more details, see Section 10.1.5.6). 87% of fans traveled in groups of two or three (**Table 11**). Vehicle occupancy was shown to significantly impact GHG emissions per passenger because the EPA emission factors for the car/personal vehicle travel method (which assumed an occupancy rate of 1.8 passengers) are based on vehicle-miles rather than passenger-miles (U.S. EPA, 2021a). Therefore, the total emissions for car travel depended on the number of vehicles traveling rather than the number of passengers. Carpooling to games resulted in reduced emissions by displacing additional vehicle trips.

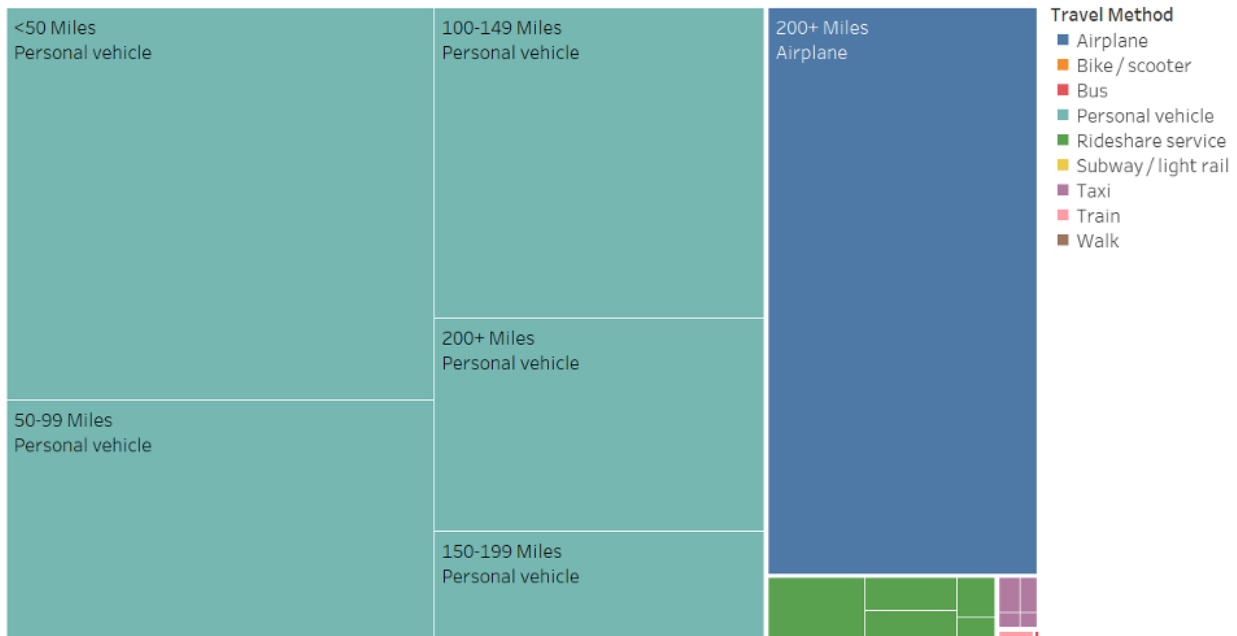


Figure 8: Comparison of emissions by transportation mode, separated by one-way distance. Box color corresponds to travel method. Box size corresponds to the relative amount of emissions for that mode-distance combination

Table 11. Vehicle occupancy rates from survey responses (all transportation modes)

| Fans Traveling Together | Number of Fans | Percentage of Total Attendance |
|-------------------------|----------------|--------------------------------|
| 1 | 1,200 | 3.1 |
| 2 | 23,100 | 59.4 |
| 3 | 10,800 | 27.7 |
| 4 | 3,500 | 9.1 |
| 5 | 245 | 0.6 |
| 6 | 12 | 0 |

6.1.1.6 Team Travel

Team travel accounted for 3.22% of the Rays’ estimated carbon footprint. GHG emissions for team travel are driven almost exclusively by airplane travel, accounting for 97% of the emissions associated with the category (**Table 12**). The flights between the East and West Coast of the United States were the five longest flights that the team took during the 2019 season and, consequently, the flights with the largest carbon footprint (**Table 13**). Emissions from these five flights alone totaled 400,000 kg CO₂e, or 28% of the total emissions associated with team travel.

Table 12. Team travel GHG emissions by type of travel activity generating emissions

| Emissions Source | Emission Factor (kg CO2e/unit) | Units | CO2e (kg) | Percent of Activity Footprint | MLB Team Data Used |
|--------------------|--------------------------------|-------------|-----------|-------------------------------|--------------------|
| Air Transportation | 0.13 | p-m | 1,120,000 | 97% | Tampa Bay Rays |
| Rental Cars | 0.46 | v-m | 20,800 | 2.0% | New York Mets |
| Hotels | 38.2 | hotel-night | 11,700 | 1% | New York Mets |
| Total | | | 1,150,000 | 100% | Combined |

EPA provides emission factors per passenger-mile (p-m) for medium-haul air travel and buses, and per vehicle-mile (v-m) for passenger cars and light-duty trucks. See Section 10.1.6 for an explanation of how the emission factor for rental cars and hotels were calculated.

Table 13. Flights with the largest carbon footprint, i.e flights between the East and West Coast

| Date | City | Estimated Mileage | CO2e (kg) |
|--------------|----------------------------|-------------------|-----------|
| 6/20/19 | Oakland (from NYC) | 2,580 | 93,000 |
| 8/9/19 | Seattle (from Tampa) | 2,520 | 91,000 |
| 4/5/2019 | San Francisco (from Tampa) | 2,390 | 86,400 |
| 9/20/19 | Tampa Bay (from LAX) | 2,160 | 66,100 |
| 8/16/19 | Tampa Bay (from San Diego) | 2,090 | 63,900 |
| Total | | | 400,300 |

6.1.1.7 Concessions

Our analysis found that the Ray's concessions purchasing ultimately accounted for 15.5% of the Rays' estimated carbon footprint. Analysis was done using the spend-based method described in the concessions detailed methodology, Section 10.1.7. Results are aggregated by commodity economic sectors. The economic sectors are the aggregated Bureau of Economic Analysis (BEA) sectors included in the EPA's Environmentally-Extended Input-Output tables (see Section 10.1.7 for further detail). Results show that the concessions carbon footprint is dominated by emissions from the packaged meat and poultry sectors – equivalent to about 50% of the total concessions footprint. Of the 70 commodity sectors included in our analysis, the top ten commodities with the largest carbon footprint account for 83% of the carbon footprint from the concessions purchased and 66% of total spend (**Table 14**). Five of the top ten commodities are animal products, including seafood. Beer is the second largest (9.2%) after packaged meat excluding poultry (41.7%).

Using a spend-based method means there is a direct relationship between spend on purchases and quantity of emissions. There is also a direct relationship between emissions intensity of the commodities and quantity of emissions. We grouped the 70 BEA economic sectors analyzed into

approximately 20 general categories and compared spend and emissions intensity of the categories to understand if commodities that contributed a lot to the carbon footprint from concessions were because they constituted a large portion of spend, because they are carbon-intensive, or both. We found that animal products have a high emissions intensity relative to other categories analyzed while alcoholic beverages represent a large portion of total spend but have a low emissions intensity (**Figure 9**).

Non-food items such as the materials and containers used to prep, cook, and serve food, which are included in this footprint, only accounted for a total of 3.7% of the carbon footprint from concessionaire purchasing despite accounting for 10.8% of total purchasing. Emissions from non-food purchases were largest from paper bags and coated paper, rubber and synthetic fibers, and plastics.

Table 14. Top ten commodities purchased for concessions with largest carbon footprint

| Commodity Name | Percent of Spend | Commodity Emission Factor (kg CO2e/2018 USD Producer Price) | CO2e (kg) | Percent of Activity Footprint |
|---|-------------------------|--|------------------|--------------------------------------|
| Packaged meat (except poultry) | 13.9% | 2.17 | 2,310,000 | 41.7% |
| Breweries and beer | 15.6% | 0.43 | 508,000 | 9.2% |
| Packaged poultry | 5.6% | 0.97 | 419,000 | 7.6% |
| Seafood | 9.2% | 0.45 | 317,000 | 5.7% |
| Cheese | 1.6% | 1.76 | 214,000 | 3.9% |
| Soft drinks, bottled water, and ice | 9.0% | 0.3 | 206,000 | 3.7% |
| Dairies | 1.0% | 2.64 | 203,000 | 3.7% |
| Distilleries and spirits | 5.3% | 0.43 | 174,000 | 3.1% |
| Fresh vegetables, melons, and potatoes | 3.2% | 0.59 | 146,000 | 2.6% |
| Tobacco, cotton, sugarcane, peanuts, sugar beets, herbs and spices, and other crops | 1.6% | 0.95 | 118,000 | 2.1% |
| Other | 33.9% | 0.047-2.64 | 923,000 | 16.7% |
| Total | 100.0% | NA | 5,540,000 | 100.0% |

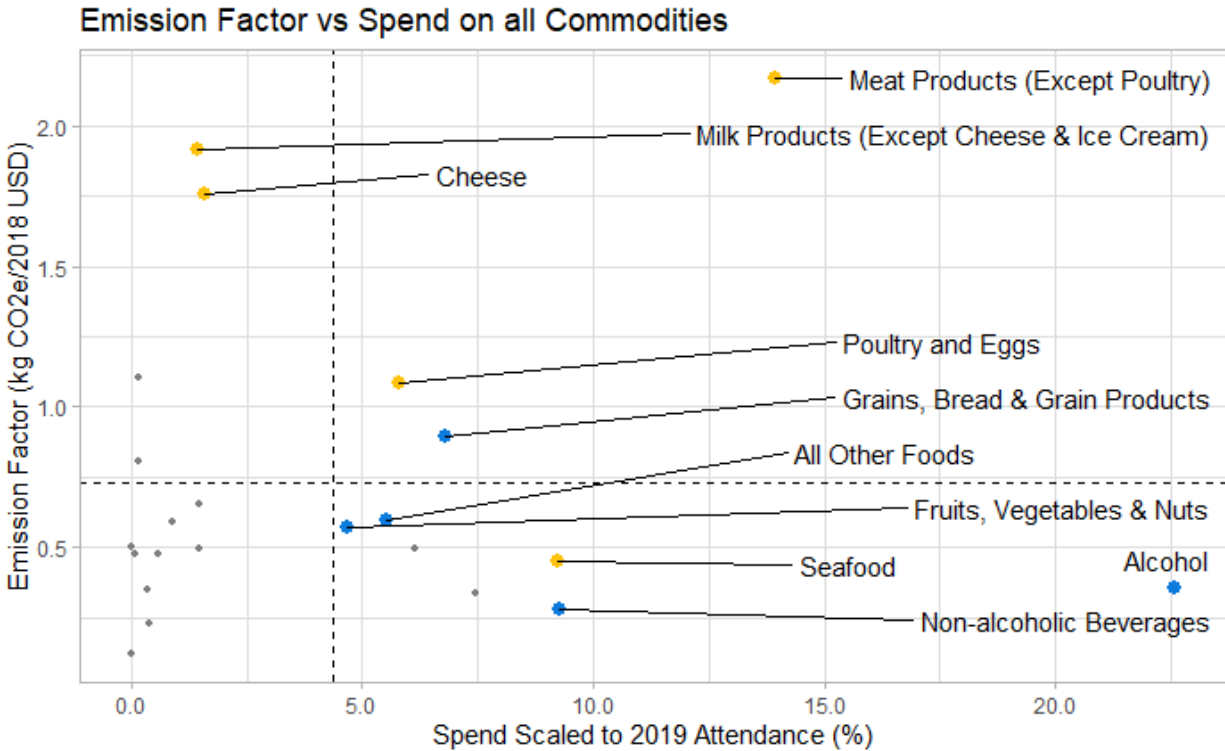


Figure 9: Emission factor of each commodity purchased for concessions compared to the percentage of total purchasing dollars spent on each commodity. Total purchasing dollars is in consumer prices, scaled to the 2019 season and adjusted for inflation. Dashed lines indicate the average emission factor of all commodities and the average percentage of total purchases of all commodities. The top ten commodities in terms of total GHG emissions are labeled. Orange labels are animal products and blue labels are non-animal products

6.1.1.8 Merchandise

Cradle-to-gate emissions for merchandise account for 1.19% of the Rays’ estimated carbon footprint. However, it should be noted that data for merchandise only included information on the top 25 items sold in terms of quantity and the top 25 items sold in terms of revenue, for a total of 41 unique items. The spend-based analysis of emissions from merchandise finds 89.8% of merchandise emissions were from merchandise categorized as clothing which included the mystery “grab bags” sold by the Rays (**Table 15**). Mystery grab bags typically contain clearance apparel with outdated logos or players that no longer play for the Rays. They are sold at a standard price (\$20) regardless of the contents of the bag (see Section 10.1.8 for further detail on mystery grab bags). Using the spend-based method, results are correlated with both quantities of product sold as well as price at which the product was sold. This correlation shows up at the product level, where the single most GHG-intensive item, the mystery grab bag, was also the best-selling item in 2019, and the second most GHG-intensive item was the special commemorative jersey, the most expensive and least-sold item of all merchandise analyzed (**Figure 10**). Again, note that emissions are an underestimate since they only represent 41 merchandise items sold by the Rays.

Table 15. GHG emissions from merchandise by BEA economic sector

| Commodity Name | Commodity Emission Factor (kg CO ₂ e/2018 USD) | CO ₂ e (kg) | Percent of Activity Footprint |
|--|---|------------------------|-------------------------------|
| Clothing | 1.97 | 392,000 | 89.8% |
| Sporting and athletic goods | 0.72 | 24,100 | 5.5% |
| Paper bags and coated paper | 0.54 | 15,700 | 3.6% |
| Other fabricated metal manufacturing | 0.47 | 1,160 | 0.3% |
| Other plastic products | 0.05 | 1,170 | 0.3% |
| Urethane and other foam products | 0.31 | 1,180 | 0.3% |
| Gaskets, seals, musical instruments, fasteners, brooms, brushes, mop and other misc. goods | 0.17 | 646 | 0.2% |
| Office supplies (not paper) | 0.52 | 517 | 0.1% |
| Total | | 437,000 | 100.0% |

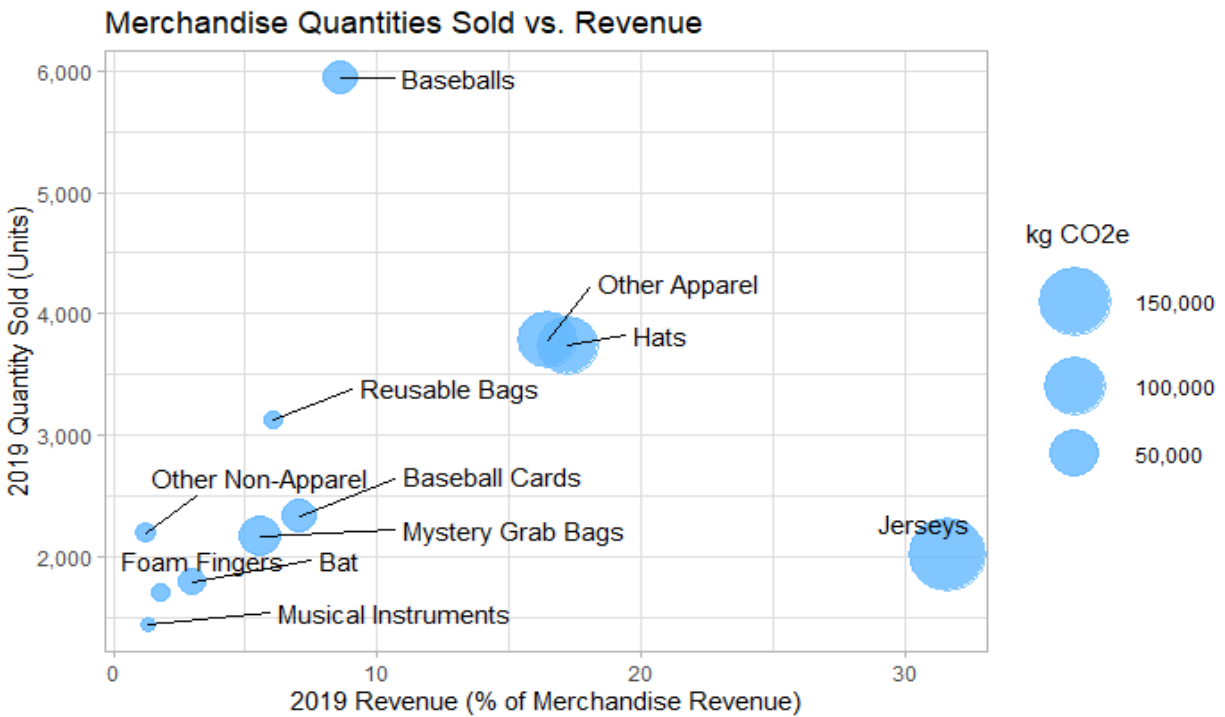


Figure 10: Percentage of merchandise revenue, quantities of merchandise sold, and estimated

emissions of all merchandise products, grouped by type of item. The x-axis shows percentage of merchandise revenue for each product type, the y-axis shows quantity sold of each item. Size and color are correlated with total GHG emissions where dark and large represent larger emissions and small and light colors represent smaller emissions

6.2 Onsite Water Use Results

We estimated the onsite water attributed to usage in various end-use categories, excluding any embodied water (**Table 16**). Data constraints limited the ability to allocate onsite water consumption across categories, resulting in an “Other” category constituting the majority of onsite water (**Figure 11**); however, we have insights into the breakdown of what is broadly included in the “Other” category and what may be driving a large portion of water consumption at Tropicana Field (**Figure 16**) (details in Section 10.2.4). Water consumed by the cooling tower constitutes the majority of the “Other” category.

Table 16. Water usage attributed to each end-use category

| End-Use Category | Water Usage (gallons) | Percent of Total Footprint |
|---|------------------------------|-----------------------------------|
| Restrooms | 3,760,000 | 35.4% |
| Field Use | 66,400 | 0.6% |
| Other (cooling tower, grandstand washing, washing machines, clubhouse showers, leaks) | 7,170,000 | 64.0% |
| | | |
| Total Annual Consumption | 11,000,000 | 100% |

Total Known Rays Water Usage

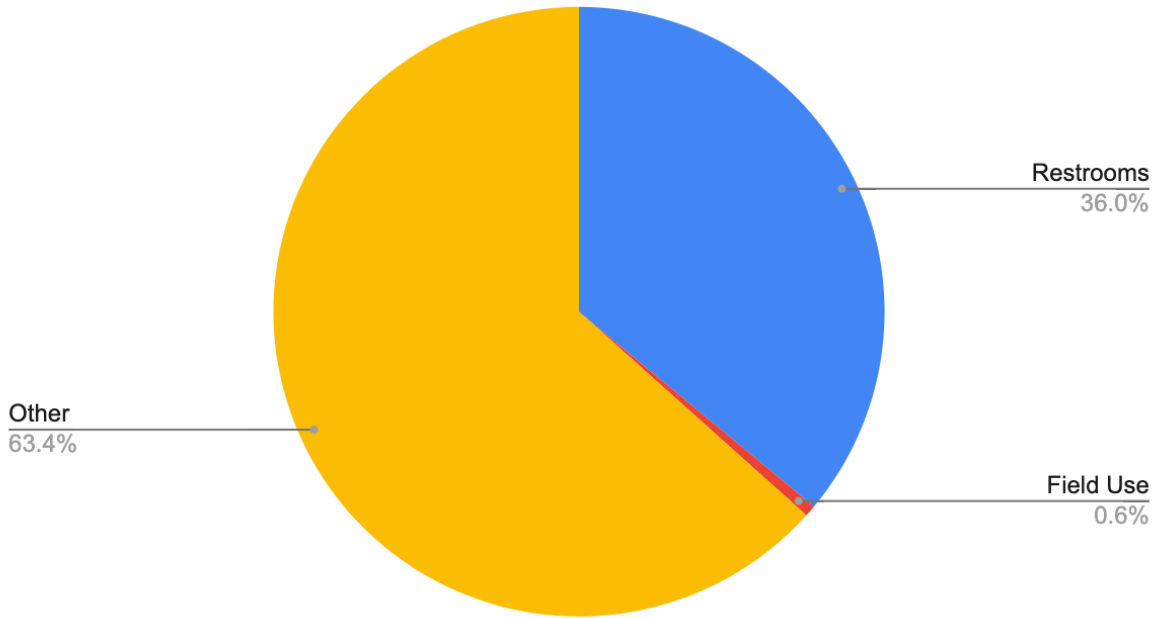


Figure 11: Water usage for end-use categories where we had first-hand data

Total Estimated Rays Water Usage

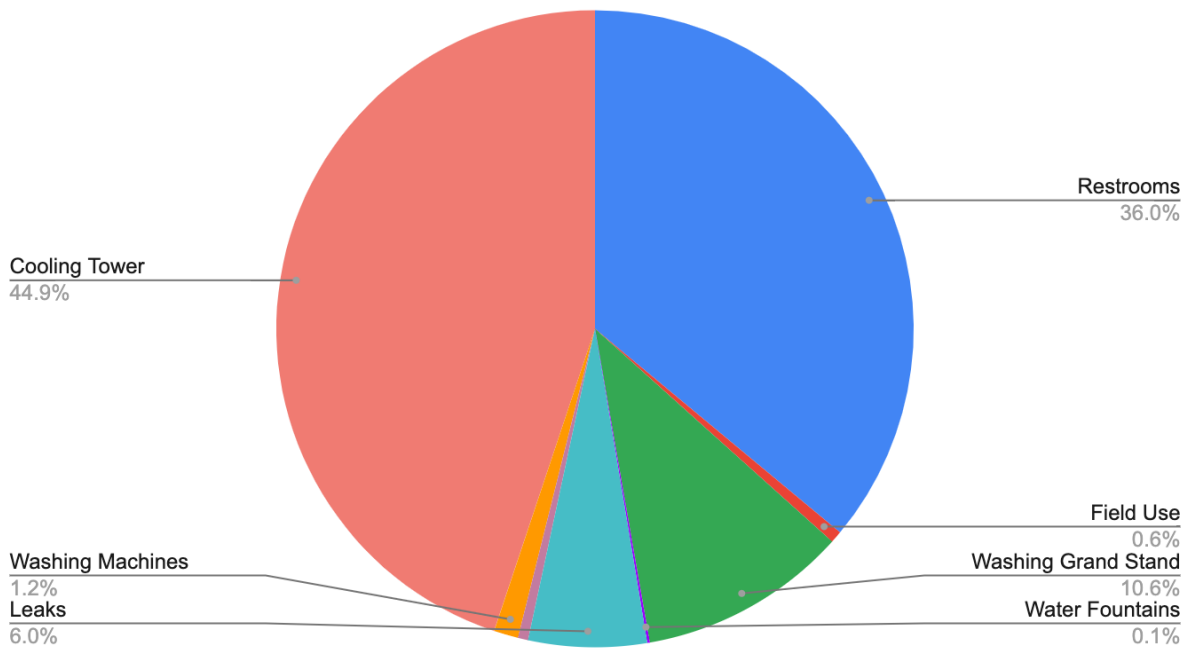


Figure 12: Onsite water usage by end-use category, including areas where we used estimates to break down the “other” category described in **Figure 11**

7. Discussion

This discussion is focused on understanding key findings from our results, addressing limitations, and providing brief recommendations for improvement. However, detailed recommendations to reduce environmental impact are provided in Section 11 of this report. With their indoor-only stadium, turf field, and isolated geographic location, the Rays are one of the most atypical teams in baseball, which makes comparing assessments of other organizations to the Rays' estimated carbon footprint and onsite water usage difficult; therefore that is not a focus of this section.

Our estimated carbon footprint revealed that fan transportation was the most significant source of GHG emissions, and that long-distance personal vehicle travel was the emissions driver for this activity. Our analysis showed that concessions were the main contributor to GHG emissions, and animal products were the largest source of emissions. Within each GHG-emitting activity quantified in our estimated carbon footprint, we were able to identify potential emission drivers and our recommendations aim to mitigate these hotspots more specifically (see Section 11). In our analysis of onsite water usage, data limitations hindered our ability to pinpoint the exact quantity of water consumed by each end-use category; however, estimations from literature were used to gain insights and we conclude that the cooling towers were responsible for the majority of the water consumed at Tropicana Field.

Our results provide focus and clarity should the MLB choose to focus sustainability initiatives on reducing GHG emissions. Considering fan transportation is overwhelmingly the largest contributor to the Rays' carbon footprint and this result likely can be extrapolated to the broader MLB community, we recommend engaging fans and MLB teams on this issue if they want to tackle climate change. Currently, sustainability metrics used by MLB have a large focus on waste reduction. This is demonstrated by the Green Glove Award, which is given to the team with the highest waste diversion rate (Baseball Almanac, n.d.). If the Rays, and MLB at large, want to prioritize initiatives that reduce GHG emissions, fan transportation presents the largest opportunity.

The largest limitation of our study was related to data availability. In particular, while all utilities are metered by the utility provider, the main meter for any one utility does not provide information about where the resource gets used; sub-meters installed in strategic locations "behind" the main meter fill these information gaps. Without access to sub-metered data or supplier-specific data, our calculations required estimations that limited precision of our results. Additionally, while evaluating GHG emissions and onsite water usage is a valuable contribution to our clients and the MLB at large's efforts toward sustainability, limiting our study to a carbon footprint and onsite water use evaluation, neglects consideration of other environmental impacts of stadium operations and team activities such as those resulting in local air pollution, eutrophication, or ecotoxicity.

The following discussion sections detail emissions hotspots, or areas responsible for the majority of emissions, for each of the eight activities included in our carbon footprint and discusses limitations in analysis. Additionally, the different components of onsite water use and limitations in analysis are discussed in Sections 7.1.9.

7.1 Carbon Footprint and Onsite Water Use

7.1.1 Scope 1 Emissions

Our results indicate that 93% of Scope 1 emissions were from combustion of natural gas. Combustion of gasoline and diesel accounted for 5% and 2% of the remaining Scope 1 emissions, respectively. As noted earlier, we know many facilities, such as AEG venues and SoFi Stadium, calculate Scope 1 emissions; however, it is difficult to find organizations willing to publicly report their emissions (*AEG's 2018 Sustainability Report*, 2018; “SoFi Stadium: Sustainability,” n.d.). However, to put the Rays’ Scope 1 emissions into context, we had access to total Scope 1 emissions from the NHL and total natural gas usage for Citi Field (home of the New York Mets) and Coors Field (home of the Colorado Rockies); we understand there are differences between the NHL, these other two MLB teams, and the Rays, but feel this is the best available data for comparison. Dividing the total NHL Scope 1 emissions (25,530 metric tonnes of CO₂e in FY2016) evenly between the 30 teams in the league equates to 850 metric tonnes of CO₂e in Scope 1 emissions per team (NHL, 2018). If we assume these teams, like the Rays, also use 61% of total natural gas usage during the season, this equates to 520 metric tonnes of CO₂e per NHL team per season, which is approximately 2.5 times larger than the Rays’ Scope 1 emissions. If we assume Citi Field also uses 61% of natural gas during the season, Citi Field uses more than five times the natural gas that Tropicana Field uses in a season. Oppositely, Coors Field uses one third of the amount of natural gas used at Tropicana Field during a season. These differences could be explained by variations in equipment using natural gas, climatic differences, and variation in stadium capacity and total attendees, but ultimately still provide some context for our results. Without sub-metered data available, it was not possible to quantify the largest sources of natural gas use at Tropicana Field or at peer facilities. However, at Citi Field, water heating accounts for 75% of the total natural gas usage and cooking appliances account for 25% of total natural gas usage.

Although gasoline combustion only accounted for 5% of Scope 1 emissions, the Rays could consider EV vehicles rather than gas-fueled trucks for their personal fleets. This could potentially be a very visible initiative to fans, increasing fan engagement on climate change-related initiatives.

Limitations

As described in Section 10.1.1, our methodology required estimating the percentage of total diesel consumption used by an emergency generator, hand-held lawn equipment, and off-road vehicles. This estimate was done using a first-hand account from Rays personnel due to a lack of records on diesel usage. Further, the lack of sub-metering of natural gas uses prevented us from determining precisely which activities and appliances at Tropicana Field were responsible for the most natural gas usage in order to tailor recommendations to the team and facility.

It should be noted that our Scope 1 emissions evaluation did not include onsite refrigerant emissions leaking from cooling equipment. Although typically small in volume, these GHGs have large GWPs and thus should not be ignored (Albarbary et al., 2020). Unfortunately, our team did not have access to data related to refrigerants used onsite, refrigerant purchases, refrigerant leakages, or cooling equipment details, nor did we have adequate information to complete an estimation for this particular area.

7.1.2 Scope 2 Emissions

Our results indicated that Scope 2 (purchased electricity) emissions from Tropicana Field were 3,320 metric tonnes of CO₂e, approximately 9% of the total estimated carbon footprint. The emissions intensity of purchased electricity depends on the regional electric grid mix, thus a comparison of teams in different regions would not be appropriate. We can, however, compare total electricity *usage* between teams for which we received data. For reference, Coors Field used 21% more kWh and Citi Field used 61% more kWh than Tropicana Field during the 2019 season. Reasons for the reduced electricity use may include the stadium's smaller capacity, as the stadium closes off the upper deck during the regular season, eliminating approximately 18,000 seats. Additionally, there are fewer non-MLB events held at Tropicana Field during the season relative to some other stadiums.

Limitations

Without sub-metered data on percent breakdown by activity, or, alternative proxy data, such as the 2018 Commercial Buildings Energy Consumption Survey (this dataset was not available at time of carbon footprint quantification (U.S. Energy Information Administration, 2021)), we could not identify likely large sources of electricity consumption. We recommend that the Rays perform an energy audit and/or install electric sub-meters to better understand what consumes electricity onsite. We would then recommend that the Rays pursue energy efficiency upgrades and look into renewable energy procurement options to reduce reliance on the fossil fuel-intensive Florida electric grid. See Section 11.1 for more detail on recommendations related to stadium energy usage.

7.1.3 Upstream Natural Gas and Upstream Water

Emissions from upstream natural gas and upstream water treatment totaled 52 metric tons CO₂e, 0.14% of the carbon footprint. Notably, 46% of the emissions associated with upstream impact of natural gas were from CH₄, a much more potent GHG than CO₂, reflecting growing concern with the impact of methane leakage in natural gas extraction and distribution (Palmer, 2022). 96% of emissions in this category were attributable to the upstream impact of natural gas while only 4% were attributable to water treatment.

Limitations

Limitations of our methodology included using national average defaults in the GREET model to estimate upstream impact of natural gas as opposed to information on the natural gas sources available to the Florida region; this choice was made because there is no Florida-specific data in the GREET model. The Rays have minimal control over emissions associated with these utilities beyond reducing natural gas and water consumption; however, reductions in these areas could also have cost savings, making it a more appealing investment.

7.1.4 Downstream Solid Waste

Waste generated at Tropicana Field is either combusted at a waste-to-energy (WTE) facility in St. Petersburg, which helps offset emissions from the Florida grid, or, recycled, which offsets emissions associated with virgin material production. These offsets result in a small emissions credit for the Rays, meaning that the team's current downstream solid waste management reduces its total estimated carbon footprint. Utilizing WTE facilities does not always generate an

emissions credit; it is dependent on the make-up of the waste sent to the facility and the make-up of the electrical grid being offset. In the Rays' case, waste high in organic materials and recycling of cardboard generate enough emissions credit to offset the fossil fuel-heavy Florida electric grid.

While waste did not add to the overall footprint, it is still a topic our clients expressed interest in understanding better. Our analysis points to the combustion of PET (plastic that is typically recyclable) as the greatest source of emissions within downstream solid waste. PET combustion could be mitigated by the implementation of better waste diversion strategies inside the stadium such as recycling infrastructure improvements and overall plastic reduction strategies; see Section 11.3 for additional details on mitigation recommendations.

Downstream solid waste management can become a large source of methane emissions for a company when sending material, especially organic material, to landfills (U.S. EPA, 2016b). Since the Rays do not send material to landfills, this is not an emissions driver for them. However, WTE facilities are not without criticism; although they may offset GHG-intensive emissions from the grid, WTE facilities can result in local air pollution (often in underrepresented communities) and produce toxic ash (Rosenberg et al., 2021), which we did not evaluate in our study.

Limitations

The U.S. EPA's WARM Model was used to analyze the Rays' waste-related GHG emissions, which requires information on the facility's waste profile (i.e., tons of material attributed to organics vs. tons of material attributed to recyclable materials). As our data from the Rays did not include a comprehensive waste profile, we relied on supplemental research for our calculations. While there are likely significant differences between the concessions and other materials used onsite for Tropicana Field and T-Mobile Park (home of the Seattle Mariners), the Mariners were the only team we found to have publicly available waste audit data; we used this data to approximate the waste profile for Tropicana Field. Even without Rays-specific waste audit data to approximate the waste profile of Tropicana Field, there would likely still be an emissions credit because the Rays utilize a WTE facility. The magnitude of this credit is dependent on the proportion of PET relative to the rest of the stadium waste; thus if PET is a larger proportion of total waste, the emissions credit would decrease relative to our baseline assumption.

An additional issue arises considering that our carbon footprint only partially accounts for production of materials, but is taking credit for waste management of *all* materials. Specifically, we have accounted for the production of concessions and merchandise. Although unconsumed food and likely some merchandise is thrown away at Tropicana Field, other materials thrown away like shipping materials, janitorial products or training equipment, were not quantified cradle-to-gate. Our waste methodology results in the Rays earning GHG emissions credits for these materials without taking into account the GHG emissions associated with producing these materials, subsequently underestimating the Rays' total carbon footprint. As detailed in Section 10.1.4.2, we estimate that emissions associated with purchased goods and services could be more

than 150% greater than estimated in our analysis. Future studies should aim to more comprehensively assess the impact of the production of all materials entering the stadium.

7.1.5 Fan Transportation

Our estimated fan transportation emissions dwarfed all other activity areas – representing about 70% of the estimated carbon footprint. While the magnitude of a fan transportation footprint can vary from one stadium to the next, due to availability of public transportation and stadium location, this result aligns with previous studies that have included fan transportation in a stadium carbon footprint (Dolf and Teehan, 2015; Edwards et al., 2016). Factors that determine emissions from fan transportation are travel mode, distance traveled, and vehicle occupancy. Our results suggest that car and air travel generated the most emissions due primarily to the number of fans who took cars and the long distances associated with flights. We note that, on a passenger-mile basis, personal vehicles on average produce fewer emissions than ride-hailing vehicles (Anair et al., 2020; Henao and Marshall, 2019) and carpooling significantly reduces emissions from car travel by displacing additional vehicle trips. The biggest opportunities for reducing transportation emissions are decreasing long-distance travel, increasing car occupancy, and encouraging adoption of low-emission transportation modes (Albarbary et al., 2020; Dolf and Teehan, 2015).

The main contributor to the Rays' 2019 season fan transportation carbon footprint is car travel; in particular, low occupancy car travel, and long-distance travel represent the bulk of emissions per person. 90% of Rays fans rode in a personal car to the stadium. Only 33% of fans traveled over 50 miles one-way (using any transportation mode), but were estimated to have produced 74% of the emissions. Although it may be tempting to jump to the conclusion that air travel is the culprit of long-distance travel emissions, flying can be a less GHG-intensive transportation mode than driving long-distance depending on the distance, type of plane, and the car's occupancy (Sunkara, 2021). Compared to a long-distance trip in a gas-powered car, flights take more efficient travel paths (a straight line) and generate relatively low emissions per passenger-mile due to the large capacity of the airplane. The more people ride in a car together, the lower the emissions per passenger-mile. Unless an average gas-powered car carries three or more passengers, the total emissions per passenger will be greater for the car travelers than for an equivalent number of air travelers on an average plane traveling over 300 miles (medium- and long-haul flights) with average occupancy (U.S. EPA, 2021a). If all of the fans who flew to the stadium (fans were assumed to have flown when one-way ground-travel distances exceed 450 miles) had instead driven personal vehicles, the total emissions from fan transportation would have *increased* by 14.12%; this increase in emissions would correspond to a 9.88% increase to the estimated total carbon footprint for the 2019 season. This comparison is not to say that flying is always a better option; this analysis hinges on our assumption that all fans visiting from out-of-town stay in town for 3.5 days, regardless of travel mode. Allocating the emissions from out-of-town travel more accurately would require knowing precisely how many days each fan spends in town; our fan transportation survey (Section 13) includes a question to obtain this information.

Despite their popularity, taxis or rideshares can often be less efficient than personal vehicles because the trips using the former include added emissions associated with cruising, idling, or deadheading (the miles driven en route to a passenger) (Anair et al., 2020; Henao and Marshall,

2019). We estimate that switching from a taxi or rideshare to personal vehicles would reduce fan transportation emissions by 0.96%; recommendations provided (Section 11.4) could incentivize this switch. The most desirable outcome is to have fans switch from taxi or rideshare to modes of transportation with the lowest emission factors: public transportation, e-bikes and e-scooters, human-powered bikes and scooters, or walking. Potential strategies to promote these fan behavioral changes are outlined in Section 11.4.

Carpooling also shows strong potential to reduce emissions from car travel. Because cars emit about the same amount of emissions regardless of whether the car has one passenger or more, total transportation emissions decrease by increasing the occupancy of each car while simultaneously displacing additional vehicle trips. However, in the interest of reducing emissions below the baseline estimation, carpooling initiatives must be focused on additionality – *increasing* carpooling where it was not occurring before. For instance, a family that always travels to the game together would not reduce additional emissions, but friends who ordinarily drive separately to the stadium would reduce additional emissions by carpooling; this idea is discussed in more detail in Section 11.4.

With these insights, we arrive at similar conclusions to previous studies – decreasing long-distance travel, increasing car occupancy, and encouraging low-emission transportation modes offer the greatest opportunities for reducing transportation emissions (Albarbary et al., 2020; Dolf and Teehan, 2015). However, the disparity between distance traveled and emissions contribution begs the question – should long-distance fan travel be effectively targeted for interventions or should “local” fans be the targets of sustainable transportation campaigns? We posit that interventions focused on local travel will be more effective because 1) these fans are more likely to attend games repetitively, thus behavioral change will have a more sustained impact, 2) these fans have a higher likelihood of being influenced by local and regional informational campaigns related to sustainable transportation (McCullough and Kellison, 2016) and 3) the more games fans attend, the more exposure they will have to team or stadium based initiatives, and thus the more likely they will try something new, such as public transportation, or participation in low-carbon transportation events such as a “bike-to-the-game” day.

Limitations

The fan transportation emissions estimate was limited by data availability and quality. Since the transportation-focused questions from the MLB post-game survey were not created with the intention of calculating emissions, they elicited ambiguous information requiring numerous assumptions to quantify emissions (all assumptions are described in detail in Section 10.1.5.6). Most notably, we made assumptions about the number of people captured in the survey (based on *who* the respondent traveled with) and details related to long-distance and out-of-town travel. We believe the combination of assumptions used to estimate emissions were reasonable given the available information. Although we could reasonably quantify emissions from the MLB survey, we were not able to gain insights into fans’ willingness-to-participate in intervention strategies or responsiveness to different incentives. We thus plan to propose modifications to the MLB-wide survey as part of this project’s final deliverables (see Sections 12-13).

We acknowledge that fan transportation carbon footprints likely vary considerably from city to city. We were unable to access survey responses from other teams to evaluate how the Rays fan

base compares to that of other teams. Therefore, we can only quantitatively evaluate potential reductions due to interventions for the Rays (see Section 7.2 for further discussion on potential next steps and analyses to compare fan transportation impacts between teams). The recommendations we propose for the Rays can be applied to other teams (although specific interventions will be more or less effective depending on the city in which they are implemented).

Lastly, we used 2021 MLB survey results as a proxy for the 2019 season (the functional unit of this study), but this extrapolation does not account for potential COVID-related behavioral changes associated with transportation mode preferences; in June 2021, national public transportation ridership was still down nearly two-thirds from 2019 levels (Ramos and Tambe, 2021). However, when considering initiatives and interventions, 2021 transportation habits may be more relevant than 2019 habits, as it is unknown what effect COVID will have on long-term public transportation ridership and transportation preferences.

7.1.6 Team Travel

Our analysis suggests that GHG emissions from team travel were almost entirely from air travel (97%). The Rays fly more than most teams by virtue of their geographic location relative to other teams, especially within their division, the American League East. Within this division, most teams are located in the northeast; the Rays must travel over 840 miles to get to their closest division rival, the Baltimore Orioles. Our analysis showed that flights to and from the U.S. West Coast produce the most GHG emissions due to the exceptionally long distances.

The basic emissions reduction opportunities from fan transportation also apply to team travel with a few key differences. Professional sports teams tend to charter their own planes and buses, so all of the emissions from those vehicles are attributable to the team regardless of how many people are on board. However, if increasing occupancy reduces the number of vehicles required to transport the entire team, the team can reduce emissions by displacing additional vehicle trips. We received anecdotal information that most teams use multiple partially-filled buses. Consolidating team personnel onto as few planes/buses as possible will reduce total emissions by displacing additional vehicles. Apart from team flights and bus rides, players tend to transport themselves individually. Two potential options for emissions reductions are to encourage carpooling, cycling, or public transportation for individual short-distance travel and encouraging commercial flights over long car rides. In terms of passenger-miles, a single passenger in an average gasoline-powered car produces more emissions than a single passenger on a commercial flight with average occupancy.

Unlike fan transportation, team travel has a much greater capacity to reduce total travel distance. Road trips during the season are not currently optimized to reduce travel distance. Note that road trips refer to series of games at other teams' stadiums and involve all travel modes, although most travel occurs by airplane. Flights for multi-city road trips tend to zig-zag, adding unnecessary mileage and increasing travel time ("Air Miles Calculator," n.d.; Baseball Almanac, 2019). Furthermore, many road trips only include visits to one or two cities at a time, resulting in a lot of flights back and forth to St. Petersburg.

While there are simple, yet promising solutions for reducing teams' season-long travel distance, the team does not have complete control of travel. The league (with some input from the teams) creates the season schedule. Therefore, the league would be responsible for reorganizing the schedule to optimize road trips. This could be accomplished by increasing the number of cities visited on each road trip and scheduling subsequent series such that travel from one city to the next occurs along a circular path rather than a zig-zag path. We explore the emissions reduction potential of these recommendations in greater detail in Section 11.6.2. The region-specific game schedule implemented during the COVID-shortened 60-game season in 2020 showed promising results for emissions reductions across the league from strategic changes to the game schedule (Wynes, 2021). Between the 2018 and 2020 seasons, the average trip length was reduced by nearly 250 miles, leading to a reduction of 1.9 tonnes CO₂e per game (league-wide). Wynes did not address the possibility that changing the number of trips and travel distances could inadvertently increase emissions elsewhere (e.g. more fans or team members' families traveling to watch the team play); the prevalence and magnitude of these induced effects are not explicitly addressed in our recommendations, but reinforces the need to critically evaluate recommendations to avoid potential backfire.

Although the team may not have control over the game schedule, it does have control over *how* they get from one city to the next and to and from the stadiums they visit. Like fan transportation, emissions can be significantly reduced by switching to less GHG-intensive transportation modes (e.g. buses to Miami or trains against rivals in the Northeast) or using vehicles with less GHG-intensive fuels (e.g. sustainable aviation fuel or hybrid/electric buses).

In addition to the aforementioned opportunities for emissions reduction, team travel poses a unique opportunity to educate players and recruit them for fan transportation-specific advocacy. Team travel affects the players more acutely than any of the other emissions-producing activities because the players are directly involved in all aspects of team travel. Getting players to use their platforms to advocate for more efficient transportation could influence fans to do the same, reducing even more emissions. Players for the Planet currently has 43 MLB player ambassadors from 22 different teams. Teams can utilize this association to highlight team-based initiatives that reduce GHG emissions, while also relating these actions to associated fan transportation initiatives. By leading by example, teams are not solely placing the onus for travel-related GHG reductions on fans.

Limitations

The team travel emissions estimate was limited in the absence of data regarding the Rays' non-air travel, hotel nights, and other team-related travel. Additionally, we had no information about the team's air travel aside from flights to cities where they were set to play and limited anecdotal information about the circumstances under which the team would use a plane rather than any alternative transportation mode. While not a perfect substitute, we used a team travel emissions report from the New York Mets as a proxy for Rays' activities (see Section 10.1.6 for details). However, we do not know the methodology used to produce the Mets' emissions report. We know that the Mets data included at least some flights beyond team travel for away games (e.g. flights from Miami to Santo Domingo), but we do not know whether the emissions data accounts for *all* team-related travel; as such, our estimate of the Rays' air travel is likely an underestimate. Furthermore, neither team had specific information on buses, which we know all

MLB teams use to get from airports to hotels and from hotels to games. Lastly, player and employee commuting to and from Tropicana Field was excluded from the footprint estimate due to lack of data from both the Rays and the Mets.

7.1.7 Concessions

Concessions purchasing accounted for 15.5% of the Rays' estimated carbon footprint; the second largest contributor to the Rays carbon footprint. Our analysis included a breakdown of 70 commodity sectors in order to identify key hotspots within concessions and determine its largest sources of emissions.

The ten commodities with the largest emissions contributed 83% of the emissions from concessions (**Table 14**). Five of the top seven commodities at Tropicana Field were related to animal products. Animal products are more GHG-intensive than plant-based products, contributing to a larger overall carbon footprint; this is demonstrated by looking at the relationship between spend and emissions. While meat and animal products were only responsible for 32% of the total purchasing, they accounted for 64% of concessions emissions. This is contrasted by the other two of the top seven commodities with highest emissions (alcohol and grains, bread, and grain products), which had considerably higher spending, but lower emissions overall. Alcohol is responsible for 13% of the emissions from concessions, but was 23% of the spend; grains, bread, and grain products made up 4% of the concession emissions, but 7% of the spend.

Limitations

Our analysis of concessions used a spend-based method, which does not include supplier-specific information that would increase precision and accuracy of emissions estimates. Because the spend-based method relies on broad sector-wide averages, the unique processes and nuances of concessions operations may not be captured without supplier-specific information. For example, the Ray's beef suppliers could have a lower or higher emissions factor than the national average. Furthermore, this method makes it difficult to address supplier-specific reduction efforts, such as the Ray's choosing to only source food locally. Data availability as well as time constraints shaped the choice for this methodology over the supplier-specific method. We were also limited by the dataset received, as it only reflected 43.2% of the season. While we did scale up to account for purchasing throughout the entire season, the complete dataset would have decreased assumptions made; for example, we scaled evenly across all commodities, whereas a complete dataset may have shown differences in purchasing volumes for specific products later in the season. Even if we had a more complete dataset, the trends found would likely carry over because menu offerings often do not vary throughout the season, therefore it is reasonable to assume that purchased quantities would be relatively consistent.

7.1.8 Merchandise

Cradle-to-gate GHG emissions from merchandise represents a small portion of the Rays' overall estimated carbon footprint. Merchandise only accounted for 1.19% of the Rays estimated carbon footprint in our analysis; this is likely due, in large part, to the fact that we only received a fraction of the Rays merchandise data (total of 41 line items) that represented the top 25 items sold by quantity and top 25 items sold by revenue. Similarly, to concessions, we estimated

emissions using the spend-based method. In this study, the two items with the largest contribution to the merchandise carbon footprint were the mystery grab bags (the best-selling item in 2019) and the commemorative jersey (most expensive and least-sold item). We assumed the grab bag likely contained an apparel item based on anecdotal information; therefore, this item and the commemorative jersey were assigned the clothing emissions factor. Further analysis of merchandise grab bags can be found in Section 10.1.8.4.

Almost 90% of all merchandise emissions were from clothing. This is likely because of three key factors: 1) The emission factor for clothing is the highest emission factor of the merchandise items in our study (1.97 kg CO₂e/2018 USD) likely because apparel manufacturing is energy-intensive; 2) the majority of revenue from merchandise is from clothing, totaling 71% percent of revenue within the provided merchandise dataset and; 3) in terms of quantity sold, in terms of quantity sold, 39% of items sold were clothing while the remaining 61% of items sold had lower emissions factors and lower revenue.

Limitations

As we only had a portion of the merchandise data, our analysis likely underrepresents emissions associated with merchandise. MLB- and team-branded merchandise items are typically sold at a higher markup than national averages for similar items (Garcia, 1995). For example, our dataset included a 20th-year commemorative jersey that retailed on MLB's website for \$399.99 (in 2021) while other comparable jerseys retailed for as little as \$109.99 (in 2021); this markup likely far exceeds the increased production costs for a limited-run item, resulting in higher profits. Without a detailed spend ledger to eliminate product markup above and beyond the national average, our calculations likely resulted in an overestimation of GHG emissions because of the spend-based methodology. Even if specialty items such as the commemorative jersey were disproportionately marked up, it would still be correct to assume that clothing will contribute largely to the Rays' overall carbon footprint, because of its high emissions intensity.

One particular area where our merchandise calculations would have greatly benefitted from access to more data was free promotional items. Many sports organizations, even outside of the professional arena, give away promotional items ("freebies") to fans. For example, fans may be given a player bobblehead upon arrival. The Rays have several giveaways throughout the season. Our analysis suggests that clothing giveaways should be minimized because of its high emissions intensity. Knowing that there are additional products not captured in the dataset, including these freebies, highlights the conclusion that our analysis is an underestimate of cradle-to-gate merchandise emissions.

7.1.9 Onsite Water Use

Results of the onsite water use indicate that public restrooms (excluding office space and the clubhouses) and the cooling towers used the majority of water consumed onsite (34.3% and 46.8%, respectively). Tropicana Field, located in humid St. Petersburg Florida, has a closed roof and air conditioning is run regularly to keep the facility cool. As such, it is unsurprising that the cooling tower, which chills water for AC use, is the dominant water consumer. Additionally, it is important to note that Tropicana Field has a synthetic turf field, one of five teams that use synthetic turf fields in the MLB. The turf field, coupled with the enclosed setting, results in water

consumption for field use that is disproportionately small (0.6% of their onsite water use) as compared to a typical MLB grass field. Additionally, landscape water use was not calculated for Tropicana Field as they have minimal landscaping. While generally a smaller portion of a typical stadium's water use, landscaping outside of stadiums includes flowers, bushes and grasses typical in parking lots, which can still consume a significant amount of water if irrigated regularly; EPA estimates that landscape irrigation accounts for nearly one-third of residential water use nationwide (U.S. EPA, 2017a). Native plants significantly reduce irrigation requirements (McMordie Stoughton, 2010). Additional recommendations for Tropicana Field and other MLB teams to reduce their water usage can be found in Section 11.2.

Limitations

We had significantly less data associated with the onsite water use, compared to the carbon footprint, thus, there were some limitations in our ability to break out end-use categories. Aside from the total water usage for the stadium (in relation to our system boundary), we were provided with only a few pieces of information related to water usage. Water use attributed to field use was calculated via first-hand recordings while onsite at Tropicana Field; it should be noted that this is still a basic estimation, as observations were only made for a limited time; the recording process and calculations to determine field water use are described in Section 10.2.2. Stadium personnel provided flow rates of urinals, commodes, and sinks; this data did not include employee or clubhouse restrooms, showers, and appliances, nor did it include estimates of fixture usages.

Stadium personnel also supplied information related to the cooling tower that was part of an investigation into water softeners in conjunction with Nalco Water. Johnson Controls, the organization that manages all cooling tower related needs for the Rays', worked with Nalco Water to develop ROIs for the installation of a water softener; this investigation was the reason any data related to the cooling tower was available. When comparing cooling tower flow rates and run-time estimates provided from the Nalco study to annual water use from Rays utility bills it became apparent that the cooling tower information provided was likely an overestimate of actual water usage for the stadium, thus cooling tower water use was later estimated; see Section 10.2.3. The lack of data only allowed for a breakdown into two categories, restrooms and field watering, and the largest end-use category in our analysis of onsite water use was "other". Using the literature, the "other" category was broken down into the cooling tower, washing the grandstand, water fountains, clubhouse showers, leaks and washing machine use. See Section 10.2.4 for information on "other" water use calculations.

Beyond assumptions used to further break down water consumption into more than three end-uses (restrooms, field watering, and "other"), it is important to note that calculations from this analysis do not consider embodied water, or water used throughout the value chain to create a product. If embodied water were measured for merchandise and energy, water consumption attributable to Tropicana Field would be higher.

7.2 General Recommendations & Future Research

While this study provides novel insights about the footprint of professional baseball operations, there are several key opportunities for future work and recommendations for teams to advance

sustainability goals. Our team provides detailed recommendations for MLB teams to reduce their environmental impact in the areas of energy, water, waste, concessions, and fan transportation in Section 11. This section provides additional recommendations aimed at improving efforts to quantify environmental impacts of one MLB season, applicable to the Tampa Bay Rays and other MLB teams interested in such an effort.

The availability of activity-specific data was a key limitation to definitively delineating how much each stadium activity contributed to the overall carbon footprint and onsite water used. The implementation of stadium-based sub-metering or comprehensive internal utilities usage audits would lead to a more detailed carbon footprint and onsite water analysis. For example, lack of sub-metering specific data resulted in assumptions necessary to break down the proportion of natural gas combusted onsite for water heating vs kitchen use. Specific end-uses of purchased electricity, such as lighting, kitchen use, or A/V needs, were not evaluated at all. Sub-metering would better illuminate specific hotspots and, therefore, focus recommendations. Sub-metering or recurring utility audits would support continuous data collection, enabling the quantification of environmental impact reduction of proposed interventions. With this quantification comes the ability to state the quantified environmental impact reduction, reducing the risk of greenwashing claims when communicating environmental improvements.

Additionally, data availability limited our ability to complete a comprehensive Scope 3 analysis, which would consider both upstream and downstream impacts of all indirect emissions (World Resources Institute, 2011). Future research should work to estimate a comprehensive Scope 3 analysis. One example of this is a complete merchandise analysis using a spend-based approach, which would provide more insights into merchandise as well as stronger recommendations for emissions reduction in this area. Furthermore, our merchandise analysis is a cradle-to-gate analysis and thus does not consider the end-of-life of all merchandise sold; apparel sustainability revolves around the durability and utility of the product, or how long the product lasts and how often it is used, thus if merchandise sold is an unnecessary item that is thrown away, there is impact to the end-of-life evaluation of the product.

Given client needs and the urgency needed to address the consequential environmental impacts of climate change and water scarcity, this study focuses solely on GHG emissions and onsite water use. Nonetheless, it does not account for the multitude of environmental impacts, such as eutrophication or air pollution and associated human health risks, occurring as a result of stadium operations. For example, although they may offset GHG-intensive emissions from the grid, WTE facilities can result in local air pollution (often in underrepresented communities) and produce toxic ash (Rosenberg et al., 2021), which we did not evaluate in our study. By focusing only on GHG emissions and onsite water use, our assessment of environmental impacts of the Rays does not assess these kinds of tradeoffs where one activity might have a low carbon footprint but have a high environmental impact in another area.

This study evaluates one MLB team, and the characteristics of this stadium, including its location (both the climate and location within the city), size, age, and amenities (the roof and turf field) make it a unique case study. While results illuminate potential BMPs applicable to the larger MLB community, the carbon footprint and onsite water usage found in this study are not necessarily representative of a typical MLB team. A comparative analysis of several MLB teams

representing these key differences in team and stadium operations would support confirmation of hotspot activity areas determined in this study. Such analysis would also confirm the validity of proposed recommendations and provide an opportunity for more comprehensive quantification of reduction strategies. For example, while likely an overarching hotspot for MLB teams and large stadium sports more broadly, the GHG emissions from fan transportation likely vary from team to team based on the availability of public transportation and stadium location. A comparative analysis between MLB teams using updated survey questions provided in Section 13 would produce a more generalizable quantification of the fan transportation carbon footprint, but also would illuminate how dominant car use actually is to the Rays' stadium as compared to other MLB stadiums.

Considering fan transportation is overwhelmingly the dominant contributor to the team's carbon footprint, future research should dive deeper into quantification and potential reduction strategies in this area. Some fan transportation recommendations outlined in this study have not been evaluated for their effectiveness in a stadium setting. Additionally, implementation of certain BMPs is team-specific; for example, appropriate park-and-ride locations. Moreover, future research should use the updated survey created as a part of this study (Section 13, methods in Section 12) to support more robust quantification and evaluate fans' willingness to participate in proposed intervention strategies. As successful intervention involves broad behavioral change on the part of fans, the potential effectiveness of recommendations is highly dependent on fan buy-in and participation and should be evaluated.

Similarly, fan behavioral change is associated with other intervention strategies such as reduced meat consumption initiatives. Evaluating fans' willingness-to-participate in such initiatives would better illuminate the GHG reduction potential of such activities and support more effective implementation. Fan surveys are one method of evaluation, but a semi-structured interview-based study with teams, cities and organizations that have already explored these types of programs is another effective method to evaluate their influence and impact.

More broadly, this project only addresses fan behavior change as it relates to reducing the Rays' carbon footprint and onsite water consumption. Casper et al., and the United Nations state that sports have the reach and fan in-group loyalty to influence fan behavior outside of games and stadium events (2019, 2022), making a strong case for sports to act as leaders to their large fanbases, but additional research could determine if fan behavioral change initiatives proposed in this study would spark even broader at-home sustainable behavioral change.

Lastly, while we provide general recommendations for strategies to reduce hotspots within each activity area studied (see Section 11), we do not conduct any financial analysis for team implementation. Additional research should evaluate the feasibility of implementation for each reduction strategy, including not only fan engagement and participation but also financial analysis, stakeholder analysis, potential auxiliary benefits, and unintended consequences.

8. Conclusion

This study estimated a carbon footprint and onsite water use for one MLB season (excluding spring training and playoffs) and related activities for a single team, the Tampa Bay Rays. While this study does not quantify all environmental impacts of an MLB season, such as land use, water

pollution, human health impacts etc., a carbon footprint and analysis of onsite water consumption was deemed appropriate for this study based on our literature review, current industry focuses, and the interests of our clients. Our team identified fan transportation, and more specifically personal vehicle use, as the largest source of GHG emissions for the Tampa Bay Rays. Concessions and Scope 2 emissions were other notable contributors to the team's carbon footprint. Our team identified the cooling tower and restrooms as the largest sources of onsite waste usage at Tropicana Field.

Due to their size and influence, MLB teams are uniquely positioned to both meaningfully reduce their own environmental impacts while simultaneously engaging the American public to reduce their own environmental footprints. By establishing a baseline carbon footprint and calculating onsite water use, and providing quantified or quantifiable reduction recommendations, the Rays will now be able to demonstrate their commitment to sustainability in sports, avoid greenwashing, and enact strategies with a higher potential for carbon or water reduction. Lastly, by demonstrating their environmental commitments via clear and quantifiable steps, and engaging fans in such initiatives, the Rays, the MLB, and professional sports at large have an opportunity to inspire lasting environmental behavioral change at home.

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Supplemental Information

10. Supplemental Information: Detailed Methodology

This section documents the specific methods used to calculate emissions or water usage for each activity area within our system boundary. Details in each subsection include sources of activity data, how we translated the data into units which correspond with emission factor data (for GHG emissions), equations to compute total emissions, components of water use, and supporting assumptions.

10.1 Carbon Footprint Methodology

10.1.1 Scope 1 Emissions

Scope 1 emissions at Tropicana Field are from onsite fossil fuel combustion. Scope 1 emissions were calculated based on purchased quantities of fossil fuels for Tropicana Field during the time period contained within the functional unit. Total annual consumption was determined from natural gas utility invoices and receipts for diesel and gasoline. Detailed sub-metering data was unavailable, thus a top-down approach based on facility manager insights, an onsite internship at Tropicana Field, and proxy data from an alternative MLB team, was used to allocate the percent of each fossil fuel type consumed by various stadium activities or uses. Equipment and fuels generating Scope 1 emissions for our functional unit are provided in **Table 17**.

Table 17. Onsite fossil fuel by type and description of equipment using each type of fossil fuel

| Fossil Fuel Type | Equipment |
|------------------|-------------------------------|
| Diesel | Off-road vehicles |
| Diesel | Emergency generator |
| Diesel | Hand-held lawn care equipment |
| Gasoline | Light-duty trucks |
| Natural Gas | Water heating |
| Natural Gas | Cooking appliances |

Once the quantity of onsite fossil fuel consumption (natural gas, gasoline, and diesel) was totaled from invoices, Scope 1 emissions were calculated using emission factors from the GHG Emissions Calculations Tool from the GHG Protocol (“The GHG Emissions Calculation Tool | Greenhouse Gas Protocol,” n.d.). **Equation 10.1.1A** illustrates how the amount of different fossil fuel types consumed at the stadium were converted and totaled into kg CO₂e. We used the same emission factor for all natural gas combustion, regardless of if natural gas was combusted for water heating or cooking. For diesel combustion, we used a different emission factor for off-road vehicles/lawn equipment and the emergency generator onsite, see the Emission Factor Description column in **Table 18**. Using a different emissions factor for each equipment type required estimating the percentage of diesel combustion in the different types of equipment, which was done using anecdotal estimations, see Percentage of Fossil Fuel Type Used by Equipment column in **Table 18**. Lastly, **Equation 10.1.1A** notes that a different conversion factor was needed based on fuel type; this is explained in the last column of **Table 18**.

Equation 10.1.1A:

$$\text{Scope 1 Emissions (kg CO}_2\text{e)} = \sum (\text{Fuel Quantity}_{\text{FT}} \times \text{Conversion Factor}_{\text{FT}} \times \sum (\text{Emission Factor}_{\text{FT-GHG}} \times \text{GWP}_{\text{GHG}}))$$

where FT stands for fuel type (natural gas, gasoline, or diesel) and GHG is CO₂, CH₄ and N₂O.

Table 18. Descriptions of emission factors applied to each type of fossil fuel-combusting equipment at Tropicana Field and required conversions for emissions calculations

| Fossil Fuel Type | Rays Equipment Description | Percentage of Fossil Fuel Type Used by Equipment | Emission Factor Description |
|------------------|---|--|--|
| Diesel | Off-road vehicles + Hand-held lawn care equipment | 5% | Diesel Combustion: Other Diesel Non-Road Vehicles |
| Diesel | Emergency generator | 95% | Stationary Combustion: Distillate Fuel Oil No. 2 |
| Gasoline | Light-duty trucks | 100% | Motor Gasoline: Gasoline Light-duty Trucks (Vans, Pickup Trucks, SUVs) |
| Natural Gas | Water heating + Cooking appliances | 100% | Stationary Combustion: Natural Gas |

10.1.1.1 Scope 1 Emissions Assumptions

Due to lack of detailed equipment-specific data to calculate the percent fossil fuel consumed by each stadium activity considered within Scope 1 emissions, anecdotal data from informational interviews with the Rays' facility manager were used for allocation of percent diesel by stadium activity (**Table 18**).

10.1.2 Scope 2 Emissions

Monthly electric utility bills from 2019 were provided to the team; total monthly electricity usage (in kWh) was recorded from the bills. Electric utility bills did not provide specific information about use, as no sub-meters are present, thus usage is assumed to be inclusive of the entire stadium operations. Monthly usages between April and September (inclusive) were added to calculate the 2019 season total; this value was multiplied by the U.S. EPA Emissions & Generation Resource Integrated Database (eGRID) emissions factor for the area. eGRID is an inventory of environmental attributes of electric power systems that pulls data from the Energy Information Administration (EIA) and EPA's Clean Air Markets Program Data (Rothschild et al., 2009). As eGRID emissions rates are based on power plant's fossil fuel categories, eGRID factors are specific to the utility region; the eGRID subregion applicable for the Rays' footprint is the Florida Reliability Coordinating Council (FRCC; US EPA, 2021b; **Table 19**). These

emission factors were multiplied by the GWP (100 year) to determine CO₂e. The product of the emission factor and GWP was multiplied by the 2019 season total to determine Scope 2 emissions in kg CO₂e (**Equation 10.1.2A**).

Equation 10.1.2A:

$$\text{Scope 2 Emissions (kg CO}_2\text{e)} = (\text{Emission Factor (kg/kWh)} \times \text{GWP (100)}) \times \text{Seasonal Electricity Usage (kWh)}$$

Table 19. 2021 emissions values for Florida Reliability Coordinating Council (FRCC) used to calculate the Rays’ 2019 season total kg CO₂e from upstream electricity

| Greenhouse Gas | kg/kWh | GWP (100) |
|-----------------------------------|-------------------------|-----------|
| Carbon Dioxide (CO ₂) | 0.39 | 1 |
| Methane (CH ₄) | 2.49 x 10 ⁻⁵ | 27.9 |
| Nitrous Oxide (NO ₂) | 3.17 x 10 ⁻⁶ | 273 |

10.1.3 Upstream Natural Gas and Upstream Water

This section quantifies Scope 3 (indirect upstream) emissions for utilities purchased at Tropicana Field. Natural gas and water are the only purchases from utilities, besides electricity (calculated as Scope 2 emissions), applicable to the Rays.

10.1.3.1 Upstream Natural Gas

Emissions associated with the production, processing, transmission, and distribution of natural gas were then calculated using data from the U.S. Department of Energy and Argonne National Laboratory’s GREET Model (Wang et al., 2021). Emission factors for natural gas were taken from the “NG” tab, Table 4.1: Energy Use, Water Consumption and Total Emissions for “Natural Gas as Stationary Fuels” as this represented the fuel pathway that would be most similar to natural gas being used in the stadium. The GREET model defaults for the split between conventional natural gas (48%) and shale natural gas (52%) were used. **Equation 10.1.3A** (below) was used to calculate total emissions:

Equation 10.1.3A:

$$\text{Total Emissions (kg CO}_2\text{e)} = T_{NG} \times CF_{NG} \times \sum (EF_T \times GWP_T)$$

Table 20. Variables used to calculate emissions from upstream natural gas

| Variable | Description | Source |
|------------------|--|--|
| TNG | Quantity of natural gas purchased during season (39412.6 therms) | Utility bills |
| CFNG | Conversion factor to MMBtu (0.1) | GHG Protocol WRI GHG Emissions Calculations Tool |
| EFT | Emission factors by GHG type (CO ₂ , CH ₄ , N ₂ O) | REET EF for natural gas purchases |
| GWP _T | Global warming potential (GWP _{CO₂} = 1; GWP _{CH₄} = 28; GWP _{NO₂} = 273) | IPCC AR6 |

10.1.3.2 Upstream Water Treatment

Water utility purchases at the stadium over the 2019 season were totaled using invoices from the utility provider (10,996,100 gallons). The Water-Energy Sustainability Tool (WEST) from UC-Berkeley uses detailed information about a water treatment plant and LCA methodology to calculate environmental impacts of water treatment. WEST includes the manufacturing of treatment infrastructure, production of required chemicals, impacts from energy consumption, and typical waste management (Stokes and Horvath, n.d.). Our team did not have detailed information about water treatment in Pinellas County to run WEST ourselves, however, a 2013 run of the model from Zaribaf et al., modeled emissions for water treatment for the City of Clearwater, FL (a city less than 25 miles from where the stadium is located and assumed to be similar in terms of water treatment facilities). The water treatment emission factor was estimated based on results of this study (Zaribaf et al., 2013; **Figure 13**).

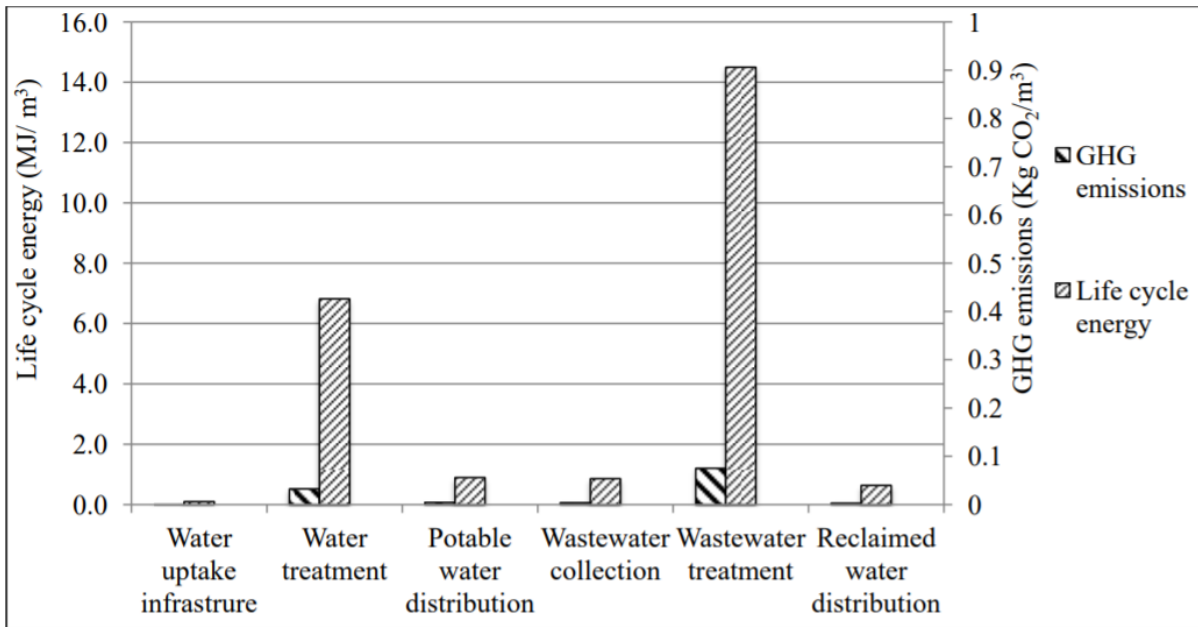


Figure 13: Life cycle energy and GHG emissions of each stage of the water treatment cycle at City of Clearwater’s water treatment plant. The right y-axis represents GHG emissions CO₂e/m³ and was used to estimate the appropriate emissions factor. (Zaribaf et al., 2013)

We estimated the GHG emissions factor for water treatment at Tropicana Field by combining the GHG emission factors for water uptake infrastrure, water treatment, and potable water distribution in Clearwater, FL (**Figure 13**); Based on this figure we estimated the water treatment emissions factor to be 0.05 kg CO₂e/m³. It is assumed that this emission factor is for CO₂e (including CH₄ and N₂O) given other discussions in the Zaribaf et al. paper (2013). This emission factor was multiplied by total water purchased at Tropicana Field in the 2019 season to estimate total GHG emissions associated with upstream water treatment.

10.1.4 Downstream Solid Waste

This section describes the methodology for quantifying GHG emissions from waste management at Tropicana Field for the period defined by our functional unit, April to September 2019. The Tampa Bay Rays provided the total tonnage of waste (including recycling) managed by waste haulers for the relevant time period in the form of the invoices provided by said waste haulers, meaning that invoices include waste for all events in the time period, not only Tampa Bay Rays baseball games. Anecdotally, non-baseball events are expected to be a very minor portion of total waste handled during the time period. For reference, the majority of all waste handled (68%) in 2019 was generated during our defined time period, April to September 2019.

Records show 95.7% of waste (by weight) during the 2019 season was handled by the City of St. Petersburg which works with Pinellas County to manage waste. Pinellas County operates a waste-to-energy (WTE) facility and a landfill. The majority of solid waste sent to the facility is incinerated with heat being captured and used to generate electricity. The only waste that is not

combusted includes ferrous and non-ferrous metals recovered for recycling with magnets. The ash created during combustion is applied as cover to the landfill (“Solid Waste Master Plan, Pinellas County, FL,” 2020).

Recycling records provided by the Rays show 4.3% of waste (by weight) during the 2019 season was handled by various recycling companies. Of recycled material, 3.9% was cardboard. The remaining 0.4% of recycled waste included shredded paper, aluminum, plastic, and e-waste.

To calculate emissions associated with waste combustion and recycling, we used the U.S. EPA’s Waste Reduction Model (WARM) -- the Version 15 Excel-Based Tool. This tool asks users to input total tons of various material types managed and to designate if material was recycled, landfilled, combusted, composted, or anaerobically digested. The tool then uses a handful of other user-designated inputs (such as geography) and U.S. EPA emissions data to calculate the GHGs associated with that specific management breakdown (U.S. EPA, 2016c). As discussed above, all material at Tropicana Field is either recycled or combusted. The quantity of material landfilled and composted was 0%.

Combustion of different types of materials releases different quantities of GHG emissions. Further, combustion of food waste produces biogenic CO₂, which the WARM Model (and subsequently our carbon footprint) does not include in its carbon footprint because biogenic emissions do not increase quantities of carbon in the biogenic, or natural, carbon cycle (IEA Bioenergy, n.d.). Thus, understanding the percentage of organic waste sent to the WTE was imperative to increasing accuracy of the carbon footprint.

Because the Rays have not performed a waste audit at Tropicana Field, in order to better estimate waste composition, we drew on results of a recycling and waste profile of the Seattle Mariners MLB team (Hershkowitz et al., 2012). The Mariners waste profile includes all materials managed at T-Mobile Park, i.e. all materials regardless of whether they were ultimately recycled, landfilled, composted, etc. We made two modifying assumptions to the Mariners waste profile:

1. Zero percent of waste at Tropicana Field is yard waste because the Tampa Bay Rays have a turf grass field;
2. Zero percent of waste at Tropicana Field is from construction debris. This is because it was unknown if the Tampa Bay Rays performed any construction during the 2019 season, and the EPA Warm Model does not have a general construction materials emission factor.

Using these assumptions, we calculated an assumed waste profile for the Rays based on the modified Mariners profile (**Table 21**). **Equation 10.1.4A** provides a sample equation (food waste) of how we calculated the “Assumed Rays Waste Profile” given the “Mariners Waste Profile” listed in **Table 21**.

Table 21. Seattle Mariners waste profile and assumed Rays waste profile

| Waste Material | Mariners Waste Profile | Assumed Rays Waste Profile |
|---|-------------------------------|-----------------------------------|
| Food Waste | 34% | 43.0% |
| Yard Waste | 17% | 0.0% |
| Non-Organic, Non-Recyclable Waste (Municipal Solid Waste - MSW) | 17% | 21.5% |
| Cardboard and Office Paper | 10% | 12.7% |
| Misc. Recyclables | 13% | 16.5% |
| PET | 5% | 6.3% |
| Construction Debris | 4% | 0.0% |
| Total | 100.0% | 100.0% |

Equation 10.1.4A:

$$\text{Rays \% food waste} = (\text{Mariners \% food waste}) / (100\% - 17\% \text{ yard waste} - 4\% \text{ construction debris}) = 34\% / (100\% - 17\% \text{ yard waste} - 4\% \text{ construction debris}) = 43\%.$$

The WARM Model gives different GHG emissions credits for combustion and recycling so it was important to allocate the total waste profile to the appropriate waste management method (WTE facility or recycling). 3.9% of all materials managed at the Rays is recycled cardboard and 0.4% of all materials are other types of recyclables (office paper, aluminum, plastics, and e-waste). 95.7% of materials handled are sent to the WTE facility. Although not explicitly stated, it was assumed all plastic recycled at Tropicana Field was PET, as PET is the most recycled plastic in the U.S. (“Fact Sheet - An Introduction to PET,” n.d.).

Table 22. The breakdown of waste management methods combining the assumed Rays waste profile and the known types and percentages of recycling at Tropicana Field

| EPA Warm Model Category | Combustion | Recycling | Total |
|---|--------------|--------------|---------------|
| Food Waste | 43.0% | 0% | 43.0% |
| Mixed MSW | 21.5% | 0% | 21.5% |
| Corrugated Containers (i.e. Cardboard)* | 2.4% | 3.89% | 6.3% |
| Office Paper* | 6.3% | 0.06% | 6.3% |
| Aluminum Cans* | 0.0% | 0.06% | 0.1% |
| PET* | 6.3% | 0.06% | 6.4% |
| Mixed Electronics | 0.0% | 0.23% | 0.2% |
| Mixed Recyclables | 16.1% | 0% | 16.1% |
| Total | 95.7% | 4.31% | 100.0% |

*The Mariners did not distinguish between cardboard and office paper in their waste profile; however, the EPA Warm Model does request that these materials be input separately. Therefore, it was assumed that half of the material was cardboard and half was office paper, i.e. 6.33% of the total waste profile, each for the Rays. Similarly, the Rays did not distinguish between the total amount of aluminum and PET recycled, so it was assumed that the split was 50/50. See sensitivity analysis (Section 10.1.4.1) for further justification.

The percentages in **Table 22** were applied to the known total tonnage of waste managed at Tropicana Field to establish inputs into the WARM Model, as shown in **Equation 10.1.4B**:

Equation 10.1.4B:

$$\text{Waste Tons (Type and Waste Management Method)} = (\text{Total Tons Managed}) \times (\% \text{ Waste Type Managed By Method})$$

Once the total tonnage for each material stream was calculated, these totals were input into the WARM Model. The WARM Model then quantified GHGs and GHG emissions credits associated with combusting and recycling the various material streams (Current WARM Tool - Version 15, (U.S. EPA, 2016d).

The credit for combustion is calculated using the estimated energy content of combusted materials, an assumed efficiency of the combustion facility based on literature review, and an average CO2e emission factor of electricity generation for the specific eGRID region (South Atlantic) where the WTE facility is located. For the emissions from recycling, WARM calculates a “recycled input credit” by assuming that the recycled material avoids, or offsets—the upstream GHG emissions associated with producing the same amount of material from virgin inputs (ICF, 2020). Outputs of the WARM Model are included in Section 6.1.1.4.

10.1.4.1 Sensitivity Analysis

Lack of available data on the precise make-up of the Rays waste and recycling streams required several assumptions about the make-up of the waste, specifically the amount of cardboard, office paper, aluminum, and plastic (PET). We assumed a 50/50 split when in doubt but have run a sensitivity analysis for 0/100 and 100/0 where applicable to assess how much this assumption

would change our results. Overall, results for downstream solid waste would change a maximum of 2.33%, a relatively negligible amount. Details below:

1. Our Rays waste profile assumes 12.7% of waste was recyclable cardboard and office paper based on the Mariners having the same proportion of recyclable cardboard and office paper in their waste stream. We know the Rays' entire waste management stream included 3.89% recycled cardboard and 0.6% recycled office paper. This implies that the remaining 8.41% ($12.7\% - 3.89\% - 0.4\% = 8.41\%$) was combusted. However, the percentage of this 8.41% that is cardboard versus office paper is unknown. We assumed, going back to the original 12.7% of waste total being office paper and cardboard, 50% of the waste was office paper and 50% was cardboard (6.33% of total waste each). To test how this assumption influenced the results, we re-ran the WARM model twice assuming once that the unknown 8.41% of combusted waste was cardboard and 0% office paper and then again assuming 8.41% was office paper and 0% was cardboard.

With our 50/50 assumption for office paper and cardboard, overall GHG emissions were -138.87 MT CO₂e, with -7.68 MT CO₂e attributable to combusting cardboard and -19 MT CO₂e attributable to combusting office paper. Assuming 8.41% of waste is combusted cardboard and 0% is combusted office paper changes these results to -139.63 MT CO₂e overall, a -0.55% decrease in the overall GHG footprint from downstream solid waste, with -108.91 MT CO₂e attributable to combusting cardboard and -1.19 MT CO₂e attributable to combusting office paper. Conversely, assuming 8.41% of waste is combusted office paper and 0% is combusted cardboard changes these results to -138.59 MT CO₂e overall, a 0.20% increase in the overall GHG footprint from downstream solid waste, with -81.49 MT CO₂e attributable to combusting cardboard and -27.57 MT CO₂e attributable to combusting office paper. This implies that our results for downstream solid waste GHG emissions would be changed a maximum of -0.55%, using different assumptions for cardboard and office paper. This is a relatively negligible difference.

2. Rays records indicate that 0.12% of the Rays waste profile consists of recycled aluminum and recycled plastic (assumed PET). However, the percentage of this 0.12% that is aluminum vs. PET is unknown. We assumed that 50% of these recycled materials were aluminum and 50% was PET (0.06% of total waste each). To test how this assumption influenced the results, we re-ran the WARM model twice assuming once that the unknown 0.12% of recyclables was aluminum and 0% PET and then again assuming 0.12% was PET and 0% was aluminum.

With our 50/50 assumption for aluminum and plastic, overall GHG emissions were -138.87 MT CO₂e, with -0.41 MT CO₂e attributable to recycling PET and -3.65 MT CO₂e attributable to recycling aluminum cans. Assuming 0.12% of recyclables was aluminum and 0% plastic changes these results to -142.11 MT CO₂e overall, a -2.33% decrease in the overall GHG footprint from downstream solid waste, with -7.30 MT CO₂e attributable to recycling aluminum and 0 MT CO₂e attributable to recycling plastics. Conversely, assuming 0.12% of recyclables was plastic and 0% aluminum changes these results to -135.64 MT CO₂e overall, a 2.33% increase in the overall GHG footprint from downstream solid waste, with 0 MT CO₂e attributable to recycling

aluminum and -0.83 MT CO₂e attributable to recycling plastics. This implies that our results for downstream solid waste GHG emissions would be changed a maximum of +/-2.33% using different assumptions for cardboard and office paper. This is a relatively negligible difference.

10.1.4.2 Methodology Limitations

The WARM model uses the avoided burden method, meaning that the Tampa Bay Rays are getting credit for recycling and combusting material for energy. This creates a potential double counting issue, if anyone else is taking credit for creating material that has recycled content and/or assuming material would be combusted for energy.

An additional issue arises considering that our carbon footprint only partially accounts for production of materials but is taking credit for waste management of all materials. Specifically, we have accounted for the production of concessions and merchandise. Although there is packaging material associated with concessions and merchandise that may have been thrown out at the stadium, much of the food and likely most merchandise will not be thrown away at the stadium because it will be eaten or taken home. Although there is some food thrown away at Tropicana Field, other materials thrown away include things like shipping materials, janitorial products or training equipment, just to name a few examples. Our waste methodology results in GHG emissions credits being earned by the Rays for these materials without taking into account the GHG emissions associated with producing these materials, subsequently underestimating the total Rays carbon footprint.

However, the WARM tool includes “production” emission factors for each material stream. These emission factors can be used to estimate the production of GHG emissions for all waste managed at Tropicana Field to provide a sense of magnitude for emissions associated with purchased goods and services that are excluded from our analysis. This total amounts to 2,635 MT CO₂e. For reference, emissions from concessions and merchandise were estimated to be 4,000 MT CO₂e. The 2,635 MT CO₂e associated with all materials thrown out includes some overlap with concessions emissions because of food waste that would have been disposed of. However, this does tell us that emissions associated with purchased goods and services could be 150% more than the estimate included in our carbon footprint. Additionally, this analysis would exclude the impact of materials purchased that were not thrown out. Future analyses should more comprehensively assess the impact of production of all materials entering the stadium; for more details, see Section 7.2.

10.1.5 Fan Transportation

Section 10.1.5 details the methodology for quantifying the carbon footprint from fan transportation to and from Tropicana Field during the 2019 Tampa Bay Rays season. We utilized data from an MLB-wide post-game fan survey to determine the GHG emissions of fan transportation. We calculated emissions as a function of:

1. Miles traveled by transportation type
2. The relative distribution of fans using different transportation methods
3. Emissions factors based on vehicle-miles and passenger-miles

Equations A-D provide our general methodology. **Equation 10.1.5A** illustrates how we calculated the total passenger-miles traveled by surveyed fans for each transportation type using their zip codes. The survey data was cleaned and coded to get the zip code distances (ZD_T). **Equations 10.1.5B** and **10.1.5C** outline how we scaled the survey data for each transportation type to account for all attendees throughout the season. **Equation 10.1.5D** explains how we converted the distances into total emissions for *all* transportation types. Emissions are first calculated for *each* transportation type using type-specific emissions factors, then summed across *all* transportation types to get an estimate of total emissions from fan transportation for a full season (based on season attendance). **Table 23** describes the variables and values included in these equations.

Equation 10.1.5A:

$$SMT_T = PPS_T \times ZD_T \times RTF$$

Equation 10.1.5B:

$$SSF = \frac{SA}{TSPA}$$

Equation 10.1.5C:

$$TMT_T = \sum SMT_T \times SSF$$

Equation 10.1.5D:

$$CO2e_T = \sum (TMT_T \times \sum (EF_T \times GWP_T))$$

Summed over CO₂, CH₄, and N₂O for all transportation types

Table 23. Variables and values used to calculate kg CO₂e for fan transportation

| Variable | Value |
|--|--|
| SMT _T (survey miles traveled by transportation type) | A (total airplane passenger-miles traveled) P _V (total personal vehicle vehicle-miles traveled) R _{RS} (total rideshare vehicle-miles traveled) B (total bus passenger-miles traveled) C (total taxicab vehicle-miles traveled) L (total subway/light rail passenger-miles traveled) S (total bike/scooter vehicle-miles traveled) W (total walking vehicle-miles traveled) |
| PPS _T (persons per survey by transportation type) | |
| ZD _T (zip code distance by transportation type) | |
| RTF (round trip factor) | 2 |
| SSF (season-scaling factor) | 29.55 |
| SA (season attendance) | 1,178,735 |
| TSP _A (Total survey passengers) | 38,896 |
| TMT _T (Total miles traveled in a season: for each transportation type) | A (total airplane passenger-miles) P _V (total personal vehicle vehicle-miles) R _{RS} (total rideshare vehicle-miles) B (total bus passenger-miles) C (total taxicab vehicle-miles) L (total subway/light rail passenger-miles) S (total bike/scooter vehicle-miles) W (total walking vehicle-miles) |
| EF _T (Emissions Factor specific to each transportation type; includes CO ₂ , CH ₄ , N ₂ O) | |
| GWP _T (Global Warming Potential; includes CH ₄ and N ₂ O) | GWP _{CH₄} = 28; GWP _{N₂O} = 273 |
| CO ₂ e _A (Total kg CO ₂ equivalent emissions for all vehicle types in a season) | |

10.1.5.1 Data

The Tampa Bay Rays provided the relevant portion of MLB-wide fan survey response data from every 2021 home game (**Table 24**).

Table 24. MLB post-game survey questions relevant to fan transportation. Results were used to calculate the portion of the Rays’ carbon footprint attributable to fan transportation

| MLB Post-Game Survey Questions | Response Type | Potential Responses |
|---|---|--|
| 1. “With which of the following did you attend [visiting team at Tampa Bay Rays (date)]?(Select all that apply.)” | Categorical Closed-ended Multiple responses allowed | “My friends” “My spouse or significant other” “My kids” “Other family members” “Colleagues or business clients” “I didn’t go with anyone” |
| 2. “Which of the following best describes where you began your trip to [Tropicana Field] for [visiting team at Tampa Bay Rays (date)]?” | Categorical Closed-ended Single response | “Home” “Work” “Somewhere else” |
| 3. “From what ZIP or postal code did you leave to travel to [Tropicana Field] for [visiting team at Tampa Bay Rays (date)]?” | Open-ended response | Ex: 33705 |
| 4. “Which of the following best describes how you traveled to [Tropicana Field] for [visiting team at Tampa Bay Rays (date)]?” | Categorical Closed-ended Single response | “Car/personal vehicle” “Rideshare service (e.g. Uber, Lyft)” “Bus” “Taxi” “Train” “Subway/light rail” “Bike/scooter” “Walk” |
| 5. “About how much time did it take for you to travel to [Tropicana Field] for [visiting team at Tampa Bay Rays (date)]?” | Categorical Closed-ended Single response | “Less than 10 minutes” “Between 10 and 30 minutes” “Between 31 and 60 minutes” “More than 60 minutes” |

The date and opponent for the game attended were also provided in conjunction with the survey responses. Question 2 was relevant here only as it relates to our return travel method assumption, detailed in Section 10.1.5.6. Note that Question 4 does not include “Airplane” as a response option; we explain this discrepancy in Section 10.1.5.6. Refer to **Table 25** for sample data.

10.1.5.2 Cleaning Data

Prior to calculating distances from the survey zip codes, we cleaned the dataset by 1) removing faulty responses, 1) converting text responses (e.g. “Dunedin”) to their corresponding zip codes, when possible, 2) using the zip code that corresponded to the longest distance to the stadium if the respondent recorded multiple zipcodes, 3) and removing faulty responses altogether. Of the 17,626 survey responses, we removed 333 responses or 1.9% of responses. While the survey response rate was only 2.3% of attendees, since most responses included multiple fans, the

survey accounted for 5.1% of attendees. Even with the responses removed, this sample is large enough to be representative of the total fan population with a 99% confidence level and a 1% margin of error (“Sample Size Calculator & Complete Guide,” 2022).

10.1.5.3 Deriving Distances from Zip Codes

We converted our zip code data to both ground distances and air distances to the stadium. We used an application programming interface (API) from the Google Maps platform to return driving distances from the reported zip codes and we used packages “zipcodeR” and “geosphere” in the R programming language to calculate Haversine air distances (Google Maps Team, 2005; Hijmans, 2021; R Core Team, 2014; Robusto, 1957). It was important to include air distance to make reasonable assumptions about air travel (Sections 10.1.5.5 and 10.1.5.6).

Table 25. Sample survey data modified with number of people in travel party, vehicle-miles, passenger-miles, and adjusted travel method; columns and rows transposed and response row added for visual clarity

| Questions | Respondent Example 1 | Respondent Example 2 | Respondent Example 3 | Respondent Example 4 | Respondent Example 5 |
|---|------------------------|-------------------------------------|--------------------------------|-------------------------|---|
| <i>With which of the following did you attend [visiting team at Tampa Bay Rays (date)]?(Select all that apply.)</i> | My friends | Other family members | My spouse or significant other | I didn't go with anyone | My spouse or significant other, My kids |
| <i>Number of people in travel party (including respondent)</i> | 2 | 2 | 2 | 1 | 3 |
| <i>Which of the following best describes where you began your trip to [Tropicana Field] for [visiting team at Tampa Bay Rays (date)]?</i> | Home | Somewhere else | Home | Home | Somewhere else |
| <i>From what ZIP or postal code did you leave to travel to [Tropicana Field] for [visiting team at Tampa Bay Rays (date)]?</i> | 34285 | 33701 | 33707 | 33771 | 45867 |
| Vehicle-miles (from zip code) | 46.58 | 3.01 | 5.56 | 13.82 | 909.23 |
| Passenger-miles (from zip code) | 46.58 | 3.01 | 11.12 | 13.82 | 2727.69 |
| <i>Which of the following best describes how you traveled to [Tropicana Field] for [visiting team at Tampa Bay Rays (date)]?</i> | Car / personal vehicle | Rideshare service (e.g. Uber, Lyft) | Bus | Bike / scooter | Car / Personal vehicle |
| <i>Adjusted travel method</i> | Car / personal vehicle | Rideshare service (e.g. Uber, Lyft) | Bus | Bike / scooter | Airplane |
| <i>About how much time did it take for you to travel to [Tropicana Field] for [visiting team at Tampa Bay Rays (date)]?</i> | More than 60 mins | Less than 10 mins | Between 10 - 30 mins | Between 10 - 30 mins | Between 10 - 30 mins |
| Date | 4/28/21 | 4/30/21 | 7/29/21 | 8/21/21 | 9/16/21 |
| Opponent | Oakland Athletics | Houston Astros | New York Yankees | Chicago White Sox | Detroit Tigers |

10.1.5.4 Vehicle GHG Emission Factors

Once round trip travel distances were calculated, we identified emission factors for the transportation types selected in the survey (**Table 26**).

Table 26. EPA 2021 GHG emission factors (EPA, 2021)

| Vehicle Type | CO2 Factor (kg/unit) | CH4 Factor (g/unit) | N2O Factor (g/unit) | Units |
|---|----------------------|---------------------|---------------------|----------------|
| Passenger Car | 0.341 | 0.009 | 0.008 | vehicle-mile |
| Light-Duty Truck | 0.464 | 0.012 | 0.01 | vehicle-mile |
| Intercity Rail - Other Routes | 0.15 | 0.0117 | 0.0038 | passenger-mile |
| Transit Rail (i.e. Subway, Tram) | 0.106 | 0.0095 | 0.0013 | passenger-mile |
| Bus | 0.054 | 0.0206 | 0.0009 | passenger-mile |
| Air Travel - Medium Haul (>= 300 miles, < 2300 miles) | 0.131 | 0.0006 | 0.0042 | passenger-mile |

Equation 10.1.5A calculated the total number of passenger-miles from survey responses. Because the emission factors for passenger cars and light-duty trucks are expressed per vehicle-mile, we modify **Equation 10.1.5A** to divide the number of passenger-miles by the number of passengers traveling together using **Equation 10.1.5.4A**.

$$\text{Equation 10.1.5.4A:}$$

$$SMT_T = \frac{PPST \times ZDT \times RTF}{PPST}$$

Emissions from mass transportation modes are expressed per passenger-mile so the emissions can be evenly distributed between passengers based on average occupancy rates. For ‘Passenger Car’ and ‘Light-Duty Truck’, the unit is a vehicle-mile because all occupants of the trip are expected to travel the same distance.

Although the EPA does not include dedicated emission factors for taxis or rideshare vehicles, multiple independent studies show rideshare vehicles, on average, produce 69% more emissions than the trips they replace due to cruising, idling, and deadheading--the miles the vehicle travels between hired rides (Anair et al., 2020; Henao and Marshall, 2019). In other words, for every one mile a rideshare vehicle travels with a passenger onboard, the vehicle drives 1.69 total miles for a capacity utilization rate of 59.2% (**Equation 10.1.5.4B**).

$$\text{Equation 10.1.5.4B:}$$

$$\text{Capacity Utilization Rate}_{Rideshare} = \frac{\text{miles traveled with passenger}}{\text{total miles traveled}} = \frac{1}{1.69} = 59.2\%$$

A comparative analysis of rideshare vehicles and taxis for five major cities revealed that the average capacity utilization rate for taxis is 38% lower than that of rideshare vehicles, resulting in a taxi capacity utilization rate of 21.2% (Cramer and Krueger, 2016); **Equation 10.1.5.4C**.

Equation 10.1.5.4C:

$$\text{Capacity Utilization Rate}_{\text{Taxi}} = 59.2\% - 38\% = 21.2\%$$

The disparity in capacity utilization rate, a measure of miles traveled with a passenger relative to total miles traveled by the taxi or rideshare, is largely due to the large scale of rideshare fleets, efficient driver-passenger matching technology, and inefficient taxi regulations. Taxis travel even more miles without passengers in the car compared to rideshare vehicles, which in turn would lead to even more emissions (Anair et al., 2020; Henao and Marshall, 2019). These emissions are directly attributable to the fan’s ride and are included in our total carbon footprint estimate for fan transportation. We determined that in a taxi, for every one mile the vehicle travels with a passenger onboard, it drives approximately 4.72 total miles, or 472% more than a personal car (Equation 10.1.5.4D).

Equation 10.1.5.4D:

$$\text{Total Miles Traveled}_{\text{Taxi}} = \frac{\text{miles traveled with passenger}}{\text{capacity utilization rate}} = \frac{1}{0.2117} \approx 4.72 \text{ miles}$$

We used the total miles driven relative to one mile traveled with a passenger on-board as a “CID factor” (cruising, idling, and deadheading) for rideshare vehicles (1.69) and taxis (4.72). Lastly, we derived distinct emission factors for rideshare vehicles and taxis using the CID factors to more accurately reflect all emissions associated with those trips (Equation 10.1.5.4E). Tables X provides emission factors used for each transportation type.

Equation 10.1.5.4E:

$$EF_{\text{Mode}} = EF_{\text{Passenger Car}} \times CID_{\text{Mode}}$$

Table 27. Emission factors used for fan transportation footprint by transportation type

| Transportation Type | CO2 Emission Factor (kg per unit) | CH4 Emission Factor (g per unit) | N2O Emission Factor (g per unit) | Unit |
|--|-----------------------------------|----------------------------------|----------------------------------|----------------|
| Airplane (Medium Haul) ¹ | 0.131 | 0.0006 | 0.0006 | passenger-mile |
| Car / Personal Vehicle ^{1, 2, 6} | 0.403 | 0.011 | 0.009 | vehicle-mile |
| Rideshare service (e.g. Uber, Lyft) ^{1,3,4,6} | 0.576 | 0.015 | 0.013 | vehicle-mile |
| Bus ¹ | 0.054 | 0.0206 | 0.0009 | passenger-mile |
| Taxi ^{1,3,4,5,6} | 1.611 | 0.043 | 0.038 | vehicle-mile |
| Train ¹ | 0.15 | 0.0117 | 0.0038 | passenger-mile |
| Subway / light rail ¹ | 0.106 | 0.0095 | 0.0013 | passenger-mile |
| Bike / scooter | N/A | N/A | N/A | |
| Walk | N/A | N/A | N/A | |

¹EPA 2021 GHG Emission Inventory Factors - Table 10, 2021; ²Transportation Energy Data Book: Edition 39 - Table 2.13, 2021; ³Anair et al., 2020; ⁴Henao and Marshall, 2019; ⁵Cramer and Krueger, 2016; ⁶personal calculations

10.1.5.5 Calculating GHG Emissions from Distances

Once we determined total passenger- and vehicle-miles, and appropriate emission factors for each transportation mode, we calculated GHG emissions for each mode and, ultimately, for the total GHG emissions from fan transportation. Travel method responses over 450 miles (one-way) were assumed to have flown (see distance threshold assumptions discussed in detail in Section 10.1.5.6). For air travel, we used the Haversine air distances; for all other transportation methods, we used the driving distances. We used ground travel distance to define the cutoff between driving and flying (i.e. if the hypothetical driving distance was greater than 450 miles, we assumed the fan(s) flew even if the air distance was less than 450 miles). The likelihood of fans traveling from over 450 miles away solely for the purpose of attending a Rays game is low, so we allocated only a fraction of the total emissions from flights. Based on local tourism data, the average length of stay in the St. Petersburg/Clearwater area is 3.5 days (Visit St. Pete/Clearwater, 2018, 2019, 2020). We chose to allocate one full day to the baseball game, thus dividing the total number of airplane passenger-miles by 3.5 (**Equation 10.1.5.5A**).

Equation 10.1.5.5A:

$$SMT_A = \frac{PPSA \times ZDA \times RTF}{3.5}$$

10.1.5.6 Assumptions

We made a number of assumptions to model the emissions from fan transportation. Broadly, we assumed that transportation trends captured in the 2021 survey accurately reflected, and could be extrapolated to encompass, the Rays' fan population in 2019. See Fan Transportation Survey Purpose, Implementation, and Analysis Section 12.2: Improving GHG Quantification by Reducing Assumptions for how our updated fan transportation survey will reduce assumptions made in future calculations.

General survey response assumptions: We assumed that all responses to Survey Question 1 (who fans traveled with) referred only to people traveling in the same vehicle. We also assumed that respondents used only the travel method indicated from the reported zip code to the stadium. In both cases, without supplemental information, our assumptions provide the best estimate.

Return travel assumption: Fans were specifically asked how they traveled to Tropicana Field and where they began their trip. We assumed that all respondents returned to the same point of origin (i.e. they traveled the same distance in both directions) and took the same transportation method. From the responses, it may not be realistic to assume that fans traveling to the stadium from "Work" or "Somewhere else" returned to those locations afterwards. However, without specific information about how and where the fans traveled after the game, our assumption provides the best estimate.

Additional passenger assumptions: Because the survey did not specifically ask respondents to state the number of people with whom they attended the game, we assumed that for every option that a respondent selected (e.g., "My friends", "My kids", "Other family members", "Colleagues or business clients", etc.) only one additional passenger traveled with the respondent. We believe this assumption is justified since the average occupancy of personal vehicles is 1.87 (Davis and Boundy, 2021).

Emission factor assumptions: We made assumptions specific to the application of emission factors. We assumed that cars traveling to Tropicana Field reflected the national average distribution of cars and trucks. As such, we created an emissions factor for the “Car / personal vehicle” option using a weighted average between the passenger car emission factors and the light duty truck emission factors (Davis and Boundy, 2021); **Table 28, Equation 10.1.5.6A**).

Table 28. Derived “Car / personal vehicle” emission factors

| Description | Value(s) |
|--|-------------------------------------|
| Passenger car: total passenger-miles (PM _{PC}) | 2,186,139 ¹ |
| Light duty truck: total passenger-miles (PM _{LDT}) | 2,248,145 ¹ |
| Passenger car: CO ₂ /CH ₄ /N ₂ O emission factor (unit per vehicle-mile) (EF _{PC}) | 0.341kg/0.009g/0.008g ² |
| Light duty truck: CO ₂ /CH ₄ /N ₂ O emission factor (kg per vehicle-mile) (EF _{LDT}) | 0.464/0.012/0.01 ² |
| “Car / personal vehicle”: CO ₂ /CH ₄ /N ₂ O emission factor used in analysis (kg per vehicle-mile) (EF _C) | 0.403/0.0105/0.009 ^{1,2,3} |

¹Transportation Energy Data Book: Edition 39 - Table 2.13; ²EPA 2021 GHG Emission Inventory Factors - Table 10; ³Personal Calculations

Equation 10.1.5.6A:

$$EF_C = \left(\frac{PM_{PC}}{PM_{PC} + PM_{LDT}} \right) \times EF_{PC} + \left(\frac{PM_{LDT}}{PM_{PC} + PM_{LDT}} \right) \times EF_{LDT}$$

Rideshare/taxi emission factor assumptions: We assumed that the rideshare vehicles and taxis that are likely to be hailed to transport passengers to a baseball game almost always fit within EPA’s passenger car designation, rather than the light-duty truck designation. Therefore, we calculated the rideshare/taxi emission factors based on the passenger car emission factors, rather than our hybrid “personal car/vehicle” emission factors. If we had used the personal vehicle emission factors for taxis and rideshare vehicles, the total emissions from fan transportation would have been 0.96% lower.

Distance threshold assumptions: When we used the zip codes to generate distances, we noticed that many respondents indicated driving or a short-distance transportation mode in spite of the fact that their stated zip code was hundreds of miles away. Our survey data did not include an airplane option. We assumed everyone traveling over 450 miles to the stadium traveled by airplane (Edwards et al., 2016). However, there are likely fans who roadtrip more than 450 miles to see a game; this is a simplification. Since emissions from local ground transportation associated with flying are miniscule relative to the emissions from air travel, these emissions were excluded from our study. If we had instead assumed, using the same partial allocation assumption, that anyone traveling over 450 miles to the stadium drove, the total emissions from

fan transportation would have been 14.1% higher than our baseline calculation. If we assumed that people flew if they traveled over 350 miles to the stadium, the total emissions from fan transportation would have been 3.34% lower than our baseline calculation. On the other hand, if we had assumed that people flew only if they traveled over 550 miles to the stadium, the total emissions from fan transportation would have been 3.90% higher than our baseline calculation.

After accounting for air travel, there were still many responses that indicated walking as the travel method for distances that were well beyond reasonable walking distance. As such, we assumed that fans walked a maximum of 15 miles each way (Cronkleton, 2019), and biked or rode a scooter for a maximum of 50 miles each way (Whitehouse, 2019). We “corrected” all walking distances beyond the 15-mile threshold and all bike/scooter distances beyond the 50-mile threshold to “Car / personal vehicle.” This assumption is supported by survey results that over 80% of surveyed fans selected the “Car / personal vehicle”. If we had not made any assumptions about the method of transportation and only partially allocated emissions from travel over 450 miles, the total emissions from fan transportation would have been 16.8% lower than our calculated baseline.

Length of stay assumptions: We assumed that the average length of stay for out-of-town fans attending Rays games is comparable to the average length of stay in the St. Petersburg/Clearwater area (Visit St. Pete/Clearwater, 2018, 2019, 2020). Because out-of-town fans most likely did more in the area than just attend the Rays game, we only allocated a fraction of the total emissions from the trip to the game. As for car travel or other modes, we could find no comparable data to delineate the mileage threshold beyond which car drivers stay overnight. So, we assumed that 100% of emissions from those vehicles ought to be attributed to the game, even if the car drove 449 miles (one-way). If we alternatively assumed that all emissions from travel should be allocated to attending the game regardless of the total distance traveled, the total emissions from fan transportation would have been 59.1% higher than our baseline calculation.

Bike/ Scooter transportation type assumption: It is unclear from the data whether survey responses that indicated “Bike / scooter” as the method of transportation, included electric or gas-powered forms. We assumed that the transportation method refers to human-powered bikes and scooters only and therefore generates no emissions. Any electric modes indirectly generate emissions relative to the electrical grid mix if they rely on electricity from the grid. Additionally, shared bikes/scooters generate emissions from rebalancing – collection and redistribution of bikes/scooters in strategic locations, by car. More rebalancing is required for dockless bikes/scooters than for docked ones. If we assumed that all bikes and scooters used to travel to the stadium were shared, dockless electric bikes, and thus generated emissions (Hollingsworth et al., 2019), the total emissions from fan transportation would have been 0.01% higher than our baseline calculation, mostly due to emissions from rebalancing. If we instead assumed that all bikes and scooters used to travel to the stadium were personal electric bikes and scooters (which would not generate additional emissions from rebalancing) (McQueen et al., 2020), the total emissions from fan transportation would have been less than 0.01% higher than our baseline calculation. If all bikes and scooters used to travel to the stadium were of the shared, docked variety (Luo et al., 2019) the total emissions would have been in between the two estimates.

10.1.5.7 Upper and Lower Bound Estimates

We examined the influence of these assumptions by estimating an upper and lower bound for possible emissions. The upper bound was calculated with distances from zipcodes and the following assumptions: all long-distance travel (defined as more than 450 miles one-way) was taken by personal vehicle rather than airplane, 100% of transportation emissions were allocated to attending the game regardless of the distance, all bikes and scooters used were electric and thus produced emissions (Hollingsworth et al., 2019). The upper bound produced more than twice (106% more) the emissions from the base set of assumptions we used to estimate fan transportation emissions. At the opposite end of the spectrum, the lower bound was calculated using categorical responses on the approximate amount of time to get to the stadium (e.g. less than 10 minutes, between 10 and 30 minutes, etc.). We thus assumed fans traveled as far as they reasonably could within the lower bound of time (i.e. if a response stated “between 10 and 30 minutes” we assumed 10 minutes), which implicitly suggests that travel over one hour (the longest time option available) is not attributable to the baseball game. Under this assumption, the lower bound produces only 64.7% of the emissions from the base set of assumptions used to estimate emissions.

10.1.5.8 Scenario Analysis Methodologies and Assumptions

EV Adoption: We estimated the magnitude of emissions savings potential related to six speculative EV adoption scenarios: 100% EV use by 1) fans driving personal vehicles, 2) all cars (personal vehicles and ride-hailing vehicles), and 3) all cars including if people drove instead of flew long distances, and 7% EV use under the three same conditions. For these calculations, we replaced the car-based emission factors with EV emission factors (derived from the 2019 FRCC eGrid subregion (and from the national average eGrid mix) using an average EV efficiency of .32kWh per mile (“Alternative Fuels Data Center: Data Sources and Assumptions for the Electricity Sources and Emissions Tool,” 2021; U.S. EPA, 2021b) (U.S. EPA, 2021a))

Carpooling: We estimated the magnitude of emissions savings potential related to a scenario in which 100% of personal vehicles traveling to the stadium were full of passengers. Using an average maximum car occupancy of four persons, we assumed that every survey respondent who took a personal vehicle to the stadium traveled in a group of four. This assumption increased the total number of fans captured in the survey by nearly 70%, which reduced our season-scaling factor to calculate emissions from the entire 2019 season.

Park-and-Ride Adoption: We estimated the magnitude of emissions savings potential from switching all “short” distance (up to 50 miles one-way) motorized travel to park-and-ride. We assumed for the sake of the analysis that all travel within 50 miles of the stadium occurred by park-and-ride bus except for walking and biking because these modes do not produce emissions. For simplicity, we used the EPA’s bus emission factors (U.S. EPA, 2021a) and maintained that passengers traveled the entire distance from their home zip code to the stadium by park-and-ride. However, depending on the number and location of park-and-ride lots, most fans would have to travel some distance to the park-and-ride lot. We attributed passenger-miles based on the total distance traveled by the buses. We assumed that the buses originated from the stadium, so the total distance attributed to each passenger was twice the distance they physically traveled (accounting for the bus travel to the pick-up point before collecting passengers and travel back to the stadium after dropping off passengers after the game).

Bike-to-the-Game: We estimated the magnitude of emissions savings potential related to three scenarios in which 100% of fan travel within ten miles (one-way) occurs by different types of bicycle: 1) human-powered, 2) shared dockless electric, 3) personal electric. In all cases, we reclassified all fan travel up to ten miles (one-way) to have been by bicycle. In the first scenario, we assumed there are no emissions from cycling. In the second scenario, we used emission factors derived from shared dockless e-scooters (Hollingsworth et al., 2019). We assumed that e-bikes and e-scooters have the same battery capacity and maximum power and could therefore use the same CO₂e emission factor. We extrapolated emissions from the use phase (including both charging and associated collection and distribution) (96.354 gCO₂e/mile). In the third scenario, we derived emission factors for personal e-bikes and e-scooters from McQueen et al. (2020). The study uses emission factors specific to the 2018 electrical grid in the Pacific Northwest (NWPP), so we converted the emission factor to make it specific to the 2019 Florida (FRCC) grid (**Equation 10.1.5.6B**). The emission factor specific to the 2019 FRCC grid was 6.591 gCO₂e/mile.

Equation 10.1.5.6B:

$$FRCC\ ebike\ Emission\ Factor = \frac{2019\ FRCC\ emission\ factor}{2018\ NWPP\ emission\ factor} \times NWPP\ ebike\ Emission\ Factor$$

No Rideshare/Taxi: We estimated the magnitude of emissions savings potential from switching all rideshare and taxi rides to personal cars. This switch eliminates additional emissions associated with cruising, idling, and deadheading. In this scenario, we used the car/personal vehicle emission factor for all cars, rideshares vehicles, and taxis. We also estimated the magnitude of increased emissions from switching from personal cars (and taxis) to rideshare vehicles. In this scenario, we used the rideshare vehicle emission factor for all cars, rideshare vehicles, and taxis.

10.1.6 Team Travel

Rays data related to team travel was limited to publicly available information about the team’s playing schedule from which air travel emissions could be inferred. The Rays’ team travel manager stated the team uses a plane for any intercity travel over 200 miles. Aside from air travel, the team travel footprint was calculated using 2019 data from the Mets (see Section 10.1.6.1). The Mets utilize a travel agency, Direct Travel; this service provides the total annual CO₂ emission (in lbs) for the following categories: air, car rental, and hotel. Transportation and accommodations are considered Scope 3 emissions. Exact values were not provided at the monthly level, but emission values were broken down by month and depicted in a bar chart (see **Figure 14** for an example), thus an estimation of the monthly emissions value was determined by the team. Monthly CO₂ emissions (in lbs) for all of the provided transport categories were gleaned from the bar charts for the April thru September 2019 period and summed to determine the season-level total emissions. These data were then converted from pounds to kg using the EPA’s Greenhouse Gas Equivalencies Calculator, where 1 pound CO₂ is equivalent to 0.4536 kg CO₂ (“Greenhouse Gas Equivalencies Calculator,” 2021).

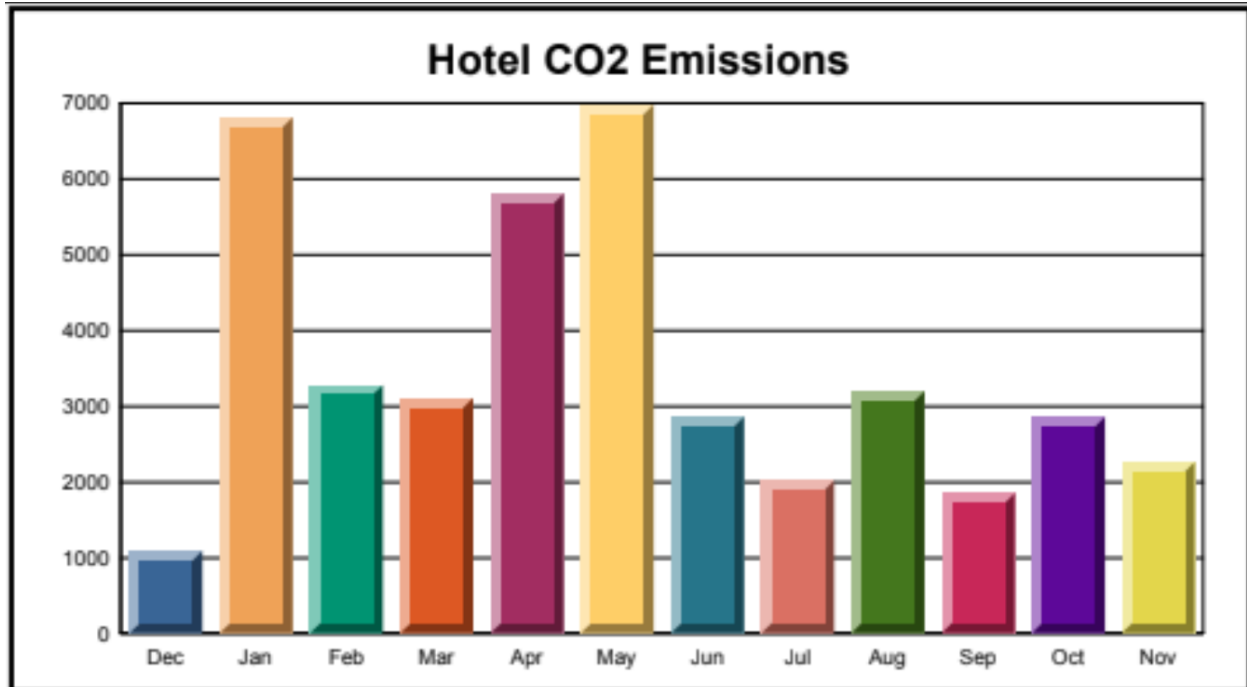


Figure 14: CO2 emissions associated with hotel stays from New York Mets 2019, prepared by DirectTravel

10.1.6.1 Comparison to Mets Data

To understand how accurately the Mets data represents the Rays team travel footprint, an analysis was performed to compare the emissions from Mets team flights to the Rays. A spreadsheet was set up using the publicly available 2019 Rays schedule to track the team’s travel between games (both home and away) and account for miles flown over the course of the season; an online “Air Miles Calculator” tool was used to determine flight miles between airports (“Air Miles Calculator,” n.d.; ESPN, 2019). EPA emission factors for 2021 GHG inventories were used to determine emissions associated with flight miles; flights are divided by the EPA into three categories: “short” (less than 300 miles), “medium” (300 to 2300 miles), and “long” (over 2300 miles) and each has specific emissions factors for flight length, as the distance flown impacts the emissions factor; shorter flights have higher emissions factors. It should be noted that the Mets data did not specify the source or year for emission factors applied, but that when comparing the Rays’ flight emissions the 2021 GHG emission factors were used for consistency across the entire body of calculations. Using the max capacity (189 people) of the 727-200 plane, which was identified as the Rays’ team plane model, kgCO₂/passenger-mile was converted to kg CO₂; **Table 29** shows the process from identifying the Rays’ flight mileage to determining the kg CO₂ associated with the flight. Note that the max capacity of the plane was used as we were unable to determine an average number of passengers for the flights; capacity is important because the more passengers, the fewer emissions per passenger-miles. **Equation 10.1.6A** summarizes the air travel emissions calculation process. Total emissions from flights associated with Rays team season travel were determined to be 1,120,349 kg CO₂; for comparison, the Mets data identified emissions of 1,224,469 kg CO₂. Because both teams had similar emissions values for air travel, and this was part of team travel we were able to determine for Rays, the air travel emissions used in our footprint stem from the Rays data.

The Mets emissions have been used as a proxy for the rest of the team travel end-use categories of the total footprint.

Table 29. Process for calculating the kg CO2 associated with each flight taken to accommodate the Rays 2019 schedule, using 2021 EPA emissions factors for various flight mileages; this table is a sample showing the three different flight types and is not inclusive of all data used

| Game Date & Location | Flight Type | Estimated Mileage Flown | Estimated Number of Passengers (max seating capacity) | Passenger Miles (estimated mileage * max seating capacity) | CO2 Emission Factor (kg/passenger mile) | kg CO2 |
|---------------------------------|----------------------------|--------------------------------|--|---|--|---------------|
| 4/5/19 at San Francisco | Long (2300+ miles) | 2390 | 189 | 452,000 | 0.161 | 72,800 |
| 5/3/19 at Baltimore | Medium (300-2300 miles) | 967 | 189 | 183,000 | 0.131 | 23,900 |
| 5/14/19 at Miami | Short (300 or fewer miles) | 204 | 189 | 38,600 | 0.206 | 7,940 |

Equation 10.1.6A:

$$\text{Team Air Travel GHG Emissions (CO2e)} = \sum (\text{Estimated Mileage Flown} \times \text{Estimated Number of Passengers} \times \text{Emission Factor}_{\text{FT-GHG}} \times \text{GWP}_{\text{GHG}}),$$

where FT is flight type (short-, long- or medium-haul) and GHG is CO2, CH4 and N2O.

10.1.7 Concessions

This subsection details the methodology for quantifying the carbon footprint from concessions at Tropicana Field during the 2019 Tampa Bay Rays season. This includes both the GHG emissions from the food produced and sold at concessions stands and the GHGs from the non-capital materials and packaging used and distributed at the concessions stands. This evaluation is considered cradle-to-stadium, meaning it includes all upstream GHG emissions such as those associated with farming, or packaging material extraction, and transporting food to stadiums. This section does not include GHG emissions associated with the “use phase” of concessions materials, i.e. onsite food production, because these GHG emissions would be from use of natural gas or electricity in the cooking process and are thus quantified in Scope 1 and Scope 2 emissions calculations. Additionally, it does not include end-of-life GHG emissions of food and materials from concessions because all GHG emissions from all waste exiting the stadium (not just concessions-related waste) are quantified and detailed in Appendix 10.2.4. Quantifying cradle-to-stadium emissions of concessions avoids double counting of GHG emissions associated with concessions use phase and end of life.

Concessions at Tropicana Field are made from purchased goods and services. The GHG Protocol Technical Guidance for Calculating Scope 3 Emissions recommends calculating emissions from purchased goods and services using supplier-specific data if possible, followed by national

average data applied to actual mass of quantities purchased, and lastly, using a spend-based method that estimates emissions for goods and services by collecting data on the economic value of goods and services purchased and multiplying it by relevant secondary (e.g., industry average) emission factors (e.g., average emissions per monetary value of goods; (Barrow et al., n.d.). Using primary data from suppliers ensures specificity, but not necessarily accuracy, with GHG emissions estimates. Using economic value as a proxy for mass or volume may reduce specificity of GHG emissions estimates, but not necessarily accuracy (Barrow et al., n.d.).

10.1.7.1 Data Available from the Rays

Our team opted to use a spend-based method to quantify GHG emissions given available data. The Rays provided our team with their purchasing data for Tropicana Field from March 1, 2021 through July 19, 2021, a time period including 59 home games at Tropicana Field. This Microsoft Excel spreadsheet contained supplier name, product name, total units purchased, total dollars spent per product (“spend”), and date of purchase. The dataset included records of 5,666 purchases of 1,626 unique products from 36 different suppliers. However, the dataset omitted detailed supplier information and the “total units purchased” was not in units of mass or volume, leaving a spend-based method as the most viable option for quantifying emissions associated with the purchases. The advantage of using this method is that it allowed us to comprehensively evaluate emission sources from the entire economy in a time-efficient manner. Limitations of this method include: broad sector averages may not represent the nuances of unique processes and products; the method lacks specificity and accuracy compared to process-based approaches; and this method makes it difficult to measure and demonstrate results of reduction efforts including purchasing from suppliers that are making GHG reduction efforts (Barrow et al., n.d.).

10.1.7.2 Emissions Dataset

Our analysis of GHG emissions associated with concessions used GHG emission factors from the U.S. EPA’s Supply Chain Emission Factors for U.S. Industries and Commodities dataset (Ingwersen and Li, 2020). These emission factors use Environmentally-Extended Input-Output (EEIO) Models, which are life cycle models of goods and services in the U.S. economy. The EEIO model pairs supply chain economic data with environmental data to understand both financial and environmental relationships between sectors throughout an organization’s supply chain. The datasets contain the financial dependencies of each economic sector on all other economic sectors. Pairing this with U.S. EPA data on GHG emissions from each sector allows the U.S. EPA to provide a dataset of emission factors that describe GHG emissions per dollar spent on an economic sector. The dataset, published in July 2020, includes GHG emission factors for ~400 economic sectors, defined with the sector codes from the U.S. Bureau of Economic Analysis (BEA). The dataset provides emissions factors for dollars spent in the years 2010-2016. Since our data is from 2021, 2016 emission factors were used - the most current emission factor. Emission factors from the model do not include biogenic emissions, or emissions derived from biomass (Ingwersen and Li, 2020).

10.1.7.3 Calculating Emissions

The process of calculating emissions required joining the Rays purchasing data with the U.S. EPA EEIO dataset from Ingwersen and Li. This was done by identifying the BEA economic sector applicable to each individual purchase record from the Rays, i.e. which economic sector

was responsible for the emissions associated with production of each item purchased by the Rays for concessions. To do this, our team performed a categorization exercise that involved manually reviewing the data line-by-line to classify each purchase with the appropriate BEA sector code. Further details on how this was done and what assumptions were used to classify the data are contained in Section 10.1.7.4. Once BEA sector codes were added to Rays purchasing data, CO₂e for each line item were calculated (Figure 15). Emissions were then totaled by the BEA economic sector; see Table 14 in Results Section 6.1.1.7 for breakdown of total emissions by the BEA sector.

Example calculation: GHG emissions from hot dog buns

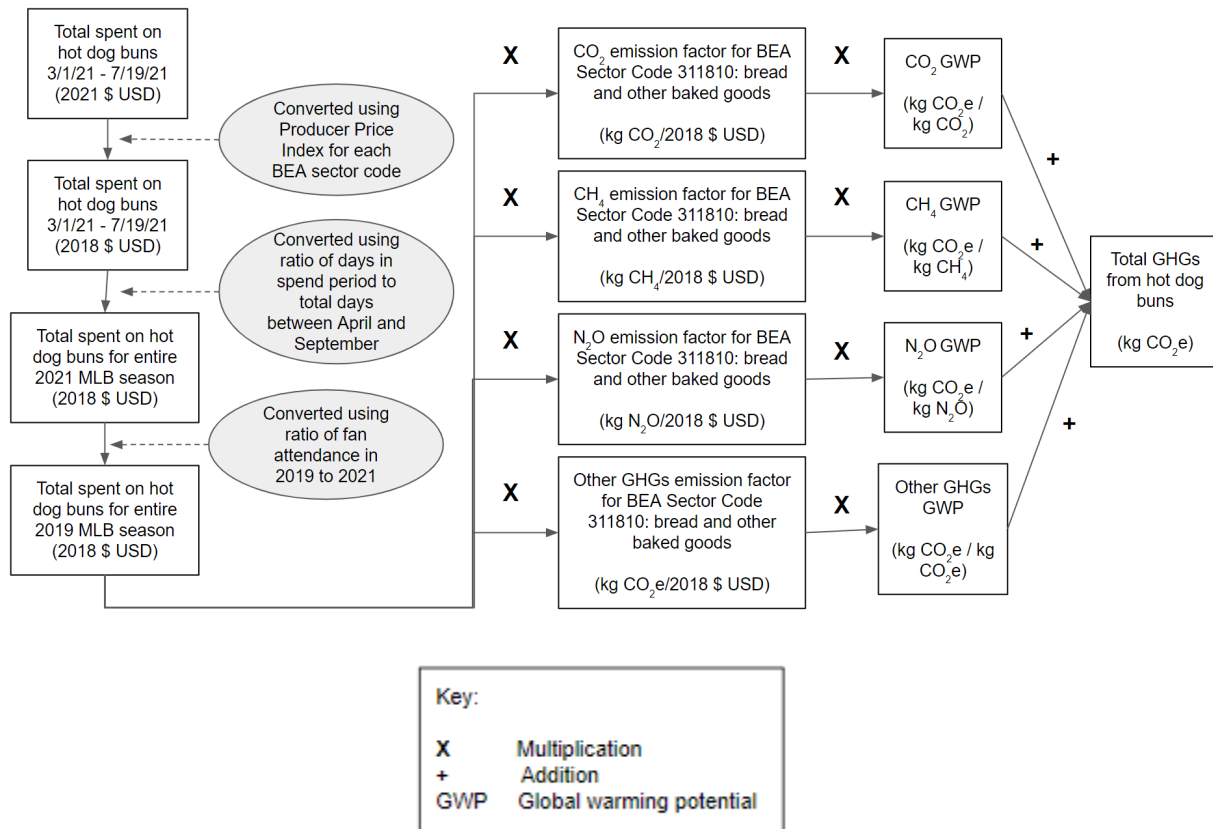


Figure 15: A visual representation of Equation 10.1.7.3A, used to calculate GHG emissions associated with each line item. The calculation begins with the total dollar quantity spent on hot dog buns in the upper left corner and then follows the arrows to total GHGs

Equation 10.1.7.3A:

$$\text{Concessions GHG Emissions (in CO}_2\text{e)} = \sum [\text{Dollar Spent}_{PG} \times \text{Producer Price Conversion Factor}_{PG} \times \sum (\text{Item Emission Factor}_{GHG} \times \text{GWP}_{GHG})],$$

where PG is an individual purchased good and GHG is CO₂, CH₄ and N₂O.

Note that, consistent with other calculations in our carbon footprint, we used 100-year GWPs from the IPCC AR6 report but that the “other GHGs” were already converted to CO₂e using IPCC AR4 GWPs (Smith and Nicholls, 2021, p. 6).

Our calculations did not convert total spend from the price that the Ray’s paid to a producer price that excludes mark-ups. This is because the U.S. EPA EEIO emission factors were already converted from producer prices to consumer prices using BEA data. This conversion factored in margins from distribution, wholesale and retail costs (Ingwersen and Li, 2020). We felt it appropriate to not convert based on the size of the Ray’s purchasing, and that bulk purchasing relates them to a wholesale price.

10.1.7.4 BEA Sector Code Assumptions

For clarity on what types of products and services fall into each BEA Sector Code, we used (“Carnegie Mellon - EIO LCA,” n.d.). Specifically, we used the 2002 U.S. National Producer Price Model because it allowed us to search for sectors using keywords. In our categorization exercise, we used the following assumptions:

- The majority of fish and meat were assumed to be processed and packaged. Therefore, all fish and meat products were classified as BEA Sector Code 31161A - Packaged meat (except poultry), 311615 - Packaged poultry, or 311700 - Seafood, as appropriate. No “farming” or “wild-caught” sector codes were used with the exception of code 112300 - Poultry farms for all egg products because this sector does include egg production
- Plastic purchases fell into BEA Sector Code 326190 - Other Plastic Products rather than Code 325211 - Plastics, which is more closely aligned with plastic resin manufacturing rather than products made from plastics.
- Fuel surcharges represented additional fuel required to transport the goods to the stadium and thus belonged to BEA Sector Code 324110 - Gasoline, fuels, and by-products of petroleum refining.
- Delivery charges corresponded to additional truck transport and were most appropriately placed in BEA Sector Code 484000 - Truck transport.
- Keg deposits were best captured by BEA Sector Code 424400 - Grocery and related product wholesalers because keg deposits represent (re)filling of brewed beer (or other beverages) rather than the brewing activity itself or the manufacturing of the keg.
- Pre-made food dips, mixes, and other amalgamations of ingredients from different sectors (such as sandwiches) were assigned BEA Sector Code 311990 - All other foods because the individual ingredients used came from a variety of other sectors and there is no other individual sector that best represented them.
- All chemicals purchased would be used for cleaning and thus fell into BEA Sector Code 325610 - Soaps and cleaning compounds.
- Synthetic materials such as nylon, velcro, or nitrile belonged to the BEA Sector Code 3252A0 - Synthetic rubber and artificial and synthetic fibers.

- All paper products directly associated with food service except 1) napkins and paper towels and 2) pizza boxes and other paper takeout containers fell into BEA Sector Code 322220 - Paper bags and coated paper. The exceptions mentioned here were assigned to 1) BEA Sector Code 322291 - Sanitary paper (tissues, napkins, diapers, etc.) and 2) BEA Sector Code 322210 - Cardboard containers.

10.1.8 Merchandise

This subsection details the methodology for quantifying the carbon footprint from merchandise at Tropicana Field during the 2019 Tampa Bay Rays season (April-September). This evaluation is considered cradle-to-gate, meaning it includes all upstream GHG emissions associated with product manufacturing, including packaging, shipping, however excluding end-of-life and use phases.

The Rays provided merchandise data that included only the top 25 items sold by quantity and volume for the 2021 season, totaling 41 merchandise items. The GHG Protocol Technical Guidance for calculating Scope 3 Emissions recommends calculating emissions from purchased goods using supplier-specific data. If unavailable it recommends using national average data applied to the mass of items purchased; lastly, if the above two options are infeasible, using a spend-based method to estimate the average emissions per monetary value of goods (Barrow et al., n.d.). Lacking access to a detailed spend ledger that included supplier specific information and annual revenue, we opted to use the spend-base method to calculate GHG emission associated with the economic value of goods purchased. By using the spend-based method the results are directly correlated with both volume of product sold as well as the price at which the product was sold.

Similar to concessions (Section 10.1.7.2), our analysis of GHG emissions associated with merchandise purchasing used GHG emission factors from the U.S. EPA's Supply Chain Emission Factors for U.S. Industries and Commodities dataset (Ingwersen and Li, 2020), paired with U.S. EPA GHG emissions factors assigned by U.S. Bureau of Economic Analysis (BEA) sector code (Ingwersen and Li, 2020).

Although data provided was for the 2019 season, data provided did not include the Rays' purchasing price or sale price; so we assigned dollar values to each merchandise product using current (2021) product prices in the Rays' online MLB store (MLB, 2022a) (see Sections 10.1.8.1-10.1.8.2 for further detail). We then converted the purchaser price to producer price using the U.S. Bureau of Economic Analysis's Commodity Composition of Personal Consumption Expenditures (PCE; ("PCE Bridge Table | 2007-2012," n.d.). Once converted to 2019 producer price, in 2021 USD, we converted to 2018 USD using the inflation rate for each product's BEA economic sector, see **Equation 10.1.8A**. The BEA Sector Code was assigned by conducting a categorization exercise that involved manually reviewing the products line-by-line, the same as was done for categorizing concessions into various BEA sector codes. Unlike concessions, merchandise already represented an entire season of sales so there was no need to scale total spend to one whole season. Once the 2019 producer price was determined in 2018 USD, we used the assigned BEA sector codes and the same EEIO models and methodology as

concessions to calculate GHG emissions for each type of merchandise. See visual representation for hot dog buns in Section 10.1.7.3 above.

Equation 10.1.8A:

$$\text{Merchandise GHG Emissions (CO2e)} = \sum [\text{Revenue Dollars}_M \times \text{Quantity Sold}_M \times \text{Producer to Consumer Price Ratio} \times \sum (\text{Item Emission Factor}_{\text{GHG}} \times \text{GWP}_{\text{GHG}})],$$

where M is an individual merchandise item and GHG is CO₂, CH₄ and N₂O.

10.1.8.1 Product Pricing Assumptions

Numerous assumptions were made in order to fill data gaps related to merchandise data received from the Rays. We assume that the 2021 online listing price of MLB apparel sold on the website would have been the same as the price in 2019, excluding inflation. Additionally, if the product was no longer available or found online, the consumer price of an item that closely resembled that product was used. In some cases, a similar item was not available and so a weighted average of related items was calculated based on all products of that type on the MLB store website.

10.1.8.2 MLB Markup Assumptions

Since the values assigned to all items were made based on assumptions, we also assumed the Rays used the U.S national average percentage mark-ups; for example apparel manufacturing is 0.42% (“PCE Bridge Table | 2007-2012,” n.d.). However, prices on merchandise items are usually assigned a higher mark-up than national averages at MLB stadiums, presumably to maximize profit margins. The above-national-average mark-ups for MLB merchandise results in above-average revenue, and therefore an overestimate of GHG emissions in our study.

10.1.8.3 PCE Table Assumption

The most recent year available on the U.S Bureau of Economic Analysis’s PCE Bridge Table is from 2012. Using a version from 2012 could greatly affect the outcome of merchandise as the trade margins have been updated that would change wholesale and retail cost.

10.1.8.4 “Grab bag” Assumptions

Specialty items such as the mystery “grab bags” and the specialty commemorative jersey accounted for 7.1% of merchandise emissions each. The “grab bag” was the top-selling product from the Rays data set. An informational interview with the Rays’ merchandise manager revealed that the “grab bag” item is part of an event called “Fill a Bag.” During spring training or on Opening Day, the Rays offer an opportunity for season ticket holders to purchase a recyclable bag and fill it with products for one price (\$20). Typical items include outdated items such as traded players’ jerseys, t-shirts with outdated logos and other miscellaneous gifts. Considering many potential “grab bag” items are apparel, and such items will typically have a greater mass and dollar value, our team used the BEA “clothing” emission factor (Ingwersen and Li, 2020). This likely resulted in an overestimate of emissions from the “grab bag” items sold because clothing was one of the BEA economic sectors with the highest emissions intensity but the “grab bags” likely also contained items that were not clothing that had a lower emissions intensity.

10.2 Onsite Water Use Methodology

This section documents the details of our methodology for calculating onsite water use. The subsections comprise the specific methods used to calculate water usage for specific activity areas within our system boundary. Details in each subsection include sources of activity data, equations to compute water usage from activity areas, and supporting assumptions.

10.2.1 Restrooms

Restroom water usage was calculated using a bottom up approach and is the sum of total sink, urinal, and toilet water use (**Equation 10.2.1A**). This calculation excludes clubhouse and office bathrooms and is based on 2019 fan attendance.

Equation 10.2.1A:

$$W_R = W_S + W_{U+C}$$

The total water used during the 2019 season for each bathroom fixture type was determined by multiplying flow rates (**Table 30**) by the estimated number of uses per season (urinal and commode) or an estimated average duration of use (sink; **Equations 10.2.1B and C**). Total urinal and commode flow rates were provided by the Rays' facilities manager (**Table 31**). We calculated an average flow rate for urinals and commodes combined, due to lack of data on the ratio of men to women fan attendance and typical bathroom habits.

Equation 10.2.1B:

$$W_S = U_B (FR_S \times T_S)$$

Equation 10.2.1C:

$$W_{U+C} = FR_{U+C} \times U_B$$

The average person goes to the bathroom 6-7 times in a day (24 hours; (“Urinary Frequency,” 2017), and the average baseball game lasts ~3 hours (Bleier, 2021). Thus, we determined the average bathroom use per game to be 1.23 (24 hours / 3 hour game / 6.5 times per day). To calculate the total bathroom uses per season (U_B), we multiplied the number of attendees per season by the above calculated average bathroom use per game.

We assumed every person washed their hands after going to the bathroom and, based on CDC guidelines on handwashing time, each user spent 20 seconds washing their hands (CDC, 2021).

Table 30. Flow rates by bathroom fixture

| Bathroom Fixture | Water Consumption |
|----------------------------|-------------------|
| Sink | 2.2 gal/min |
| Urinal | 1 gal/flush |
| Commode | 3 gal/flush |
| Average Urinal and Commode | 2 gal/flush |

Table 31. Variables from **Equations 10.2.1A-C** used to calculate the total water consumed by bathroom fixtures

| Variable | Definition |
|-----------------|---------------------------------------|
| W_B | Total Bathroom Water Use per season |
| U_B | Total Bathroom Uses per Season |
| W_S | Sink Water Use |
| FR_S | Flow Rate Sink |
| T_S | Average hand washing time |
| W_{U+C} | Combined urinal and commode water use |
| FR_{U+C} | Average Flow Rate (Urinal + Commode) |

10.2.2 Field Use

Tropicana Field does not have any water sub-meters, thus, determining the water usage attributed to field watering required observation and approximation. As the Rays utilize a synthetic turf, rather than the traditional grass many teams play on, field watering is only on the clay. The Rays primary groundskeeper filled a 32 gallon bucket using their hose in the same conditions as a regular field watering session to estimate water usage from field watering; the hose used had a diameter of one inch and a maximum pressure of 125 psi. The time it took for the bucket to be filled was recorded to determine a flow rate. The flow rate was calculated to be 16 gallons per minute, as it took two minutes to fill the 32 gallon bucket. Once the flow rate was determined, it was applied to recorded observations of watering that occurred across several home games to determine the average gallons of water used on the field on a typical gameday.

Table 32. Sample record of gameday field watering observations

| Game Date | Pre-Game Watering Time (mins) | Post-Game Watering Time (mins) | Total Watering Time (mins) | Total Field Use Water (gal) |
|------------------|--------------------------------------|---------------------------------------|-----------------------------------|------------------------------------|
| 7/19/21 | 12 | 11 | 23 | 368 |
| 7/21/21 | 11 | 8 | 19 | 304 |
| 7/23/21 | 14 | 13 | 27 | 432 |
| 7/27/21 | 11 | 11 | 22 | 352 |
| 7/29/21 | 12 | 11 | 23 | 368 |

Using the gallons estimated per game in **Table 32**, the average volume of water used to water the field for a game was determined to be 364.8 gallons. Anecdotal data from conversations with the Rays’ two primary groundskeepers identified watering frequency as everyday during the season, thus it is assumed a daily watering rate of 364.8 gallons during the season. Using an average value of 364.8 gal/day, over the course of the seasonal boundary of 182 days, the total water use on the field is estimated to be 66,393.6 gallons, 0.6% of the season’s total water usage.

10.2.3 Cooling Towers

Cooling tower water usage is described by **Equation 10.2.3A**, whereby makeup (in gallons per minute) equals the sum of evaporation and blowdown (U.S. EPA, 2017b).

Equation 10.2.3A:

$$W_{CT} = E + B$$

The Rays utilize Johnson Controls for their cooling tower service and maintenance; Johnson Controls collaborated with Nalco to provide data regarding the estimated flow rate and operating schedule of the two cooling tower systems onsite; see **Table 33**. Given that the footprint has a boundary of April through September (the typical season), an operating schedule of 182 days was used for the 800-ton cooling system when completing calculations; the 6000 ton system had a reported 100 days of operation.

Upon calculating the gallons used for each cooling tower it became clear the information provided from Johnson Controls and Nalco was not accurate enough to determine the actual water usage associated with the cooling towers, as the amount calculated for the cooling towers was larger than the total annual billed water consumption. Based on this finding, the cooling tower was not included as a formal category within onsite water use; instead, it was incorporated as part of “other”. Given the available information, it is reasonable to estimate that a significant portion of the “other” category is tied to the cooling tower and ultimately was allocated the remaining water consumed not accounted for in “back-of-the-envelope” calculations used to determine all other end uses within the “other” category (**Equation 10.2.3B**).

Equation 10.2.3B:

$$W_{CT} = W_T - W_R - W_{FU} - (W_G - W_{WF} - W_{CS} - W_{WM})$$

Table 33. Cooling tower data and water consumption

| | 800 Ton Cooling Tower | 6000 Ton Cooling Tower |
|---------------------------|------------------------------|-------------------------------|
| Flow Rate (gal/min) | 30.6 | 184 |
| Operating Days/Year | 365 | 100 |
| Operating Hours/day | 24 | 12 |
| Gallons per Season | 8,019,648 | 13,248,000 |

10.2.4 Other Calculations

Alternative water uses at Tropicana Field include water fountains, leaks, clubhouse use (including showers, soak tubs, water fountains), cooking, stadium cleaning, and landscaping. These activities were not able to be measured nor was sub-metered data available. Since cooling tower water consumption calculations resulted in a use estimate greater than the water utility bill, the cooling tower was moved to the other category. As a result, this category accounts for the majority of water usage. “Back-of-the-envelope” calculations using literature were conducted to provide a best estimate of the percent breakdown of the “other” category. Rough calculations were conducted for washing the grandstand, water fountains, clubhouse showers, leaks, and

washing machines. Kitchen use, office bathrooms and water fountains, other clubhouse uses besides showers, and any landscaping were not calculated. Using a Minnesota Twins study, washing the grandstand was calculated by **Equation 10.2.4A** (Minnesota Department of Health, 2010).

Equation 10.2.4A:

$$\text{Washing the Grandstand (gal)} = (x \text{ gal/min}) \times (y \text{ min. washing}) \times (z \text{ games per person})$$

Water fountain use was calculated based on the number of water fountains in Tropicana Field (provided by the Rays), the flow rate and automatic shut off time of a common public water fountain type, and an estimation of the number of uses per fountain per game (**Equation 10.2.4B**).

Equation 10.2.4B:

$$\text{Water Fountains (gal)} = (\# \text{ Water Fountains}) \times (x \text{ gal/sec}) \times (y \text{ sec/use}) \times (z \text{ uses/fountain}) \times (\# \text{ games per season})$$

Only shower water use was calculated for water used in clubhouse operations and was based on assumptions for the average shower length, and number of showers per game; we did not include use after practices (**Equation 10.2.4C**).

Equation 10.2.4C:

$$\text{Clubhouse Showers (gal)} = (\text{Showerhead Flow Rate (gal/min)}) \times (\text{min/shower}) \times (\text{shower/game}) \times (\text{games/season})$$

Leaks were assumed to be 6% of the total water usage based on EPA calculations of a typical commercial building (U.S. EPA, 2017c).

Data on the type, quantity and reason of use were provided for Tropicana Field washing machines. We assumed the number of minutes per wash, based on machine spec sheets and that each washing machine was used only once per home game. **Equation 10.2.4D** is the sum of each washing machine as there are different types requiring different water amounts.

Equation 10.2.4D:

$$\text{Washing Machines (gal)} = \sum_{WM \text{ Type}} (x \text{ Washing Machines}) \times (y \text{ gal/min}) \times (z \text{ min/cycle}) \times (\# \text{ games per season})$$

11. Recommendations

The following sections are a compendium of resources and suggestions for the Tampa Bay Rays to reduce their environmental impact and engage fans on issues surrounding energy, water, waste, fan transportation, and concessions; some recommendations have broader application and can be utilized by outside organizations. Recommendations have been numbered to provide structure only; the numbers do not imply prioritization or correlate to a hierarchy.

We chose our five recommendation categories (energy, water, waste, fan transportation, and concessions) based on client interest (in the case of energy, water and waste) or because the results of our study indicate these are large GHG emissions drivers for the Rays and, thus, represent the biggest opportunities to reduce emissions (fan transportation and concessions). In order to identify recommendations for each of these categories, our team conducted a literature review for each of the categories with a specific focus on: recommendations related to the identified hotspots in our study for each category, existing initiatives by other professional sports organizations, and proposed initiatives and recommendations from leading experts such as Dr. Allen Hershkowitz and the EPA.

This portfolio of options is a detailed jumping-off point for the Rays and the larger MLB community. It is enhanced with evidence (when possible) from other organizations, and includes potential percent reductions based on the results of this study, and additional resources. Recommendations are tailored toward the Rays, as they are based on results of their carbon footprint and onsite water usage, but can generally be considered by other teams. Further investigation on the part of the Rays or other teams is needed to determine which options should be prioritized and to evaluate effective implementation (see Section 7.2).

Each of the five subsections provides general background information on the impact area, and its significance for the Rays and sports more broadly. Additionally, a note on anything unique to the Rays and the recommendations for chosen impact categories are included. Recommendations are generally categorized as either technology enhancements, behavioral changes, special events or days, community partnerships & engagement, or corporate partnerships. Lastly, a small recommendation section is included specific to broader potential MLB-wide interventions in cases where we believe the league has more control or influence to enact change than individual clubs (see Section 11.6).

Overarching recommendations applicable to most activities include:

1. Sub-metering and utility audits: You can't manage what you don't measure!
2. Fan engagement to model stadium sustainability at home
3. Partner with local groups to offset GHG emissions and water consumption and increase fan engagement
4. Consult LCA studies when selecting recommendations for implementation

General Recommendation #1: Sub-metering and Utility Audits: You Can't Manage What You Don't Measure!

Data and accurate baselines are necessary for teams or facilities managers to set environmental goals and manageable intermediate milestones, as it is impossible to manage what is not

measured (“Why accurate measurement is essential for effective climate action,” 2015). Additional and more robust datasets would provide a greater level of insight into operations at Tropicana Field, leading to more specific and thus, effective recommendations. For example, an energy audit could indicate specific sources of high onsite energy consumption. A general recommendation for the Rays, or any organization interested in reducing their environmental impact, is to prioritize data collection as a preliminary action. A first step in this data collection is sub-metering utilities like water and electricity, and performing a waste audit. Sub-metering or audits enable more accurate quantification of utilities and waste directly attributable to operations related to baseball games, as opposed to non-Rays-related events that may occur at the stadium when the team is away. Given the opportunity for more detailed operational insight into potential efficiencies, utility sub-metering and a waste audit will also likely save clubs money (“Smart Water Meters Make a Difference,” 2020). Money savings may also come from verifying waste hauler data. The Rays can use a waste audit to directly compare waste hauler receipts and search for hidden or unnecessary fees (Great Forest, 2018). Teams across the league have performed waste audits such as the Seattle Mariners, San Francisco Giants and Chicago Cubs.

General Recommendation #2: Fan Engagement to Model Stadium Sustainability at Home

Sports teams have a significant opportunity to influence sustainability beyond the confines of a stadium. Since quantifiable reduction is now possible with a baseline carbon footprint and onsite water assessment, the Rays have an opportunity to advertise their reduction strategies in such a way to engage fans and inspire personal sustainability. For example, the Trailblazers have three opportunities for fans to get involved and reduce their own environmental impact in each of their impact areas: in relation to water, the Trailblazers encourage fans to install efficient showerheads and faucets; they can text a number to restore 1,000 gallons of fresh water via restoration efforts for Oregon rivers; or they can volunteer with Friends of Trees to plant trees in ones’ local neighborhood (“Change the Course – BEF | Sustainability Products and Services,” 2022; “Live Greener,” n.d.). Players for the Planet also supports such initiatives. They have partnered with One Tree Planted to support team-sponsored local tree planting events, as well as planting trees as a part of larger reforestation projects (“One Tree Planted”, 2022). Players for the Planet also uses its roster of professional athletes to promote sustainable actions fans can take at home (e.g. planting trees, recycling, or refusing single-use plastics), presenting an opportunity to highlight stadium initiatives and connect them to corresponding actions fans can take at-home. Partnering with Players for the Planet or local organizations will allow teams to support such auxiliary initiatives, without taking on the costs of organization and implementation.

General Recommendation #3: Partner with Local Groups to Offset GHG Emissions and Water Consumption and Increase Fan Engagement

Similarly, the Rays and other MLB teams can partner with local non-profits to increase fan engagement and demonstrate teams’ commitments to sustainability, all while increasing visibility. Moreover, local organizations have the knowledge to efficiently initiate projects and programs with the greatest impact for the community. Such initiatives should relate to stadium-led initiatives and be quantified appropriately as to avoid potential greenwashing. While stadium specific carbon and water use reduction strategies are preferred, purchasing carbon or water offset credits is another opportunity to demonstrate a teams’ interest in and commitment to carbon neutrality and water conservation. For example, in 2012, the MLB committed to

purchasing Water Restoration Credits from the Bonneville Environmental Foundation for All-star events and, the Trailblazers have partnered with local nonprofits in two important Oregon watersheds to plant 800,000 trees, improving water quality, filtration, restore habitat and increase local water resilience (Hershkowitz et al., 2012; “Live Greener,” n.d.).

General Recommendation #4: Consult LCA Studies When Selecting Recommendations for Implementation

Note that our team has not quantified potential environmental tradeoffs associated with recommended solutions. Conducting a complete LCA would allow for the consideration of a broader range of environmental impacts and support the evaluation of such environmental tradeoffs. For example, as discussed in the waste recommendations Section 11.3, there is a recent trend to switch to single use aluminum cups over single use plastic cups in an effort to reduce plastic consumption and/or disposal. While this switch will reduce plastic disposal and/or combustion, likely reducing local air pollutants associated with combustion, a recent LCA found all single-use cups performed worse than reusable cups across all environmental impacts measured and single-use aluminum cups are the worst option for the climate by far, using 47% more energy over their life-cycle and creating 86% more carbon dioxide than other single-use plastic options. This highlights the complexity of environmental problems and environmental tradeoffs associated with potential solutions. Consulting LCAs in concert with results of this study, would also support a more informed decision-making process.

11.1 Energy

Considering that professional ballparks average 1 million sq. ft., it is not surprising that stadiums require huge amounts of power (Energy Efficiency & Renewable Energy, 2017). From our calculations, Scope 2 emissions (purchased electricity) were the third largest emissions-producing activity (or second largest if fan transportation emissions are excluded). During games, when energy demand is at its peak, the Dallas Cowboys’ 80,000 seat stadium consumes ten MW of electricity (Mason, 2016). Game days typically have more energy-intensive demands, as lighting, air-conditioning, and video screens are all in use, but even outside of the season, stadiums need large amounts of power for maintenance (Unwin, 2019). Conversations with our clients revealed that energy use is a current industry focus area. Reducing energy consumption is also of interest to our clients and other similar organizations because there is a financial incentive to reduce. We propose the following recommendations for the Tampa Bay Rays, all considered technology enhancements:

1. Efficiency upgrades
 - a. Lighting
 - b. Building automation systems
2. Investment in renewable energy

Recommendation #1: Efficiency Upgrades

Efficiency is a key component of energy usage reduction. According to an industry report, only 68 professional teams have energy-efficiency programs out of the thousands of stadiums across the US (“Tips for improving utility efficiency in stadia and sporting venues,” 2019). Many parts of a stadium’s operations can benefit from energy optimization, including refrigeration,

humidification systems, concessions, HVAC, lighting, and AV systems (Mason, 2016). Financial savings have prompted many stadiums to prioritize energy efficiency; for example, a 2010 report found that a 5% improvement in energy efficiency at AT&T Stadium (home of the Dallas Cowboys) would provide \$120,000 in savings each year (Colker and Gutierrez, 2017). Even more impressive, the Seattle Mariners reportedly save approximately \$1.5 million in annual utility costs via energy saving investments (Colker and Gutierrez, 2017). ENERGY STAR presents lots of opportunities to reduce energy and increase cost savings (Energy Star, 2021). Busch Stadium (home of the St. Louis Cardinals) partnered with ENERGY STAR to install more energy-efficient heating, AC and refrigeration systems, resulting in 20% energy savings; since making these improvements; Busch Stadium operates at a level 39% better than the national average for most entertainment buildings (“10 of the Most Energy Efficient MLB Stadiums,” n.d.; Energy Efficiency & Renewable Energy, 2017). In addition to energy efficiency improvements, energy conservation programs, such as timers for lights and HVAC, can reduce consumption; Lincoln Financial Field reported a 33% reduction in electricity usage via conservation programs (“NFL’s 5 Most Energy-Efficient Stadiums,” 2014; Kummer, 2018). Two broad categories of energy improvements related to efficiency and conservation are lighting and building automation systems.

Lighting

The U.S. Department of Energy estimates that a comprehensive shift to LED lighting in the U.S. would decrease total annual energy consumption by 60%, and save \$380 billion annually (Hwang, n.d.). In 2014, the Mariners became the first MLB team to use LED lights on the playing field; this reduced power usage by 784,000 kWh per season – saving more than \$50,000 (Energy Efficiency & Renewable Energy, 2017). The Rays already use LED lights for the fields; however, there is opportunity to install LEDs in the front offices and other areas to save more energy. In addition to switching to LED, automation specific to lighting has been shown to reduce energy demand. MetLife Stadium (home of the New York Giants and New York Jets) employs an automated lighting control system that minimizes energy consumption, whereas Lumen Field (home of the Seattle Seahawks) uses point-of-use lighting controls to cut energy (“NFL’s 5 Most Energy-Efficient Stadiums,” 2014). Additionally, modern lighting appliances and motion sensors decrease energy demand associated with lighting by 20% at the Dacia Arena in Italy (Manni et al., 2018).

Building Automation Systems

In addition to lighting-specific efficiency improvements, building automation systems more broadly can be used to optimize an arena’s energy management (Manni et al., 2018). Building Automation Systems (BAS) use setbacks to manage airflow, temperature, and other setpoints to save energy; stadiums are well suited for automation because the majority of their operation is based on a well-set schedule (Mason, 2016). Although different uses of the stadium (e.g. games vs. practices) require different levels of energy and utility use, automation can recommend and maintain optimal temperatures that accommodate different events and different times of year. Additionally, BAS allows for greater visibility into utility and energy data, and benchmarking this data over time allows operators to pinpoint ideal start up and shut down times, which saves time, energy, and money (“Tips for improving utility efficiency in stadia and sporting venues,” 2019). At Lincoln Financial Field, increased monitoring of energy consumption decreased usage

by 21% between 2009 and 2010 (“NFL’s 5 Most Energy-Efficient Stadiums,” 2014); the same decrease is estimated to save the Rays almost \$300,000 in electricity costs. It has been demonstrated that understanding how a building and its equipment functions allows for more accurate energy use prediction; this optimization will decrease usage and cost (“Tips for improving utility efficiency in stadia and sporting venues,” 2019).

Recommendation #2: Investment in Renewable Energy

In addition to energy efficiency improvements and building optimization, renewables provide ways for stadiums to lower their energy-related footprint. More than 30% of North American professional sports teams have incorporated renewable resources into their operations (Energy Efficiency & Renewable Energy, 2017). The Colorado Rockies installed 46 photovoltaic (PV) solar panels that, in total, provide more than 14,000 kWh of energy at Coors Field (Colker and Gutierrez, 2017); over 4,000 PV panels at Mercedes Benz Stadium (home of the Atlanta Falcons) provide 1.6 million kWh each year (Unwin, 2019). Because renewable energy is generated onsite, the energy provided by these sources corresponds to an equivalent reduction in energy that must be purchased from the grid. Supplementing approximately 800,000 kWh of electricity annually with solar or another renewable source would lead to a 1% reduction in the total estimated carbon footprint. Solar power at Lusail Stadium, host of the 2022 FIFA World Cup, is expected to lower GHG emissions at the stadium by 40% (Unwin, 2019). The Philadelphia Eagles made Lincoln Financial Field the first professional stadium in the US to be “energy self-sufficient” through the installation of over 2,000 solar panels, 80 wind turbines, and a biodiesel generator (“NFL’s 5 Most Energy-Efficient Stadiums,” 2014). As Florida’s grid mix is heavy in fossil fuels, investments in renewables are particularly advantageous for the Rays.

11.2 Water

Our analysis of onsite water revealed the cooling tower and restrooms to be major water consumers; however, it is important to note that due to necessary back-of-the-hand calculations, and the atypical features of Tropicana Field, these hotspots may not be extrapolated to other MLB stadiums (see Section 10.2). The Rays use synthetic turf, which requires a fraction of the water required by natural grass (Adachi et al., 2016). If we consider the entire lifecycle, meaning including embodied water, or the amount of water it takes to make the product, this number increases a bit to 24.3% (Adachi et al., 2016). The Rays save a significant amount of water by using synthetic turf, and should be an example for other teams in the league who are considering water saving initiatives.

Although the Rays onsite water use is likely different from the majority of other teams, the strategies recommended below address common activities and can be operationalized in most MLB stadiums. These recommendations all are considered technological enhancements and many of these strategies will also work to support LEED certification, which sets a higher standard for environmentalism in a facility.

In order to reduce their onsite water consumption we recommend the Rays:

1. Enhanced maintenance and maintenance training
2. Switch to low-flow bathroom fixtures
3. Install water and energy efficient appliances

4. Consider greywater reuse strategies and rainwater harvesting

Recommendation #1: Enhanced Maintenance and Maintenance Training

The cooling tower consumes the majority of water at Tropicana Field (46.8%). The Rays can save water by optimizing operation and maintenance of the cooling tower. Monitoring and controlling the quantity of blowdown provides the most significant opportunity to conserve water in cooling tower operations (U.S. EPA, 2012). The Rays previously explored a water softener for the cooling towers, which would increase the number of cycles in the tower, leading to reduced water consumption. This project should be evaluated further, as our onsite water use shows the projections previously provided from Nalco are over-estimations. Another solution for reducing cooling tower water usage is to install a new heat exchange; the Cardinals changed the operation and controls on pumps and recovered heat from waste condensate to reduce the amount of heat that must be generated for other applications; this process eliminated five million gallons of cooling tower water (NRDC, 2012). Enhanced maintenance and maintenance training can also save water by identifying and fixing potential leaks before they occur. As outlined in our results of onsite water use, on average, leaks can account for more than six percent of a facility's total water use (U.S. EPA, 2017d). Maintenance can evaluate and fix leaks, while maintenance training can provide employees with alternative janitorial practices that use less water. For example, the San Jose Earthquakes conduct spot mopping in place of power washing, which saves 25,000 gallons per event (Thorrington, n.d.).

Recommendation #2: Low-Flow Toilets and Fixtures

Bathroom water use (urinals, commodes, and sinks) was the second largest water consumer at Tropicana Field (34.2%). In order to reduce water consumed in restrooms, low-flow toilets and fixtures should be installed as well as waterless urinals. Low-flow urinals, dual-flush toilets, and aerated faucets use 30 percent less potable water than conventional fixtures (U.S. EPA, 2021c). Several stadiums have already made this upgrade and have saved both water and money on their utility bill. For example, the Montreal Canadiens upgraded 258 washrooms and reduced their overall water consumption by 20% (Hershkowitz et al., 2012). The Minnesota Twins use low-flow urinals, dual-flush toilets, and aerated faucets at their stadium, Target Field. This upgrade has saved them an estimated 4.2 million gallons of water annually (Hershkowitz et al., 2012).

Waterless urinals save even more water. Currently, Tropicana Field's urinals use one gallon of water per flush. Using our estimations of bathroom water consumption, eliminating water from urinal use could cut bathroom water usage by 36%. Other stadiums that have made the switch to waterless urinals, include Fenway Park (home of the Boston Red Sox) and Citi Field (home of the New York Mets). Additionally, the installation of waterless urinals at Crypto.com Arena in Los Angeles saved approximately seven million gallons of water and about \$28,200 in onsite water costs (Hershkowitz et al., 2012).

Recommendation #3: Water and Energy Efficient Appliances

While cooking appliances were not evaluated in this study, energy and water efficient appliances, including washing machines, which account for 1.2% of our onsite water, are a relatively simple

upgrade that can save water, energy and money. ENERGY STAR® qualified dishwashers, ice machines, and steam cookers are at least 10% more water efficient and 15% more energy efficient than standard models, with some models saving significantly more (U.S. EPA, 2017c). ENERGY STAR® qualified commercial washing machines are about 25% more efficient and use about 45% less water than standard models (Energy Star, n.d). Although washing machine water consumption is a relatively small portion of the overall water consumption, when considering new stadium construction, it is a smart decision all around.

Recommendation #4: Harvesting Rainwater

Rainwater capture system installation during new field construction presents a large opportunity for water savings. Captured rainwater can be used for field maintenance, stand washing, the cooling tower, and landscaping. Specifically in St. Petersburg, Florida, the average rainfall during the normal baseball season (April-September) is 21.0,” or 1.75 ft. Tropicana Field thus has the capacity to capture about 6.38 million gallons of water during the baseball season, greater than half of the water used during the season (**Equation 11.2**). The Rays’ rainwater capture potential can be expanded with the installation of permeable pavement, and other green infrastructure design elements such as bioswales. Rainwater capture not only lowers utility costs, but also, with respect to cooling tower maintenance, minimizes chemical treatment costs and reduces the amount of water utilized in the process to flush out the tower water (“Rainwater Harvesting for Cooling Towers,” n.d.). Additionally, BAS can be incorporated for monitoring and control of collection conditions and system operation. BAS also has implications for energy use, as discussed in Section 11.1.

Equation 11.2:

$$\text{Rainwater Capture Potential (gal)} = \text{Roof Area (ft}^2\text{)} \times \text{Average Rainfall During Baseball Season (ft)} \times 7.48 \text{ gal/ft}^3 \text{ (conversion factor)}$$

A few professional teams have already reduced their water usage via rainwater capture systems. Using their advertising potential, the Minnesota Twins partnered with a local corporation, Pentair, to install a rainwater capture system at Target Field with little cost to the team; captured water is currently only used to wash the grandstand but the team is exploring options to expand capture for field irrigation (Hershkowitz et al., 2012). A Twins official reported savings of “14,000 to 21,000 gallons of water and 86 gallons of gasoline, as well as 57 man-hours of labor, per game” from using recycled water to wash down the stands. Other teams exploring rainwater capture include: the Seattle Sounders FC, who received the Green Globe Award for using reclaimed water for field irrigation; the Orlando Magic, who capture AC condensation as well as rainwater used for irrigation (Hershkowitz et al., 2012); the New York Mets, who have installed permeable pavers and a green roof to capture water for field irrigation (MLB, 2012); and the Atlanta Falcons, whose stadium is equipped with a 2.1 million gallon stormwater management and collection system is sufficient for landscaping and cooling tower water consumption (“Water,” n.d.).

Recommendation #5: Greywater Reuse Strategies

Greywater capture and reuse strategies pose another large opportunity for water saving. Greywater is water captured from shower use, washing machines, dishwashers, sinks, field

irrigation or other water consuming activities besides commodes or urinals. It is not potable water but can be used for many stadium water uses. While they do not have their own capture system, Sofi Stadium sources recycled water for landscape irrigation, maintenance, and aesthetic purposes (West Basin Municipal Water District, 2020).

11.3 Waste

Waste generated at sports stadiums is one of the most highly visible environmental impacts seen by fans during the game-day experience. According to Waste Management (WM), an MLB fan generates an average of 0.47 lbs of waste at a single game (Waste Management, n.d.). For context, this is about 10% of the average waste generated by Americans in a given day, which the EPA estimates at 4.9 lbs per person (U.S. EPA, 2017d). Waste management at the Rays does not significantly contribute to GHG emissions within our functional unit, because material is sent to a WTE facility; if the team were to switch waste methods by landfilling, it is possible that methane emissions from anaerobic decay of waste could increase the Rays' carbon footprint. Besides from the impact to greenhouse gas emissions, the high visibility of waste and fan concerns over impacts have led organizations like the MLB to often focus sustainability initiatives on improving waste management. For example, in 2006 the MLB created the Green Glove Award, to incentivize waste reduction and diversion at stadiums. The award goes to teams with the highest recycling rates and largest quantities of diverted waste from landfills. Because waste management is an important environmental issue for both fans and MLB, our clients were interested in recommendations to reduce the environmental impact of waste at stadiums, with particular interest in environmental impact reduction of waste at Tropicana Field. Our recommendations to reduce the environmental impact of solid waste management, center around changes to infrastructure and materials used at the stadium which are broadly categorized as technology enhancements but would likely require behavioral change campaigns and corporate partnerships to maximize effectiveness. We propose the following recommendations for the Tampa Bay Rays:

1. Onsite composting
2. Improve recycling infrastructure
3. Reduce plastic consumption

Recommendation #1: Onsite Composting

Due to the unique nature of WTE facilities, composting would not necessarily decrease the Rays' carbon footprint or water usage, however, it presents an additional opportunity to engage fans with sustainability issues and increase visibility of a team's environmental impact reduction initiatives. In terms of environmental impact, we re-ran the WARM model to assess how much the Rays' carbon footprint would have changed if, instead of sending all food waste to the WTE facility in 2019, they had composted all food waste; emissions from solid waste management would have increased by 2.7%. This increased the total estimated carbon footprint for the Rays by 0.01%, a negligible amount. However, LCA studies have found that composting food waste, rather than incinerating it, can reduce acidification and eutrophication impacts (Gao et al., 2017; Khoo et al., 2010). Not to mention that WTE facilities can result in local air pollution (often in underrepresented communities) and produce toxic ash (Rosenberg et al., 2021) that could be reduced with implementation of a composting program. For teams that send waste to landfills,

composting can reduce methane emissions associated with decomposition of food waste in landfills (U.S. EPA, 2016d). Reducing these environmental impacts in addition to the opportunities to engage fans and support MLB sustainability initiatives makes composting an attractive option for the Rays.

Ten MLB teams currently have composting systems in place as part of their waste management systems (MLB, n.d.). The Seattle Mariners are leaders in waste diversion; in 2018 they received an award from the EPA for diverting 761 tons of food waste by composting. Even further, in 2019, 98% of all waste was either recycled, composted or reused. The Mariners have also realized the importance of fan engagement in making initiatives successful and developed an event that was brought back for multiple years called the “Sustainable Saturday ” at ten home games in a season (Russell and Hale, 2014). The event raised awareness around zero waste initiatives, providing fans with opportunities to win prizes by answering trivia questions. This event provides opportunities for fan engagement and education.

A behavioral study conducted by Taylor and Todd measured the behavior of participation and engagement in composting activities and showed that as long as systems complexity stays low, people engage in composting activities (1995). In other words, a person's willingness to participate in composting or other waste reduction strategies rapidly declined as the knowledge or level of participation required from users increased. If composting efforts remain simple with properly displayed colored bins, then fans will most likely participate in stadium composting. Having compost bins throughout the stadium as well as in the concessionaire kitchens will help improve waste diversion. Composting food waste does not require industrial composting. However, several stadiums have begun to eliminate other plastics such as straws and switched to compostable concession packaging and utensils to increase organics diversion, which does require industrial composting (MLB, n.d.).

Recommendation #2: Improve Recycling Infrastructure

Our results indicated that combustion of PET plastic was the material stream contributing the largest to the Rays carbon footprint. To improve and increase recycling at Tropicana Field, preventing plastic waste from entering landfills and incinerators, we recommend implementing a new recycling program that will educate fans and staff on proper recycling and disposal techniques. GHG emissions benefits are two-fold: PET is not combusted at WTE facilities and the recycled plastic reduces the need for fossil fuel extraction for virgin plastic production. Stadiums have implemented collection programs for at least some recyclable materials, including glass, aluminum, plastic and cardboard (MLB, n.d.). In 2020, the Milwaukee Brewers partnered with the SC Johnson Company to recycle plastic stadium cups into containers for the company's products (“Home Run! SC Johnson and Milwaukee Brewers Partnership is a Win for the Planet,” 2021). Oftentimes fans now expect recycling containers to be available, and are willing to put extra effort into placing recyclables in their proper place. Successful programs involve creative outreach and education so fans are aware of available recycling containers as well as having proper signage indicating what items should or should not be placed inside (Briana, 2011). Waste-sorting behavioral studies find that bin colors such as blue for recycling, green for composting, and brown for landfill combined with strategic placement around high traffic areas increase separation efficiencies (Leeabai et al., 2021). New color-coded bins should be placed

strategically throughout the stadium in high traffic areas, such as near restrooms, walkways, and concession stands so fans can conveniently access and use them.

Establishing a new recycling program will provide an additional opportunity to engage fans on various sustainability issues and will pair nicely with a new composting program.

Recommendation #3: Reduce Plastic Consumption

Single-use plastics are a common material used at sporting events and are still a rapidly growing segment of municipal solid waste (U.S. EPA, 2017d). In 2018, over 14.5 million tons of plastic from bags, packaging and polyethylene terephthalate (PET) bottles and jars contributed to landfill waste (U.S. EPA, 2017d). As discussed in Section 6, combustion of PET was the largest emissions driver for solid waste management. Having better recycling infrastructure in place will help divert plastic from combustion at the WTE facility. However, reducing plastic consumption and/or switching to alternative materials could also reduce PTE combusted at the WTE facility, thus leading to lower GHGs in their overall carbon footprint.

With the MLB encouraging waste diversion via the Green Glove Awards, many teams are focused on reducing use of plastics. Teams such as The White Sox have eliminated plastic straws and the Minnesota Twins have partnered with Eco-products to switch all cups, trays and plates to compostable materials to help reduce plastic consumption (Kane, 2018; MLB and CSRwire, 2019). The newest of material switching trends, especially in football, is replacing single-use plastic cups with shiny new aluminum cups made by the Ball Corporation. The Hard Rock Stadium, home to the Miami Dolphins, was the first National Football League (NFL) stadium to begin using 20-ounce aluminum cups in 2019 (LoRé, 2018). SoFi Stadium in Los Angeles, home to the Chargers and Rams, has also switched to aluminum cups (Newhart, 2019). The Rays are also currently considering using the same alternative.

However, we emphasize that efforts that *reduce the need for single-use more broadly* should be the priority and that teams should not necessarily focus on switching from plastic to other single-use materials because these other materials could be worse for the environment than plastic. A recent LCA assessed the environmental impact of single-use plastic cups, single-use aluminum cups (which the Rays are considering), and reusable plastic and stainless steel cups, and found that all single-use cups performed worse than reusable cups across all environmental impacts measured and single-use aluminum cups are the worst option for the climate by far. Single-use aluminum cups used 47% more energy over their life-cycle and created 86% more carbon dioxide than other single-use plastic options. Recycling the cups does not negate the fact that on average, they are only composed of 73% recycled content (Wentz et al., 2021). Given the results of this LCA, the Rays and other teams may be better suited to focus on plastics reduction and consider viable systems to employ reusables, rather than switching to single-use aluminum. More generally speaking, this LCA suggests reusable options are promising alternatives that could be used at stadiums to reduce the amount of plastic material that could end up in a landfill or WTE facility.

Waste management impact reduction does not have a one size fits all solution. What might seem like a great solution could have unintended environmental trade-offs. In addition to overhauling recycling and possibly introducing composting infrastructure, we recommend and emphasize

using tools such as LCA and carbon accounting to assess solid waste management strategies before implementing them. Only then can the Rays begin to consider what materials will minimize their environmental footprint.

11.4 Fan Transportation

Fan transportation contributed over 70% of the emissions for the Rays' total carbon footprint estimate. Our analysis suggests that car travel is responsible for 73.6% of total emissions from fan transportation. It is important to note that this result may not be indicative of prevailing transportation habits of fans in other cities. The following section describes a handful of recommendations related to reducing these emissions. Given the magnitude of fan transportation emission relative to other activity areas, recommendations are presented here which may appear to have a small impact on total fan transportation emissions; however, these reductions are significant in comparison with other activity areas. While there are some interventions that may be applied universally, one-size-fits-all solutions to fan transportation are few and far between. Different teams, in different cities, with different resources, demographics, and infrastructure require more individualized solutions. For example, the New York Yankees, a giant market team in a densely populated city, with a sprawling public transportation network will elicit different intervention strategies from the San Diego Padres, one of the smallest market teams in a much smaller city with limited public transportation (Trueblood, 2012; Ortegren, 2020). It is important to consider that proposed interventions will only be successful when they reinforce, rather than divert people away from, low or zero emission modes they may already be using. For example, if people who had previously used public transportation to get to the game were enticed to carpool instead, the emissions from their travel would increase, not decrease. We note where recommendations are specifically relevant to the Tampa Bay Rays. Broadly speaking, relatively few long-distance travelers account for an outsized portion of total GHG emissions. Targeting behavior change in a small subset of the fan population that likely won't attend more than one game per season has a lower likelihood of success compared to the local fanbase. Therefore, most of the recommendations included below are focused on fan travel within a 200 mile radius of the stadium. It is worth noting that, although we did not include emissions from employee commuting in our system boundary, all of these BMPs could be applied to employees and player travel not coordinated by the team to reduce emissions from commuting activities.

We propose the following recommendations for the Tampa Bay Rays. These recommendations are broadly categorized as either behavioral change, special days & events, community partnerships and engagement, or corporate partnerships.

1. Encourage and incentivize EV use
2. Promote and incentivize carpooling
3. Encourage fans to use existing public transportation or establish park-and-ride services to Tropicana Field
4. Encourage biking to the stadium
5. Encourage shifting to transportation modes other than rideshare
6. Leveraging partnerships and sponsorships
7. Use public information campaigns to support shifting fans to sustainable transportation modes

Recommendation #1: Encourage and Incentivize EV Use

Although the energy required to power an electric vehicle (EV) does produce some GHG emissions, these emissions pale in comparison to those from internal combustion engine vehicles (U.S. Department of Energy, 2021). By encouraging the adoption and subsequent use of EVs for travel to the stadium, MLB teams can drastically reduce their carbon footprint. Outlined below are several options for teams to encourage EV adoption include: increase EV charging, offer free or reduced charging or parking fees, strategic placement of chargers within parking structures, and bidirectional charging.

If all fans that drove personal cars to Rays games used EVs, the emissions from personal cars would be 69.1% below baseline and the total emissions from fan transportation would be 50.9% below baseline. This scenario would reduce the total Rays carbon footprint by 35.6%. If ride-hailing vehicles are included, the total emissions from fan transportation would be 52.6% lower than baseline, corresponding to a 37.0% reduction to the total estimated carbon footprint. If all fans who traveled by plane drove EVs instead of flying, the emissions from fan transportation would be reduced by 63.2%, which would reduce the Rays overall carbon footprint by 44.3%. Understanding that 100% EV adoption is not realistic in the near-term, this stark reduction potential makes a strong case for EV incentivization. The IEA projects that 7% of the global automobile fleet will be EVs by 2030 (IEA, 2021). If only 7% of the personal cars on the road were EVs, fan transportation emissions would be reduced by 3.56%. If 7% of personal cars and rideshare vehicles were EVs, only personal vehicles were EVs, fan transportation emissions would be reduced by 3.68%.

EV adoption has been a slow, gradual process in part due to limited distribution of public EV charging infrastructure (Pan et al., 2020). Even those who currently own an EV may be wary of driving it to the stadium if they can't charge the car while at the game. MLB teams can ease range anxiety among EV drivers and encourage additional EV adoption by incorporating EV chargers into their stadiums' parking infrastructure. There are currently only six chargers available in Tropicana Field parking lots.

Although EV chargers can be revenue-generating instruments, to incentivize EV transportation, charging should be initially offered for free or at cost. Alternatively, teams could offer competitively priced charging opportunities coupled with a reduced rate for parking. To further incentivize EV transportation, chargers should be located in well-marked, easy-to-find parking areas located in prime locations close to stadium entrances.

Strategic placement of EV chargers within the stadium's parking infrastructure may also influence fans who do not already own an EV, to purchase or lease one. The chargers currently at Tropicana Field are in inconspicuous spots, either in the center of a large parking lot or the corner of the lot far from both the entrance to the lot and the entrance to the stadium. Locating EV chargers in highly visible parking areas, such as those closest to the entrance of the parking lot/structure or closest to the stadium entrance, not only makes driving an EV easier than a gas-powered car by gaining access to desirable parking locations, but will also prominently display the chargers and potentially a variety of EV models. Public visibility of EVs and charging infrastructure are among the strongest factors driving EV adoption (Coffman et al., 2017; "Signage for Plug-in Electric Vehicle Charging Stations," n.d.).

Bidirectional charging could offer a win-win-win opportunity for fans, the team, and the local electrical utility. Businesses are taking advantage of bidirectional charging, sometimes called vehicle-to-building (or V2B), to draw electricity directly from EVs to augment the energy supplied to their facilities (Briones et al., 2012). Depending on the time of day, electricity stored in the vehicles can be a cleaner, cheaper alternative to electricity from the grid. Electricity demand tends to peak in the late afternoon and early evening, which requires the use of more polluting power plants to meet demand at a considerable expense to the utility and end-user. Most MLB night games begin during this peak demand window, but end hours after the surge in demand has subsided. If teams were to use V2B charging, they could draw free electricity from EVs when the price of electricity from the utility is most expensive (and most GHG-intensive) and recharge the EVs with relatively cheap electricity from the grid once the peak is over. Since this method may not guarantee a significant boost in charge for the EVs, we advise that charging be free in order to prioritize EV adoption incentivization. While V2B charging poses potential promise for teams, fans and the planet, currently the Nissan Leaf, Mitsubishi Outlander, and Hyundai Ioniq 5 are the only EVs equipped with V2B charging capabilities (Donnelly, 2021; Zimmermann, 2021). However, technology is improving rapidly; the 2022 F-150 Lightning will have V2B and Kia, Hyundai, VW, and Tesla have stated that their future models will also be V2B capable (Donnelly, 2021; Zimmermann, 2021). Since trends in EV technology are moving towards V2B, we recommend that MLB teams invest in V2B charging infrastructure to provide a significant source of low-cost energy.

Recommendation #2: Promote and Incentivize Carpooling

While it is far from a novel concept, carpooling can provide numerous societal and individual benefits (Shaheen et al., 2018) and appears to be the most cost-effective solution to reducing the Rays' fan transportation emissions. If every personal vehicle traveling to Tropicana Field carried four passengers, the total emissions from fan transportation would be reduced by 41.1%. This would equate to a 29.0% emissions reduction from the Rays' estimated total carbon footprint (see Section 10.1.5.8 for methodology and assumptions).

It is important to note that carpooling will only reduce emissions when more passengers travel in fewer cars; although a household of fans who have always carpoled together should be commended for doing so, maintaining the status quo will not yield additional emissions reductions. The biggest opportunities for carpooling are encouraging friends to travel together and connecting fans who may not be acquainted to share rides to games. MLB teams can actively encourage carpooling through public education campaigns, parking prices that correspond to vehicle occupancy, or tools that make carpooling more convenient such as establishing (or promoting existing) commuter planning resources or carpool matching services and apps (Shaheen et al., 2018; *Stadium Expansion Parking Plan and Transportation Management Report*, 2016).

Recommendation #3: Encourage Fans to Use Existing Public Transportation or Establish Park-and-Ride Services to Tropicana Field

Among motorized transportation methods for “short” distance travel, public transportation options are the least GHG-intensive (excluding walking and biking which have zero emissions associated with them). Even at partial capacity, public transportation only requires 20% of the

energy per passenger-mile (and produces fewer emissions) relative to a personal vehicle carrying a single passenger (MacKay, 2009).

There are ten bus and trolley routes that stop within a half-mile of Tropicana Field, some of which service stops as far as 19 miles away (“Pinellas Suncoast Transit Authority | PSTA,” 2022). Most of these routes also stop at the nearby Grand Central Station, which connects to six more routes. Although taking public transportation to Tropicana Field from the majority of the surrounding area is entirely feasible, the service is severely underutilized; the MLB post-game survey showed that only 0.11% of Rays fans use public transportation to get to the stadium (**Table 10** in Section 6.1.1.5; note COVID-19 may have impacted ridership).

Aside from informational asymmetries such as understanding public transportation options, or how to ride, unreliability and inconvenience are two potential reasons why public transportation adoption is so low. First, passengers need to be able to rely on transit service both to *and* from the stadium (Soza-Parra et al., 2021). Nearly two-thirds of MLB games are played at night (Dorfman, 2013); in many cities, including St. Petersburg, most of the buses have stopped running by the conclusion of night games (Pinellas Suncoast Transit Authority, n.d.). Second, frequent stops to pick up and drop off passengers along routes reduces convenience, a leading factor in the decision to forego public transportation methods in favor of faster alternatives (Gooch, 2018). Additionally, accelerating from a stopped position demands more energy (and thus fuel and emissions) than maintaining speed, so the more times a public transit vehicle stops, the more emissions it produces (MacKay, 2009). Efforts to increase public transportation ridership will be more successful if concerns about unreliability and inconvenience are mitigated. Improvements to the public transportation system would require the Rays to collaborate with the local transit authority to provide late-night service, increase the frequency of buses and trolleys both before and after games, and consider modifying existing routes or adding express routes to reduce the number of stops along the routes.

Alternatively, the Rays could implement a park-and-ride program to reduce personal vehicle usage and reduce travel time relative to typical buses and trolleys. Park-and-ride services use buses or shuttles to transport passengers from a park-and-ride lot directly to a specific destination. Many large venues use park-and-ride programs to reduce parking and traffic immediately around the venue (Truong and Marshall, 2014); however, they tend to transport fans to the venue from less than five miles away (“Dodger Stadium Express,” n.d.; “IPARK & GO,” 2021; “The Galaxy Express | Dignity Health Sports Park,” n.d.). Additionally, the main factors that influence park-and-ride users are avoiding traffic, enjoying a less stressful journey, and costly or limited parking (Memon et al., 2021). Rays pitcher Tyler Glasnow speculated that fan attendance at Tropicana Field is low due to the stress of getting to the stadium, and particularly navigating the one-way streets immediately around the park (Topkin, 2021). In order to achieve their GHG reduction potential, park-and-ride services must be located in such a way to actually reduce personal vehicle miles traveled, reduce congestion, and increase convenience, promoting broader adoption (Truong and Marshall, 2014). Additional analysis is needed to determine ideal park-and-ride locations that would effectively reduce congestion, increase convenience, and reduce personal vehicle use.

If all fans who traveled up to 50 miles one-way using motorized transportation (excluding emission-free biking and walking), switched to park-and-ride, the total emissions from fan transportation would be up to 10.8% lower than baseline. This would equate to a 7.57% reduction of the entire Rays' carbon footprint. This estimate assumes that park-and-ride buses will have the same occupancy rate as typical city buses; if park-and-ride buses were filled to capacity, the resulting emissions reductions would be even greater (see Section 10.1.5.8 for methodology and additional assumptions).

A park-and-ride system can also circumvent common deterrents to public transportation adoption and eliminate emissions from passenger-related stops. Return service issues can be eliminated as buses will wait for fans at the end of the game, and the number of vehicles needed for return service will be informed by the number of passengers who used park-and-ride to get to the game (Trout and Ullman, 1997). Lastly, if an MLB team used its influence to gain access to a low-carbon bus fleet, the emissions savings from switching to park-and-ride would be even greater.

Since parking at Tropicana Field is at least \$15, offering cheaper fares for park-and-ride shuttles could further incentivize fans to take the shuttle instead of more expensive alternatives. The team could also recoup lost parking revenue by selling advertising space on the park-and-ride buses. Although a park-and-ride program would require dedicated personnel to aid in crowd control, creating a volunteer program where volunteers work for a certain number of hours in exchange for occasional free or discounted tickets can reduce potential personnel expenses (Trout and Ullman, 1997).

Recommendation #4: Encourage Biking to the Stadium

Commuting by bicycle or electric-assist bicycle (e-bike) to baseball games produces low to zero emissions. Although e-bikes do generate emissions from charging (and in the case of public dockless bikes, collection and distribution by cars), they still produce significantly fewer emissions than cars, with the emissions from personal e-bikes producing only 1.6% of the emissions from cars and public dockless e-bikes producing only 23.6% of the emissions from cars (Hollingsworth et al., 2019; McQueen et al., 2020; U.S. EPA, 2021a, 2021b). If all fans traveling up to ten miles one-way to Rays games rode bicycles, the total emissions from fan transportation would be 1.37% below baseline, reducing the Rays total estimated carbon footprint by 0.96% (see Section 10.1.5.8 for methodology and assumptions).

Periodic “bike-to-the-game” events effectively motivate people across the spectrum of the cycling experience to ride to the game in conjunction with that particular event (Piatkowski et al., 2015; Rose and Marfurt, 2007). The Colorado Rockies have incentivized fans to bike to the game by offering an exclusive giveaway item to the first 150 fans to arrive by bike (“Colorado Rockies Green Campaign,” 2021). Although periodic events can increase non-event cycling by assuaging various biking-related concerns (e.g. safety, comfort, infrastructure, etc.), these targeted biking events have been shown to only modestly influence transportation behavior permanently (Piatkowski et al., 2015; Rose and Marfurt, 2007). Therefore, it is important to hold recurring events to reduce more transportation emissions and introduce practices that reduce common barriers to ridership permanently.

The main barriers to bicycle commuting are related to 1) safety and infrastructure, 2) convenience and climate, and 3) costs and other concerns (Piatkowski et al., 2015). The main way for an MLB team to lower these barriers and encourage cycling is to establish robust bicycle amenities at the stadium. Would-be riders are discouraged from biking to games if they cannot bring their bike helmets into the stadium or check them for free (Annis, 2018). Similarly, convenient and secure storage options, including accessible bike racks, lockers, or a valet service (“Bike Riders | Chicago Cubs,” 2022), are critical to ensure cyclists will feel comfortable biking to the game.

In addition to barriers that might discourage a person from cycling at all, there are several factors that may influence a person’s decision to ride to the game on a particular day including having to wear business attire, longer commute distances, commuting in the dark, or poor weather conditions (Heinen et al., 2011). With this in mind, “bike-to-the-game” events (or generally encouraging fans to cycle to games) should be planned for weekend games (to reduce the likelihood of people traveling from work), day games (to avoid commuting in the dark), and/or during the time of year when weather is likely favorable to improve the likelihood of fan participation. The Rays could benefit even more from these events by simultaneously promoting walking to the game for fans who live in close proximity to the stadium but might be reluctant to ride a bike to the stadium. While 6.55% of Rays fans live within five miles of the stadium, only 1.07% of fans walked to the stadium.

Most studies of biking to events have focused on human-powered cycling (Berry, 2019; Linden et al., 2020; Piatkowski et al., 2015; Rose et al., 2016; Rose and Marfurt, 2007). There is reasonable evidence to suggest that the recent proliferation of e-bikes and e-scooters reduces many of the challenges associated with riding to the game, particularly those related to safety, commuting distances, the need for specific biking clothes, stadium based bike-friendly policies, and infrastructure at the stadium including bike and helmet storage (MacArthur et al., 2018; McQueen et al., 2020). E-bikes allow riders to avoid overexertion without sacrificing speed, making for a quick and fun ride to the stadium, and largely eliminate the need to change out of work clothes. Additionally, if people used *public* e-bikes or e-scooters to get to the stadium, they could avoid the hassle of dealing with securely storing their bikes. St. Petersburg currently has a fleet of more than 350 shared e-bikes and 350 e-scooters (Brezina-Smith, 2020a, 2020b). If all fans traveling up to 20 miles one-way to Rays games rode personal e-bikes, the total emissions from fan transportation would be 4.48% below baseline. If the e-bikes used to get to the stadium were shared, dockless bikes, the total emissions from fan transportation would be 3.47% below our baseline. Dockless e-bikes or scooters have higher associated emissions due to necessary collection, and redistribution typically conducted by vans (Hollingsworth et al., 2019). While these reductions may seem negligible, it is important to remember the magnitude of emissions from fan transportation relative to the Rays’ overall carbon footprint; even in the shared, dockless e-bike scenario, the total Rays footprint would be reduced by 2.4%, enough to offset the emissions from Scope 1 and upstream natural gas and upstream water combined (see Section 10.1.5.8 for methodology and assumptions).

Recommendation #5: Encourage Shifting to Transportation Modes Other Than Rideshare

Although the popularity of rideshare services has skyrocketed in the last decade, evidence suggests that rideshare vehicles actually produce more emissions than alternative transportation modes (Anair et al., 2020; Heno and Marshall, 2019). In comparing the emissions from ride-hailing vehicles (rideshares and taxis) to other transportation options available, all other things being equal, the ride-hailing trips are the most GHG-intensive (see Sections 10.1.5.4 and 10.1.5.6). Incentivizing fans to shift from using rideshare services to one of the above mentioned recommendations will reduce fan transportation emissions by about 1%, translating to a total estimated carbon footprint reduction of 0.7% (see Section 10.1.5.8 for methodology and assumptions). This reduction is minimal because only 2% of fans used this transportation mode. Alternatively, if all personal car users switched to rideshare services, fan transportation emissions could increase by up to 31.4%, corresponding to a 22.0% increase to the Rays' total estimated carbon footprint; therefore, it is important that team-sponsored initiatives do not induce more rideshare trips.

Recommendation #6: Leveraging Partnerships and Sponsorships

Many of the proposed recommendations in this section could be implemented more easily, and likely at lower cost, if the Rays were to either leverage existing partnerships and sponsorships or establish new ones. Partnering with an EV charger company, with an established local and regional presence, could lower charger installation costs and incentivize EV adoption. A rewards program in which drivers accumulate points for charging (based on the number of kWh added to the vehicle) that can be redeemed for Rays game tickets would likely increase the number of people driving EVs to the game. For example, an established Fuel Rewards program incentivizes drivers to attend events by offering a \$0.10/gal discount (up to 20 gallons of gas) for every \$50 spent on event tickets ("Event Tickets | Fuel Rewards program," 2022). Incorporating a similar strategy specific to EVs into a Rays - EV charger partnership could incentivize both game attendance and EV adoption, by offering a discount on a charging session as a reward for buying Rays tickets. In either case, a rewards program would benefit the charging company by increasing its visibility and encouraging people to seek out their chargers around town, while reducing upfront costs associated with charger installation.

Partnering with an e-bike or e-scooter company would increase the visibility of using micro-mobility options to get to the stadium. The Rays would reduce their emissions (as long as people shift from more GHG-intensive transportation modes, i.e. not walking or riding a human-powered bike) and the company would enjoy increased ridership.

As discussed previously, partnering with the local transit authority or municipality would reduce costs and other barriers to enhancing public transportation or establishing a park-and-ride system. Cities have previously worked with teams to establish an exclusive bus lane for a portion of the route on game days (Hymon, 2013). The municipality has an incentive to provide financial support for the program since it would directly benefit from reduced air pollution and traffic congestion surrounding the stadium (Trout and Ullman, 1997). The Rays and the city can also collaborate with the Tampa Bay Clean Cities Coalition to secure funding for transportation related initiatives ("Tampa Bay Clean Cities Coalition," 2022).

Recommendation #7: Use Public Information Campaigns to Support Shifting Fans to Sustainable Transportation Modes

It is ultimately the responsibility of the fans themselves to select more sustainable transportation options and reduce emissions from getting to and from the ballpark. However, professional sports teams have a strong influence over fan attitudes and behaviors (Hershkowitz et al., 2012) and ought to exert their influence by raising awareness about the emissions associated with different transportation methods, the variety of sustainable transportation alternatives available, how to access them, as well as other ways to reduce their travel-related emissions. Any amenities at the stadium that directly support these objectives should be highlighted including bike storage facilities, EV charging infrastructure, or stops for public transit routes. Benefits to the user associated with carpooling, park-and-rides, and other proposed initiatives should be communicated.

Most MLB teams describe public transportation information under the “Stadium” tab on their websites. Some teams even include information about biking to the stadium (“Bike Riders | Chicago Cubs,” 2022; “Dodger Stadium | Public Transit | Los Angeles Dodgers,” 2022; MLB, 2022b). The order of the various transportation options mentioned on the webpage may be perceived as a hierarchy of options with the most important or desirable ones at the top. Highlighting low-emission transportation options at or near the top of the webpage may have a larger impact on fans than they would if they were closer to the bottom of the page or out of view in the browser window. The Rays’ website does not currently include information about how to travel to the stadium by public transportation; this should be highlighted more prominently than info about parking, driving directions to the stadium, and rideshare pickup locations.

There are a plethora of tactics for carrying out a public information campaign and the most effective campaigns will use multiple tactics concurrently. The team will likely have a stronger influence over the transportation habits of fans who attend games more frequently; regularly follow games on tv, radio, or social media; or live closer to the stadium (Meyners et al., 2017).

11.5 Concessions

Upstream GHG emissions associated with producing and transporting food and concessions materials to stadiums can be a significant source of GHG emissions for MLB teams. Concessions purchased for one Tampa Bay Rays season accounted for 15.3% of the Rays total estimated carbon footprint; the second largest activity evaluated in our study. Because concessions is an emissions hotspot, and the Rays have more control over concessions purchasing than fan transportation, there is a significant opportunity for the Tampa Bay Rays to reduce their carbon footprint by making changes in this sector. Notably, animal products are particularly carbon intensive concessions. Animal products accounted for 64% of the concessions carbon footprint, but only 32% of the total purchases. Alcoholic beverages are another notable category because it makes up such a large percentage of purchases for the Rays although it is much less carbon intensive than animal products. At 23% of total purchases, alcoholic beverages account for 13% of concessions’ carbon emissions.

Given the emissions intensity of meat consumption within the concessions carbon footprint, the majority of our recommendations center around methods to reduce meat consumption and sales.

Transitioning to a more vegetarian-focused menu could also result in cost savings for the Rays. In upper-middle-income to high-income countries, a predominantly plant-based diet has been found to be 22-34% lower in cost than diets with more meat consumption (Springmann et al., 2021). Further, meat substitutes like Impossible Foods have reached scales making them equivalent in price to meat and are projecting that costs will lower even further in the future (Cohen, 2021).

Our research identified “nudging” strategies (Recommendation #4) as the most effective intervention that the Rays could implement to reduce meat consumption (Kwasny et al., 2022). Nudging strategies are not bans or prohibitions of meat products, rather, these strategies increase the attractiveness, visibility or availability of vegetarian meals. This includes changing the order of items on menus, highlighting certain vegetarian options, and providing more vegetarian options at concessions stands. As part of recommendation #4, we ran a scenario analysis assessing the carbon footprint reduction if the Rays were to adopt “nudging” strategies to promote purchase of vegetarian meals. We estimate that adoption of these strategies could reduce the carbon footprint of concessions purchasing by 26% and reduce the Rays *overall* carbon footprint by 4%. See Recommendation #4 for further detail.

Our recommendations for concessions prioritize reduction in meat consumption, but also include recommendations on reducing the impact of alcoholic beverages and concessions overall. Our recommendations for reduced meat consumption can broadly be grouped into recommendations related to behavioral change, community engagement, and special events. Alcoholic beverage and overall concessions recommendations focus on working with suppliers to increase sustainability of their operations and thus reducing the emissions intensity of supplier operations. These recommendations include corporate partnerships and technology enhancements. We propose the following recommendations for the Tampa Bay Rays:

1. Trigger emotions that reduce meat consumption by humanizing and creating empathy for animals
2. Social media campaign highlighting vegetarian athletes
3. Create themed days that incentivize plant-based diets
4. Nudging strategies
5. Evaluate craft brewing partnerships based on the sustainable practices of the organizations
6. Implement a demand tracking system
7. Install a hydroponic system
8. Create relationships with local organic farmers to maximize year-round availability of organic produce

Recommendation #1: Trigger Emotions that Reduce Meat Consumption by Humanizing and Creating Empathy for Animals

Triggering empathy for animals, or triggering disgust or guilt for eating animals are more effective personal interventions than simply providing information to consumers on the negative health or environmental impacts of eating meat. Humanizing animals by emphasizing animal friendships effectively triggers guilt, while focusing on the cuteness of the animals triggers empathy, although women are triggered more often than men (Kwasny et al., 2022).

However, often when presented with conflicting information about one's values, people experience cognitive dissonance (Kwasny et al., 2022). For example, if presented with information that eating meat is bad, but eating meat is part of one's personal values and beliefs, one will experience cognitive dissonance, which means shutting down the conflicting emotional response, denying responsibility, and ignoring the information. However, studies have shown that triggering empathy by humanizing animals can occasionally overcome this cognitive dissonance and reduce meat consumption (Kwasny et al., 2022). We recommend that the Rays trigger emotions that reduce meat consumption by capitalizing on every opportunity to humanize and create empathy for animals. This could be through additional mascots that are cute farm animals, or posting pictures of animal-human friendships, if appropriate, at the stadium or on social media, and adopting philanthropic causes that support animal welfare.

Because of the tricky and nuanced nature of triggering emotional responses without triggering cognitive dissonance, the Tampa Bay Rays should proceed with caution using this strategy.

Recommendation #2: Social Media Campaign Highlighting Vegetarian Athletes

From a social-cultural perspective, consumers adapt their attitudes and behaviors to match what they perceive as the “social norm” (Kwasny et al., 2022). Messaging focused on the popularity of reduced meat consumption can be effective, but if the consumer perceives vegetarians to be a part of the “out-group,” and meat eaters as part of the “in-group,” vegetarian messages are seen as less legitimate. The Rays should debut an informational campaign aimed at enforcing vegetarianism as a social norm by highlighting players that follow a vegetarian or reduced meat diet on their social media and in other player spotlights.

Educational campaigns that provide information on the negative impacts of meat consumption are less effective than emotional campaigns, but are most effective when messaging includes both information on the negative health impacts *and* negative environmental impacts, since people tend to act more on information that affects them personally (their health) than society at large (the environment; Kwasny et al., 2022). Players should make sure to highlight both the health and environmental impacts of meat consumption for maximum success.

Recommendation #3: Create Themed Days that Incentivize Plant-Based Diets

One way to make vegetarian or vegan diets be seen as a social norm is to highlight them and reward customers who follow them on special themed game nights. For example, on February 4, 2020, the Dallas Stars (NHL) team hosted a “Vegan Night.” Special sections of the arena were dedicated to those who bought “Vegan Night” tickets. For \$25, customers received their ticket to the game and one of three vegan food options: an Unreal Reuben made with Unreal Corned Beef, a Vegan Brat made with Beyond Sausage, or a Beyond Burger (Gubbins, n.d.).

We thus recommend the Rays (and other MLB teams) create themed days that incentivize plant-based diets to avoid potential blow-back from “out-group” messaging and make vegetarianism be seen as a social norm.

Recommendation #4: Nudging Strategies

Eating is a strongly habitualized behavior, often done without a conscious cognitive process, making “breaking the habit” of meat consumption one of the main barriers to reducing

consumption. However, because ordering food is often an automatic process, external interventions can be some of the *most effective* strategies available to reduce meat consumption. “Nudging,” where changes are made to make vegetarian options more attractive or easy to pick without actually reducing or banning meat options, are considered the most effective strategies to reduce meat consumption. In particular, providing more vegetarian options, listing them higher on the menu, or calling them out as the “dish of the day” or the “chef’s recommendation” are demonstrated effective strategies to decrease meat consumption (Kwasny et al., 2022).

The Natural Resources Defense Council (NRDC) and the Green Sports Alliance (GSA) also recommend menu planning that prioritizes vegetarian vegan options to reduce GHG emissions associated with concession stands (Henly et al., 2015). Levi’s Stadium (home of the San Francisco 49ers) offers the most vegetarian items of any NFL stadium at more than 20% of the menu. They started with creating and serving at least one vegan option appropriately themed for each of the concessions concepts (Henly et al., 2015). The Forest Green Rovers, a British football club, are the world’s first 100% vegan team, serving a 100% vegan menu with options like vegan pizzas, fajitas, salads and sweet potato fries. (“Vegan Food | FGR,” n.d.)

MLB teams can prioritize “nudging” strategies by offering vegetarian alternatives at all concession stands. The Rays should list the items high on the menu and differentiate the options with phrases that will make them appealing choices.

An additional way to nudge fans toward vegetarian versions of dishes is to declare vegetarian versions of a dish the official version of the team. The Seattle Kraken (NHL) have declared the Impossible Burger the “official burger” of the team when the Climate Pledge Arena opened two concession stands in partnership with Impossible Foods in October of 2021. Early numbers indicated the stands are extremely popular with guests (Canham-Clyne, 2021).

Alternatively, making vegetarian dishes the default option also reduces meat consumption (Kwasny et al., 2022). This is achieved through a perceived high switching cost to add meat to the dish or switch dishes entirely. A ban on meat, for example through a “Meatless Monday” campaign, is likely to backfire and reduce overall sales. However, there is limited evidence demonstrating people already considering reducing their personal meat consumption, may be more likely to adopt a more vegetarian diet in the medium-term. We thus recommend that meals where meat is not the focus of the dish, should be vegetarian as a default with meat available to add as an extra option.

Scenario analysis: Nudging Strategies to Reduce Meat Consumption

Research on implementing “nudging” strategies to reduce meat consumption is a relatively new field. One study found that changing menu order and enhancing visibility of the lone vegetarian option at a restaurant increased vegetarian meal sales by an average of 6% compared to the control restaurant (Kurz, 2018). A separate study found that doubling the portion of vegetarian meals offered at three different cafeterias of an English university from 25% to 50% increased sales of vegetarian meals between 7.8% and 14.9% (Garnett et al., 2019). The average change in vegetarian meal sales in these studies is 10.8%.

We conducted a back of the hand calculation assessing potential GHG emissions reductions if “nudging” strategies were implemented at Tropicana Field. We assumed the Rays could achieve

a change in vegetarian meal sales of +10.8% if they were to adopt several nudging strategies. To assess the change in GHG emissions we determined the dollar value of a 10.8% increase in vegetarian meal purchasing. We assume that a 10.8% increase in vegetarian meal sales would directly equate to a 10.8% increase in vegetarian ingredient purchasing. We assume a “vegetarian meal” could be represented by BEA Economic Sector 111200: Fresh vegetables, melons, and potatoes, Sector 311810: Bread and other baked goods, Sector 111300: Fresh fruits and tree nuts, and Sector 1111B0: Fresh wheat, corn, rice, and other grains. We then totaled the Rays adjusted 2019 scaled seasoned spend on these four sectors to calculate a 10.8% increase giving us \$75,600 in increased vegetarian meal sales. Split equally, that is an additional \$18,900 spent on each of the four “vegetarian meal” economic sectors. Assuming a one-to-one substitution, we re-ran our spend-based method for calculating the carbon footprint of concessions purchasing, decreasing total spending on BEA Economic Sector 31161A: Packaged meat (except poultry) by \$75,600.

This analysis reduced total concessions CO₂e emissions from 5,540 metric tons to 4,080 metric tons, a 26% decrease in GHGs. We thus estimate that implementation of nudging strategies away from meat products towards vegetarian options at Tropicana Field concessions stands would decrease the total estimated carbon footprint of the Tampa Bay Rays by 4%.

Recommendation #5: Evaluate Craft Brewing Partnerships Based on the Sustainable Practices of the Organizations

Alcohol was the economic sector with the second largest GHG emissions for Tampa Bay Rays concessions purchasing, due to the high volume of sales. Although the emissions intensity of alcohol is lower than that of animal products, there are still ways that the Rays can reduce the footprint of alcohol consumption. For example, by partnering with breweries that are reducing their own carbon footprint. The largest independently owned brewery partner at Citizens Bank Park (home of the Philadelphia Phillies MLB team) is Victory Brewing Company, a local brewery that has won awards for sustainable practices including powering operations with renewable energy and donating spent grain to local farmers for use in feed (Henly et al., 2015). As noted earlier, our study used a spend-based method to estimate emissions from concessions which uses economy-wide average emission factors for the various economic sectors. If MLB teams switch to less GHG-intensive suppliers, the actual GHG emissions associated with their supply chain will reduce. However, without switching to a supplier-specific methodology to calculate GHG emissions, this decrease will not be reflected in their GHG emission calculations. Nonetheless, using leverage as a large customer with multinational beverage corporations like AB InBev could be one way to push the industry as a whole to lower the emissions intensity of their products. We thus recommend that the Rays evaluate craft brewing partnerships based on the sustainable practices of the organizations and should use their own influence and leverage within the MLB, to push larger brewing corporations like AB InBev to reduce environmental impacts of their operations.

Recommendation #6: Implement a Demand Tracking System

The GHG emissions impact of food operations can be reduced via tracking demand (Henly et al., 2015). At Moda Center (home of the Portland Trail Blazers NBA team), Levy Restaurants, a popular concessionaire, uses a program called Trim Tracks to monitor food waste in all the arena’s kitchens. The program requires kitchen staff to measure their scraps on large kitchen

scales at the end of each night. Staff are required to review the food scraps and come up with strategies to minimize the waste in the future with more precise cuts during food preparation or finding creative uses for scraps (Henly et al., 2015). We recommend that other MLB stadiums implement similar systems.

Recommendation #7: Install a Hydroponic System

Several stadiums and arenas have built onsite gardens (or even hydroponic towers) to prepare food as locally as possible, including the Sonoma Raceway (NASCAR), Citi Field (home of the New York Mets), and Amalie Arena (home of the Tampa Bay Lightning). Onsite gardens create a great way to tell sustainable stories about food production with fans, potentially shifting focus from food waste diversion towards low-impact food production. Advantages of the Lightning's hydroponic towers include that they take up less space than onsite gardens, produce more flavorful greens, have forced the organization to adopt a more veggie-centric menu (to use all greens as they ripen), and will have a five-year payback period (Reiley, 2014). Hydroponic systems create a discussion and informational point with fans as well as allow teams to sustainably source produce onsite. Note that this recommendation is focused on increasing fan engagement related to sustainable concessions, because, as detailed in Recommendation #2 of this section, an important component of changing eating behaviors includes changing social norms surrounding diets. An LCA would need to be conducted to determine if this recommendation actually has fewer environmental impacts than current food procurement practices.

Recommendation #8: Create Relationships with Local Organic Farmers to Maximize Year-Round Availability of Organic Produce

Further, environmental impact of concessions can be reduced by using local and seasonal ingredients, as well as procuring foods that are USDA Organic, antibiotic-free, as well as certified sustainable seafood. Benefits, according to the GSA and NRDC, include reduced GHG emissions, reduced antibiotic-resistant bacteria, promoting soil health, and reduced fertilizer run-off (Henly et al., 2015).

At FirstEnergy Stadium (home of the Cleveland Browns), the team sources organic food when possible from their high-volume food provider, Sysco. However, they have established relationships with smaller local produce companies to be able to source organic during times of the year when high-volume distributors are not able to provide as many organic options (Henly et al., 2015).

There are some notable limitations to this recommendation. Academic literature is mixed on the environmental sustainability of organic food. Although potentially better for soil health because of reduced pesticide and fertilizer application, some researchers argue increased land requirements owing to decreased yields of organically grown foods, may actually increase the GHG emissions associated with organic agriculture over conventional agriculture (Varanasi, 2019). Similarly, while local food is considered to contribute a multitude of social benefits such as just food access, community building, diversified economics, increased local jobs, civic engagement and climate resilience (Ballamingie et al., 2020; Diekmann et al., 2020), local food is not *necessarily* better for the environment. A large meta-analysis of the carbon footprints of various foods shows the amount attributable to transportation is less than 10% the carbon

footprint of most foods (Samuel, 2020). Lastly, there is a growing movement toward regenerative agriculture as a key tool to mitigating climate change (Rhodes, 2017). It is often defined by agricultural techniques that improve soil health and promote carbon sequestration in soil such as no-till farming, cover crops, diverse crop rotation, and rotational livestock grazing. While most agree that these practices improve soil health and reduce soil erosion, additional research in the field is needed to evaluate the carbon-sequestering potential regenerative agriculture provides (Ranganathan et al., 2020). Although local, organic or regeneratively produced food is important for the Rays to consider, the Rays should prioritize meat reduction strategies when it comes to reducing their carbon footprint.

11.6 MLB Specific Recommendations

The below recommendations are applicable MLB-wide and would not function at a team level. Instead, the below recommendations are for the MLB as a league and should be considered at this higher level.

11.6.1 Leveraging Partnerships/Sponsorships to Spur EV Adoption

MLB can amplify its influence over fan transportation habits and decision-making by leveraging its existing partnerships and sponsorships. The league's relationship with Chevrolet presents a unique opportunity to promote the purchase and use of EVs. While the automobile brand advertises in stadiums and on MLB media, presenting the winner of the World Series MVP award with a new Chevy is arguably the sponsor's most potent marketing strategy. The prize vehicles have mostly included trucks, SUVs, sports cars, and muscle cars (Colletti, 2020). As of 2021, Chevrolet has only produced two EV sedan models, neither of which fit the typical description of a World Series MVP prize vehicle. However, GM recently announced plans for a new EV truck, the Silverado EV, and two EV SUVs, the Equinox EV and Blazer EV, slated for release in late 2023 ("Future & Upcoming Chevy EVs | Chevrolet," 2022). The 2023 World Series would likely coincide with the release of these EVs, creating a golden opportunity to market the new EV offerings to baseball fans everywhere by presenting one to the World Series MVP. Since Chevrolet has been the official vehicle of Major League Baseball for over 15 years, MLB may be well-positioned to have Chevrolet either prioritize, or exclusively advertise EVs over gas-powered cars.

11.6.2 Team Travel Recommendations

Team travel is especially relevant for geographically isolated teams like the Tampa Bay Rays. Within the current MLB schedule structure, teams play 72 games against other teams in their division. The closest division opponent to the Rays is the Baltimore Orioles, located over 840 miles away by plane. While many teams take buses and trains for shorter distance trips, relying on these slower transportation modes is impractical for longer distance trips. Therefore, a team's ability to shift its transportation mode is dictated, in part, by the organization of the game schedule set by the MLB.

Even though the Rays are isolated, there are opportunities to reduce overall travel emissions by reducing the distance of trips, particularly between different cities on a single road trip (Wynes, 2021). Of the Rays' twelve total road trips during the 2019 season, only four trips included more than two series (three were three-series trips) and two trips were made to face a single team. In

both of the single-series road trips, the Rays flew over 1,800 round trip. For an example of how the league could help reduce team transportation emissions, we can examine the Rays’ road trip from April 27th to May 6th. The road trip began with a series in Boston, followed by a series in Kansas City, and then a series in Baltimore before returning home to Tampa. This route required 4,250 miles of air travel. The team could have reduced its travel distance by up to 733 miles, and reduced emissions from team flights by 18,100 kg CO₂ (1.62%), if it had been scheduled to play in both Boston and Baltimore either before the series in Kansas City (**Figure 16**; Air Miles Calculator, n.d.). We assume that 1) the team planes and buses are filled to capacity to account for the fact that the emission factors are calculated per passenger-mile and the vehicles are exclusively transporting people affiliated with the team and 2) teams will use buses (or a similar low-emission transportation mode) for travel under 100 miles.

*City-to-City Team Travel Distances (in miles) from 2019 Schedule
(4/27 - 5/6)*

$$\begin{aligned} & \text{(TB} \rightarrow \text{BOS} \rightarrow \text{KC} \rightarrow \text{BAL} \rightarrow \text{TB)} \\ & (1,185 + 1,256 + 967 + 842) \\ & = \underline{4,250\text{mi}} \end{aligned}$$

Optimized City-to-City Travel Distances (in miles)

$$\begin{aligned} & \text{(TB} \rightarrow \text{BAL} \rightarrow \text{BOS} \rightarrow \text{KC} \rightarrow \text{TB)} \\ & (842 + 371 + 1,256 + 1,048) \\ & = \underline{3,517\text{mi}} \end{aligned}$$

Figure 16: Team travel emissions reduction potential via circular flight pattern

Extending this same framework to consolidate road trips into fewer, longer trips (i.e. playing more series per road trip without increasing the total number of away games played) can result in even greater reductions. In general, teams arrive in a city the night before the first game of the series is set to be played and depart the city immediately after the conclusion of the final game of the series. Assuming this travel framework remains the same, consolidating road trips would not increase hotel stays. With an equivalent number of total days/nights on the road over the course of the season, we anticipate there would be no increase in other GHG-emitting activities not considered in our footprint estimate (e.g. rides, meals, or other pleasure activities indirectly related to accommodations or transportation to the field which occurs by bus). Assuming that extending the length of individual trips would not change player and employee travel norms, it is unlikely that extending the time spent on the road for a single trip would induce additional trips (e.g. for a player to fly home between games, etc). The extended time away from home may incentivize family members of team personnel to travel more to see the team play, but using our team footprint framework, those emissions would be attributed to the home team. As mentioned above, the Rays’ schedule included two roadtrips where they only played one series: against

Cleveland and against Toronto. If these two road trips had been combined, the team could have avoided 1,829 miles of travel and reduced emissions from team flights by over 100,000 kg CO₂ (8.94%; **Figure 17**).

*City-to-City Team Travel Distances (in miles) from 2019 Schedule
(5/23 - 5/27 and 9/27 - 9/30)*

$$\begin{aligned} & (\text{TB} \rightarrow \text{CLE} \rightarrow \text{TB}) + (\text{TB} \rightarrow \text{TOR} \rightarrow \text{TB}) \\ & (927 + 927) + (1095 + 1095) \\ & = \underline{4,044\text{mi}} \end{aligned}$$

Combined Trip City-to-City Travel Distances (in miles)

$$\begin{aligned} & (\text{TB} \rightarrow \text{CLE} \rightarrow \text{TOR} \rightarrow \text{TB}) \\ & (927 + 193 + 1095) \\ & = \underline{2,215\text{mi}} \end{aligned}$$

Figure 17: Team travel emissions reduction potential via combining short road trips

Rearranging the schedule to consolidate a team’s cross-country trips may yield the greatest reductions. During the 2019 season, the Rays visited the Seattle Mariners, San Francisco Giants, Oakland Athletics, Los Angeles Dodgers, Los Angeles Angels of Anaheim, and San Diego Padres. The team’s schedule broke these series into four trips (three of which included stops in cities in other parts of the country; **Figure 18**). If the West Coast trips had been consolidated into a single, long road trip moving south to north or north to south (and corresponding trips to the other cities had been consolidated as well), the team could have avoided almost 14,000 miles of travel and reduced emissions from team flights by over 370,000 kg CO₂e (33.1%). Even if the five-series trip were divided into two, the team could still have traveled nearly 11,700 fewer miles and reduced emissions from team flights by over 317,000 kg CO₂e (28.3%; **Figures 19-20**) In both reduction scenarios, we assume that the team would not relocate between the San Francisco series and the Oakland series.

An added benefit of visiting cities in close proximity to one another is that the teams could take more efficient transportation modes including buses or trains. We recognize such schedule changes could result in players and employees being away from their families for longer periods of time. Conducting informational interviews or focus groups with players could be useful to assess buy-in and inform the feasibility of such interventions.

*City-to-City Team Travel Distances (in miles) from 2019 Schedule
(4/5 - 4/16, 6/17 - 6/28, 8/9 - 8/16, 8/22 - 8/30, 9/10 - 9/20, 9/27 - 9/30)*

$$\begin{aligned}
 & (TB \rightarrow SF \rightarrow CHI \rightarrow TOR \rightarrow TB) + (TB \rightarrow NYY \rightarrow OAK \rightarrow MIN \rightarrow TB) + \\
 & (2393 + 1846 + 436 + 1095) + (1090 + 2576 + 1578 + 1306) + \\
 & (TB \rightarrow SEA \rightarrow SD \rightarrow TB) + (TB \rightarrow BAL \rightarrow HOU \rightarrow TB) + \\
 & (2520 + 1050 + 2087) + (842 + 1235 + 787) + \\
 & (TB \rightarrow TEX \rightarrow LAA \rightarrow LAD \rightarrow TB) + (TB \rightarrow TOR \rightarrow TB) \\
 & (929 + 1205 + 40^* + 2158) + (1095 + 1095) \\
 & = \underline{27,323mi} \\
 & (*indicates bus travel)
 \end{aligned}$$

Figure 18: 2019 cross-country team trips without intervention

*Reorganized Schedule City-to-City Travel Distances (in miles)
(1 West Coast trip + consolidated trips to other cities)*

$$\begin{aligned}
 & (TB \rightarrow SEA \rightarrow SF/OAK \rightarrow LAD \rightarrow LAA \rightarrow SD \rightarrow TB) + \\
 & (2520 + 679 + 337 + 40^* + 94^* + 2087) + \\
 & (TB \rightarrow MIN \rightarrow CHC \rightarrow TOR \rightarrow TB) + (TB \rightarrow BAL \rightarrow NYY \rightarrow TOR \rightarrow TB) + \\
 & (1306 + 334 + 436 + 1095) + (842 + 184 + 366 + 1095) + \\
 & (TB \rightarrow HOU \rightarrow TEX \rightarrow TB) \\
 & (787 + 224 + 929) \\
 & = \underline{13,335mi} \\
 & (*indicates bus travel)
 \end{aligned}$$

Figure 19: Team travel emission reduction potential via consolidating cross-country trips into one

*Reorganized Schedule City-to-City Travel Distances (in miles)
 (2 West Coast trips + consolidated trips to other cities)*

$$\begin{aligned}
 & (\text{TB} \rightarrow \text{SEA} \rightarrow \text{SF/OAK} \rightarrow \text{TEX} \rightarrow \text{TB}) + \\
 & \quad (2520 + 679 + 1464 + 929) + \\
 & (\text{TB} \rightarrow \text{HOU} \rightarrow \text{SD} \rightarrow \text{LAA} \rightarrow \text{LAD} \rightarrow \text{TB}) + \\
 & \quad (787 + 1303 + 94* + 40* + 2158) + \\
 & (\text{TB} \rightarrow \text{MIN} \rightarrow \text{CHC} \rightarrow \text{TOR} \rightarrow \text{TB}) + (\text{TB} \rightarrow \text{BAL} \rightarrow \text{NYY} \rightarrow \text{TOR} \rightarrow \text{TB}) + \\
 & \quad (1306 + 334 + 436 + 1095) + \quad (842 + 184 + 366 + 1095) + \\
 & \quad (\text{TB} \rightarrow \text{HOU} \rightarrow \text{TEX} \rightarrow \text{TB}) \\
 & \quad (787 + 224 + 929) \\
 & \quad = \underline{15,632\text{mi}} \\
 & \quad (*\text{indicates bus travel})
 \end{aligned}$$

Figure 20: Team travel emission reduction potential via consolidating cross-country trips into two

12. Supplemental Information: Fan Transportation Survey Purpose, Implementation, and Analysis

12.1 Fan Transportation Survey Purpose and Background

This supplemental fan transportation survey serves two purposes:

1. To improve estimates of greenhouse gas (GHG) emissions from fan transportation and
2. To assess fans' willingness-to-participate in potential team- (or MLB-) sponsored initiatives aimed at reducing these GHG emissions as a means to determine the net environmental benefits of best management practices (BMPs).

Fan transportation is overwhelmingly the largest contributor to the Rays', and more broadly MLB teams', large carbon footprint (see Section 7.1.1.5). Team intervention strategies focused on fan transportation present a significant opportunity to reduce the team's Scope 3 emissions; however, reducing emissions associated with fan transportation relies on fans changing their behavior. In order to select and initiate successful team-sponsored initiatives that effectively change fan behavior, fans' willingness-to-participate in proposed intervention strategies should be assessed. The current MLB-wide survey used in this study to quantify fan transportation GHG emissions was not designed with quantification in mind, resulting in the need for numerous assumptions to quantify this portion of the Rays' carbon footprint. Survey questions provided here tie directly to transportation quantification methods used in this study and will reduce the need for assumptions during analysis.

Generally, fostering sustainable behavior change involves five key steps: 1) Selecting behavior(s) to be promoted; 2) identifying the barriers and benefits associated with the selected behavior(s); 3) designing a strategy that utilizes effective behavior-change mechanisms to address these barriers and enable benefits; 4) piloting the strategy, and; 5) evaluating the impact of the program once it has been implemented (McKenzie-Mohr, 2013). Using literature and the results of the Rays' fan transportation carbon footprint, behaviors to be promoted were identified (see Section 11.4). Results of this survey will address Steps 2 and 3.

Originally, this survey was created as a stand-alone survey to be distributed during the 2021 MLB season, but timing and legal constraints prevented distribution. As such, the survey may be considered too lengthy to be integrated into the broader MLB-wide survey as is, but details on the purpose of each section and question outlined in the Survey Structure Section will support the use of portions of the survey without compromising data analysis should length become an issue. Such details provided in the Survey Structure Section will allow users to make educated decisions on question inclusion vs. exclusion.

Results of this study will not only support more accurate GHG quantification and gauge fans' willingness-to-participate in proposed intervention strategies, but they will also: help validate BMPs proposed in this study; provide an opportunity for cross-sectional analysis between teams should the survey be implemented by the MLB; and potentially support the evaluation of broader MLB-wide initiatives. Additionally, survey implementation may have an auxiliary benefit in that

it can serve as an educational tool. Questions that gauge fans' willingness-to-participate in less GHG-intensive transportation methods may introduce fans to, or get them thinking about, a variety of more sustainable transportation options they may have never considered. Lastly, as stated in the main body of this report, while a key contributor to the overall carbon footprint, fan transportation emissions are not currently being quantified in other congruent initiatives aimed at quantifying the environmental impacts of sports (e.g. Green Sports Alliance's PLAY campaign and Honeycomb Strategies' Sustainable Sports Index). These factors confirm our study and this augmented survey as a valuable contribution to professional sports teams' efforts to improve the sustainability of their operations.

12.2 Improving GHG Quantification by Reducing Assumptions

For the purposes of estimating the GHG emissions of fan transportation, the MLB's post-game fan survey questions are insufficient due to the limited number of questions and imprecise phrasing of certain questions and response options. To estimate Rays' fan transportation emissions from these questions, several assumptions regarding transportation mode, distance, and number of people traveling together were made, likely reducing the accuracy of our results. The following section outlines the assumptions we made during our analysis and how our updated survey questions reduce these assumptions. The section is divided into the following broad assumption categories: out-of-town travel, automobile emission factors, additional passengers, bike/scooter, return travel, and multi-modal travel. Within each subsection, the first paragraph describes our assumptions using the MLB-wide survey and why we felt the assumptions were needed, and the second paragraph includes how our proposed survey questions would address and reduce the need for assumption(s). For more details on any individual assumption used in our study, see Section 10.1.5.6.

Out-of-Town Travel

Even though the zip codes from which fans originated were known, the survey only indicated the fans' last transportation mode on the way to the stadium. For example, if a fan flew to the city, took a taxi to a nearby hotel, and walked to the stadium, they would only record on the survey that they walked to the stadium. We attempted to account for the non-reported modes by establishing distance thresholds beyond which we would assume the fan drove or flew (depending on the distance from the zip code and original transportation mode selected). For out-of-town travel, we needed to know how long fans spent in town since only a portion of the emissions from their travel to town should be allocated to attending the game. We assumed that fans traveling from out-of-town spent 3.5 days in the area, based on the average length-of-stay for visitors to the area around Tropicana Field (Visit St. Pete/Clearwater, 2021, 2020, 2019).

In our proposed survey, we ask fans explicitly 1) whether they were visiting the stadium from out of town and, if so, 2) which transportation mode they used to get to town, 3) what their home zip code is, and 4) how many days they spent/plan on spending in town; these questions eliminate the need for the distance threshold and length-of-stay assumptions for partial emissions allocation. We include an airplane response option among the potential transportation modes used to get to town to eliminate the need for air travel assumptions. Knowing both the respondent's home zip code for out-of-town visitors and the zip code from which the respondent

traveled directly to the stadium enables more accurate estimates of the total miles traveled and emissions associated with the two distinct trips.

Automobile Emission Factors

Because we could not glean from the survey whether someone who selected “Car/personal vehicle” drove or rode in a passenger car, truck, van, or SUV, we assumed the distribution of car types fans took to the stadium reflected the national average distribution. Similarly, because we had no way of knowing whether any cars were electric vehicles, we assumed all cars were gas-powered. For our quantification of Rays’ fan transportation emissions from cars, we calculated an emission factor that incorporated the national distribution of passenger-miles between passenger cars and light-duty trucks (for which the EPA has distinct emission factors; (U.S. EPA, 2021a).

Questions about transportation modes in our proposed survey include distinct response options for passenger cars and light-duty trucks, and indicate specifically which vehicle types are included in those broader categories, so that we would not have to assume the cars reflect the national average; instead, we would use the EPA passenger car emission factors for responses when “Passenger car, minivan, SUV, or small pickup truck ” is selected and use the light-duty truck emission factors for responses when “Full-size truck, full-size van, or extended-length SUV” is selected. Additionally, we include a distinct response option for electric vehicles for which the CO₂e emission factor can be calculated using **Equation 12.6C**.

Additional Passengers

Since we used the survey responses to scale up to the full 2019 season attendance, the number of people captured in the survey (i.e. respondents and everyone traveling with them) has a major impact on the scaling factor. The survey currently asks a categorical question: “With which of the following did you attend the game?” Not only does this question not elicit a number of additional travelers, it also does not specifically refer to *travel* to the game; with this wording, an individual survey response could have accounted for several people who traveled separately and met at the game. As such, we assumed the number of additional people traveling with the respondent by adding one additional passenger for each response option selected.

In our survey, we modified the MLB survey question to read, “How many people traveled *with you* to the game,” emphasizing the words “with you” in italics. We expect this modification will result in a more accurate estimate of the scaling factor necessary to translate emissions from survey responses into emissions for the entire season attendance.

Bike/Scooter

We assumed that all respondents who selected the “bike/scooter” option used the human-powered analogue. In doing so, we assumed that bike/scooter travel produced no emissions.

In our survey, we add three e-bike/e-scooter response options to the list of transportation modes: one for personal bikes/scooters, one for shared, docked bikes/scooters, and one for shared, dockless bikes/scooters; these options eliminate the need to assume all bikes/scooters used are

human-powered. We distinguish between the three varieties because shared bikes/scooters generate emissions from both charging and rebalancing (collection and redistribution of bikes/scooters) using automobiles; docked ones produce fewer emissions than dockless ones because most docked bikes/scooters are returned to docks for charging requiring less rebalancing (Luo et al., 2019). Personal bikes/scooters only produce emissions from charging.

Return Travel

Since the MLB survey questions about zip code and transportation mode refer only to how the respondent traveled *to* the stadium, we had to assume that all fans returned to the same location after the game and used the same mode.

In our survey, we directly ask whether the respondent used (or will use) the same mode of transportation leaving the stadium as they did to arrive at the stadium. If not, we ask which mode they used (or will use) and which zip code they expect to travel to. These explicit questions will reduce assumptions related to return travel.

Multi-modal Travel

The MLB survey only accepts a single transportation mode response, so we could not identify whether a respondent took more than one transportation mode or what the additional mode(s) was (were). As such, we assumed that the survey respondents took *only* the single mode indicated in their response.

As mentioned above, we ask explicitly about transportation modes used to get to town and return home after the game. These questions would allow analysts to calculate a more accurate carbon footprint from fan transportation. In the interest of reducing respondent burden, we do not ask additional questions to ascertain whether respondents took multiple modes to get to town, get to the game, or get home. For all questions about transportation mode, we ask only for the main mode used. Evaluating the *main* mode of transportation will give us the most accurate emissions results while maintaining minimal respondent burden.

12.3 Survey Structure

Our survey consists of six sections, each serving a distinct purpose, which could be included or excluded for eventual distribution based on the desired purpose of the survey distributor. Here, we discuss the purpose and value of each section. We stress that each section has been carefully crafted and the most robust findings will come from implementing this survey in its entirety, but we understand the reality that it may be difficult to incorporate all questions into the existing MLB-wide survey. Broadly, Part I and Part V of the survey are the most important sections as they correspond to quantification and willingness-to-participate in transportation initiatives. Notably, 19 questions or 41% of the survey are conditional questions, meaning most survey participants will not see all questions, reducing respondent burden. While including only specific parts of this survey, or deleting specific questions is an option to reduce respondent burden based on the goals of survey administrators, we recommend *not* changing any question response options unless specifically indicated, as they have been carefully selected for quantification purposes or based on behavioral change research.

Part I: Quantification

The purpose of this section is to provide robust quantification of GHG emissions from fans traveling to and from the stadium (and to and from town, if applicable). Questions directly tied to quantification are listed with their corresponding variable for emissions calculation in Table 34 (Section 12.6).

Questions 1-11, and 17-20 address elements of quantification. Barring Questions 14-17 which address return travel (discussed below), to support robust GHG quantification, no quantification questions should be deleted or modified (see Section 12.3). Questions 12, 13, 18, and 19 provide context for why respondents chose the transportation mode they did on this occasion and in the past, touching on key factors such as convenience that often hinder low-emission transportation adoption, and will be useful for assessing attitudes towards different transportation modes more broadly. They are included here because, while they do not help to quantify emissions, this question order will reduce respondent burden as they are directly related to quantification questions and should appear sequentially. Easy-to-follow questionnaire formats are imperative to improve response rates (Dillman et al., 1993).

Questions 1-9 address out-of-town travel vs in-town travel – important for quantification because long-distance travel accounts for the majority of fan transportation emissions. In the survey, we include a standardized definition of out-of-town travel as “any visit that requires an overnight stay.” Questions 5, 7, and 10 evaluate the broad transportation mode used for travel to town, travel to the stadium for non-local fans, and travel to the stadium for local fans, respectively. Questions 6, 8, and 11 allow the respondent to select a more specific automobile option (based on EPA emission factors) to reduce the number of response options listed for everyone, reducing respondent burden. Question 9 elicits the fan’s planned length-of-stay to be used for partial emissions allocation.

Questions 2-4 ask for the respondent’s zip code(s) to estimate distance traveled and associated emissions. Question 2 is a conditional question (which only appears to those who are visiting from out-of-town) and focuses on the distance traveled from the respondent’s home zip code to the location in which the baseball game is being played (calculated from the respondent’s reported home zip code to the reported local zip code). Questions 3 and 4 focus on the distance traveled between some local origin and the stadium. Wording is slightly different between the two to differentiate between in-town and out-of-town for out-of-town visitors.

Question 12 asks why the fan took the transportation mode they did and Question 18 asks why the fan took a different transportation mode to leave the stadium (if they did). Results from these questions and Questions 19, 35, and 36 address typical barriers to taking alternative forms of transportation. Understanding key mode-switching barriers will allow the Rays or other MLB teams to structure team interventions that will address these barriers.

Because Question 13 refers to how the fans have traveled to the stadium *in the past*, responses that differ from the transportation mode they used today will offer insights into fans’ current flexibility or willingness to try different transportation modes.

Questions 14-18 seek to determine whether fans return to the same place from which they traveled to the stadium, whether they use the same transportation mode to leave the stadium, and why. Results from these questions can enable more effective estimates of distance (and emissions) for alternate destinations and/or modes of transportation. Additionally, how people leave the stadium can be a useful insight when determining accommodations for fans to support lower GHG-emitting modes of transportation. If survey length is a serious concern, we believe these questions are *least* important for quantification and could be removed with limited value lost.

Questions 20-21 refer to the number of people traveling together in the same vehicle. Question 21 specifically identifies the number of people traveling with the respondent from outside their household. This question addresses additionality for carpooling. People who live together will typically carpool as a matter of convenience. It is important to understand how many *additional* people carpooled with respondents to assess baseline carpooling behaviors and the potential for improving carpooling rates.

Part II: Involvement with Current Team Resources

Questions 22-27 address the extent to which fans have engaged with team resources pertaining to transportation specifically, or team initiatives more broadly. These questions help tease apart whether team resources are currently being leveraged to disseminate information and whether past participation in initiatives make fans more likely to participate in a team-based transportation initiative. Responses to Questions 22 and 23 have been left blank to be modified by individual teams or the MLB. Question 27 assesses fans' awareness/familiarity with bike-share and scooter-share programs and is included in this section because it is specific to the team's city.

Part III: Broader Transportation Habits

Questions 28-31 address non-game-related transportation habits and awareness of or access to different transportation options. If respondents report using public transportation or a bike on a regular basis, but don't use these modes to get to the stadium, barriers to participation are likely more situation-specific, and actions on the part of the team will likely be more effective. Likewise, if respondents have access to an electric vehicle, for example, but use a more GHG-intensive mode to get to the stadium, team-sponsored initiatives are likely more salient. Additionally, if people already generally engage with alternative modes of transportation, they may be more likely to participate in incentive programs to take public transit or other less GHG-emitting modes of transportation to the stadium. Results from this set of questions also work as explanatory variables for the results of parts V and VI.

Part IV: In-group Behavior

Questions 32-34 address the relative influence that the people you attend games with and the team have over your choices of transportation to the game. Question 32 addresses our strategy to target fans attending multiple games in a season for mode-switching intervention strategies. This is important for four reasons: 1) The more times they go to the stadium, the more they will be exposed to behavioral change messaging and BMPs; 2) If a fan switches to a more sustainable mode of transport, then the more times this fan goes to a stadium, the greater the emissions reduction potential; 3) Literature states fans are more likely to change their behavior if they are a

part of the "in-group," meaning the degree of fandom influences willingness to change one's behavior. It can be reasonably assumed that fans attending more than one game a season have a higher degree of fandom. 4) Targeted messaging related to transportation mode-switching can be created for these fans specifically. If in-group behavior is relatively strong, based on the results of Question 33, intervention strategies that focus on peer pressure and social interactions, such as a social media campaign, may be more useful. Question 34 is a temperature check for whether or not the respondent would be receptive to mode suggestions from the team.

Part V: Willingness to Participate in Proposed Team Initiatives

Questions 35-43 address fans' willingness-to-participate in specific prospective team initiatives. Questions 34-35 identify barriers to participation in carpool and mode-switching initiatives. Questions 36-38 and 40-43 introduce a variety of generic and mode-specific incentives to encourage participation in a particular initiative. The incentives included in this survey could be modified, but MLB/teams are encouraged to not remove incentives since they are not committed to providing any incentives merely by distributing the survey. Any trends identified from the list of incentives can be cataloged for use if/when the initiatives come to pass. Question 39 is the only question that does not refer to specific incentives, but instead a proposed "bike to the game" event, already conducted by a couple MLB teams. Results of these questions will help the team(s) determine which initiatives or incentives fans' are most likely to engage with to help determine which initiatives will likely be the most successful.

Part VI: Concluding Questions

Questions 44-46 wrap up the survey. Question 44 addresses the utility of the survey itself as a tool for informing/influencing fans about sustainable transportation options, since participants will likely be spending 15-20 minutes engaging with the material. Question 45 gives the respondents an opportunity to contribute any additional thoughts related to the advancement of sustainable transportation initiatives. This open-ended question is important for building respondent trust, a key factor to support robust survey results, as it is important for respondents to feel they are being heard and the goals of both the administrator and respondent are met (Dillman et al., 2014). Question 46 is an administrative question specific to the idea of bolstering survey participation by offering a reward or entry into a raffle to potentially receive a prize. The inclusion of a reward for survey completion has been shown to significantly increase both survey response and completion rates (Dillman et al., 2014; Singer et al., 1999).

12.4 Survey Creation Methods

The creation of this survey followed survey design best practices to reduce respondent burden and survey bias, providing robust survey results (Dillman et al., 2014; NOAA, 2015). The purpose and goals of the survey, details on confidentiality and consent, and the typical time requirement needed for completion are clearly outlined in the intro/background section preceding the start of the survey. Questions follow a logical and sequential order to avoid respondent bias. For example, quantification questions come before questions on broader behavioral habits and these broader transportation habit questions come before questions on incentives to avoid respondents being more generous in their use of sustainable modes of transit to be perceived as more environmentally conscious. It is common for survey respondents to want to appear more favorable in the eyes of survey administrators. Questions are neutral, non-leading questions,

tailored to an audience with little knowledge on sustainable transportation methods, and simple wording was carefully selected. This survey passes the Flesch reading ease test, meaning it is considered easily understood by a 13-15 year-old student. In order to reduce respondent burden, question format is generally consistent when possible, more complex response options are repeated throughout multiple questions, fill in the blank is used when appropriate, bolding is used to orient survey takers to the key differences between questions, and conditional formatting is used to reduce the amount of questions seen by most survey-takers. Lastly, questions that test the degree of agreeance or willingness to participate use a five-point (odd numbered) likert scale. This survey has been approved through University of California Santa Barbara's Institutional Review Board, meaning sufficient steps have been taken to protect the rights and welfare of participants, and the study presents more benefits than risks to participants.

12.5 Distribution Methods

We recommend that the MLB either incorporate some or all of these survey questions into the MLB-wide survey or distribute this survey as a standalone transportation-specific survey in its entirety either via email or at the stadium. If these questions are incorporated into the existing MLB survey, we suggest quantification-based questions replace the transportation-related questions in the current MLB survey. If distributed at the stadium, several options are suggested to increase survey response rate and avoid sampling bias: if the stadium uses mobile ticketing only, attendees can be prompted to take the survey via a notification through the app on their phone between innings; similarly, attendees can be invited to take the survey on the jumbotron with a corresponding announcement between innings (this option invites an opportunity for sponsorship); or attendees can use their cellphones to scan strategically placed QR codes, advertising the opportunity to win a prize. If this survey is distributed as a stand-alone survey via email, care should be taken to send to all attendees or ticket purchasers to avoid sampling bias. If a stand-alone transportation survey is distributed, we recommend the inclusion of an incentive such as a giveaway for all who participate or to be entered into a drawing for a chance to win a more coveted prize (an option likely to have less logistics involved) to increase survey response and completion rates (Dillman et al., 2014; Singer et al., 1999). With either distribution method survey distribution best practices should be followed to ensure the integrity of survey results (Dillman et al., 2014).

12.6 Survey Analysis Methods

Results of this survey can be analyzed following the same general quantification methods used in this study to estimate emissions from fan transportation more accurately (see Section 10.1.5). However, additional analysis is needed to account for out-of-town travel and return travel after the game (if it is different from the mode used or distance to the game). The differentiation between travel to town, travel to the game, and travel from the game for out-of-town survey respondents would follow **Equation 12.6A** (variables in **Table 34**). Translation from emissions from a single survey response to total estimated emissions from fan transportation would follow **Equation 12.6B**.

Equation 12.6A:

$$E_S = PPS_T \times \sum \left((RTF \times D_{TT} \times \left(\frac{1}{L}\right) \times EF_T \times GWP_T) + (D_{AT} \times EF_T \times GWP_T) + (D_{DT} \times EF_T \times GWP_T) \right)$$

Summed over CO2, CH4, and N2O

Equation 12.6B:

$$E_A = SSF \times \sum E_S$$

Summed over all survey responses

Table 34. Variables used in **Equations 12.6.A** and **12.6B** to calculate emissions from data from Sustainaball survey

| Variable | Description (Units) | Corresponding Survey Question(s) |
|----------|---|----------------------------------|
| E_S | Total transportation emissions (kg CO ₂ e) for one survey response ¹ | |
| PPS | Number of passengers + 1 (to include respondent) ² | 18 |
| RTF | Round trip factor (=2) | |
| D_T | One-way travel distance to town (miles) ^{2*} | 2 |
| τ | Transportation mode ² | 5, 6, 8, 10, 11, 16, 17 |
| L | Length of stay (days) ^{2*} | 8 |
| EF_T | Emission factor for transportation mode (mass of GHG / passenger-mile or vehicle-mile) ³ | |
| GWP_T | Global warming potential for GHG ⁴ | |
| D_A | One-way local travel distance to game (miles) ² | 3, 4 |
| D_D | One-way local travel from stadium after game (miles) ² | 14 |
| E_A | Total transportation emissions (kg CO ₂ e) for entire season | |
| SSF | Season scaling factor ⁵ | |

*Travel distance to town should be calculated from the respondent's home zip code to the local zip code they report. If the respondent is not visiting from out of town (and does not receive Question 8), $D_T = 0$ and $L = 1$. ¹Calculated in **Equation 12.6.A**; ² Survey Responses; ³ EPA 2021 GHG Emission Inventory Factors - Table 10; ⁴IPCC AR6; ⁵**Equation 10.1.5B**

The additional transportation mode options will not fundamentally change the methodology, but they will need discrete emission factors. Because some vehicle emission factors change as fleets are modernized and pollute less, the emission factors used for estimation will need to be updated periodically. Emission factors for the majority of vehicles in our survey are included in EPA's GHG Emissions Hub, which is updated annually (U.S. EPA, 2021a). The remaining modes will require at least one additional piece of information to calculate emissions. Electric modes, including cars, personal or docked e-bikes/e-scooter, and dockless e-bikes/e-scooters, produce emissions from electricity use; the local eGrid subregion has emission factors in lbs CO₂e per MWh. Additionally, efficiency information (i.e. kWh per mile) is needed for each vehicle type to calculate emissions (**Equation 12.6B**). Information on EV efficiency can be found on Alternative Fuels Data Center (U.S. Department of Energy, 2021). Efficiencies for dockless and personal e-bikes and scooters were found in scientific studies (Hollingsworth et al., 2019; McQueen et al., 2020), but as the technologies develop, updated numbers will likely become available. For shared e-bikes/e-scooters, additional emissions (in kg CO₂e/mi) must be added to the total calculated in **Equation 12.6C** to account for rebalancing (Hollingsworth et al., 2019; Luo et al., 2019).

Equation 12.6C:

Electric Transportation Mode Emissions (CO₂e in kg/miles) = Electric transportation mode efficiency (kWh/mi) x MWh/1000kWh x eGrid emission factor (lbs CO₂e/MWh) x .4536kg/lb

Taxi and rideshare vehicle emissions can be based on passenger car emission factors from EPA GHG Emissions Hub, but should be multiplied by the CID factor described in Section 10.1.5.4 to account for additional emissions from cruising, idling, and deadheading. We calculated CID factors from Anair et al. (2020) and Cramer & Krueger (2016), but new CID factors should be calculated if better information relating the emissions or capacity utilization factor of taxis and rideshare vehicles to cars becomes available.

Certain transportation modes have different emission factors depending on the distance traveled or region where traveling took place. Travel by intercity rail in the Northeast Corridor should be distinguished from other routes around the country; the emission factors for the Northeast Corridor should be used only for a stadium along the corridor (i.e. Washington DC to Boston). Airplane emissions vary depending on the distance and should be differentiated based on the zip code distance from home to stadium. Emission factors used in this study are presented in **Table 27**.

12.7 Mode-Switching and Avoiding Backfire

Beyond using survey results to estimate GHG emissions produced from fan transportation, results of this survey will help teams determine which incentives, events, or team interventions will work best to support behavioral change on behalf of fans. Results of this survey must account for potential “backfire.” Simply evaluating the results of part V and VI is not sufficient to determine the validity of these incentives; fans must switch from more GHG-emitting transportation modes to less, not the other way around. Teams should not promote interventions where the majority of fans are shifting to more GHG-intensive modes (e.g. walking to e-bike). Evaluating potential backfire can be done by linking results from questions that address current transportation methods and incentive questions. Results should first be filtered based on Questions 6 and 12 to view results of questions in parts III-V. From here, a comparative analysis can help to gauge which interventions will likely stimulate behavioral change from more intensive modes of transportation to less intensive modes of transportation, or vice versa. The degree of potential backfire will be difficult to evaluate based on these survey results, but a general idea as to which barriers, interventions and incentives may cause a backfire effect is valuable information to determine a team’s intervention strategy. Lastly, descriptive statistics (e.g., mean, median, and standard deviation) can be used to summarize survey results and may be sufficient to gaining insights into the best intervention strategies for a team, but inferential statistics, which reveal the degree to which different variables are related will allow for a more robust analysis, particularly when examining how results from different parts of the survey influence each other (e.g. how broader transportation habits and in-group behavior influence fans’ willingness-to-participate).

12.8 Concluding Remarks

In sum, this survey will identify barriers and benefits associated with switching to more sustainable modes of transportation and support the implementation of a team-led strategy that utilizes effective behavior-change mechanisms to address these barriers and benefits to taking more sustainable modes of transportation to games. The MLB-wide survey used to quantify GHG emissions from fan transportation was not designed for these purposes, thus many assumptions were made during analysis. Updated questions provided here will support more precise GHG emission estimation. Survey results will also provide auxiliary benefits to teams by providing an opportunity to validate best management practices (BMPs) proposed in this study; provide an opportunity for cross-sectional analysis between teams should the survey be implemented by the MLB; support the evaluation of broader MLB wide initiatives; and lastly, the survey itself can serve as an educational tool to respondents.

13. Supplemental Information: Fan Transportation Survey

Consent/Introduction

Complete this survey to enter into a chance to win memorabilia autographed by [team member]! The purpose of this survey is to better understand how fans are traveling to MLB games and to assess fan's willingness to participate in potential transportation-based team-sponsored initiatives.

Your participation in this survey is completely voluntary and responses are anonymous. You can choose not to answer any question you do not wish to answer. You can also choose to stop taking the survey at any time. Upon survey completion, you will have the option to enter into a chance to win [insert prize]. You must provide your email to be entered, but survey responses will not be associated with your email.

You must be at least 18 years old to participate. The survey will take about 20 minutes to complete.

[PART I: QUANTIFICATION]

1. Are you visiting the stadium from out-of-town today? (We define out-of-town as any visit that requires an overnight stay.)
 - a. Yes
 - b. No

2. **(Conditional:** If yes to “Are you visiting the stadium from out-of-town today?”)
Please state your home zip code. (open-ended)

3. **(Conditional:** If yes to “Are you visiting the stadium from out-of-town today?”)
Please indicate the local zip code you traveled to the stadium from today. (open-ended)

4. **(Conditional:** If no to “Are you visiting the stadium from out-of-town today?”)
Please indicate the zip code you traveled to the stadium from today. (open-ended)

5. **(Conditional:** If yes to “Are you visiting the stadium from out-of-town today?”)
Which of the following best describes how you got *into* town? (Select one option)
 - a. Plane
 - b. Automobile
 - c. Train
 - d. Bus

- e. Other: please specify
6. **(Conditional:** If “Automobile” to “Which of the following best describes how you got *into* town?”)
- Which of the following best describes your automobile?
- a. Passenger car, minivan, SUV, or small pickup truck
 - b. Full-size truck, full-size van, or extended-length SUV
 - c. Electric vehicle
7. **(Conditional:** If yes to “Are you visiting the stadium from out-of-town today?”)
- Once in town, which of the following best describes how you got to the stadium today?
(Select one option)
- a. Automobile
 - b. Rideshare (e.g. Uber, Lyft)
 - c. Taxi
 - d. Bus
 - e. Intercity rail (e.g. Amtrak)
 - f. Commuter rail (rail service between a central city and adjacent suburbs)
 - g. Transit rail (e.g. subway, elevated railway, metro, streetcars, trolley cars, and tramways)
 - h. Walk
 - i. Bicycle/scooter (human-powered)
 - j. E-bike/e-scooter (personal)
 - k. E-bike/e-scooter (shared docked)
 - l. E-bike/e-scooter (shared dockless)
 - m. Other: please specify
8. **(Conditional:** If “Automobile” to “Once in town, which of the following best describes how you got to the stadium today?”) Which of the following best describes your automobile?
- a. Passenger car, minivan, SUV, or small pickup truck
 - b. Full-size truck, full-size van, or extended-length SUV
 - c. Electric vehicle
9. **(Conditional:** If yes to “Are you visiting the stadium from out-of-town today?”)
- How many total days will you spend in town on this trip?
- a. Fill in the blank answer: _____ days
10. **(Conditional:** If no to “Are you visiting the stadium from out of town today?”)

Which of the following best describes how you got to the stadium today? (Select one option)

- a. Automobile
 - b. Rideshare (e.g. Uber, Lyft)
 - c. Taxi
 - d. Bus
 - e. Intercity rail (e.g. Amtrak)
 - f. Commuter rail (rail service between a central city and adjacent suburbs)
 - g. Transit rail (e.g. subway, elevated railway, metro, streetcars, trolley cars, and tramways)
 - h. Walk
 - i. Bicycle/scooter (human-powered)
 - j. E-bike/e-scooter (personal)
 - k. E-bike/e-scooter (shared docked)
 - l. E-bike/e-scooter (shared dockless)
 - m. Other: please specify
11. **(Conditional:** If “Automobile” to #10 “Which of the following best describes how you got to the stadium today?”)
- Which of the following best describes your automobile?
- a. Passenger car, minivan, SUV, or small pickup truck
 - b. Full-size truck, full-size van, or extended-length SUV
 - c. Electric vehicle
12. Why did you choose to use the transportation method that you did? (Check all that apply)
- a. Most convenient option
 - b. Cheapest option
 - c. Quickest option
 - d. Someone else recommended the option
 - e. It’s my regular method
 - f. It was not my choice
 - g. Only option available
 - h. Other (please explain)
13. Which of the following ways have you traveled to this stadium in the past? (Check all that apply)
- a. Automobile
 - b. Rideshare (e.g. Uber, Lyft)
 - c. Taxi

- d. Bus
 - e. Intercity rail (e.g. Amtrak)
 - f. Commuter rail (rail service between a central city and adjacent suburbs)
 - g. Transit rail (e.g. subway, elevated railway, metro, streetcars, trolley cars, and tramways)
 - h. Walk
 - i. Bicycle/scooter (human-powered)
 - j. E-bike/e-scooter (personal)
 - k. E-bike/e-scooter (shared docked)
 - l. E-bike/e-scooter (shared dockless)
 - m. Other: please specify
 - n. I've never been to this stadium before
14. Will you be returning to the same zip code after the game today? If not, please indicate the zip code you will travel to after the game.
- a. Yes
 - b. No, I will be traveling to _____
15. Will you be taking a different transportation method to leave the stadium today?
- a. Yes
 - b. No
 - c. Unsure
16. (**Conditional:** If yes to “Will you be taking a different transportation method to leave the stadium today?”)
- Which of the following methods best describes how you will be leaving the stadium today? (Select one option)
- a. Automobile
 - b. Rideshare (e.g. Uber, Lyft)
 - c. Taxi
 - d. Bus
 - e. Intercity rail (e.g. Amtrak)
 - f. Commuter rail (rail service between a central city and adjacent suburbs)
 - g. Transit rail (e.g. subway, elevated railway, metro, streetcars, trolley cars, and tramways)
 - h. Walk
 - i. Bicycle/scooter (human-powered)
 - j. E-bike/e-scooter (personal)
 - k. E-bike/e-scooter (shared docked)

- l. E-bike/e-scooter (shared dockless)
 - m. Other: please specify
17. **(Conditional:** If “Automobile” to “Which of the following best describes how you will be leaving the stadium today?”)
Which of the following best describes your automobile?
- a. Passenger car, minivan, SUV, or small pickup truck
 - b. Full-size truck, full-size van, or extended-length SUV
 - c. Electric vehicle
18. **(Conditional:** If yes to “Will you be taking a different transportation method to leave the stadium today?”)
Why will you be taking a different transportation method to leave the stadium today?
(Open ended)
19. How long did it take you to get to the stadium today?
- a. Less than 30 minutes
 - b. 30 minutes - 1 hour
 - c. 1-2 hours
 - d. 2-3 hours
 - e. 3 or more hours
 - f. I don’t know
20. How many people traveled *with you* to the game today, if any?
- a. Fill in the blank question: _____ people (must be a numerical value)
21. **(Conditional:** if any option other than 0 to “How many people traveled (in the same vehicle with you to get to the stadium today, if any?”)
How many of the people traveling to the game with you today are from outside your household?
- a. Fill in the blank question: _____ people (must be a numerical value)

[PART II: INVOLVEMENT WITH CURRENT TEAM RESOURCES]

22. Which of these team initiatives have you heard about? Check all that apply.
- a. **Specific to individual teams
23. Which of these team initiatives have you participated in? Check all that apply.
- a. **Specific to individual teams

24. Have you ever consulted the transportation resources on the team's website?
- a. Yes
 - b. No
 - c. Unsure
25. (**Conditional:** If yes to "Have you ever consulted the transportation resources on the team's website?")
Did those resources include any transportation methods that you have never considered before?
- a. Yes
 - b. No
26. (**Conditional:** If yes to "Have you ever consulted the transportation resources on the team's website?")
Did those resources influence your decision of how to get to the stadium?
- a. Yes
 - b. No
27. Are you aware of the bike-share and/or scooter-share services available in your team's town?
- a. Yes
 - b. No

[PART III: BROADER TRANSPORTATION HABITS]

28. In a typical month, how likely are you to take public transportation?
- a. Very likely
 - b. Likely
 - c. Somewhat likely
 - d. Unlikely
 - e. Very unlikely
29. In a typical month, how likely are you to commute by bicycle?
- a. Very likely
 - b. Likely
 - c. Somewhat likely
 - d. Unlikely
 - e. Very unlikely

30. In general, what modes of transportation do you use throughout the year? (Check all that apply)
- a. Automobile
 - b. Rideshare (e.g. Uber, Lyft)
 - c. Taxi
 - d. Bus
 - e. Intercity rail (e.g. Amtrak)
 - f. Commuter rail (rail service between a central city and adjacent suburbs)
 - g. Transit rail (e.g. subway, elevated railway, metro, streetcars, trolley cars, and tramways)
 - h. Walk
 - i. Bicycle/scooter (human-powered)
 - j. E-bike/e-scooter (personal)
 - k. E-bike/e-scooter (shared docked)
 - l. E-bike/e-scooter (shared dockless)
 - m. Other: please specify
31. Which of the following vehicles do you own, lease, or have consistent access to? (Check all that apply)
- a. Passenger car, minivan, SUV, or small pickup truck
 - b. Full-size truck, full-size van, or extended-length SUV
 - c. Electric vehicle
 - d. Bike
 - e. E-bike/e-scooter
 - f. Standing scooter

[PART IV: IN-GROUP BEHAVIOR QUESTIONS]

32. On average, how often do you attend [team] games during the season?
- a. Less than one game per season
 - b. 1 game per season
 - c. 2-5 games per season
 - d. 6-10 games per season
 - e. 11-20 games per season
 - f. More than 20 games per season
33. When I attend games with a group of people, I will take the same method of transportation to the game as the group I am attending with - *even if it is less convenient.*

- a. Strongly agree
- b. Agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

34. If the team were to suggest taking a particular mode of transportation to the game, I would follow their advice.

- a. Strongly agree
- b. Agree
- c. Neutral
- d. Disagree
- e. Strongly disagree

[PART V: WILLINGNESS TO PARTICIPATE IN PROPOSED TEAM INITIATIVES]

35. Which of the following modes of transportation would you be unwilling or unable to use to get to the stadium? (Check all that apply)

- a. Carpool with friends
- b. Carpool with fans you don't know
- c. Drive an electric vehicle
- d. Use a park-and-ride shuttle (involves parking at a pre-arranged pick-up point to take a shuttle bus directly to the stadium)
- e. Use public transportation
- f. Use a personal bike or scooter (human-powered)
- g. Use a personal e-bike or e-scooter
- h. Use a bike-share or scooter-share program
- i. Walk

36. For what reasons would you be unwilling or unable to participate in any of the transportation methods from the previous question? (Check all that apply- conditional matrix format)

- a. This option is too expensive
- b. I would feel unsafe using this option
- c. I would be physically uncomfortable using this option
- d. This option is too complicated to navigate
- e. This option takes too long
- f. City infrastructure is insufficient (e.g no designated bike lanes, insufficient EV charging stations, etc)

- g. Stadium policies make it difficult to participate
- h. The people I go to games with are unwilling or unable
- i. This option is located too far from my home/destination
- j. I don't have access to this option
- k. Other (please explain)

37. Which of the following incentives would make you most likely take **public transportation**? Please rank your top three options.

- a. If the pickup point nearest to the stadium added more buses, trains, subway cars, or shuttles after the game to reduce wait times to get you home more quickly
- b. If the cost of transportation were included in your ticket price
- c. If your ticket price were reduced by the cost of transportation
- d. If your ticket price were reduced by a portion of the cost of transportation
- e. If you received a free transportation pass with your ticket
- f. If you could receive one or more free tickets for taking public transportation to [X amount] games
- g. If you could receive a special giveaway item
- h. If you could receive a free food/drink item at the stadium

38. Which of the following incentives would make you most likely take a **park-and-ride service**? Please rank your top three options.

- a. If the pickup point nearest to the stadium added more park-and-ride shuttles after the game to reduce wait times to get you home more quickly
- b. If the cost of transportation were included in your ticket price
- c. If your ticket price were reduced by a portion of the cost of transportation
- d. If you could receive one or more free tickets for taking public transportation or a park-and-ride shuttle to [X amount] games
- e. If you could receive a special giveaway item
- f. If you could receive a free food/drink item at the stadium

39. (**Conditional:** If one of the automobile-based travel options is selected for “How did you get to the stadium today?” OR “Which transportation methods do you typically use to get to the stadium?”)

Which of the following incentives would make you most likely to **carpool** to the game with fans from *outside your household*? Please rank your top three options.

- a. If a carpool-matching program were provided (such as RideMatch, etc.)
- b. Priority carpool parking close to stadium entrances
- c. If your ticket price were reduced by \$[X]
- d. If your cost of parking were reduced

40. Would you be willing to participate in a “Bike to the Game” event?
- Yes
 - No
41. Which of the following incentives would make you most likely to ride a **personal bike, e-bike, standing scooter, or e-scooter** to the game? Please rank your top three options.
- If (more) bike/scooter storage were available at the stadium
 - If free bike/scooter valet were provided at the stadium
 - If you could ride with a group of people
 - If your ticket price were reduced by \$[X]
 - If you could receive a special giveaway item
 - If you could receive a free food/drink item at the stadium
 - If you could receive one or more free tickets for biking/scooter to [X] games
42. Which of the following incentives would make you most likely to use a **bike-share or scooter-share** to get to the game? Please rank your top three options.
- If you could guarantee that enough bikes/scooters would be available to get home at the end of the game
 - If you received a promo code for the bike-share or scooter-share service
 - If your ticket price were reduced by the cost of the bike-share/scooter-share service
 - If you could receive a special giveaway item
 - If you could receive a free food/drink item at the game
 - If you could receive one or more free tickets for using a bike-share/scooter-share service to get to [X amount] games
43. (**Conditional:** If “electric vehicle” is selected for “Which of the following vehicles do you own, lease, or have consistent access to?” AND if response to “How did you get to the stadium today?” or “Which transportation methods do you typically use to get to the stadium?” does not include “electric-powered automobile”)
- If you have access to an electric vehicle, but choose not to drive it to the stadium, which of the following incentives would make you most likely to drive your **EV vehicle** to the stadium? Please rank your top three options.
- If the stadium provided (more) EV charging stations
 - If you received priority EV parking near lot entrance/exit
 - If you received priority EV parking close to stadium entrances
 - If the price of *charging your vehicle* at the stadium were reduced
 - If the price of *parking at the stadium* were reduced

- f. If you could participate in a rewards program in which drivers accumulate points for charging (based on the number of kWh added to the vehicle) that can be redeemed for Rays game tickets

[PART VI: CONCLUDING QUESTIONS / ADDITIONAL INFORMATION]

- 44. Have any of the preceding questions caused you to consider using a transportation mode you had never considered using to get to the stadium?
 - a. Yes
 - b. No

- 45. Please share any final thoughts or suggestions on what your team can do to help you use more sustainable transportation options.

- 46. Thank you for completing our survey! If you would like to be entered for a chance to win a signed prize, please enter your email below. Email addresses will NOT be associated with survey responses.