NPS-CE-25-247

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Bottle Filling Fixtures on Navy Vessels: A Business Case Analysis

June 2024

LCDR Alan T. Ulichney, USN
LCDR Kelly L. Allen, USN
LCDR Donald H. Graybill, USN

Thesis Advisors: Dr. Jesse Cunha, Associate Professor
Dr. Aruna U. Apte, Professor

Department of Defense Management

Naval Postgraduate School

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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

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The research presented in this report was supported by the Acquisition Research Program of the Department of Defense Management at the Naval Postgraduate School.

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ABSTRACT

In this report, we investigate the feasibility, costs, and benefits of installing gooseneck fixtures on U.S. Navy ships to reduce plastic waste and improve Sailors' quality of life. By equipping water coolers across 162 surface ships with these vertical filling fixtures at a relatively low cost, the Navy can achieve a 50% reduction in single-use plastic bottles, saving approximately $5.6 million in the first year alone. With an initial investment of $1.1 million and a break-even point of just two months, we propose this initiative as a cost-effective and proactive measure toward environmental sustainability. By installing fixtures at a ratio of 1 per 40 Sailors, we underscore the Navy's commitment to environmental stewardship and highlight substantial cost savings and enhanced quality of life for its personnel.

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ACKNOWLEDGMENTS

Our team would like to express our gratitude to our advisor, Dr. Jesse Cunha, for his support throughout our research and Dr. Aruna Apte for her review of our work. Their motivation, knowledge, and insight were key to our success. We would also like to thank the teams at NAVSUP-WSS and NAVSEA for providing data and subject matter experts to talk to. Additionally, we would like to thank our families for supporting us throughout the writing of this report and our time at NPS.

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LIST OF ACRONYMS AND ABBREVIATIONS

APPS	Act to Prevent Pollution from Ships
BCA	Business Case Analysis
COA	Course of Action
COTS	Commercial-off-the-shelf
CNSP	Commander, Naval Surface Force, U.S. Pacific Fleet
CLF	Combat Logistics Force
CMU	Compress Melt Unit
CR	Continuing Resolution
DOD	Department of Defense
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
IMO	International Maritime Organization
MARPOL	International Convention for the Prevention of Pollution from Ships
MILSPEC	Military Specification
MWR	Morale, Welfare and Recreation
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NOAA	National Oceanic and Atmospheric Agency
NEXCOM	Navy Exchange Service Command
NSS	National Security Strategy
OMB	Office of Management and Budget
PAWDS	Plasma Arc Waste Destruction System
PRIME	Plastics Removal in a Marine Environment
WRAPS	Waste Reduction Afloat Protects the Sea
RAS	Replenishment at Sea
SHIPALT	Shipboard Alteration
TYCOM	Type Commanders
USAID	U.S. Agency for International Development

Ship Classes

CG	Guided Missile Cruiser
CVN	Nuclear-Powered Aircraft Carrier
DDG	Guided Missile Destroyer
LCC	Amphibious Command Ship
LCS	Littoral Combat Ship
LHA	Amphibious Assault Ship
LPD	Amphibious Transport Dock
LSD	Dock Landing Ship
MCM	Mine Countermeasure Ship

EXECUTIVE SUMMARY

This business case analysis (BCA) examines the feasibility of installing gooseneck water bottle fixtures onto existing water coolers onboard U.S. Navy ships. Gooseneck fixtures are vertical spout attachments that allow for the refilling of bottles. The goals are to encourage water consumption and to reduce shipboard-generated plastic waste by providing an efficient means for Sailors to fill reusable water bottles. The current water coolers onboard ships do not efficiently support this function, and installing gooseneck fixtures will reduce the reliance on single-use plastic bottles.

Internationally, the International Maritime Organization (IMO) mandates various regulations, including those on plastics. The U.S. Navy adheres to these through domestic laws and internal environmental programs, such as Plastics Removal in a Marine Environment (PRIME) and Waste Reduction Afloat Protects the Sea (WRAPS). Despite extensive efforts, shipboard-generated plastic waste remains a significant challenge, with bottled beverages accounting for 15% of all shipboard-generated plastic waste (Whitman, 2017).

The BCA highlights a critical gap: current water coolers on ships are not optimized for filling personal water bottles, which increases the use of single-use plastic bottles. Addressing this, the proposed installation of gooseneck fixtures across 162 surface ships is analyzed for its potential to reduce plastic waste while enhancing Sailor morale and contributing to the Navy's environmental goals.

Our analysis reviewed several acquisition scenarios with varying Sailor-to-fixture ratio courses of action (COAs), COA 1 (50:1), COA 2 (40:1), and COA 3 (30:1), alongside diversion rates ranging from 10% to 90%. For example, at a 10% diversion level, the program reduces single-use bottle acquisition by 10% and is more cost-effective than the status quo within one year. As diversion levels increase to 90%, the replacement of most single-use bottles leads to significantly more cost savings much faster. Our analysis shows the best option is 40:1 with a 50% diversion rate. We recognize that results may vary, and we present and address other options and potential outcomes.

Assuming a 50% diversion rate from single-use plastic bottles, the analysis projects substantial cost savings in acquisition, labor, disposal, and environmental costs. Using a ratio of 40:1 for the number of Sailors to gooseneck fixtures, the analysis determined the need for 2,738 fixtures across all evaluated ships. The initial investment of approximately $958,000 for acquiring the fixtures, combined with labor costs of approximately $150,000 for installation, is offset through the reduction of the other associated costs. This initiative reaches a break-even point of around two months due to reduced plastic waste disposal costs and savings on water bottle purchases. Additionally, the analysis suggests that the gooseneck fixtures offer enhanced hydration access for Sailors, leading to improved morale and crew satisfaction.

Moreover, we recognize the qualitative benefits that add significant value to the Navy's environmental stewardship efforts. Installing these fixtures can help strategically phase out single-use bottles and enhance the accessibility and use of water coolers, influencing Sailors' purchasing trends and consumption habits over time. Promoting reusable water bottles can help reinforce the Navy's commitment to reducing plastic waste and supporting sustainability. This initiative not only enhances Sailor morale but also strengthens the Navy's reputation for environmental leadership on the global stage.

We recommend that the Navy implement this fixture onboard all surface ships using COA 2 (40:1 Sailors-to-gooseneck fixture) with an expected 50% diversion rate. This fixture is a commercial-off-the-shelf (COTS) solution and therefore easily retrofitted onto current water coolers, making it more compelling for the Navy to adopt. COA 2 saves the Navy around $5.6 million after only one year.

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I. INTRODUCTION

A. MOTIVATION

The *National Security Strategy* (NSS) frequently references the threat of climate change and climate crisis as one of the greatest shared problems the world currently faces (Biden, 2022). The life cycle of plastics contributes to the threat of climate change, which generates "about 4% of global greenhouse gas emissions" (United Nations Framework Convention on Climate Change [UNFCCC], 2024). Plastic waste generation continues to rise due to the 73% increase in single-use water bottle sales globally over the past decade (Ramirez, 2023). As the effects of global warming become undeniable, climate change discussions increase on the world stage, leading to changes in climate policy (United Nations, 2022). This awareness of global warming encourages people to make slight changes, such as increasing their use of reusable water bottles, with an aim to reduce single-use plastic waste (Ingilizian et al., 2021). The United States (U.S.) needs to promote environmental stewardship and the Navy can be the service lead to implement more eco-friendly practices. In this paper, we explore options for a small onboard capital improvement project by installing water bottle-filling fixtures or "gooseneck fixtures" on U.S. Navy surface ships. The installation of this fixture onto currently installed water coolers can help the Navy reduce its shipboard-generated plastic waste. It can be one part of a larger overall effort to become a more environmentally conscious Navy while increasing the quality of life for Sailors onboard ships.

B. SUBJECT OF THE BUSINESS CASE ANALYSIS

This business case analysis (BCA) focuses on the cost of implementing gooseneck fixtures on U.S. Navy ships. Implementing this practical solution offers a variety of advantages to the Navy including reducing its plastics waste stream and the costs associated with disposal, and qualitative advantages, such as increasing Sailor morale, promoting better hydration practices, and positively influencing public perception. There are various models of bottle-filling fountains on the market; our solution utilizes a fixture that is commercial-off-the-shelf (COTS). Naval Sea Systems Command (NAVSEA) procures water coolers, and they are easily retrofitted with the gooseneck fixture. Other procurement options, such as wall-mounted units, are available. Wall-mounted units require changes to a ship's infrastructure, and they do not meet required standards for shipboard use. These alternatives are more expensive and therefore, the gooseneck fixture is the best option. This BCA will also include an analysis of risks and benefits, as well as barriers to the implementation of this shipboard solution.

C. RESEARCH QUESTIONS

The primary research questions are:

1. What are the acquisition costs associated with installing gooseneck fixtures in habitability spaces on Navy ships?
2. What quantitative and qualitative benefits, including environmental improvements and cost savings, can be expected from reducing plastic water bottle usage?
3. Do the anticipated benefits of installing gooseneck fixtures outweigh the costs, thereby justifying their implementation?

D. ORGANIZATION OF THE STUDY

The study is organized into several chapters to systematically address the research questions.

- Chapter I introduces the motivation, background, and objectives of the study.
- Chapter II examines the current status of water fountains on Navy ships and the environmental impact of single-use plastics.
- Chapter III details the BCA for the proposed bottle-filling fixtures, analyzing costs, benefits, and break-even points.
- Chapter IV discusses potential barriers to implementation and strategies to overcome them.

- Chapter V concludes with a summary of findings and recommendations based on the BCA.

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II. BACKGROUND

A. MARPOL REGULATIONS AND THE UNITED STATES

The United Nations established the International Maritime Organization (IMO), a specialized agency, in 1948, whose primary purpose is to regulate international shipping (International Maritime Organization [IMO], n.d.). Even though IMO focuses on maritime safety, the organization has evolved over time to include environmental protection efforts. The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is the most significant event to come from the IMO. The policies addressed pollution generated from ships that ranged from air pollution and sewage to garbage, including specifics on plastic waste (IMO, n.d.).

The U.S. Congress passed the Act to Prevent Pollution from Ships (APPS) to enact the MARPOL 73/78 Protocol (Act to Prevent Pollution from Ships [APPS], 1980). The U.S. ratified the MARPOL Protocol and its annexes in 1987. Annex V bans various forms of garbage disposed at sea, including plastics. To enforce these regulations, the U.S. Congress passed Public Law 100-220, the Maritime Plastic Pollution Research and Control Act (United States-Japan Fishery Agreement Approval Act, 1987). Additionally, the U.S. is engaged at other national and international levels to develop and explore ways to fight plastic pollution.

At the operational level, the U.S. Navy complies with the MARPOL Protocol through U.S. laws and within its own manual, the Environmental Readiness Program Manual OPNAV M-5090.1 (Department of the Navy [DN], 2021). To help with compliance, Naval Supply Systems Command (NAVSUP) created programs like Plastics Removal in the Marine Environment (PRIME) and Waste Reduction Afloat Protects the Sea (WRAPS) to increase solid waste awareness and evaluate new packing solutions onboard ships (Whitman, 2023).

B. PLASTIC WASTE GENERATION ON NAVY SHIPS

Due to operational requirements and space restrictions, shipboard-generated plastic waste creates significant challenges for ship's personnel. NAVSEA (2018) estimates shipboard-generated plastic waste at 0.30 lbs. per person per day or 0.231 cubic feet per person per day. While the galley generates most of the shipboard waste (45.6%), personnel cannot process this plastic food packaging in the same way as plastic waste from the ship's store (Hazardous Material and Pollution Prevention Department, 2017). Alternatives to plastic food packaging will need industry involvement.

Bottled beverages, including water, soda, and sports drinks, account for 15% of shipboard-generated plastic waste, while water bottles account for 1.6% (Whitman, 2017). Plastic bottles are brought onboard through the purchase of beverages via the Navy Exchange Service Command (NEXCOM). NEXCOM manages all items purchased via Navy ships for resale within their ship's stores and vending machines. Most classes of surface ships have ship's stores and vending machines. To reduce the stream of ship-board plastic waste generated by bottled beverages and their logistics footprint, initiatives such as the use of ValidFill RFID refillable cups with Coke Freestyle machines have been proposed (Whitman, 2017). Cruise ships and theme parks have successfully implemented this concept; however, the Navy must conduct a pilot project onboard a ship to address implementation challenges.

C. PLASTIC WASTE PROCESSING ON NAVY SHIPS

To reduce the amount of space unprocessed plastic waste requires, the Navy equips ships with shredders. Shredded plastic waste is placed into Compress Melt Units (CMUs) where a heated drum crushes and melts plastic into twenty by four-inch-thick disks for storage (Diaz, 2019). Plastic disks can weigh between seven and thirteen and a half pounds, based on whether personnel shred the plastic waste prior to melting (Walker, 2013). All disks are sealed into odor-barrier bags "to contain odors that might result from any remaining food contamination" (Kelly et al., 1997). These bags are consolidated in tri-wall containers in preparation for offload.

The Navy is exploring innovative solutions and modern technologies to address the challenges of managing shipboard-generated plastic waste. For example, on Ford-class CVNs the plasma arc waste destruction system (PAWDS) turns all plastic waste into a harmless inorganic ash (Buchanan, 2020). The Department of Defense (DOD) and the

Navy increasingly recognize the need to manage shipboard-generated plastic waste more effectively to protect the environment and enhance operational efficiency.

D. ENVIRONMENTAL AND ECONOMIC IMPACT OF PLASTIC WASTE ON NAVY SHIPS

Plastic waste, particularly from single-use water bottles, poses significant environmental and economic challenges. Discarded bottles often accumulate in landfills or as litter where they can take centuries to decompose (UN, 2021). They also release harmful chemicals into the soil and water systems, disrupting wildlife habitats, and contaminating food chains (UNFCCC, 2024). Cleanup and waste management costs strain municipal budgets, while producing these bottles inefficiently uses non-renewable fossil fuels and contributes to resource depletion. Societal impacts include losing natural beauty in recreational areas, suffering negative health effects from microplastics entering the food supply and the perpetuation of wasteful consumption habits (Mamun et al., 2022). Addressing plastic waste on Navy ships by reducing the reliance on disposable water bottles can mitigate these far-reaching consequences, setting a positive precedent for sustainable resource management.

Economic costs arise from collection and processing, while specialized machinery and waste transfer lead to increased operational costs. Efficiently managing this waste stream is crucial to reduce operational disruptions and expenses. Reducing the use of plastic water bottles on Navy ships can help alleviate these burdens, ensuring optimal space utilization, improved crew efficiency, and minimized machinery costs, enhancing operational effectiveness and sustainability in naval operations.

E. CURRENT STATE OF WATER COOLERS ON NAVY SHIPS

The Navy mandates water coolers aboard ships to maintain crew hydration and health. Coolers are in all berthing spaces, many engineering spaces, and other communal areas. These coolers adhere to Military Specifications (MILSPEC) MIL-C-24166B established by the DOD to ensure sound construction, limit corrosion, and ensure vibration resistance on items installed on ships. Currently installed coolers cannot fill water bottles efficiently. Figure 1 represents the proposed solution to this problem. The gooseneck fixture is compatible with water coolers through an adapter kit. The ship's crew can complete the installation, allowing Sailors to fully fill their own reusable bottles while helping reduce single-use plastic bottles.

Figure 1. Gooseneck Fixture. Adapted from Elkay (n.d.).

Table 1 from NAVSEA lists the maximum personnel per water cooler for living and messing spaces on surface ships by accommodations that are specific to berthing areas.

Table 1. Water Cooler Requirements for Living and Messing Spaces on Surface Ships. Source: Naval Sea Systems Command (2016).

Occupants	Max # accommodations per water cooler in passage serving living area	Max # mess seats per water cooler per messing space
Officers	40	75
CPO/SNCO	40	75
Crew/Troop	100	50

Table 2 lists the water cooler requirements for spaces other than living and messing spaces. The spaces listed do not represent one specific platform but cover all platforms across the Navy and the minimum requirements for crew support.

Table 2. Water Cooler Requirements for Spaces Other than Living and Messing Spaces. Source: Naval Sea Systems Command (2016).

Space	Minimum quantity
Main machinery space	1 each level
Auxiliary machinery space	1 each level
Shop (in passage)	1 per group
Control station	1 each
Ready room	1 each
Medical treatment (in passage)	1 each
Hospital area (outside ward)	1 each
Office area (in passage)	1 per group
Hangar	2 per bay
Dental area (in passage)	1 each
Combat Information Center (CIC)/C4I, Ship Mission Center	1 each
Bridge	1 each
LMRC (in passage)	1 each
Brig facility	1 each
Laundry room	1 each
Physical fitness room	1 each
Damage Control Repair Stations (in passage)	1 each
Unit Patrol Lockers/Stations (in passage)	1 each
Self Service Laundry	1 each

The number of coolers on Navy ships vary depending on other spaces and crew sizes, which average between 85 to 5000+ Sailors aboard MCMs to CVNs (United States Navy, n.d.). While the crew has ample access to water, those with personal water bottles have limited means to easily refill them. The Mess Decks, where the crew eat their meals, have a water dispenser, but most ships prohibit crew members from filling personal water bottles at these machines for sanitation reasons. The space also has a water cooler, but it does not have the fixture to fill a water bottle. Additionally, access is restricted to the mess decks before and after mealtime to allow the Culinary Specialists and Mess Deck Attendants time to prepare and clean up, limiting access to these dispensers and coolers.

III. BUSINESS CASE ANALYSIS

A. SCOPE OF THE PROJECT

In this BCA, we estimate the costs and considerations associated with installing gooseneck fixtures on Navy ships. This project specifically focuses on habitability areas, like berthing's, because this is where water coolers are easily accessed by all crew and can be retrofitted with the gooseneck fixture. We also review qualitative benefits, such as public perception of the Navy and quality of life for Sailors. Our analysis determines the main benefit of the gooseneck fixture is cost savings, which comes from a reduction in single-use plastics, and costs associated with environmental, disposal, and operations.

B. METHODOLOGY

In this analysis, we evaluate the feasibility of installing gooseneck fixtures on water coolers across the surface fleet at various ratios. The Navy currently consists of 238 ships in commission per the Naval Vessel Register (Naval Sea Systems Command Shipbuilding Support Office [NAVSHIPSO], 2024). Our analysis addresses 162 surface ships, to include all Nimitz and Ford-class Nuclear-Powered Aircraft Carriers (CVN), America-class Amphibious Assault Ships (LHA), Wasp-class Amphibious Assault Ships (LHD), San Antonio-class Amphibious Transport Docks (LPD), Whidbey Island-class Dock Landing Ships (LSD), Ticonderoga-class Cruisers (CG), Arleigh Burke and Zumwalt-class Destroyers (DDG), Freedom and Independence-class Littoral Combat Ships (LCS), and Avenger-class Mine Countermeasure Ships (MCM). Crew size utilized is based on normal crew complement excluding possible embarked crew. We conduct a detailed cost-benefit analysis for each ship class over a 35-year operational lifespan. Specific areas analyzed include the cost of investment, replacement, labor/operations, material disposal, and environmental costs. We calculate totals and multiply them by a discount rate of 2.5% to compute the present value, in accordance with the annual Office of Management and Budget (OMB) Circular No. A-94 discount rates (OMB, 2023). Net present values for the status quo and gooseneck fixture installations are computed by summing the present values over 35 years. The option with the lowest net present value represents the most cost-effective choice. Furthermore, our study looks at various courses of action (COAs) based on various ratios of goosenecks fixtures at a 50% diversion. We will also show qualitative benefits associated with the installation.

Appendix A details our analysis of various ratios of acquisition and total water cooler fixture upgrades by individual ship classes and the analysis of all ships in this study. Appendix B shows the plastic generation rates per ship class and associated disposal costs. Appendix C shows the cost comparison and break-even point summary for the entire surface fleet based on data from Appendix D. Appendix D shows the cost comparison and break-even analysis for each individual ship class by single ship and total class over its operational lifespan.

C. COST CALCULATIONS

When calculating costs, we start by assessing the number of water coolers currently installed on Navy ships, which determines the gooseneck fixtures to be procured. The habitability manual provides a maximum 100:1 ratio of Sailors to water coolers (NAVSEA, 2016). However, based on first-hand experience as Supply Officers, we know that the ratio of Sailors to water coolers in habitability spaces is closer to 40:1. Table 3 shows our calculations of alternate ratios of 50:1 and 30:1, to account for variations in berthing and procurement options. Furthermore, we understand that some berthing's have more water coolers than others, highlighting the variation in water cooler distribution across ship classes.

Our calculations consider two scenarios: maintaining the status quo or implementing gooseneck fixtures. Since it is unrealistic to assume that ships will eliminate the use of single-use plastic water bottles, we assume a 50% diversion. This means that by adopting the gooseneck fixture solution, a ship may reduce its water bottle usage by 50%.

Table 3. Sailor-to-Fixture Ratio COA Analysis

	Status Quo	Gooseneck Option COA 1 (50:1)	COA 2 (40:1)	COA 3 (30:1)
Plastic Bottle Purchase	$ 11,706,019	$ 5,853,009	$ 5,853,009	$ 5,853,009
Investment	$ -	$ 886,250	$ 1,107,813	$ 1,661,719
Replacement	$ -	$ 35,024	$ 43,780	$ 65,669
Labor & Operations	$ 1,860,693	$ 930,347	$ 930,347	$ 930,347
Material Disposal	$ 6,234	$ 3,117	$ 3,117	$ 3,117
Environmental	$ 10,331	$ 5,165	$ 5,165	$ 5,165
Total	$ 13,583,277	$ 7,712,912	$ 7,943,231	$ 8,519,027
Savings	$ -	$ 5,870,364	$ 5,640,046	$ 5,064,250

Our cost calculations detailed in Appendix C (fleet data) and Appendix D (individual ship class data) are based on the 40:1 Sailor-to-fixture ratio. In Table 3, we calculate the total costs at a 50% diversion to illustrate potential savings and expenses with varying levels of gooseneck fixture upgrades. With our recommended 40:1 Sailor-to-fixture ratio at a 50% diversion, the Navy will break even approximately two months after installation, as shown in Appendix C. Regardless of the selected COA, our analysis indicates that installing the gooseneck fixtures will save the Navy money within the first year.

1. Cost of Investment

a. Status Quo

All costs in this analysis are normalized to FY24 values. To evaluate the financial implications of maintaining current practices, we need to consider the initial investment costs associated with the continuous use of single-use water bottles. Sailors typically purchase these bottles from the ship's store and vending machines, which replenishes the revolving ship's store fund. The average retail price for a 16.9-ounce water bottle is set at $1.25, based on a gross profit margin of 20% in Retail Stores and 55% in vending machines, as stipulated by NEXCOM (Navy Exchange Service Command [NEXCOM], 2014). These profits help cover operation and transport expenses, with any excess funds supporting the ship's Morale, Welfare, and Recreation (MWR) fund. Despite this system's benefits in funding shipboard amenities, we recognize that the continued reliance on single-use plastic bottles incurs substantial costs and logistical challenges for the Navy.

On an average CVN, about 35,625 water bottles are sold each month, which translates to approximately 85.5 bottles per person per year (Whitman, 2017). When we project this across the 162 ships included in this study, the total expenditure by sailors on single-use water bottles reaches $11,706,019 per year. This considerable amount highlights the financial burden of the status quo, emphasizing the potential for significant cost savings through the implementation of gooseneck fixtures.

b. Gooseneck

Our initial investment for acquiring and installing gooseneck fixtures includes labor and materials. Each gooseneck fixture kit, comprising models Elkay 98498C and Halsey Taylor 96852CA, costs $350 (Elkay, n.d.; Halsey Taylor, n.d.a). The kit includes the metal gooseneck fixture, tubing, fittings, and other necessary hardware. Based on a 40:1 Sailor-to-fixture ratio, we need 2,738 gooseneck fixtures for the 162 ships in our study, totaling an initial investment of $958,300 for the kits.

We will install these gooseneck fixtures using the ship's crew, leveraging their skills and available tools to ensure cost efficiency and avoid the higher costs of employing civilian labor. We determine the labor involves 30 minutes for sailors to review the installation manual and gather the required tools, followed by 60 minutes for the actual installation of each fixture. Our labor estimates focus strictly on the physical installation, excluding administrative tasks such as tag-out procedures. We assume all water coolers in habitability areas can be retrofitted. The DOD composite standard average rate for paygrades E-1 to E-5, as shown in Table 4, is rounded to $37.00 per hour (McAndrew, 2023). The labor cost to install 2,738 gooseneck fixtures is $149,513. The total cost for the initial acquisition and installation is $1,107,813.

Table 4. Military Composite Pay Rate. Adapted from OMB (2023)

Paygrade	DOD Composite Standard	
E-5	$	107,381.00
E-4	$	86,100.00
E-3	$	70,691.00
E-2	$	64,004.00
E-1	$	56,590.00
AVG	$	76,953.20
AVG HR Rate	$	37.00

2. Cost of Replacement

a. Status quo

We determine there is no cost of replacement associated with the status quo option.

b. Gooseneck

We estimate the gooseneck fixture failure rate at 5% per year. This rate is based on our assumption that the gooseneck fixture's protruding design above the water cooler makes it more susceptible to damage. For this replacement, the Halsey Taylor Glass Filler 8561 is available for $265 per unit (Halsey Taylor, n.d.b).

The labor costs associated with these replacements are consistent with the rates applied during the initial installation. For instance, on a CVN, we might replace approximately six gooseneck fixtures annually, whereas on an MCM, a replacement may be required once every ten years. This infrequency underscores the overall durability and cost-effectiveness of the gooseneck fixture installation over the long term. The total annual cost for replacing these fixtures across the fleet is $43,780.

3. Cost of Labor and Operations

a. Status Quo

To accurately assess the labor and operation costs associated with processing shipboard-generated plastic waste, we need to differentiate between conditions when a ship is in port and when it is underway. These two scenarios necessitate separate cost analyses due to the different methods used in waste processing. When underway, Sailors' compact plastic waste using shredders and CMUs, leading to higher costs per pound compared to in port processing, where trash remains uncompacted.

The processing costs for plastic while underway includes the life-cycle cost of processing, corrective maintenance on plastic equipment, associated materials, disk disposal, and odor barrier bags, originally calculated at $2.99 per pound (Walker, 2013). To tailor these calculations to the specific ship classes involved in our study, we revised the calculations based on the fleet's total annual cost of $12,722,126 and the total plastic waste generation of 3,819,360 pounds per year. This refinement results in a cost of $3.30 per pound. We apply this figure to the number of days each ship spends underway and the volume of shipboard-generated plastic waste from water bottles to determine the annual underway processing cost of $231,102. For in port processing, we calculate costs by estimating the yearly man-hour labor costs for approximately 1% of the crew, who spend about 10 minutes each day bringing garbage bags to dumpsters at the end of the pier. This activity translates to a labor cost of $6.17 per Sailor based on the composite rate from Table 4, resulting in an in port processing cost of $1,629,591. The total labor and operations costs are $1,860,693 as shown in Appendix C.

b. Gooseneck

Labor and operations costs associated with the gooseneck fixtures are minimal. Once we install them onto existing water coolers, the gooseneck fixtures are not expected to significantly increase water or energy consumption. This efficiency is a key advantage of retrofitting the water coolers.

Given that we are aiming for a 50% diversion, half of the labor and operations costs associated with the status quo will still apply to the gooseneck fixtures. This results in the total annual cost of $930,347 per year for all 162 ships included in our study, as shown in Appendix C.

4. Cost of Material Disposal

a. Status Quo

To accurately assess the disposal costs associated with shipboard-generated plastic waste, we began by calculating the amount of plastic waste a single Sailor typically generates in one day. We based this calculation on the monthly solid waste data from water bottles sold in the ship's store on a CVN, which amounts to 786 lbs. (Whitman, 2017). Converting this figure to a daily rate gives us approximately 25.68 lbs. per day, which, when divided by the average crew size of a CVN, results in about 0.00517 lbs. of water bottle plastic per sailor per day.

For disposing of this waste, we applied the flat rate of $0.03 per pound to all plastic waste generated underway and in port. This cost is calculated using the average cost of landfilling one ton of solid waste in the U.S. as of 2022 (Paben, 2023). The total annual disposal cost is $6,234. It is important to note that this calculation does not include disposal costs outside the continental United States (OCONUS), due to variable exchange rates and the differing regulations in foreign countries. Moreover, the irregularity of port visits adds further complexity to estimating these costs.

Additionally, while we acknowledge there are costs associated with the retrograde transportation of plastic waste generated underway—including potential fuel costs for helicopters moving tri-wall containers and fees from Combat Logistics Force (CLF) ships—we do not include these figures due to insufficient data on operational frequencies and the specific expenses related to waste transport and disposal in foreign ports. We assume, however, that these logistics would increase the overall disposal costs for the Navy.

b. Gooseneck

By implementing our gooseneck fixture option, we project that disposal costs will be significantly reduced. By achieving a 50% diversion from the current disposal rates for shipboard-generated single-use plastic bottles, our installation of these fixtures decreases the volume of plastic waste. Additionally, we estimate that 5% of the gooseneck fixtures will break annually and will need to be disposed of. The disposal of these broken fixtures will adhere to the disposal rate of $0.03 per pound. These two costs add up to a total annual disposal cost of $3,121.

5. Environmental Costs

a. Status Quo

Environmental costs associated with using single-use water bottles within naval operations represent an opportunity cost. The $0.05 per bottle we use in this analysis represents an average benefit under the "bottle bill" legislation, which provides financial incentives for recycling (Whittaker, 2021). States who implement a bottle bill offer a deposit that consumers pay when purchasing bottled beverages and get a refund upon returning the empty bottles (Whittaker, 2021). Deposit values vary between states. For our calculations, we use $0.05. This system encourages recycling and reduces litter by assigning a monetary value to the environmental cost of each unrecycled bottle, thus promoting resource conservation and environmental responsibility by attaching a direct cost to the failure to recycle.

To calculate the total environmental cost, we multiply the plastic waste generated per sailor per day by the number of sailors and apply the recycling benefit of $0.05 per bottle. For all 162 ships in the fleet, the annual environmental cost is $10,331.

b. Gooseneck

By implementing gooseneck fixtures, we estimate a potential 50% diversion from the current use of single-use water bottles. This anticipated shift could significantly reduce the Navy's environmental costs associated with plastic waste management. Enabling Sailors to refill reusable bottles is projected to cut the Navy's annual environmental costs by half, bringing them down to $5,165 across the fleet.

D. RISK/BENEFIT ANALYSIS

1. Risks

As we consider the implementation of gooseneck fixtures aboard Navy ships, we first address the potential risks associated with this initiative. While the fixtures are compatible with existing water coolers, challenges may arise, especially with older models or units that might not align perfectly with the new hardware. Such discrepancies could lead to leaks or complications during the retrofit, requiring Sailors to make unforeseen adjustments or add additional components.

Dependence on a few suppliers for the fixtures and components introduces another risk, particularly supply chain issues. Delays or disruptions in supply could impede the timely maintenance and broader rollout of the fixtures across the fleet.

Addressing these risks is crucial for the Navy's successful adoption of gooseneck fixtures. This includes implementing regular performance reviews and updating installation and maintenance procedures based on operational feedback. Proactive risk management will ensure that the installation of gooseneck fixtures aligns with the Navy's operational needs.

2. Qualitative Benefits

Our analysis determines many qualitative benefits. A primary benefit for the Navy is the improvement in crew morale and well-being. By providing Sailors with easy access to refill their personal reusable water bottles, we not only enhance daily convenience but also boost overall satisfaction in working conditions.

This installation acts as a "nudge," encouraging Sailors to make more environmentally conscious decisions, not only onboard but in other areas of their lives (Byerly et al., 2018). By facilitating the use of reusable bottles and reducing reliance on single-use plastics, the fixtures subtly promote sustainable habits among crew members. This "nudge" can lead to broader environmental awareness by Sailors, reinforcing the Navy's commitment to sustainability.

Furthermore, these fixtures enhance the Navy's public and international perception. They send a powerful message globally about the Navy's active commitment to reducing its environmental footprint and adopting sustainable practices. This initiative not only highlights the Navy's dedication but also sets a precedent for other nations and maritime organizations, potentially influencing their environmental outlook.

Additionally, the Navy's proactive approach to sustainability can positively impact its diplomatic relations. By demonstrating leadership in environmental stewardship, the Navy helps bridge gaps with other governments, military organizations, and environmental groups, facilitating effective collaborations and policy initiatives. This strategic positioning strengthens the Navy's global reputation, aligning with the President's NSS and enhancing the U.S.'s soft power to "galvanize the world and incentivize further action" on the international stage (Biden, 2022, p. 27). Through these efforts, the Navy not only contributes to global environmental efforts but also gains potential savings and strategic advantages from its reduced ecological footprint.

E. SENSITIVITY ANALYSIS

1. Number of Gooseneck Fixtures

The total number of fixtures used in this BCA was 2738, based on a 40:1 Sailor-to-fixture ratio. We also calculate other COAs at ratios of 30:1 and 50:1. While COA 1 (50:1) is the maximum per accommodation for water coolers in berthing's, we chose COA 2 (40:1) due to our first-hand knowledge of habitability spaces, which is more in line with what we encounter on DDG's. Regardless of the COA, we found that the associated costs are low for a project encompassing almost all of the surface fleet and break-even in a couple of months.

Appendix C (fleet data) and Appendix D (individual ship class data) show our gooseneck upgrade data at a 50% diversion. This means that 50% of the status quo costs still exist in our solution for COA 2. Table 5 shows our spectrum of cost savings at different diversions.

Table 5. Diversion Analysis and Cost Savings Calculations

	Status Quo	Gooseneck Option Water Bottle Diversion				
		90%	70%	50%	30%	10%
Plastic Bottle Purchase	$ 11,706,019	$ 1,170,602	$ 3,511,806	$ 5,853,009	$ 8,194,213	$ 10,535,417
Investment	$ -	$ 1,107,813	$ 1,107,813	$ 1,107,813	$ 1,107,813	$ 1,107,813
Replacement	$ -	$ 43,780	$ 43,780	$ 43,780	$ 43,780	$ 43,780
Labor & Operations	$ 1,860,693	$ 186,069	$ 558,208	$ 930,347	$ 1,302,485	$ 1,674,624
Material Disposal	$ 6,234	$ 623	$ 1,870	$ 3,117	$ 4,364	$ 5,610
Environmental	$ 10,331	$ 1,033	$ 3,099	$ 5,165	$ 7,232	$ 9,298
1 Year Total	$ 13,583,277	$ 2,509,920	$ 5,226,575	$ 7,943,231	$ 10,659,886	$ 13,376,541
Savings	$ -	$ 11,073,357	$ 8,356,701	$ 5,640,046	$ 2,923,391	$ 206,735

2. Comparison of Bottle Filling Stations

We considered other options to fill water bottles, including wall-mounted units. We found that a wall-mounted alternative would be the most practical, but they are more expensive and would require additional alterations on the ship. On the open market, this type of cooler, which combines a traditional drinking fountain and a bottle refill station, costs approximately $1,800. For this alternative, the initial cost of procurement for the Navy is $4,928,400 to replace 2738 currently installed water coolers. This excludes other costs such as labor and a ship alteration (SHIPALT) due to the requirement to change the functional design of the ship to accommodate wall-mounting. Another consideration is that wall-mounted units have not been shipboard tested or authorized, meaning they do not meet the current MILSPEC, which could lead to higher initial costs for the Navy after testing is complete.

In contrast, we found that the gooseneck fixture can be installed with minimal intrusion, making it a more cost-effective and practical choice for Navy ships where space and budget constraints are significant considerations. While the wall-mounted alternative may offer certain design advantages, its higher cost and technical complexities make the gooseneck fixture a more favorable option for the Navy to retrofit.

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IV. BARRIERS TO IMPLEMENTATION

A. CHALLENGES IN RETROFITTING EXISTING WATER COOLERS

Retrofitting the gooseneck fixture onto previously installed water coolers poses several challenges, including time, labor, and fiscal challenges. The first significant challenge is time. Before retrofitting begins, personnel need to tag out the equipment because the fountains have power and water running to them. Tagging out electrical systems is a safety precaution that involves multiple personnel documenting the work, hanging the danger tags, and verifying the equipment is de-energized and safe to work on. While tag outs are not an overly complicated procedure, they can be time intensive and require advance planning before any work can begin. Additionally, because each fountain has a waterline running to it, personnel also need to tag out this line and close the appropriate valves to support the installation, which could impact water to other parts of the ship while work is completed.

Labor poses another challenge due to manning issues across the Navy. Most ships have the qualified personnel to install this fixture but not enough of them to complete the work with other competing priorities. This could lead to delays in the retrofit of the water coolers with the gooseneck fixtures.

The implementation of this fixture introduces a fiscal challenge, primarily stemming from the upfront costs of purchase and installation in conjunction with budget constraints. Within fiscal year 2024, policy makers have passed two continuing resolutions (CRs) to keep the government operating, with an average of four CRs since 1977 (Saturno, 2023). This instability in budget means that funding for ships is tightly controlled among the numerous operational needs a ship has. The decision to implement this fixture must be balanced against other critical funding requirements, such as maintenance or systems upgrades. This balancing act highlights the complexity between introducing a novel upgrade to aid in reducing plastics and managing the fiscal responsibilities inherent within the Navy.

B. NEXCOM RESERVATIONS

As the prime source for all ship's store goods, NEXCOM might have reservations on decreasing water bottle sales in the fleet. However, this would be a negligible change due to vendors adapting to purchasing trends. The Navy's cost savings do not translate to NEXCOM's bottom line, but we see the very visible qualitative benefits and probable increase in emblematic sales as good reasons for NEXCOM to find this solution palatable. Any negligible impact to MWR contributions from ship's store profits could be offset by increased emblematic sales and vendor's adapting to consumer trends by selling water in something other than plastic bottles.

V. CONCLUSIONS AND RECOMMENDATIONS

We strongly recommend the implementation of COA 2. With a 40:1 Sailor-to-fixture ratio and a goal of 50% diversion, ships will realize cost savings within the first year. The availability of gooseneck fixtures as COTS solutions that can be easily retrofitted onto existing water coolers further underscores the practicality of adopting this measure.

We recommend Type Commanders (TYCOM) distribute funds to facilitate procurement of fixtures. This enables ships to customize installation timelines based on operational tempo. Ship crews would perform the straightforward retrofit, minimizing downtime and disruption, making this a feasible project across the fleet within days.

In addition to the direct cost savings and reduction in plastic waste, the qualitative benefits of installing gooseneck fixtures are substantial. These benefits extend beyond environmental impact, enhancing the Navy's public image as a leader in environmental stewardship. This shift not only bolsters international perceptions of the Navy but also supports more sustainable practices. Moreover, the improvement in Sailor morale and health, driven by their direct involvement in sustainable practices, enhances overall job satisfaction.

By positioning the Navy as a proactive force in addressing the challenges of plastic pollution and climate change, the gooseneck fixtures align with broader strategic objectives outlined in the NSS. The initiative supports the Navy's commitment to operational efficiency and environmental responsibility, displaying an adaptable and forward-thinking approach that can serve as a model for other military organizations.

As part of ongoing efforts to optimize and enhance the efficacy of the gooseneck fixture installations, several areas for future research and development have been identified:

1. 3D Printing of Fixtures: Investigating the feasibility of using 3D printing technology to produce customized gooseneck fixtures on-demand could significantly reduce logistics and storage costs while allowing for rapid onsite adjustments or repairs.

2. Enhanced Water Fountain Models: Exploring the development and acquisition of new water fountain models that integrate gooseneck fixtures as a standard feature could streamline new ship constructions and major retrofits, ensuring uniformity and reducing the need for subsequent modifications.

3. Wall-mounted Fountain Options: Assessing the long-term benefits and feasibility of wall-mounted units that meet MILSPEC standards could provide alternatives that offer additional benefits, such as improved accessibility and aesthetic integration.

Overall, the implementation of gooseneck fixtures is not just a cost-effective modification but a strategic enhancement that contributes significantly to the Navy's operational capabilities and environmental goals. This initiative represents a crucial step in modernizing the Navy's infrastructure to better align with contemporary environmental and operational challenges.

APPENDIX A. SHIPBOARD WATER COOLER COUNT CALCULATIONS

This appendix provides an overview of the count calculations used for this BCA. The number of Sailors-to-water coolers is based on a range of ratios from the team's collective experience serving onboard Navy ships.

Sailor to Water Cooler Ratio Analysis

Ship Class	Current Inventory	Percent of Study	Crew Size	Per Ship 30:1	Per Ship 40:1	Per Ship 50:1	Per Ship Class 30:1	Cost	40:1	Cost	50:1	Cost
CVN	11	6.88%	5000	167	125	100	1833	$641,667	1375	$481,250	1100	$385,000
LHD	7	4.38%	1500	50	38	30	350	$122,500	263	$91,875	210	$73,500
LHA	2	1.25%	1204	40	30	24	80	$28,093	60	$21,070	48	$16,856
LCC	2	1.25%	564	19	14	11	38	$13,160	28	$9,870	23	$7,896
LPD	12	7.50%	420	14	11	8	168	$58,800	126	$44,100	101	$35,280
LSD	10	6.25%	397	13	10	8	132	$46,317	99	$34,738	79	$27,790
CG	13	8.13%	359	12	9	7	156	$54,448	117	$40,836	93	$32,669
DDG	74	46.25%	330	11	8	7	814	$284,900	611	$213,675	488	$170,940
LCS	23	14.38%	75	3	2	2	58	$20,125	43	$15,094	35	$12,075
MCM	8	5.00%	84	3	2	2	22	$7,840	17	$5,880	13	$4,704
Total	162						3651	$1,277,850	2738	$958,388	2191	$766,710

APPENDIX B. ANALYSIS OF FLEET PLASTIC WASTE GENERATION AND PROCESSING COSTS

This table shows the overview of plastic waste generated by each class of ship and by person. It breaks down processing costs while in port as well as days underway per ship which this BCA focuses on.

Analysis of Fleet Plastic Waste Generation Costs

Ship Class	Current Ship Inventory	Crew Size	Underday days per year	Daily: Water Bottle Plastic (lb/ship)	Daily: Underway Labor & Operations	Daily: In-port Labor & Operations	Daily: Material Disposal	Daily: **Total per Ship Class**	Yearly: Water Bottle Plastic (lbs/ship)	Yearly: Labor & Operations	Yearly: Material Disposal	Yearly: Total	Yearly: **Total per Ship Class**
CVN	11	5000	128	25.84	$29.90	$200.19	$0.78	$2,539.60	9,432	$83,984	$284.56	$84,268	$926,952
LHD	7	1500	128	7.75	$8.97	$60.06	$0.23	$484.83	2,830	$25,195	$85.37	$25,281	$176,964
LHA	2	1204	112	6.22	$6.30	$51.46	$0.19	$115.90	2,271	$21,083	$68.52	$21,151	$42,302
LCC	2	564	88	2.91	$2.32	$26.39	$0.09	$57.60	1,064	$10,480	$32.10	$10,512	$21,024
LPD	12	420	111	2.17	$2.18	$18.02	$0.07	$243.19	792	$7,373	$23.90	$7,397	$88,764
LSD	10	397	121	2.05	$2.24	$16.36	$0.06	$186.71	749	$6,792	$22.59	$6,815	$68,149
CG	13	359	120	1.86	$2.01	$14.86	$0.06	$220.06	677	$6,158	$20.43	$6,179	$80,322
DDG	74	330	123	1.71	$1.90	$13.49	$0.05	$1,142.50	623	$5,617	$18.78	$5,635	$417,013
LCS	23	75	89	0.39	$0.31	$3.50	$0.01	$87.87	141	$1,390	$4.27	$1,394	$32,073
MCM	8	84	60	0.43	$0.24	$4.33	$0.01	$36.61	158	$1,666	$4.78	$1,670	$13,364
Total	162												**$1,866,927**

Plastic Waste Generation (lb/person/day)	0.005168
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03

APPENDIX C. COST COMPARISON AND BREAK-EVEN POINT FOR ENTIRE FLEET

The graphs and charts show a detailed analysis of the break-even point for the fleet and the costs and savings associated with the gooseneck fixture.

Ship Class:	Operational Surface Fleet
Number in Service:	162
Personnel:	109,530
Plastic Waste Generation (lb/person/day)	0.005168
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	2.02

Cost Comparison For Entire Fleet	
Lifecycle Cost of Status Quo:	$338,393,427
Lifecycle Cost with upgrade:	$171,266,605
Lifecycle Savings with Upgrade:	$167,126,822

Bottles purchased / yr	9,364,815
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for Entire Fleet:

Status Quo

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0
1	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.025	$13,251,977
2	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.050	$12,936,454
3	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.075	$12,635,606
4	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.100	$12,348,433
5	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.125	$12,074,024
...	...	...	...	...	...	...	...	...
10	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.250	$10,866,621
...	...	...	...	...	...	...	...	...
15	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.375	$9,878,747
...	...	...	...	...	...	...	...	...
20	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.500	$9,055,518
...	...	...	...	...	...	...	...	...
25	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.625	$8,358,939
...	...	...	...	...	...	...	...	...
30	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.750	$7,761,872
...	...	...	...	...	...	...	...	...
35	$11,706,019	$0	$1,860,693	$6,234	$10,331	$13,583,277	1.875	$7,244,414
Total:	$409,710,656	$0	$65,124,265	$218,178	$361,580	$475,414,679		
							NPV	$338,393,427

Gooseneck Fixture

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$1,107,813	$0	$0	$0	$0	$1,107,813	1.000	$1,107,813
1	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.025	$6,663,665
2	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.050	$6,505,006
3	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.075	$6,353,727
4	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.100	$6,209,324
5	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.125	$6,071,339
...	...	...	...	...	...	...	...	...
10	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.250	$5,464,205
...	...	...	...	...	...	...	...	...
15	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.375	$4,967,459
...	...	...	...	...	...	...	...	...
20	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.500	$4,553,504
...	...	...	...	...	...	...	...	...
25	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.625	$4,203,235
...	...	...	...	...	...	...	...	...
30	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.750	$3,903,004
...	...	...	...	...	...	...	...	...
35	$5,853,009	$43,780	$930,347	$3,121	$5,165	$6,830,257	1.875	$3,642,804
Total:	$205,963,141	$1,532,287	$32,562,132	$109,233	$180,790	$240,166,793		
							NPV	$171,266,605

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

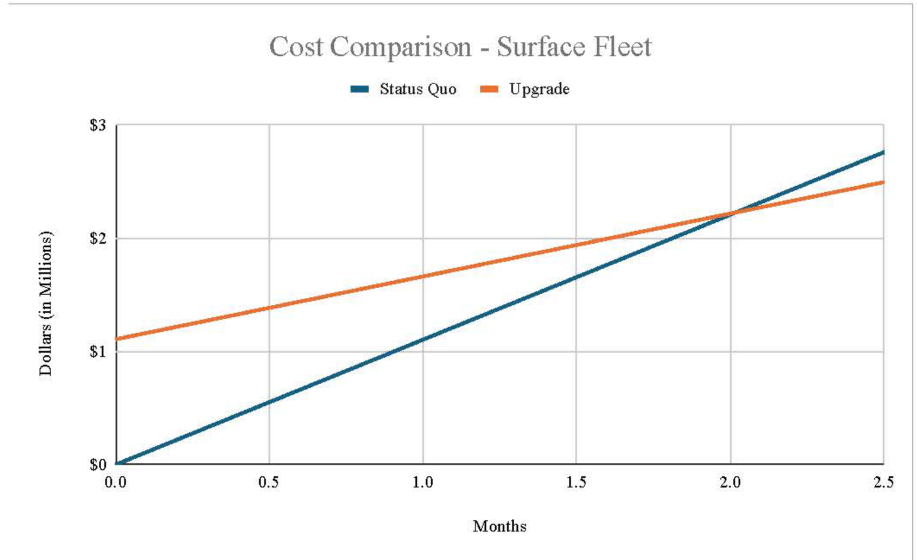
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$1,107,813	$1,107,813
1	$13,251,977	$7,771,478	-$5,480,500
2	$26,188,431	$14,276,484	-$11,911,947
3	$38,824,037	$20,630,211	-$18,193,826
4	$51,172,470	$26,839,535	-$24,332,935
5	$63,246,494	$32,910,874	-$30,335,620
6	$75,058,039	$38,850,228	-$36,207,811
7	$86,618,274	$44,663,212	-$41,955,062
8	$97,937,671	$50,355,093	-$47,582,579
9	$109,026,060	$55,930,812	-$53,095,248
10	$119,892,681	$61,395,018	-$58,497,664
11	$130,546,232	$66,752,082	-$63,794,150
12	$140,994,906	$72,006,125	-$68,988,781
13	$151,246,435	$77,161,036	-$74,085,400
14	$161,308,122	$82,220,485	-$79,087,637
15	$171,186,868	$87,187,944	-$83,998,924
16	$180,889,209	$92,066,699	-$88,822,510
17	$190,421,333	$96,859,862	-$93,561,471
18	$199,789,110	$101,570,383	-$98,218,726
19	$208,998,111	$106,201,066	-$102,797,045
20	$218,053,628	$110,754,570	-$107,299,058
21	$226,960,695	$115,233,427	-$111,727,268
22	$235,724,099	$119,640,044	-$116,084,055
23	$244,348,402	$123,976,715	-$120,371,687
24	$252,837,950	$128,245,625	-$124,592,324
25	$261,196,889	$132,448,860	-$128,748,029
26	$269,429,178	$136,588,410	-$132,840,768
27	$277,538,597	$140,666,175	-$136,872,422
28	$285,528,759	$144,683,973	-$140,844,786
29	$293,403,123	$148,643,542	-$144,759,581
30	$301,164,995	$152,546,546	-$148,618,449
31	$308,817,545	$156,394,578	-$152,422,968
32	$316,363,810	$160,189,165	-$156,174,645
33	$323,806,701	$163,931,771	-$159,874,930
34	$331,149,013	$167,623,801	-$163,525,211
35	$338,393,427	$171,266,605	-$167,126,822



Breakeven Point
2.02 months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$205,963,141	$1,532,287	$32,562,132	$109,233	$180,790
Status Quo	$409,710,656	$0	$65,124,265	$218,178	$361,580

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	various	$350	$265	various	$37

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APPENDIX D. COST COMPARISON AND BREAK-EVEN BY SHIP CLASS

The graphs and charts show a detailed analysis of the break-even point for each ship class and the costs and savings associated with the gooseneck fixture.

Ship Class:	CG
Number in Service:	13
Crew Size:	359
Plastic Waste Generation (lb/person/day)	0.005166
Number of Fixtures per ship (1:40):	9
Number of Underway Days per Year:	120
Annual Fixture Replacement Per Ship:	0.5
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	2.03

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$14,437,975
Lifecycle Cost with Upgrade:	$7,307,660
Lifecycle Savings with Upgrade:	$7,130,315

Bottles purchased / yr	30,695
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for One Vessel:

Status Quo

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0
1	$38,368	$0	$6,158	$20	$34	$44,581	1.025	$43,493
2	$38,368	$0	$6,158	$20	$34	$44,581	1.050	$42,458
3	$38,368	$0	$6,158	$20	$34	$44,581	1.075	$41,470
4	$38,368	$0	$6,158	$20	$34	$44,581	1.100	$40,528
5	$38,368	$0	$6,158	$20	$34	$44,581	1.125	$39,627
...	...	...	...	...	...	...	...	...
10	$38,368	$0	$6,158	$20	$34	$44,581	1.250	$35,664
...	...	...	...	...	...	...	...	...
15	$38,368	$0	$6,158	$20	$34	$44,581	1.375	$32,422
...	...	...	...	...	...	...	...	...
20	$38,368	$0	$6,158	$20	$34	$44,581	1.500	$29,720
...	...	...	...	...	...	...	...	...
25	$38,368	$0	$6,158	$20	$34	$44,581	1.625	$27,434
...	...	...	...	...	...	...	...	...
30	$38,368	$0	$6,158	$20	$34	$44,581	1.750	$25,475
...	...	...	...	...	...	...	...	...
35	$38,368	$0	$6,158	$20	$34	$44,581	1.875	$23,776
Total:	$1,342,884	$0	$215,535	$715	$1,185	$1,560,320		
							NPV	$1,110,613

Gooseneck Fixture

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$3,649	$0	$0	$0	$0	$3,649	1.000	$3,649
1	$19,184	$144	$3,079	$10	$17	$22,418	1.025	$21,871
2	$19,184	$144	$3,079	$10	$17	$22,418	1.050	$21,350
3	$19,184	$144	$3,079	$10	$17	$22,418	1.075	$20,854
4	$19,184	$144	$3,079	$10	$17	$22,418	1.100	$20,380
5	$19,184	$144	$3,079	$10	$17	$22,418	1.125	$19,927
...	...	...	...	...	...	...	...	...
10	$19,184	$144	$3,079	$10	$17	$22,418	1.250	$17,934
...	...	...	...	...	...	...	...	...
15	$19,184	$144	$3,079	$10	$17	$22,418	1.375	$16,304
...	...	...	...	...	...	...	...	...
20	$19,184	$144	$3,079	$10	$17	$22,418	1.500	$14,945
...	...	...	...	...	...	...	...	...
25	$19,184	$144	$3,079	$10	$17	$22,418	1.625	$13,795
...	...	...	...	...	...	...	...	...
30	$19,184	$144	$3,079	$10	$17	$22,418	1.750	$12,810
...	...	...	...	...	...	...	...	...
35	$19,184	$144	$3,079	$10	$17	$22,418	1.875	$11,956
Total:	$675,092	$5,048	$107,768	$358	$593	$788,265		
							NPV	$562,128

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

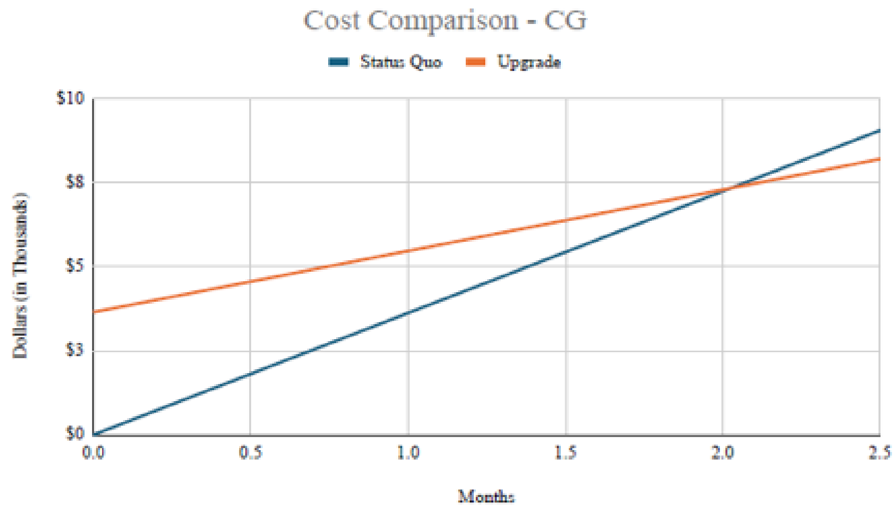
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$3,649	$3,649
1	$43,493	$25,520	-$17,973
2	$85,951	$46,870	-$39,081
3	$127,421	$67,724	-$59,697
4	$167,949	$88,104	-$79,845
5	$207,576	$108,030	-$99,546
6	$246,342	$127,524	-$118,818
7	$284,283	$146,603	-$137,680
8	$321,433	$165,284	-$156,149
9	$357,826	$183,584	-$174,241
10	$393,490	$201,518	-$191,972
11	$428,455	$219,101	-$209,355
12	$462,748	$236,345	-$226,403
13	$496,394	$253,264	-$243,130
14	$529,416	$269,869	-$259,547
15	$561,838	$286,173	-$275,665
16	$593,682	$302,186	-$291,496
17	$624,966	$317,917	-$307,049
18	$655,712	$333,378	-$322,334
19	$685,936	$348,576	-$337,360
20	$715,656	$363,521	-$352,135
21	$744,889	$378,221	-$366,668
22	$773,651	$392,684	-$380,967
23	$801,956	$406,918	-$395,038
24	$829,819	$420,929	-$408,890
25	$857,253	$434,724	-$422,529
26	$884,272	$448,310	-$435,961
27	$910,887	$461,694	-$449,193
28	$937,111	$474,881	-$462,230
29	$962,954	$487,877	-$475,078
30	$988,429	$500,687	-$487,742
31	$1,013,545	$513,316	-$500,229
32	$1,038,312	$525,770	-$512,541
33	$1,062,740	$538,054	-$524,686
34	$1,086,837	$550,172	-$536,666
35	$1,110,613	$562,128	-$548,486



Breakeven Point
2.03 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$675,092	$5,048	$107,768	$358	$593
Status Quo	$1,342,884	$0	$215,535	$715	$1,185

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	9	$350	$265	32.9%	$37

Ship Class:	CVN
Number in Service:	11
Crew Size:	5000
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	125
Number of Underway Days per Year:	128
Annual Fixture Replacement Per Ship:	6.3
Underway Processing Cost per lb:	$ 3.30
Disposal Cost per lb:	$ 0.03
Breakeven Point (Months):	2.03

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$169,660,748
Lifecycle Cost with Upgrade:	$ 85,872,286
Lifecycle Savings with Upgrade:	$ 83,788,461

Bottles purchased / yr	427,500
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for One Vessel:

	Status Quo								Gooseneck Fixture							
Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0	$50,687	$0	$0	$0	$0	$50,687	1.000	$50,687
1	$534,375	$0	$83,984	$285	$472	$619,115	1.025	$604,015	$267,188	$2,003	$41,992	$142	$236	$311,325	1.025	$303,732
2	$534,375	$0	$83,984	$285	$472	$619,115	1.050	$589,633	$267,188	$2,003	$41,992	$142	$236	$311,325	1.050	$296,500
3	$534,375	$0	$83,984	$285	$472	$619,115	1.075	$575,921	$267,188	$2,003	$41,992	$142	$236	$311,325	1.075	$289,605
4	$534,375	$0	$83,984	$285	$472	$619,115	1.100	$562,832	$267,188	$2,003	$41,992	$142	$236	$311,325	1.100	$283,023
5	$534,375	$0	$83,984	$285	$472	$619,115	1.125	$550,324	$267,188	$2,003	$41,992	$142	$236	$311,325	1.125	$276,733
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	$534,375	$0	$83,984	$285	$472	$619,115	1.250	$495,292	$267,188	$2,003	$41,992	$142	$236	$311,325	1.250	$249,060
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	$534,375	$0	$83,984	$285	$472	$619,115	1.375	$450,265	$267,188	$2,003	$41,992	$142	$236	$311,325	1.375	$226,418
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20	$534,375	$0	$83,984	$285	$472	$619,115	1.500	$412,743	$267,188	$2,003	$41,992	$142	$236	$311,325	1.500	$207,550
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
25	$534,375	$0	$83,984	$285	$472	$619,115	1.625	$380,994	$267,188	$2,003	$41,992	$142	$236	$311,325	1.625	$191,585
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	$534,375	$0	$83,984	$285	$472	$619,115	1.750	$353,780	$267,188	$2,003	$41,992	$142	$236	$311,325	1.750	$177,900
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
35	$534,375	$0	$83,984	$285	$472	$619,115	1.875	$330,195	$267,188	$2,003	$41,992	$142	$236	$311,325	1.875	$166,040
Total:	$18,703,125	$0	$2,939,434	$9,960	$16,506	$21,669,024			$9,402,249	$70,108	$1,469,717	$4,986	$8,253	$10,947,061		
							NPV	$15,423,704							NPV	$7,806,571

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

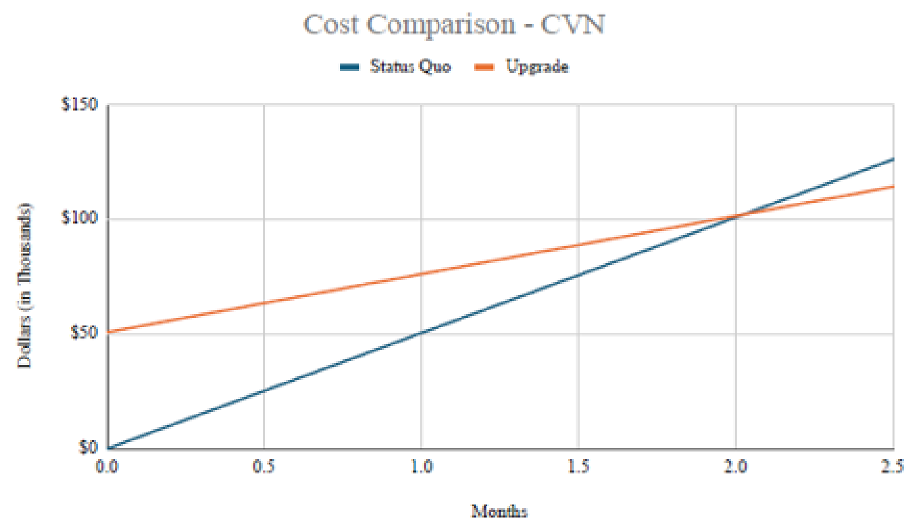
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$50,687	$50,687
1	$604,015	$354,419	-$249,596
2	$1,193,648	$650,919	-$542,729
3	$1,769,569	$940,523	-$829,046
4	$2,332,401	$1,223,546	-$1,108,855
5	$2,882,725	$1,500,279	-$1,382,446
6	$3,421,086	$1,770,997	-$1,650,089
7	$3,947,992	$2,035,954	-$1,912,038
8	$4,463,921	$2,295,391	-$2,168,530
9	$4,969,321	$2,549,534	-$2,419,787
10	$5,464,613	$2,798,594	-$2,666,019
11	$5,950,194	$3,042,771	-$2,907,423
12	$6,426,436	$3,282,251	-$3,144,185
13	$6,893,693	$3,517,214	-$3,376,479
14	$7,352,296	$3,747,825	-$3,604,472
15	$7,802,562	$3,974,243	-$3,828,319
16	$8,244,787	$4,196,618	-$4,048,169
17	$8,679,254	$4,415,092	-$4,264,162
18	$9,106,229	$4,629,799	-$4,476,431
19	$9,525,968	$4,840,866	-$4,685,102
20	$9,938,712	$5,048,416	-$4,890,295
21	$10,344,689	$5,252,564	-$5,092,125
22	$10,744,118	$5,453,419	-$5,290,699
23	$11,137,207	$5,651,085	-$5,486,121
24	$11,524,153	$5,845,663	-$5,678,490
25	$11,905,147	$6,037,248	-$5,867,899
26	$12,280,369	$6,225,930	-$6,054,439
27	$12,649,989	$6,411,795	-$6,238,194
28	$13,014,175	$6,594,928	-$6,419,247
29	$13,373,082	$6,775,406	-$6,597,676
30	$13,726,862	$6,953,306	-$6,773,556
31	$14,075,659	$7,128,700	-$6,946,959
32	$14,419,612	$7,301,659	-$7,117,953
33	$14,758,853	$7,472,248	-$7,286,605
34	$15,093,510	$7,640,531	-$7,452,978
35	$15,423,704	$7,806,571	-$7,617,133



Breakeven Point
2.03 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$9,402,249	$70,108	$1,469,717	$4,986	$8,253
Status Quo	$18,703,125	$0	$2,939,434	$9,960	$16,506

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	125	$350	$265	35.1%	$37

Ship Class:	DDG
Number in Service:	74
Crew Size:	330
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	8
Number of Underway Days per Year:	123
Annual Fixture Replacement Per Ship:	0.4
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	1.96

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$75,465,056
Lifecycle Cost with Upgrade:	$38,180,249
Lifecycle Savings with Upgrade:	$37,284,807

Bottles purchased / yr	28,215
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for One Vessel:

Status Quo

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0
1	$35,269	$0	$5,617	$19	$31	$40,935	1.025	$39,937
2	$35,269	$0	$5,617	$19	$31	$40,935	1.050	$38,986
3	$35,269	$0	$5,617	$19	$31	$40,935	1.075	$38,079
4	$35,269	$0	$5,617	$19	$31	$40,935	1.100	$37,214
5	$35,269	$0	$5,617	$19	$31	$40,935	1.125	$36,387
...	...	...	...	...	...	...	...	...
10	$35,269	$0	$5,617	$19	$31	$40,935	1.250	$32,748
...	...	...	...	...	...	...	...	...
15	$35,269	$0	$5,617	$19	$31	$40,935	1.375	$29,771
...	...	...	...	...	...	...	...	...
20	$35,269	$0	$5,617	$19	$31	$40,935	1.500	$27,290
...	...	...	...	...	...	...	...	...
25	$35,269	$0	$5,617	$19	$31	$40,935	1.625	$25,191
...	...	...	...	...	...	...	...	...
30	$35,269	$0	$5,617	$19	$31	$40,935	1.750	$23,392
...	...	...	...	...	...	...	...	...
35	$35,269	$0	$5,617	$19	$31	$40,935	1.875	$21,832
Total:	$1,234,406	$0	$196,579	$657	$1,089	$1,432,732		
							NPV	$1,019,798

Gooseneck Fixture

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$3,244	$0	$0	$0	$0	$3,244	1.000	$3,244
1	$17,634	$128	$2,808	$9	$16	$20,580	1.025	$20,078
2	$17,634	$128	$2,808	$9	$16	$20,580	1.050	$19,600
3	$17,634	$128	$2,808	$9	$16	$20,580	1.075	$19,144
4	$17,634	$128	$2,808	$9	$16	$20,580	1.100	$18,709
5	$17,634	$128	$2,808	$9	$16	$20,580	1.125	$18,294
...	...	...	...	...	...	...	...	...
10	$17,634	$128	$2,808	$9	$16	$20,580	1.250	$16,464
...	...	...	...	...	...	...	...	...
15	$17,634	$128	$2,808	$9	$16	$20,580	1.375	$14,967
...	...	...	...	...	...	...	...	...
20	$17,634	$128	$2,808	$9	$16	$20,580	1.500	$13,720
...	...	...	...	...	...	...	...	...
25	$17,634	$128	$2,808	$9	$16	$20,580	1.625	$12,665
...	...	...	...	...	...	...	...	...
30	$17,634	$128	$2,808	$9	$16	$20,580	1.750	$11,760
...	...	...	...	...	...	...	...	...
35	$17,634	$128	$2,808	$9	$16	$20,580	1.875	$10,976
Total:	$620,447	$4,487	$98,289	$329	$545	$723,552		
							NPV	$515,949

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

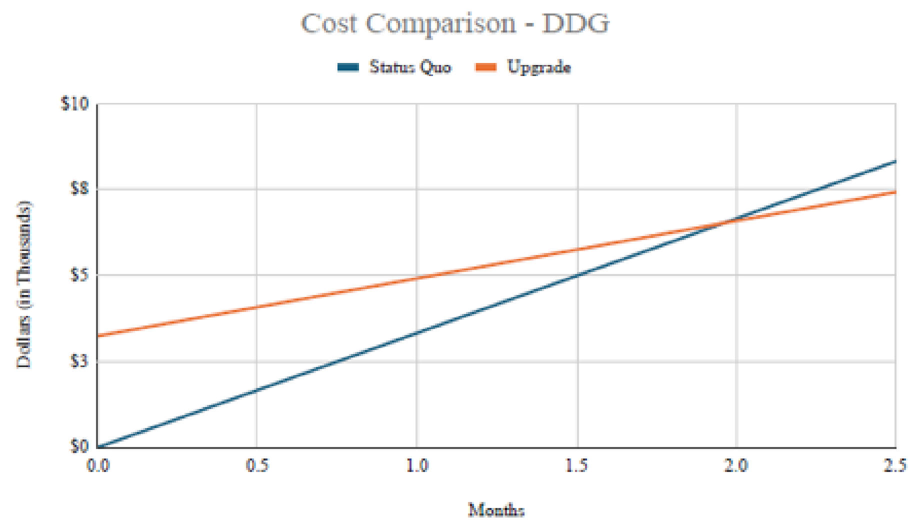
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$3,244	$3,244
1	$39,937	$23,322	-$16,615
2	$78,923	$42,922	-$36,000
3	$117,002	$62,067	-$54,935
4	$154,216	$80,776	-$73,440
5	$190,603	$99,070	-$91,533
6	$226,198	$116,966	-$109,233
7	$261,037	$134,481	-$126,556
8	$295,149	$151,631	-$143,519
9	$328,566	$168,431	-$160,135
10	$361,314	$184,895	-$176,419
11	$393,420	$201,037	-$192,383
12	$424,909	$216,868	-$208,041
13	$455,803	$232,400	-$223,403
14	$486,126	$247,645	-$238,481
15	$515,897	$262,612	-$253,285
16	$545,136	$277,312	-$267,824
17	$573,863	$291,754	-$282,108
18	$602,094	$305,948	-$296,146
19	$629,846	$319,900	-$309,946
20	$657,136	$333,621	-$323,516
21	$683,979	$347,116	-$336,863
22	$710,389	$360,393	-$349,996
23	$736,380	$373,460	-$362,919
24	$761,964	$386,323	-$375,641
25	$787,155	$398,988	-$388,167
26	$811,964	$411,460	-$400,504
27	$836,403	$423,747	-$412,656
28	$860,483	$435,853	-$424,629
29	$884,213	$447,784	-$436,429
30	$907,605	$459,544	-$448,061
31	$930,667	$471,138	-$459,528
32	$953,409	$482,572	-$470,837
33	$975,839	$493,849	-$481,990
34	$997,966	$504,973	-$492,993
35	$1,019,798	$515,949	-$503,849



Breakeven Point
1.96 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$620,447	$4,487	$98,289	$329	$545
Status Quo	$1,234,406	$0	$196,579	$657	$1,089

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	8	$350	$265	33.7%	$37

Ship Class:	LCC
Number in Service:	2
Crew Size:	564
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	14
Number of Underway Days per Year:	88
Annual Fixture Replacement Per Ship:	0.7
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	1.98

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$3,529,727
Lifecycle Cost with Upgrade:	$1,786,071
Lifecycle Savings with Upgrade:	$1,743,656

Cost Comparison for One Vessel:

Bottles purchased / yr	48,222
Water bottle price	$1.25
Diversion level	50%

Status Quo

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0
1	$60,278	$0	$10,480	$32	$53	$70,842	1.025	$69,115
2	$60,278	$0	$10,480	$32	$53	$70,842	1.050	$67,469
3	$60,278	$0	$10,480	$32	$53	$70,842	1.075	$65,900
4	$60,278	$0	$10,480	$32	$53	$70,842	1.100	$64,402
5	$60,278	$0	$10,480	$32	$53	$70,842	1.125	$62,971
...	...	...	...	...	...	...	...	...
10	$60,278	$0	$10,480	$32	$53	$70,842	1.250	$56,674
...	...	...	...	...	...	...	...	...
15	$60,278	$0	$10,480	$32	$53	$70,842	1.375	$51,522
...	...	...	...	...	...	...	...	...
20	$60,278	$0	$10,480	$32	$53	$70,842	1.500	$47,228
...	...	...	...	...	...	...	...	...
25	$60,278	$0	$10,480	$32	$53	$70,842	1.625	$43,595
...	...	...	...	...	...	...	...	...
30	$60,278	$0	$10,480	$32	$53	$70,842	1.750	$40,481
...	...	...	...	...	...	...	...	...
35	$60,278	$0	$10,480	$32	$53	$70,842	1.875	$37,783
Total:	$2,109,713	$0	$366,789	$1,123	$1,862	$2,479,487		
							NPV	$1,764,864

Gooseneck Fixture

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$5,677	$0	$0	$0	$0	$5,677	1.000	$5,677
1	$30,139	$224	$5,240	$16	$27	$35,619	1.025	$34,750
2	$30,139	$224	$5,240	$16	$27	$35,619	1.050	$33,923
3	$30,139	$224	$5,240	$16	$27	$35,619	1.075	$33,134
4	$30,139	$224	$5,240	$16	$27	$35,619	1.100	$32,381
5	$30,139	$224	$5,240	$16	$27	$35,619	1.125	$31,661
...	...	...	...	...	...	...	...	...
10	$30,139	$224	$5,240	$16	$27	$35,619	1.250	$28,495
...	...	...	...	...	...	...	...	...
15	$30,139	$224	$5,240	$16	$27	$35,619	1.375	$25,905
...	...	...	...	...	...	...	...	...
20	$30,139	$224	$5,240	$16	$27	$35,619	1.500	$23,746
...	...	...	...	...	...	...	...	...
25	$30,139	$224	$5,240	$16	$27	$35,619	1.625	$21,919
...	...	...	...	...	...	...	...	...
30	$30,139	$224	$5,240	$16	$27	$35,619	1.750	$20,354
...	...	...	...	...	...	...	...	...
35	$30,139	$224	$5,240	$16	$27	$35,619	1.875	$18,997
Total:	$1,060,533	$7,852	$183,395	$562	$931	$1,252,342		
							NPV	$893,036

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

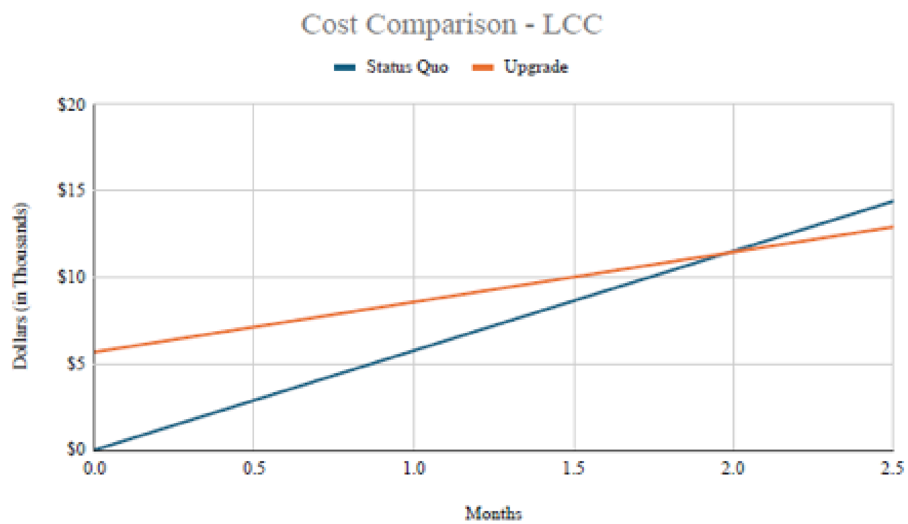
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$5,677	$5,677
1	$69,115	$40,427	-$28,687
2	$136,584	$74,350	-$62,234
3	$202,484	$107,484	-$95,000
4	$266,886	$139,865	-$127,021
5	$329,857	$171,526	-$158,331
6	$391,459	$202,499	-$188,960
7	$451,751	$232,813	-$218,937
8	$510,786	$262,496	-$248,290
9	$568,617	$291,573	-$277,044
10	$625,291	$320,068	-$305,223
11	$680,853	$348,004	-$332,849
12	$735,348	$375,404	-$359,944
13	$788,814	$402,286	-$386,528
14	$841,290	$428,670	-$412,619
15	$892,811	$454,575	-$438,236
16	$943,413	$480,017	-$463,396
17	$993,127	$505,013	-$488,114
18	$1,041,984	$529,578	-$512,406
19	$1,090,013	$553,726	-$536,287
20	$1,137,241	$577,472	-$559,769
21	$1,183,695	$600,829	-$582,866
22	$1,229,400	$623,809	-$605,591
23	$1,274,379	$646,424	-$627,955
24	$1,318,656	$668,686	-$649,970
25	$1,362,251	$690,606	-$671,646
26	$1,405,186	$712,193	-$692,993
27	$1,447,480	$733,458	-$714,022
28	$1,489,152	$754,410	-$734,742
29	$1,530,220	$775,059	-$755,161
30	$1,570,702	$795,413	-$775,289
31	$1,610,613	$815,480	-$795,133
32	$1,649,970	$835,268	-$814,702
33	$1,688,788	$854,785	-$834,002
34	$1,727,081	$874,039	-$853,042
35	$1,764,864	$893,036	-$871,828



Breakeven Point
1.98 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$1,060,533	$7,852	$183,395	$562	$931
Status Quo	$2,109,713	$0	$366,789	$1,123	$1,862

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	14	$350	$265	24.1%	$37

Ship Class:	LCS
Number in Service:	23
Crew Size:	75
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	2
Number of Underway Days per Year:	89
Annual Fixture Replacement Per Ship:	0.1
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	2.13

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$5,395,937
Lifecycle Cost with Upgrade:	$2,732,960
Lifecycle Savings with Upgrade:	$2,662,977

Bottles purchased / yr	6,413
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for One Vessel:

Status Quo

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0
1	$8,016	$0	$1,390	$4	$7	$9,417	1.025	$9,188
2	$8,016	$0	$1,390	$4	$7	$9,417	1.050	$8,969
3	$8,016	$0	$1,390	$4	$7	$9,417	1.075	$8,760
4	$8,016	$0	$1,390	$4	$7	$9,417	1.100	$8,561
5	$8,016	$0	$1,390	$4	$7	$9,417	1.125	$8,371
...	...	...	...	...	...	...	...	...
10	$8,016	$0	$1,390	$4	$7	$9,417	1.250	$7,534
...	...	...	...	...	...	...	...	...
15	$8,016	$0	$1,390	$4	$7	$9,417	1.375	$6,849
...	...	...	...	...	...	...	...	...
20	$8,016	$0	$1,390	$4	$7	$9,417	1.500	$6,278
...	...	...	...	...	...	...	...	...
25	$8,016	$0	$1,390	$4	$7	$9,417	1.625	$5,795
...	...	...	...	...	...	...	...	...
30	$8,016	$0	$1,390	$4	$7	$9,417	1.750	$5,381
...	...	...	...	...	...	...	...	...
35	$8,016	$0	$1,390	$4	$7	$9,417	1.875	$5,023
Total:	$280,547	$0	$48,658	$149	$248	$329,602		
							NPV	$234,606

Gooseneck Fixture

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$811	$0	$0	$0	$0	$811	1.000	$811
1	$4,008	$32	$695	$2	$4	$4,737	1.025	$4,622
2	$4,008	$32	$695	$2	$4	$4,737	1.050	$4,512
3	$4,008	$32	$695	$2	$4	$4,737	1.075	$4,407
4	$4,008	$32	$695	$2	$4	$4,737	1.100	$4,306
5	$4,008	$32	$695	$2	$4	$4,737	1.125	$4,211
...	...	...	...	...	...	...	...	...
10	$4,008	$32	$695	$2	$4	$4,737	1.250	$3,790
...	...	...	...	...	...	...	...	...
15	$4,008	$32	$695	$2	$4	$4,737	1.375	$3,445
...	...	...	...	...	...	...	...	...
20	$4,008	$32	$695	$2	$4	$4,737	1.500	$3,158
...	...	...	...	...	...	...	...	...
25	$4,008	$32	$695	$2	$4	$4,737	1.625	$2,915
...	...	...	...	...	...	...	...	...
30	$4,008	$32	$695	$2	$4	$4,737	1.750	$2,707
...	...	...	...	...	...	...	...	...
35	$4,008	$32	$695	$2	$4	$4,737	1.875	$2,526
Total:	$141,084	$1,122	$24,329	$75	$124	$166,610		
							NPV	$118,824

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

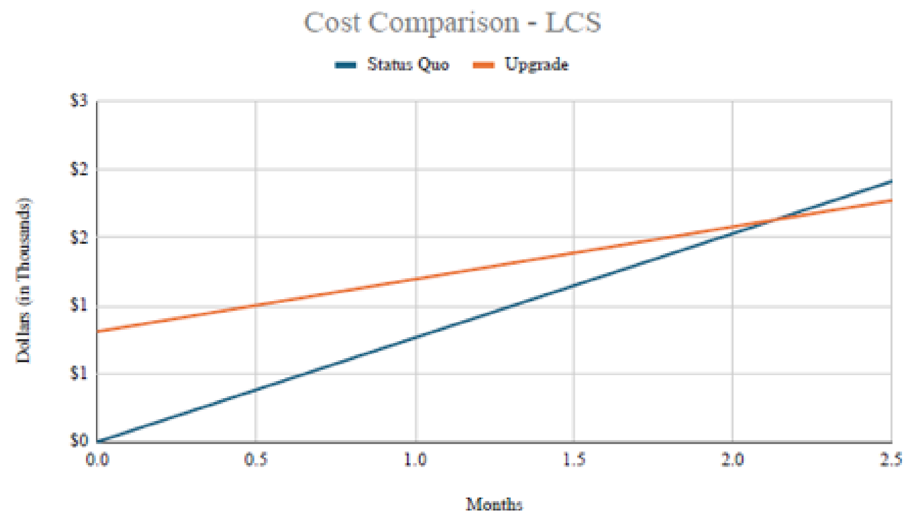
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$811	$811
1	$9,188	$5,433	-$3,755
2	$18,156	$9,944	-$8,212
3	$26,916	$14,351	-$12,566
4	$35,478	$18,657	-$16,820
5	$43,848	$22,868	-$20,980
6	$52,037	$26,987	-$25,050
7	$60,052	$31,019	-$29,033
8	$67,900	$34,966	-$32,933
9	$75,587	$38,833	-$36,754
10	$83,121	$42,623	-$40,498
11	$90,507	$46,338	-$44,168
12	$97,751	$49,982	-$47,768
13	$104,858	$53,558	-$51,301
14	$111,834	$57,067	-$54,767
15	$118,683	$60,512	-$58,171
16	$125,409	$63,895	-$61,514
17	$132,018	$67,220	-$64,798
18	$138,512	$70,487	-$68,026
19	$144,897	$73,698	-$71,199
20	$151,175	$76,856	-$74,319
21	$157,350	$79,963	-$77,388
22	$163,426	$83,019	-$80,407
23	$169,405	$86,027	-$83,379
24	$175,291	$88,987	-$86,304
25	$181,086	$91,902	-$89,184
26	$186,794	$94,773	-$92,020
27	$192,416	$97,601	-$94,814
28	$197,955	$100,388	-$97,567
29	$203,414	$103,134	-$100,280
30	$208,796	$105,841	-$102,955
31	$214,101	$108,510	-$105,591
32	$219,333	$111,142	-$108,191
33	$224,493	$113,737	-$110,756
34	$229,583	$116,298	-$113,286
35	$234,606	$118,824	-$115,782



Breakeven Point
2.13 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$141,084	$1,122	$24,329	$75	$124
Status Quo	$280,547	$0	$48,658	$149	$248

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	2	$350	$265	24.4%	$37

Ship Class:	LHA
Number in Service:	2
Crew Size:	1204
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	30
Number of Underway Days per Year:	112
Annual Fixture Replacement Per Ship:	1.5
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	2.01

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$7,470,870
Lifecycle Cost with Upgrade:	$3,780,891
Lifecycle Savings with Upgrade:	$3,689,979

Bottles purchased / yr	102,942
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for One Vessel:

Status Quo

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0
1	$128,678	$0	$21,083	$69	$114	$149,942	1.025	$146,285
2	$128,678	$0	$21,083	$69	$114	$149,942	1.050	$142,802
3	$128,678	$0	$21,083	$69	$114	$149,942	1.075	$139,481
4	$128,678	$0	$21,083	$69	$114	$149,942	1.100	$136,311
5	$128,678	$0	$21,083	$69	$114	$149,942	1.125	$133,282
...	...	...	...	...	...	...	...	...
10	$128,678	$0	$21,083	$69	$114	$149,942	1.250	$119,954
...	...	...	...	...	...	...	...	...
15	$128,678	$0	$21,083	$69	$114	$149,942	1.375	$109,049
...	...	...	...	...	...	...	...	...
20	$128,678	$0	$21,083	$69	$114	$149,942	1.500	$99,961
...	...	...	...	...	...	...	...	...
25	$128,678	$0	$21,083	$69	$114	$149,942	1.625	$92,272
...	...	...	...	...	...	...	...	...
30	$128,678	$0	$21,083	$69	$114	$149,942	1.750	$85,681
...	...	...	...	...	...	...	...	...
35	$128,678	$0	$21,083	$69	$114	$149,942	1.875	$79,969
Total:	$4,503,713	$0	$737,891	$2,398	$3,975	$5,247,976		
							NPV	$3,735,435

Gooseneck Fixture

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$12,165	$0	$0	$0	$0	$12,165	1.000	$12,165
1	$64,339	$481	$10,541	$34	$57	$75,395	1.025	$73,556
2	$64,339	$481	$10,541	$34	$57	$75,395	1.050	$71,805
3	$64,339	$481	$10,541	$34	$57	$75,395	1.075	$70,135
4	$64,339	$481	$10,541	$34	$57	$75,395	1.100	$68,541
5	$64,339	$481	$10,541	$34	$57	$75,395	1.125	$67,018
...	...	...	...	...	...	...	...	...
10	$64,339	$481	$10,541	$34	$57	$75,395	1.250	$60,316
...	...	...	...	...	...	...	...	...
15	$64,339	$481	$10,541	$34	$57	$75,395	1.375	$54,833
...	...	...	...	...	...	...	...	...
20	$64,339	$481	$10,541	$34	$57	$75,395	1.500	$50,263
...	...	...	...	...	...	...	...	...
25	$64,339	$481	$10,541	$34	$57	$75,395	1.625	$46,397
...	...	...	...	...	...	...	...	...
30	$64,339	$481	$10,541	$34	$57	$75,395	1.750	$43,083
...	...	...	...	...	...	...	...	...
35	$64,339	$481	$10,541	$34	$57	$75,395	1.875	$40,211
Total:	$2,264,021	$16,826	$368,945	$1,201	$1,987	$2,650,993		
							NPV	$1,890,445

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

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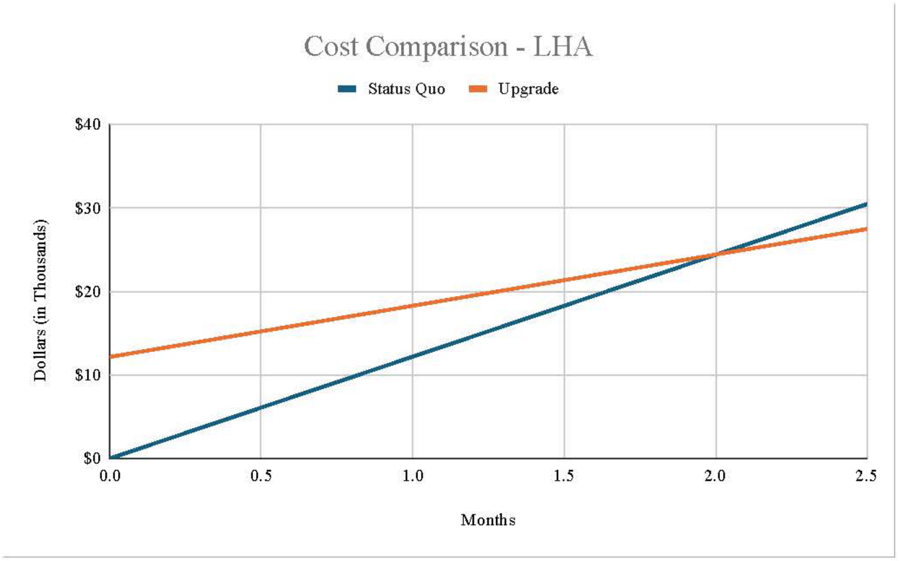
Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$12,165	$12,165
1	$146,285	$85,721	-$60,564
2	$289,087	$157,526	-$131,561
3	$428,568	$227,661	-$200,907
4	$564,879	$296,202	-$268,677
5	$698,161	$363,220	-$334,942
6	$828,546	$428,781	-$399,765
7	$956,156	$492,947	-$463,209
8	$1,081,108	$555,776	-$525,332
9	$1,203,510	$617,323	-$586,187
10	$1,323,463	$677,639	-$645,824
11	$1,441,065	$736,772	-$704,293
12	$1,556,405	$794,769	-$761,637
13	$1,669,569	$851,671	-$817,899
14	$1,780,637	$907,519	-$873,119
15	$1,889,686	$962,352	-$927,335
16	$1,996,788	$1,016,205	-$980,583
17	$2,102,010	$1,069,114	-$1,032,896
18	$2,205,419	$1,121,111	-$1,084,308
19	$2,307,075	$1,172,226	-$1,134,848
20	$2,407,036	$1,222,490	-$1,184,547
21	$2,505,359	$1,271,929	-$1,233,430
22	$2,602,096	$1,320,571	-$1,281,525
23	$2,697,297	$1,368,441	-$1,328,856
24	$2,791,011	$1,415,563	-$1,375,448
25	$2,883,283	$1,461,960	-$1,421,323
26	$2,974,157	$1,507,654	-$1,466,503
27	$3,063,675	$1,552,666	-$1,511,009
28	$3,151,876	$1,597,016	-$1,554,860
29	$3,238,799	$1,640,723	-$1,598,076
30	$3,324,480	$1,683,806	-$1,640,674
31	$3,408,955	$1,726,282	-$1,682,673
32	$3,492,256	$1,768,168	-$1,724,088
33	$3,574,416	$1,809,481	-$1,764,935
34	$3,655,466	$1,850,235	-$1,805,231
35	$3,735,435	$1,890,445	-$1,844,990



Breakeven Point
2.01 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$2,264,021	$16,826	$368,945	$1,201	$1,987
Status Quo	$4,503,713	$0	$737,891	$2,398	$3,975

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	30	$350	$265	30.7%	$37

Ship Class:	LHD
Number in Service:	7
Crew Size:	1500
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	38
Number of Underway Days per Year:	128
Annual Fixture Replacement Per Ship:	1.9
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	2.05

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$32,389,779
Lifecycle Cost with Upgrade:	$16,396,617
Lifecycle Savings with Upgrade:	$15,993,162

Bottles purchased / yr	128,250
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for One Vessel:

	Status Quo								Gooseneck Fixture							
Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0	$15,409	$0	$0	$0	$0	$15,409	1.000	$15,409
1	$160,313	$0	$25,195	$85	$141	$185,734	1.025	$181,204	$80,156	$609	$12,598	$43	$71	$93,406	1.025	$91,127
2	$160,313	$0	$25,195	$85	$141	$185,734	1.050	$176,890	$80,156	$609	$12,598	$43	$71	$93,406	1.050	$88,958
3	$160,313	$0	$25,195	$85	$141	$185,734	1.075	$172,776	$80,156	$609	$12,598	$43	$71	$93,406	1.075	$86,889
4	$160,313	$0	$25,195	$85	$141	$185,734	1.100	$168,850	$80,156	$609	$12,598	$43	$71	$93,406	1.100	$84,914
5	$160,313	$0	$25,195	$85	$141	$185,734	1.125	$165,097	$80,156	$609	$12,598	$43	$71	$93,406	1.125	$83,027
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	$160,313	$0	$25,195	$85	$141	$185,734	1.250	$148,588	$80,156	$609	$12,598	$43	$71	$93,406	1.250	$74,724
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	$160,313	$0	$25,195	$85	$141	$185,734	1.375	$135,080	$80,156	$609	$12,598	$43	$71	$93,406	1.375	$67,931
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20	$160,313	$0	$25,195	$85	$141	$185,734	1.500	$123,823	$80,156	$609	$12,598	$43	$71	$93,406	1.500	$62,270
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
25	$160,313	$0	$25,195	$85	$141	$185,734	1.625	$114,298	$80,156	$609	$12,598	$43	$71	$93,406	1.625	$57,480
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	$160,313	$0	$25,195	$85	$141	$185,734	1.750	$106,134	$80,156	$609	$12,598	$43	$71	$93,406	1.750	$53,375
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
35	$160,313	$0	$25,195	$85	$141	$185,734	1.875	$99,058	$80,156	$609	$12,598	$43	$71	$93,406	1.875	$49,816
Total:	$5,610,938	$0	$881,830	$2,988	$4,952	$6,500,707			$2,820,878	$21,313	$440,915	$1,496	$2,476	$3,284,602		
							NPV	$4,627,111							NPV	$2,342,374

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

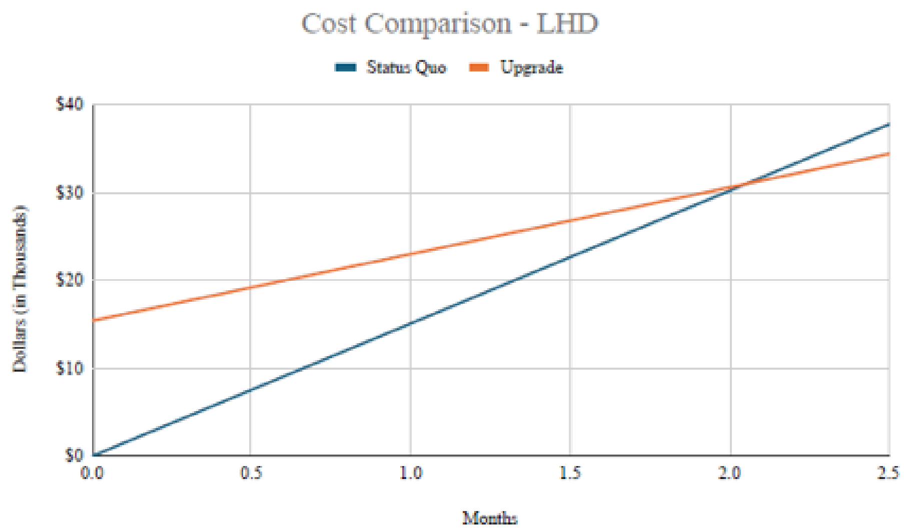
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$15,409	$15,409
1	$181,204	$106,536	-$74,668
2	$358,094	$195,494	-$162,601
3	$530,871	$282,383	-$248,488
4	$699,720	$367,297	-$332,423
5	$864,818	$450,324	-$414,494
6	$1,026,326	$531,546	-$494,780
7	$1,184,398	$611,040	-$573,358
8	$1,339,176	$688,878	-$650,298
9	$1,490,796	$765,127	-$725,669
10	$1,639,384	$839,852	-$799,532
11	$1,785,058	$913,111	-$871,947
12	$1,927,931	$984,961	-$942,969
13	$2,068,108	$1,055,456	-$1,012,652
14	$2,205,689	$1,124,645	-$1,081,044
15	$2,340,769	$1,192,577	-$1,148,192
16	$2,473,436	$1,259,295	-$1,214,141
17	$2,603,776	$1,324,843	-$1,278,933
18	$2,731,869	$1,389,260	-$1,342,609
19	$2,857,790	$1,452,586	-$1,405,205
20	$2,981,613	$1,514,856	-$1,466,757
21	$3,103,407	$1,576,106	-$1,527,301
22	$3,223,235	$1,636,367	-$1,586,868
23	$3,341,162	$1,695,672	-$1,645,489
24	$3,457,246	$1,754,051	-$1,703,195
25	$3,571,544	$1,811,531	-$1,760,013
26	$3,684,111	$1,868,141	-$1,815,970
27	$3,794,997	$1,923,905	-$1,871,092
28	$3,904,252	$1,978,850	-$1,925,403
29	$4,011,925	$2,032,998	-$1,978,927
30	$4,118,059	$2,086,372	-$2,031,686
31	$4,222,698	$2,138,995	-$2,083,703
32	$4,325,884	$2,190,887	-$2,134,997
33	$4,427,656	$2,242,068	-$2,185,588
34	$4,528,053	$2,292,558	-$2,235,495
35	$4,627,111	$2,342,374	-$2,284,737



Breakeven Point
2.05 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$2,820,878	$21,313	$440,915	$1,496	$2,476
Status Quo	$5,610,938	$0	$881,830	$2,988	$4,952

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	38	$350	$265	35.1%	$37

Ship Class:	LPD
Number in Service:	12
Crew Size:	420
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	11
Number of Underway Days per Year:	111
Annual Fixture Replacement Per Ship:	0.6
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	2.11

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$ 15,642,306
Lifecycle Cost with Upgrade:	$ 7,921,458
Lifecycle Savings with Upgrade:	$ 7,720,847

Bottles purchased / yr	35,910
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for One Vessel:

Status Quo

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0				$0	1.000	$0
1	$44,888	$0	$7,373	$24	$40	$52,324	1.025	$51,048
2	$44,888	$0	$7,373	$24	$40	$52,324	1.050	$49,833
3	$44,888	$0	$7,373	$24	$40	$52,324	1.075	$48,674
4	$44,888	$0	$7,373	$24	$40	$52,324	1.100	$47,567
5	$44,888	$0	$7,373	$24	$40	$52,324	1.125	$46,510
...	...	...	...	...	...	...	...	...
10	$44,888	$0	$7,373	$24	$40	$52,324	1.250	$41,859
...	...	...	...	...	...	...	...	...
15	$44,888	$0	$7,373	$24	$40	$52,324	1.375	$38,054
...	...	...	...	...	...	...	...	...
20	$44,888	$0	$7,373	$24	$40	$52,324	1.500	$34,883
...	...	...	...	...	...	...	...	...
25	$44,888	$0	$7,373	$24	$40	$52,324	1.625	$32,199
...	...	...	...	...	...	...	...	...
30	$44,888	$0	$7,373	$24	$40	$52,324	1.750	$29,900
...	...	...	...	...	...	...	...	...
35	$44,888	$0	$7,373	$24	$40	$52,324	1.875	$27,906
Total:	$1,571,063	$0	$258,060	$837	$1,387	$1,831,345		
							NPV	$1,303,525

Gooseneck Fixture

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$4,460	$0	$0	$0	$0	$4,460	1.000	$4,460
1	$22,444	$176	$3,687	$12	$20	$26,319	1.025	$25,677
2	$22,444	$176	$3,687	$12	$20	$26,319	1.050	$25,065
3	$22,444	$176	$3,687	$12	$20	$26,319	1.075	$24,482
4	$22,444	$176	$3,687	$12	$20	$26,319	1.100	$23,926
5	$22,444	$176	$3,687	$12	$20	$26,319	1.125	$23,394
...	...	...	...	...	...	...	...	...
10	$22,444	$176	$3,687	$12	$20	$26,319	1.250	$21,055
...	...	...	...	...	...	...	...	...
15	$22,444	$176	$3,687	$12	$20	$26,319	1.375	$19,141
...	...	...	...	...	...	...	...	...
20	$22,444	$176	$3,687	$12	$20	$26,319	1.500	$17,546
...	...	...	...	...	...	...	...	...
25	$22,444	$176	$3,687	$12	$20	$26,319	1.625	$16,196
...	...	...	...	...	...	...	...	...
30	$22,444	$176	$3,687	$12	$20	$26,319	1.750	$15,039
...	...	...	...	...	...	...	...	...
35	$22,444	$176	$3,687	$12	$20	$26,319	1.875	$14,037
Total:	$789,992	$6,170	$129,030	$419	$693	$925,610		
							NPV	$660,122

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

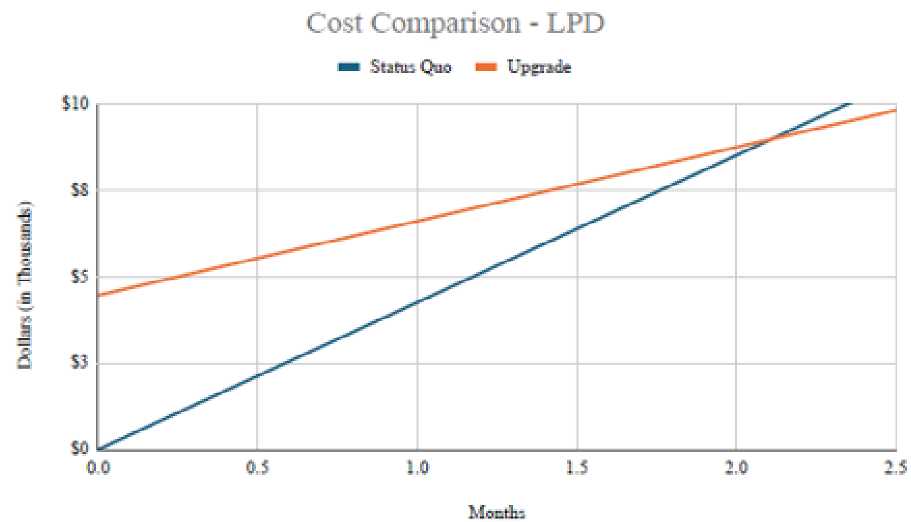
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$4,460	$4,460
1	$51,048	$30,137	-$20,911
2	$100,880	$55,202	-$45,678
3	$149,554	$79,685	-$69,869
4	$197,121	$103,611	-$93,511
5	$243,632	$127,005	-$116,627
6	$289,131	$149,891	-$139,240
7	$333,662	$172,289	-$161,373
8	$377,266	$194,222	-$183,044
9	$419,979	$215,706	-$204,273
10	$461,839	$236,761	-$225,078
11	$502,877	$257,403	-$245,474
12	$543,127	$277,648	-$265,479
13	$582,616	$297,511	-$285,105
14	$621,375	$317,006	-$304,369
15	$659,429	$336,147	-$323,282
16	$696,803	$354,946	-$341,857
17	$733,522	$373,415	-$360,107
18	$769,608	$391,566	-$378,042
19	$805,082	$409,409	-$395,673
20	$839,964	$426,955	-$413,010
21	$874,275	$444,213	-$430,063
22	$908,033	$461,192	-$446,840
23	$941,255	$477,903	-$463,352
24	$973,957	$494,352	-$479,605
25	$1,006,157	$510,548	-$495,609
26	$1,037,868	$526,498	-$511,370
27	$1,069,107	$542,211	-$526,896
28	$1,099,885	$557,693	-$542,193
29	$1,130,218	$572,950	-$557,269
30	$1,160,118	$587,989	-$572,129
31	$1,189,596	$602,816	-$586,780
32	$1,218,665	$617,438	-$601,228
33	$1,247,336	$631,859	-$615,477
34	$1,275,619	$646,085	-$629,534
35	$1,303,525	$660,122	-$643,404



Breakeven Point
2.11 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$789,992	$6,170	$129,030	$419	$693
Status Quo	$1,571,063	$0	$258,060	$837	$1,387

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	11	$350	$265	30.4%	$37

Ship Class:	LSD
Number in Service:	10
Crew Size:	397
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	10
Number of Underway Days per Year:	121
Annual Fixture Replacement Per Ship:	0.5
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	2.04

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$12,277,303
Lifecycle Cost with Upgrade:	$6,214,462
Lifecycle Savings with Upgrade:	$6,062,841

Cost Comparison for One Vessel:

Bottles purchased / yr	33,944
Water bottle price	$1.25
Diversion level	50%

	Status Quo								Gooseneck Fixture							
Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0	$4,055	$0	$0	$0	$0	$4,055	1.000	$4,055
1	$42,429	$0	$6,792	$23	$37	$49,282	1.025	$48,080	$21,215	$160	$3,396	$11	$19	$24,782	1.025	$24,178
2	$42,429	$0	$6,792	$23	$37	$49,282	1.050	$46,935	$21,215	$160	$3,396	$11	$19	$24,782	1.050	$23,602
3	$42,429	$0	$6,792	$23	$37	$49,282	1.075	$45,843	$21,215	$160	$3,396	$11	$19	$24,782	1.075	$23,053
4	$42,429	$0	$6,792	$23	$37	$49,282	1.100	$44,802	$21,215	$160	$3,396	$11	$19	$24,782	1.100	$22,529
5	$42,429	$0	$6,792	$23	$37	$49,282	1.125	$43,806	$21,215	$160	$3,396	$11	$19	$24,782	1.125	$22,029
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
10	$42,429	$0	$6,792	$23	$37	$49,282	1.250	$39,425	$21,215	$160	$3,396	$11	$19	$24,782	1.250	$19,826
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
15	$42,429	$0	$6,792	$23	$37	$49,282	1.375	$35,841	$21,215	$160	$3,396	$11	$19	$24,782	1.375	$18,024
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
20	$42,429	$0	$6,792	$23	$37	$49,282	1.500	$32,854	$21,215	$160	$3,396	$11	$19	$24,782	1.500	$16,522
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
25	$42,429	$0	$6,792	$23	$37	$49,282	1.625	$30,327	$21,215	$160	$3,396	$11	$19	$24,782	1.625	$15,251
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
30	$42,429	$0	$6,792	$23	$37	$49,282	1.750	$28,161	$21,215	$160	$3,396	$11	$19	$24,782	1.750	$14,161
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
35	$42,429	$0	$6,792	$23	$37	$49,282	1.875	$26,284	$21,215	$160	$3,396	$11	$19	$24,782	1.875	$13,217
Total:	$1,465,028	$0	$237,730	$791	$1,311	$1,724,859			$746,569	$5,609	$118,865	$396	$655	$871,438		
							NPV	$1,227,730							NPV	$621,446

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

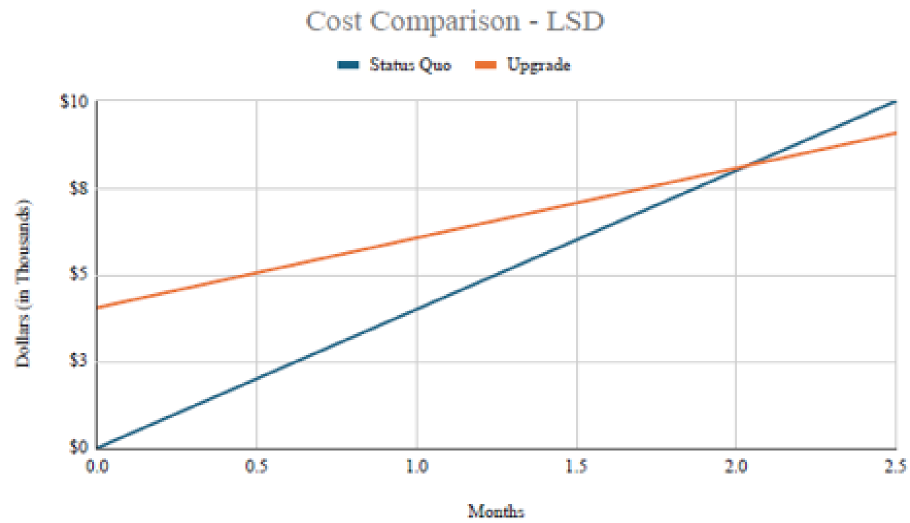
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$4,055	$4,055
1	$48,080	$28,233	-$19,847
2	$95,015	$51,835	-$43,179
3	$140,858	$74,889	-$65,970
4	$185,660	$97,418	-$88,242
5	$229,466	$119,447	-$110,019
6	$272,319	$140,997	-$131,323
7	$314,261	$162,088	-$152,173
8	$355,329	$182,740	-$172,589
9	$395,559	$202,971	-$192,589
10	$434,984	$222,796	-$212,188
11	$473,637	$242,234	-$231,403
12	$511,546	$261,297	-$250,249
13	$548,739	$280,001	-$268,739
14	$585,244	$298,358	-$286,886
15	$621,086	$316,382	-$304,704
16	$656,287	$334,083	-$322,204
17	$690,871	$351,474	-$339,396
18	$724,858	$368,566	-$356,292
19	$758,269	$385,367	-$372,902
20	$791,124	$401,889	-$389,235
21	$823,440	$418,140	-$405,300
22	$855,234	$434,128	-$421,106
23	$886,524	$449,863	-$436,661
24	$917,325	$465,352	-$451,973
25	$947,652	$480,603	-$467,050
26	$977,520	$495,622	-$481,898
27	$1,006,942	$510,418	-$496,524
28	$1,035,931	$524,996	-$510,935
29	$1,064,500	$539,362	-$525,138
30	$1,092,661	$553,524	-$539,137
31	$1,120,426	$567,486	-$552,940
32	$1,147,804	$581,254	-$566,551
33	$1,174,808	$594,833	-$579,975
34	$1,201,447	$608,229	-$593,218
35	$1,227,730	$621,446	-$606,284



Breakeven Point
2.04 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$746,569	$5,609	$118,865	$396	$655
Status Quo	$1,485,028	$0	$237,730	$791	$1,311

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	10	$350	$265	33.2%	$37

Ship Class:	MCM
Number in Service:	8
Crew Size:	84
Plastic Waste Generation (lb/person/day)	0.005168
Number of Fixtures per ship (1:40):	2
Number of Underway Days per Year:	60
Annual Fixture Replacement Per Ship:	0.1
Underway Processing Cost per lb:	$3.30
Disposal Cost per lb:	$0.03
Breakeven Point (Months):	1.88

Cost Comparison For Entire Class	
Lifecycle Cost of Status Quo:	$2,123,726
Lifecycle Cost with Upgrade:	$1,073,949
Lifecycle Savings with Upgrade:	$1,049,776

Bottles purchased / yr	7,182
Water bottle price	$1.25
Diversion level	50%

Cost Comparison for One Vessel:

Status Quo

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$0	$0	$0	$0	$0	$0	1.000	$0
1	$8,978	$0	$1,666	$5	$8	$10,656	1.025	$10,396
2	$8,978	$0	$1,666	$5	$8	$10,656	1.050	$10,148
3	$8,978	$0	$1,666	$5	$8	$10,656	1.075	$9,912
4	$8,978	$0	$1,666	$5	$8	$10,656	1.100	$9,687
5	$8,978	$0	$1,666	$5	$8	$10,656	1.125	$9,472
...	...	...	...	...	...	...	...	...
10	$8,978	$0	$1,666	$5	$8	$10,656	1.250	$8,525
...	...	...	...	...	...	...	...	...
15	$8,978	$0	$1,666	$5	$8	$10,656	1.375	$7,750
...	...	...	...	...	...	...	...	...
20	$8,978	$0	$1,666	$5	$8	$10,656	1.500	$7,104
...	...	...	...	...	...	...	...	...
25	$8,978	$0	$1,666	$5	$8	$10,656	1.625	$6,557
...	...	...	...	...	...	...	...	...
30	$8,978	$0	$1,666	$5	$8	$10,656	1.750	$6,089
...	...	...	...	...	...	...	...	...
35	$8,978	$0	$1,666	$5	$8	$10,656	1.875	$5,683
Total:	$314,213	$0	$58,300	$167	$277	$372,957		
							NPV	$265,466

Gooseneck Fixture

Year	Investment	Replace-ment	Labor & Operations	Material Disposal	Environ-mental	Total	Disc. Factor	PV
0	$811	$0	$0	$0	$0	$811	1.000	$811
1	$4,489	$32	$833	$2	$4	$5,356	1.025	$5,225
2	$4,489	$32	$833	$2	$4	$5,356	1.050	$5,101
3	$4,489	$32	$833	$2	$4	$5,356	1.075	$4,982
4	$4,489	$32	$833	$2	$4	$5,356	1.100	$4,869
5	$4,489	$32	$833	$2	$4	$5,356	1.125	$4,761
...	...	...	...	...	...	...	...	...
10	$4,489	$32	$833	$2	$4	$5,356	1.250	$4,285
...	...	...	...	...	...	...	...	...
15	$4,489	$32	$833	$2	$4	$5,356	1.375	$3,895
...	...	...	...	...	...	...	...	...
20	$4,489	$32	$833	$2	$4	$5,356	1.500	$3,571
...	...	...	...	...	...	...	...	...
25	$4,489	$32	$833	$2	$4	$5,356	1.625	$3,296
...	...	...	...	...	...	...	...	...
30	$4,489	$32	$833	$2	$4	$5,356	1.750	$3,061
...	...	...	...	...	...	...	...	...
35	$4,489	$32	$833	$2	$4	$5,356	1.875	$2,857
Total:	$157,917	$1,122	$29,150	$84	$139	$188,273		
							NPV	$134,244

Status Quo Formulas:

Investment:	(Bottles purchased per year) * (Price of one bottle)
Labor/Operations:	((Underway Days/365) * Underway Processing Cost * Crew size * Plastic Waste Generation Rate) + ((1 - (Underway Days/365)) * (10 minutes per hour * Labor Rate per hour * (1% * Crew Size)) * 365)
Disposal:	(Crew size * Plastic Waste Generation Rate * 365 days per year * Disposal Cost)
Environmental:	(Crew size * Plastic Waste Generation Rate * 365 days per year) * ($0.05)

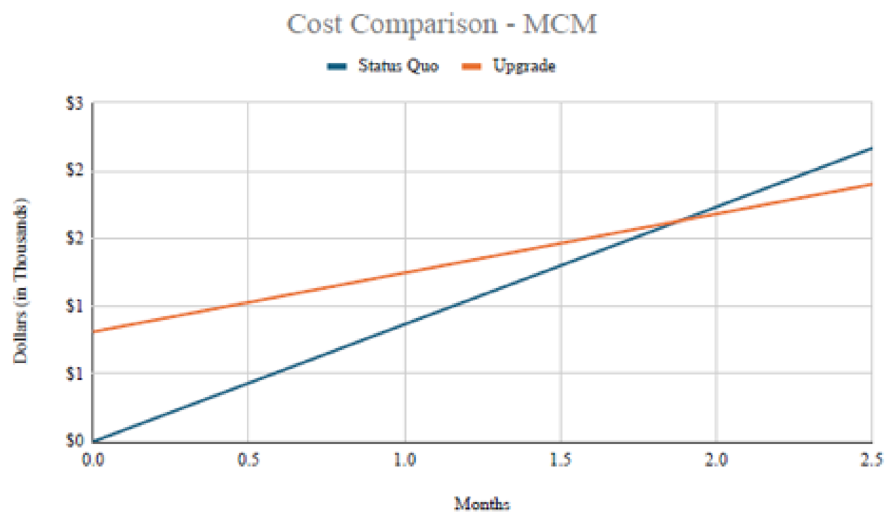
Gooseneck Formulas:

Investment:	((Number of Fixtures per ship * Cost Per Fixture) + Number of Fixtures per ship) * (Initial Cost + (Time to Install * Labor Cost per hour)
Replacement Cost:	(Annual Fixture Replacement * $265 Replacement Cost) + (Labor Cost per hour) * (Time to Install) * (# of personnel)
Labor/Operations:	(Status Quo Labor/Operations Cost) * (1 - Diversion %)
Disposal:	(Annual Fixture Replacement * Disposal Cost) + (Status Quo Disposal Cost) * (1 - Diversion %)
Environmental:	(Status Quo Environmental Cost) * (1 - Diversion %)

Total Formulas:

Total:	(Investment) + (Replacement) + (Operation) + (Disposal) + (Environmental)
Discount Rate:	1 + (discount rate) * (year)
PV:	(Total) / (Discount Rate) ^ (year)

Year	Status quo cost, Cum PV	Upgrade cost, Cum PV	Cum. cost Savings
0	$0	$811	$811
1	$10,396	$6,036	-$4,360
2	$20,545	$11,137	-$9,407
3	$30,457	$16,120	-$14,337
4	$40,144	$20,989	-$19,155
5	$49,616	$25,750	-$23,866
6	$58,882	$30,407	-$28,475
7	$67,951	$34,966	-$32,985
8	$76,831	$39,429	-$37,402
9	$85,530	$43,801	-$41,728
10	$94,054	$48,086	-$45,968
11	$102,412	$52,287	-$50,125
12	$110,609	$56,407	-$54,202
13	$118,651	$60,449	-$58,202
14	$126,544	$64,417	-$62,128
15	$134,294	$68,312	-$65,982
16	$141,905	$72,138	-$69,768
17	$149,383	$75,896	-$73,487
18	$156,732	$79,590	-$77,142
19	$163,957	$83,221	-$80,735
20	$171,061	$86,792	-$84,268
21	$178,048	$90,304	-$87,744
22	$184,923	$93,760	-$91,163
23	$191,688	$97,161	-$94,528
24	$198,348	$100,508	-$97,840
25	$204,906	$103,804	-$101,102
26	$211,364	$107,050	-$104,314
27	$217,726	$110,248	-$107,478
28	$223,994	$113,398	-$110,596
29	$230,171	$116,503	-$113,668
30	$236,260	$119,564	-$116,696
31	$242,264	$122,582	-$119,682
32	$248,184	$125,557	-$122,627
33	$254,023	$128,492	-$125,531
34	$259,783	$131,387	-$128,395
35	$265,466	$134,244	-$131,222



Breakeven Point
1.88 Months

Cost Factors					
System	Investment	Replacement	Labor/Ops	Mat'l Disposal	Environmental
Upgrade	$157,917	$1,122	$29,150	$84	$139
Status Quo	$314,213	$0	$58,300	$167	$277

Assumptions	# of fixtures	Fixture Cost	Replace. Cost	% at Sea	Labor Cost
	2	$350	$265	16.4%	$37

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Acquisition Research Program
Naval Postgraduate School
555 Dyer Road, Ingersoll Hall
Monterey, CA 93943

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