Corrosion Factors in DoD Facilities

FINAL Submittal

Vision Point Systems

10/24/2014

Executive Summary

The purpose of the Corrosion Factors in DoD Facilities report is to determine causes of corrosion in facilities based on data from the Facilities and Infrastructure Corrosion Evaluation Study and determine categories of causes leading to corrosion of facilities. This study seeks to identify the building and infrastructure components and systems which are the most problematic and costly with respect to corrosion deterioration, as well as any relevant sensitivities of those components to environmental and corrosion factors.

Corrosion factors are determined through analysis. An analysis of trends between corrosion costs and the Environmental Severity Index (ESI) corrosion factor concludes that installations in ESI zones 11 and above require increased attention to corrosion-durable components and facility design. Analyzing the relationship of the cost of corrosion to facility components and systems (Maintenance Objects), to the description of deterioration, and to possible causes, resulted in identifying other corrosion factors that can be applied to facility systems and components. These factors are Time of Wetness, Humidity, Temperature, Salt Fall Rain Fall, Chlorides, Sulfides, Nitrides, Ultraviolet Radiation, Water Immersion, Water Chemistry, Water Acidity/Basicity Measure.

The report investigates how the primary use of a facility affects its corrosion cost. Facility types are characterized either by having a smaller number of high-cost jobs, or a larger number of low-cost jobs. This analysis found that facilities falling under the former category include Unit Headquarters Buildings, Electronic and Communication Maintenance Shops, Vehicle Maintenance Shops, Open Mess and Club Facility, Indoor Physical Fitness Facility, and Transient Lodging. Additionally, it was found that facilities in the latter category include General Administrative Buildings, Enlisted Unaccompanied Personnel Housing, and Covered Storage Buildings. The primary use analysis was of limited value in determining a focus for corrosion issues, however did provide some insight into corrosion issues that are primarily derived from large renovation projects and those derived from smaller maintenance driver repairs.

The report then investigates the description details of the top ten cost driver categories and the top twenty-five maintenance objects. This investigation concludes that Facilities, Structure is the number one cost driver category, and within that, Doors are the top maintenance object in terms of corrosion costs. Installation of interior components in exterior environments are found to contribute significantly to corrosion costs. For interior maintenance objects, the primary causes of corrosion are from two sources: roof and plumbing leaks and high humidity bathroom spaces.

Lastly, the report summarizes the current Unified Facilities Criteria that link to the top cost drivers and maintenance objects. Updates to incorporate the corrosion factors into the Unified Facilities Criteria policy documents would allow for the institutionalization of proper corrosion-durable maintenance objects and facility designs.

Table of Contents

Table of Figures

1. Background

The Department of Defense acquires, operates, and maintains a vast array of physical assets that range from vehicles, aircraft, ships, and other materiel to wharves, buildings, and other stationary structures and infrastructure. All of these assets are susceptible to corrosion.

Efforts to prevent and control the detrimental effects of corrosion (including repair and replacement) contribute significantly to the total ownership costs of DoD assets. To control these costs, the Department must track the effects of corrosion, assess the cost of those effects, and work to prevent corrosion of systems and structures. Congress required the Director of the Office of Corrosion Policy and Oversight (DCPO) to investigate strategies for enhancing the sustainability of existing facilities and ensuring the integration of corrosion prevention and mitigation technologies in newly constructed facilities and infrastructure.

Specifically, the House Armed Service Committee Report accompanying H.R. 1540, The National Defense Authorization Act (NDAA) for Fiscal Year 2012 (H.R. Rep. No 112-78, p. 293), requested the DCPO conduct an evaluation of DoD facilities and infrastructure in corrosion matters. With the Department of Defense's $22.5 billion annual cost to address the impact of corrosion, the committee believes that there may be more cost-efficient opportunities for developing strategies to enhance the sustainability of existing facilities and ensure the integration of corrosion prevention and mitigation technologies into the buildup of future facilities. As a result of this request, DCPO produced the "Facilities and Infrastructure Corrosion Evaluation Study: Final Report,"[1] or "FICE Study" for short.

The CPO has set up the DoD Facilities and Infrastructure Working Integrated Product Team (WIPT) specifically to share information, problems, and solutions between DoD services. Based on the FICE Study, the Facilities and Infrastructure WIPT initiated the study "Corrosion Factors in DoD Facilities" to further investigate the FICE Study conclusions.

2. Purpose

The purpose of this study is to determine causes of corrosion in facilities based on data from the FICE study and determine categories of causes leading to corrosion in facilities. In addition, this study seeks to identify the building and infrastructure components which are the most problematic (i.e., high maintenance cost and frequent occurrence) with respect to corrosion deterioration, as well as any relevant sensitivity to environmental and corrosion factors of those components. To accomplish this, four separate data analyses are presented:

1) Environmental Severity Index (ESI) Trend Analysis: This analysis seeks to identify corrosion cost drivers that correlate to ESI using the FICE data.

[1] FICE Study. *Facilities and Infrastructure Corrosion Evaluation Study*, Department of Defense, the Director of Corrosion Policy and Oversight, July 2013. http://www.wbdg.org/pdfs/fice_study.pdf.

2) Facility Primary Use Analysis: This analysis merges the Real Property Assets Database with the FICE data to determine the relationship between a facility's primary use and corrosion cost.
3) Actionable Item Analysis: This analysis examines the Fault Detail Description and Fault Summary Description in the FICE data to identify the actionable corrosion issues for the top ten FICE cost drivers and the top twenty-five maintenance objects.
4) Unified Facilities Guide Specification and Unified Facilities Criteria (UFGS/UFC) Analysis: This analysis links the top ten FICE Study cost drivers to their corresponding UFGS and UFCs.

3. Methodology

3.1. Data Discovery

Vision Point Systems (VPS) engineers (B. Shaw, W. McGaulley, and E. Parson) met with LMI representatives to discuss the basis of the data from the FICE study. LMI presented the methodology used to gather and analyze data from facilities and infrastructure maintenance records for the FICE study. From this meeting it was recognized that LMI had aggregated the raw facilities and infrastructure data into a single database and linked the maintenance records to corrosion cost (preventative and corrective), corrosion key words (and phrases), Environmental Severity Index (ESI), and maintenance end items. While this final database was considered proprietary, LMI had a process by which information could be requested. Subsequent to the LMI meeting, VPS requested LMI's cleaner data set for the unique maintenance items identified in Table 3-1 on pages 3-2, 3-5, and 3-7 of the FICE report.

LMI provided the enhanced data set in Microsoft Access format. The data were stored in four tables across two databases. Access queries were used to export the data for the initial phase of analysis with data migrated from Access into a SQL database for more rigorous analysis in later phases. The database fields and definitions are provided in Appendix A.

The databases contained the following quantities of corrosion records (that is, records where total calculated corrosion costs did not equal zero) by aggregated fiscal years:

- Database for FY05, FY07, and FY08: 412,983 records
- Database for FY09, FY10, and FY11: 531,826 records
- Combined Total: 944,809 records

To begin the data transformation process, the non-corrosion records (those records with a total calculated corrosion cost less than or equal to zero) were removed from the data and excluded from further analysis. Next, the ESI values for each Installation's master name were appended to the corrosion record data. To do this, a column assigning each record its respective ESI was generated using each record's installation master name and corresponding ESI.

LMI has developed a list of explicit corrosion keywords based on previous experience with maintenance records. The supplied data tables identified each record with the corrosion keyword or identified the combination of keywords for records without the explicit corrosion keyword. The records with explicit keywords were analyzed to determine the significance of the corrosion keywords. To determine the significance, the percentage of cost associated with each Corrosion Keyword by Maintenance End Item

was presented in a pivot table of all corrosion records for all Fiscal Years. As shown in Figure 1, the phrases 1-word; 1,2-word; 2-word; and 3-word are significant.

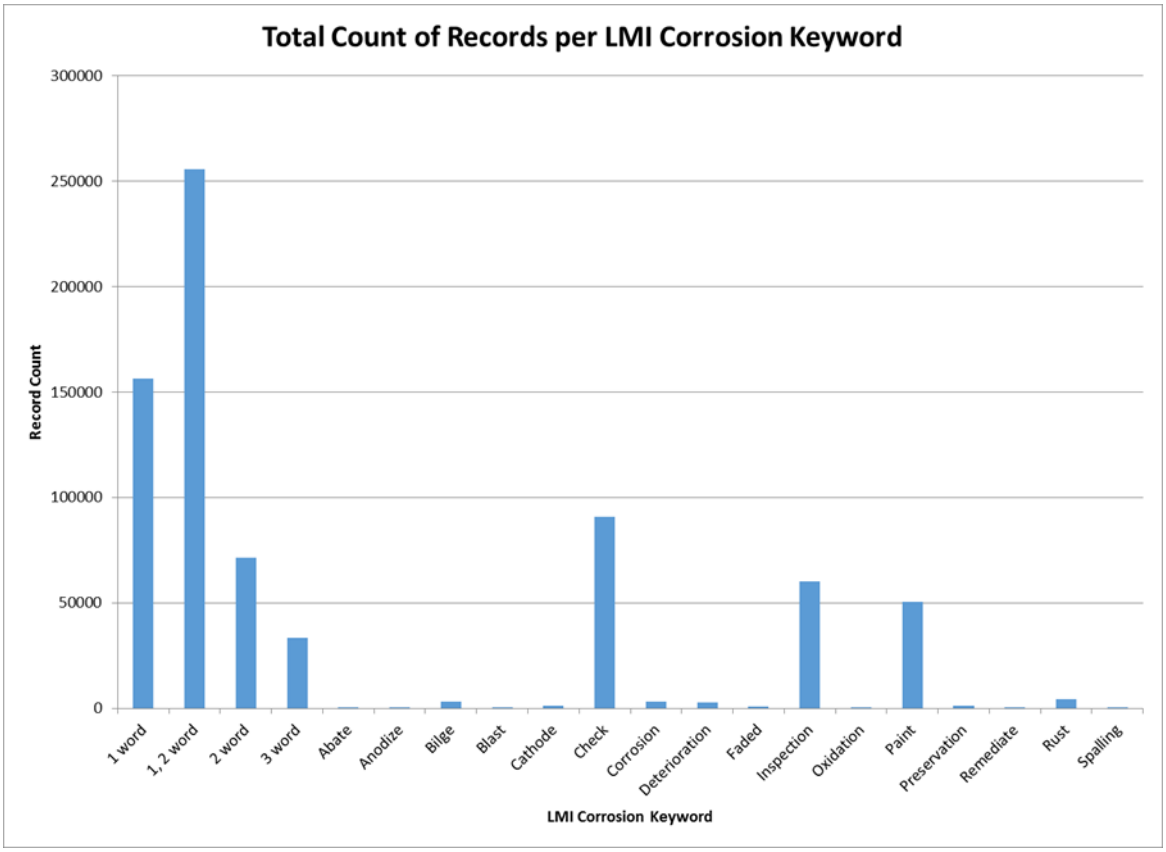

Figure 1. Count of Corrosion Records per LMI Corrosion Keyword

These phrases refer to non-explicit Corrosion Keywords that are designated as 1-word, 2-word, 3-word, or 1,2-word which refer to the noun, verb, and/or adjective that comprise any given corrosion record. Words that are identified by the non-explicit Corrosion Keywords were pulled from a craftsman roundtable matrix that was created by LMI. The craftsman roundtable matrix is considered proprietary by LMI and was not available for our analysis. However, any given record indicates which words qualify as its respective verb, noun, and/or adjective. It was decided to substitute the maintenance verb for the records lacking a defined corrosion keyword. From there, maintenance verbs were examined on a per-cost driver basis. It was observed that all cost drivers had roughly three to five verbs, which comprised the vast majority (frequently over 80%) of the associated costs for that cost driver. As such, these top verbs were extracted for each cost driver and became the list of critical verbs for analysis. This down-selected list of critical verbs was then combined with the remaining Corrosion Keywords. This list now contained several words that were functionally describing the same thing and needed to be combined for further analysis. Therefore, the words inspect, inspection, and check were all combined into "inspection." The words paint and re-paint were combined into "paint." The words rust and corrosion were combined into "corrosion." The keywords Oxidation and Anodize both were observed to have records which required further separation. Within the Oxidation keyword results, records for paint and corrosion existed. A search was conducted within the maintenance operation description text field for

those records with keyword “Oxidation” for the word paint, and the resultant records were combined with the aforementioned “paint” keyword. Subsequently, a search for the words “oxide” and “oxidation” was conducted, and the resulting records were added to the “corrosion” keyword. The records within the “Anodize” keyword were separated by searching the maintenance operation description text field for the terms “anode” and “impressed current.” These records were then placed into the new keyword “ICCP” based on the phrase “impressed current cathodic protection.” Therefore, the final Keyword list consisted of the down-selected “corrosion keywords,” and the top three to five maintenance verbs based on each Maintenance End Item. The Finalized Corrosion Keyword (FCW) list is:

Finalized Corrosion Keyword List		
Abate	Faded	Preservation
Assemble	ICCP	Remediate
Bilge	Inspection	Remove
Blast	Install	Repair
Cathode	Insulate	Replace
Corrosion	Order	Service
Describe	Overhaul	Spalling
Deterioration	Paint	

Figure 2. Finalized Corrosion Keyword (FCW) List

3.2. FICE Study Cost Drivers

The purpose of this work is to identify corrosion issues in facilities so that unified specifications and standards can be improved, leading to a significant reduction in military-wide corrosion costs. However, it was quickly discovered that many of the records in the database did not have an obvious corrosion connection. Many maintenance records included in the database do not explicitly describe a corrosion issue, but rather describe general maintenance issues. For example, a record was identified for replacement of a window due to a leak that was caused by someone breaking the window (i.e., physical damage as opposed to corrosion damage). Corrosion may still play a part in the total cost of replacement through the time required or cost of materials for replacement. Given the objective to capture all costs due to corrosion, some of this cost should be captured as corrosion cost.

These records do not point to issues that are actionable by the facilities’ WIPT to target specifications and standards that will reduce corrosion costs. Therefore, VPS created a data sampling plan to identify explicit corrosion issues and develop a matrix of known facilities corrosion issues to be addressed. First, the cost driver categories needed to be consolidated to concentrate common corrosion issues.

For this effort, Building Ext/Painting and Roof were consolidated into the Facilities/Structure Cost Driver Category. Additionally, Electrical Enclosure (originally not in the top ten) was combined with Exterior Electrical. With these cost drivers consolidated a sampling plan to identify the corrosion specific records was conducted.

The sampling plan consisted of the following: Filter the records with maintenance cost equaling corrosion cost, corrosion cost greater than zero, and keywords “Corrosion,” “Deterioration,” “Rust,” and

"Paint." That subset was then narrowed by combining records of common FICE cost driver and maintenance object combinations, adding those costs for all records together, and filtering again for total costs greater than $90k. This sampling resulted in a collection of cost significant corrosion records that can be analyzed for corrosion issues. From this analysis the top ten FICE corrosion Cost drivers were identified as:

1. Facilities/Structure
2. Plumbing
3. HVAC
4. Electrical
5. Water Heater
6. Wastewater
7. Fence
8. Lighting
9. Cooling/Chiller
10. Pavement/Concrete

4. Corrosion Factors

4.1. Corrosion Factor Discussion

Corrosion, as defined by the Code of Laws of the United States of America, is "the deterioration of a material or its properties due to a reaction of that material with its chemical environment."[2] This is traditionally thought of as the deterioration of a metal due to an oxidization reaction, as in the rusting of steel. However, corrosion also includes the degradation of non-metallic materials, such as rotting of wood, carbonation of concrete, mold and mildew destruction of fabrics and organics, degradation of composite materials. Additional mechanisms of corrosion include fluid flow (i.e., erosion corrosion), stress corrosion cracking, embrittlement, biological processes, and solar/UV exposure.

Corrosion factors exist both in a macro large climatic sense, characterized as being generically in a desert, rainforest, tropical, or arctic environment, as well as smaller micro level conditions, such as pooling water, proximity to the waterfront, industrial contamination, etc. In general, corrosion factors include proximity to salt water, salt fall, industrial activity contaminates (sulfides, nitrides, chlorides, etc.), acid rain, UV exposure, humidity, temperature, rainfall, soil corrosivity, and erosion effects. However, some inherently design-oriented factors, such as dissimilar metals, drainage (pooling water), inaccessible voids, lap joints, crevices, skip weld construction, material considerations, and maintainability can often prove to be more damaging than the macro environment. Attempts have been made to try and consolidate these factors into a single metric such as the Environmental Severity Index (ESI).

ESI (as applied in FICE) relies primarily on a linear ranking of general corrosion rate data taken for steel and aluminum coupons, boldly exposed atmospherically, at facilities throughout the world. This data is supplemented by the FICE researchers with a qualitative weighting of saltfall and humidity for each site.

[2] 10 U.S.C. § 2228(f)(1).

That is, if a site is within one mile of the coast, it gets a saltfall weighting, and if the available data indicate a particular macro-environment surrounding a particular facility has a relative humidity of over 70% most of the time, it gets an additional time-of-wetness weighting.

These additional weightings do follow the rational trend of many researchers that have examined the various important environmental variables that impact corrosivity of sites. Saltfall and time-of-wetness are largely thought to be the two most important variables in determining corrosivity and are often measured and included in indices of site corrosivity. Prime examples are the ISO 9223 standard for corrosivity of environments[3] and research conducted by Federal Highway Administration[4], National Institute of Science and Technology[5], and the U.S. Air Force[6]. Other international efforts have been and are being conducted to address this issue as well. The FICE researchers recognize this limitation to ESI and do well to attempt to address this fact.

In examining the data, it is clear that while corrosion of DoD structures and equipment is certainly influenced by the corrosivity of the general (macro) environment, there is a significant influence of variables that cannot be quantified by a macro environmental index. The microenvironment established by the materials, configuration and orientation of structures and objects has a controlling influence over the specific corrosivity of specific case.

While saltfall is certainly important and impactful, the general quantification of saltfall in a guideline approach is extremely difficult to do in an effective way. For example, qualitative metrics which place the macro environment into a high corrosivity category, such as "saltfall within one mile of the coast" are useful, but not definitive. There is extensive existing data which shows that corrosion rates depend not only on displacement from bodies of salt water, but also on height above the ground, local wind patterns, and the effect of extreme events and storms. Figure 3[7] shows measured corrosion rates for carbon steel at various locations and orientations. This table clearly indicates the potential error of assumption associated with putting definitive weight on macro environment for corrosion design determinations. Macro environment is a good starting point at best, with microenvironment being the true determination of local targeted corrosion rates.

[3] International Standards Organization (ISO) Standard 9223 – Corrosion of Metals and Alloys – Corrosivity of Atmospheres – Classification, Determination, and Estimation.

[4] Ault, P., Ellor, J., Repp, J., and Shaw, B. (2000). "Characterization of the Environment." FHWA-RD-00-030. Federal Highway Administration. McLean, VA.

[5] Ricker, Richard, "Analysis of Pipeline Steel Corrosion Data From NBS (NIST) Studies Conducted Between 1922 – 1940 and Revelance to Pipeline Management," National Institute of Standards and Technology, Jan 2010.

[6] Junge, E., Gustafson, P.E., "On the Distribution of Sea Salt over the United States and its Removal by Precipitation," U.S. Air Force Research Center, Cambridge, MA 1956.

[7] Coburn, S. K., Larrabee, C. P., and Lawson, H. H. (1968). "Corrosiveness of Various Atmospheric Test Sites as Measured by Specimens of Steel and Zinc," *Metal Corrosion in the Atmosphere, Seventieth Annual Meeting, Boston, MA, 25-30 June 1967, ASTM STP 435*, American Society for Testing and Materials. Philadelphia, PA.

Location	Macro Environment	Section Loss (mils/1 yr)	Section Loss (mils/2 yr)
Phoenix, AZ	Rural	0.26	0.36
Vancouver, B.C.	Rural-Marine	0.68	1.05
Detroit, MI	Industrial	0.91	0.28
Potter County, PA	Rural	0.86	1.62
State College, PA	Rural	0.99	1.81
Durham, N.H	Rural	1.39	2.15
Middletown, OH	Semi-industrial	1.43	2.27
Pittsburgh, PA	Industrial (moderate)	1.69	2.41
Bethlehem, PA	Industrial (moderate)	2.17	2.96
Newark, NJ	Industrial	2.85	4.02
Bayonne, NJ	Industrial	5.0	6.1
East Chicago, IN	Industrial	4.37	6.65
Cape Kennedy, FL (0.8 km from coast)	Marine	1.62	6.81
Brazos River, TX	Marine	4.21	7.36
Cape Kennedy, FL (54 m from coast, 18m elevation)	Marine	2.41	10.35
Kure Beach, NC (240 m from coast)	Marine	3.35	11.50
Cape Kennedy, FL (54 m from coast, 9 m elevation)	Marine	2.79	12.99
Daytona Beach, FL	Marine	8.23	23.31
Cape Kennedy, FL (54 m from coast, ground level)	Marine	7.52	34.80
Point Reyes, CA	Marine	12.40	39.53
Kure Beach, NC (24 m from coast)	Marine	28.03	42.13
Cape Kennedy, FL (beach)	Marine	41.61	N/A

Figure 3. Corrosion rates for carbon steel at various locations

Likewise, time-of-wetness, taken by itself, can provide valuable threshold level information about a site, but the actual time of wetness of a surface is a product of its macro environment, materials, orientation (e.g., it is well proven that vertical surfaces have a much lower time of wetness than horizontal surfaces) and its orientation and proximity to features that drain or concentrate runoff. Research has also shown

that it is not just the time of wetness in a generic sense that increases corrosion rates, but the cleanliness of the wetness is a major driver as well. For example, a high time of wetness in the Pacific Northwest, where the rain is heavy but generally "chemically clean," can be far less corrosive than a lower time of wetness in an environment with heavy pollution or airborne contaminants. Additionally, a "time of wetness" measurement within the engineering analysis of corrosivity of an environment is a "reserve indicator" of source. That is, the vast majority of macro environments have plenty of moisture naturally present to support the corrosion process given the complementary presence of an additional chemical or configuration driver for corrosion. All macro environments (except for the very dry, desert-like climates) contain sufficient moisture available in a cyclic fashion to support corrosion of exposed steel if there is chloride present or if the configuration of the structure somehow concentrates or extends the period of the moisture. With this in mind, it is reasonable to assume that while "time of wetness" is certainly an important metric to determine the specific corrosivity of a site, it is not the primary driver, and in the presence of other more critical corrosion drivers (e.g., chlorides), it is only important in that it is present. In the presence of sufficient chlorides, the amount of water present is generally less significant.

Based on this analysis, the 13 corrosion factors for the top maintenance objects and cost drivers are Time of Wetness, Humidity, Temperature, Salt Fall, Rain Fall, Chlorides, Sulfides, Nitrides, Ultraviolet Radiation, Water Immersion, Water Chemistry, Water Acidity/Basicity Measure, and Environmental Severity Index. Figure 4 lists and abbreviates these factors for use and reference in other parts of this report.

Abbreviation	Definition
TOW	Time of Wetness
H	Humidity
Temp	Temperature
SF	Salt Fall
RF	Rain Fall
Cl	Chlorides
S	Sulfides
N	Nitrides
UV	Ultraviolet Radiation
WI	Water Immersion
WC	Water Chemistry
pH	Water Acidity/Basicity Measure
ESI	Environmental Severity Index

Figure 4. Legend of Corrosion Factors

4.2. ESI Trend Analysis

To analyze environmental factors that are impacting corrosion costs, an analysis using Environmental Severity Index (ESI) was conducted. This study sought to determine whether or not ESI provided a correlation to corrosion costs from the FICE study. To determine this correlation ESI values were attached to the records in the FICE data set. Figure 5 presents the installation and corresponding ESI in ascending order along with total corrosion costs and total count of corrosion records for each installation.

ESI and Installation Name	Percent of Cost	Percent of Record Count
2	**1.57%**	**1.80%**
Joint Base Elmendorf-Richardson	1.57%	1.80%
6	**4.49%**	**9.16%**
MCAS Miramar	4.49%	9.16%
7	**3.96%**	**7.34%**
Fort Detrick	2.27%	5.78%
Joint Base Andrews	1.69%	1.56%
8	**7.18%**	**10.52%**
Fort Ap Hill	0.26%	0.26%
Mcb Quantico Va	6.92%	10.26%
11	**25.29%**	**10.79%**
Navsta Norfolk Va	25.29%	10.79%
14	**16.23%**	**28.94%**
FRC North Island	6.50%	7.83%
Mcb Camp Pendleton Ca	9.73%	21.11%
18	**18.35%**	**18.56%**
Fort Shafter	0.06%	0.26%
Joint Base Pearl Harbor-Hickam	16.09%	10.90%
Schofield Barracks	2.20%	7.41%
19	**22.92%**	**12.89%**
Joint Region Marianas	3.77%	2.84%
MCB Hawaii Kaneohe	18.22%	8.82%
Nas Corpus Christi Tx	0.92%	1.23%
Grand Total	**100.00%**	**100.00%**

Figure 5. ESI and Installation Name by Percent Cost of Corrosion and Percent Count of Corrosion Record

Highlighting has been added to Figure 5, with 25% and greater highlighted in red, 5%-25% highlighted in green, and less than 5% highlighted in yellow. Figure 5 demonstrates that there are no direct correlations between ESI and total cost or record count. If there were such a correlation, one would expect cost and/or number of records to increase based on a more severe ESI. This table does demonstrate that the majority of cost are associated with ESI 11 and the majority of the count of records with ESI 14. Additionally one is able to see that of the majority of costs and number of corrosion records are in ESI zones greater than 8.

However, this data could be skewed due to the number of available records for Installations in the 6-8 ESI range being more plentiful than the total number in 14-18 ESI locations. Any further top level ESI analysis would require normalization of the data to facility age and number of facilities per Installation to be meaningful.

Next, an analysis was conducted comparing ESI with the Facility Cost Drivers (FCDs), as shown in Figure 6.

Percent of FCD Corrosion Cost	ESI								
FCD	2	6	7	8	11	14	18	19	Grand Total
Boiler	0.00%	0.01%	1.16%	0.10%	83.79%	7.89%	3.94%	3.10%	100.00%
Bridge	0.00%	0.00%	0.00%	7.42%	1.07%	1.37%	56.97%	33.18%	100.00%
Compressor	0.03%	0.90%	2.27%	3.74%	39.39%	21.11%	17.38%	15.18%	100.00%
Conveyance Line, etc	1.23%	10.08%	3.97%	14.45%	17.55%	27.87%	8.41%	16.44%	100.00%
Cooling, Chiller	0.00%	0.82%	3.40%	4.39%	20.86%	7.61%	15.59%	47.32%	100.00%
Culvert, Ditch	0.31%	0.53%	2.42%	9.87%	18.30%	33.98%	20.57%	14.04%	100.00%
Distribution	0.00%	0.00%	19.65%	0.00%	13.93%	0.63%	48.57%	17.22%	100.00%
Facilities, Structure	2.19%	4.29%	3.12%	10.00%	16.74%	13.75%	17.09%	32.82%	100.00%
Fence	0.00%	6.61%	1.55%	1.19%	25.63%	12.59%	40.04%	12.40%	100.00%
Fire Suppression	1.04%	19.05%	2.29%	9.18%	29.25%	18.93%	11.06%	9.20%	100.00%
Fuel Distribution	10.42%	0.15%	42.13%	41.76%	0.00%	5.95%	0.00%	-0.41%	100.00%
Generator	0.03%	2.36%	1.28%	1.05%	1.44%	0.99%	88.92%	3.94%	100.00%
High Voltage	0.00%	0.68%	0.32%	2.50%	0.00%	37.17%	56.12%	3.21%	100.00%
Hot Water Tank	2.03%	9.76%	0.41%	0.76%	68.60%	9.40%	4.44%	4.59%	100.00%
HVAC	0.53%	3.35%	5.02%	7.61%	32.24%	16.98%	14.17%	20.11%	100.00%
Hydrant	0.03%	54.74%	1.10%	2.89%	4.19%	29.86%	2.00%	5.19%	100.00%
Insulation	0.08%	1.79%	2.83%	9.88%	22.88%	33.71%	14.60%	14.22%	100.00%
Ladder	1.16%	15.86%	0.54%	11.66%	23.82%	14.35%	7.70%	24.90%	100.00%
Lighting, etc	0.03%	0.31%	4.26%	1.96%	8.19%	22.95%	61.04%	1.26%	100.00%
Mold	0.00%	23.38%	0.01%	0.05%	0.00%	72.63%	2.94%	0.99%	100.00%
Pavement, Concrete	8.97%	2.66%	13.37%	5.46%	0.77%	33.66%	20.67%	14.43%	100.00%
Plumbing	1.61%	2.18%	1.45%	2.85%	44.36%	20.84%	13.02%	13.70%	100.00%
Sign	0.16%	2.97%	48.58%	6.43%	4.04%	18.30%	15.21%	4.30%	100.00%
Spillway	0.00%	0.00%	0.00%	53.20%	0.00%	46.80%	0.00%	0.00%	100.00%
Staircase	0.96%	6.23%	2.85%	7.05%	28.22%	12.34%	20.75%	21.61%	100.00%
Steam and Distribution	11.97%	0.03%	25.45%	4.19%	32.50%	25.84%	0.00%	0.02%	100.00%
Storage	0.00%	0.36%	0.00%	7.17%	7.43%	6.52%	1.80%	76.72%	100.00%
Tank, Tower	0.00%	0.00%	3.64%	0.90%	44.03%	14.74%	23.60%	13.10%	100.00%
Valve	0.44%	3.09%	4.23%	4.56%	23.13%	37.28%	12.14%	15.13%	100.00%
Wash Rack	25.68%	0.74%	0.00%	0.28%	15.18%	43.74%	13.60%	0.78%	100.00%
Wastewater	0.09%	1.86%	9.21%	5.48%	13.84%	24.91%	19.23%	25.38%	100.00%
Water Heater	0.29%	3.16%	3.43%	5.53%	38.69%	29.06%	7.35%	12.49%	100.00%
Water Pipe	0.17%	0.21%	12.98%	2.54%	9.12%	57.19%	13.30%	4.50%	100.00%
Waterfront	0.00%	14.48%	0.00%	0.00%	51.43%	0.78%	32.08%	1.22%	100.00%
Electrical	0.84%	3.73%	5.82%	10.80%	19.98%	24.07%	17.30%	17.47%	100.00%
Grand Total	1.57%	4.49%	3.96%	7.18%	25.29%	16.23%	18.35%	22.92%	100.00%

Figure 6. Percent Cost of Corrosion for FCD by ESI

Looking at each FCD separately, one can observe that some trend upward with ESI. Specifically, FCDs Building Exterior – Paint; Cooling, Chiller; Facilities, Structure; Ladder; Storage; and Wastewater tend to demonstrate higher cost percentage with higher ESI. In addition, on a global basis, it is interesting to note that 41 of the 48 percentages above 25% are captured by ESIs of 11 or above. For an ESI of 7 or greater, 46 of the 48 percentages above 25% are captured. If a future goal of relating ESI to

specification decision making is to eliminate high cost items and actions, these data may point to a threshold level which catches a significant majority of bad actions and applications.

Figure 7 depicts a table comparing FCW and ESI based on percentage of total corrosion. In general, the FCWs Corrosion, Deterioration, Faded, and Paint tend to demonstrate higher corrosion costs with higher ESI levels. As in Figure 6, Figure 7 demonstrates that an ESI of 11 or greater captures the majority of the corrosion cost and records.

In Appendix B, an in-depth analysis for each FCW per each FCD was conducted looking at total Corrosion Cost per FCD by FCW.

Percent of FCW Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	2.37%	26.06%	1.32%	0.25%	0.95%	56.11%	7.04%	5.90%	100.00%
Assemble	0.12%	4.21%	1.26%	28.86%	17.75%	28.40%	8.66%	10.74%	100.00%
Bilge	0.00%	0.02%	0.00%	0.00%	4.26%	0.48%	95.22%	0.02%	100.00%
Blast	0.01%	1.02%	1.51%	0.33%	90.52%	5.14%	1.09%	0.39%	100.00%
Cathode	0.00%	0.25%	21.07%	13.40%	24.34%	4.33%	18.58%	18.02%	100.00%
Corrosion	0.09%	3.59%	2.75%	1.94%	7.11%	22.99%	27.26%	34.26%	100.00%
Describe	0.11%	0.19%	0.01%	2.01%	28.39%	7.95%	0.01%	61.34%	100.00%
Deterioration	1.52%	1.69%	0.59%	0.91%	4.46%	2.92%	11.43%	76.48%	100.00%
Faded	0.01%	7.33%	2.55%	5.53%	0.80%	23.19%	29.22%	31.37%	100.00%
ICCP	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Inspect	0.21%	10.75%	6.58%	7.71%	17.37%	29.50%	9.29%	18.58%	100.00%
Install	1.18%	2.17%	8.77%	8.52%	48.72%	16.37%	8.40%	5.87%	100.00%
Insulate	0.12%	0.24%	1.41%	0.93%	68.58%	21.73%	2.49%	4.50%	100.00%
Order	0.01%	0.08%	0.74%	0.27%	64.34%	31.07%	0.39%	3.08%	100.00%
Overhaul	0.00%	0.19%	0.11%	0.01%	90.05%	0.41%	7.48%	1.76%	100.00%
Paint	2.83%	7.82%	5.21%	18.11%	11.40%	19.63%	14.78%	20.21%	100.00%
Preservation	0.20%	4.71%	9.32%	0.95%	4.46%	43.16%	27.38%	9.82%	100.00%
Remediate	0.00%	0.00%	0.01%	0.31%	0.58%	9.31%	79.59%	10.20%	100.00%
Remove	0.75%	-0.05%	4.99%	4.96%	52.98%	11.94%	10.46%	13.97%	100.00%
Repair	2.28%	2.83%	3.50%	5.45%	36.33%	13.82%	27.30%	8.50%	100.00%
Replace	0.47%	2.09%	3.20%	3.93%	43.18%	17.31%	10.47%	19.34%	100.00%
Service	0.04%	12.37%	0.40%	7.04%	35.79%	21.02%	15.01%	8.34%	100.00%
Spalling	7.62%	8.66%	48.71%	0.20%	0.67%	1.07%	5.21%	27.87%	100.00%
Grand Total	**1.57%**	**4.49%**	**3.96%**	**7.18%**	**25.29%**	**16.23%**	**18.35%**	**22.92%**	**100.00%**

Figure 7. Percent Cost of Corrosion for FCW by ESI

The ESIs assigned to each DoD Installation are provided in Appendix D.

5. Facility Primary Use Analysis

The following Figures 8 through 17 are tables listing the predominant facility current use, sum of corrosion costs, and counts of number of corrosion records for each of the ten previously defined FICE cost drivers. It should be noted that entries regarded as NULL are comprised of general grounds maintenance records, records that could not be matched via the above methodology, and records in the LMI data which were missing a facility number. For those cost drivers which have tables longer than ten

records, the tables will be truncated to the top ten, as the vast majority of costs are concentrated within the top five records for any given cost driver.

Predominant Current Use	Sum	Count
Large Unit Headquarters Building	$ 23,937,631	51
Electronic and Communication Maintenance Shop	$ 20,371,137	18
Vehicle Maintenance Shop	$ 16,180,423	75
General Administrative Building	$ 15,571,651	489
NULL	$ 12,173,636	503
Open Mess and Club Facility	$ 2,507,157	53
Indoor Physical Fitness Facility	$ 1,395,520	73
Transient Lodging	$ 1,151,020	39
Enlisted Unaccompanied Personnel Housing	$ 1,147,146	476
Covered Storage Building, Installation	$ 925,066	222

Figure 8. Breakdown of Top 10 Costs for FCD Facilities, Structure

The facility use for the Facilities, Structure cost driver category can be broken into two groups. The first group which is characterized by a small number of large cost jobs such as renovations and refurbishments. The facility types in the first group are Unit Headquarters Buildings, Electronic and Communication Maintenance Shops, Vehicle Maintenance Shops, Open Mess and Club Facility, Indoor Physical Fitness Facility, and Transient Lodging. The second group is characterized by smaller cost jobs that are much more frequent. These are classified as maintenance intensive buildings and include General Administrative Buildings, Enlisted Unaccompanied Personnel Housing, and Covered Storage Buildings.

Predominant Current Use	Sum	Count
NULL	$ 1,367,610	283
General Administrative Building	$ 383,733	59
Applied Instruction Building	$ 381,810	32
Enlisted Unaccompanied Personnel Housing	$ 371,845	379
Prison/Confinement Facility	$ 214,008	6
Small Unit Headquarters Building	$ 211,131	113
Marine Maintenance Shop	$ 209,974	21
Recruit/Trainee Barracks	$ 175,895	29
Vehicle Maintenance Shop	$ 145,415	50
Enlisted Unaccompanied Personnel Housing, Transient	$ 120,828	25

Figure 9. Breakdown of Top 10 Costs for FCD Plumbing

For the Plumbing cost driver the facilities that typically have less frequent but relatively higher cost corrosion issues are General Administrative Buildings, Applied Instruction, Prison/Confinement Facility, Marine Maintenance Shop, recruit/Trainee Barracks, Vehicle Maintenance Ship, and Enlisted Unaccompanied Personnel Housing, Transient. Facilities with low cost but frequent plumbing corrosion issues include Enlisted Unaccompanied Personnel Housing and Small Unit Headquarters Building.

Predominant Current Use	Sum	Count
Covered Storage Building, Installation	$ 12,716,894	26
Family Housing Dwelling	$ 4,575,170	7
NULL	$ 1,996,750	281
Enlisted Unaccompanied Personnel Housing	$ 302,596	78
General Administrative Building	$ 237,184	88
Open Mess and Club Facility	$ 229,857	45
Flight Simulator Facility	$ 218,911	7
Medical Research Laboratory	$ 126,575	13
Vehicle Maintenance Shop	$ 124,934	75
Exchange Sales Facility	$ 121,994	35

Figure 10. Breakdown of Top 10 Costs for FCD HVAC

The two facility types that have the largest HVAC corrosion issues include Covered Storage Building, Installation and Family Housing Dwelling. These two facility types account for greater than 75% of the FICE data in the HVAC cost driver. Other facilities with significant HVAC corrosion issues include Enlisted Unaccompanied Personnel Housing, General Administrative Building, Open Mess and Club, Flight Simulator, Medical research Laboratory, Vehicle Maintenance Shop, and Exchange Sales Facility.

Predominant Current Use	Sum	Count
NULL	$ 1,149,062	148
Communications Building	$ 133,896	3
Ammunition Storage, Depot and Arsenal	$ 130,962	46
Marine Maintenance Shop	$ 118,244	9
Utility Building	$ 110,710	19
Exchange Eating Facility	$ 65,667	8
Large Unit Headquarters Building	$ 50,208	24
General Administrative Building	$ 48,206	18
Enlisted Unaccompanied Personnel Housing	$ 45,403	32
Family Housing Dwelling	$ 44,930	8

Figure 11. Breakdown of Top 10 Costs for FCD Electrical (Exterior Electric and Electrical Enclosures)

The vast majorities of the Electrical FICE Cost Driver records were not associated with a facility and are assumed to be exterior electrical components such as transformers and electrical transmission lines. Facilities that do exhibit some electrical corrosion costs from the FICE data include Communications Building, Ammunition Storage, Depot and Arsenal, Marine Maintenance Shop, Utility Building, Exchange Eating Facility, Large Unit Headquarters Building, General Administrative Building, Enlisted Unaccompanied Personnel Housing, and Family Housing Dwelling.

Predominant Current Use	Sum	Count
NULL	$ 70,102	27
Miscellaneous Operations Support Building	$ 64,934	24
Reserve Training Facility	$ 15,302	2
Fire Station Facility	$ 14,071	6
Small Unit Headquarters Building	$ 12,449	11
Applied Instruction Building	$ 10,650	2
General Administrative Building	$ 9,377	4
Flight Simulator Facility	$ 8,560	9
Working Animal Support Building	$ 4,533	1
General Purpose Instruction Building	$ 3,884	6

Figure 12. Breakdown of Top 10 Costs for FCD Water Heater

Most of the records for water heaters were not associated with a particular type of facility. Therefore a correlation to facility type is not relevant.

Predominant Current Use	Sum	Count
NULL	$ 121,167	18
Small Craft Berthing	$ 26,246	1
Recreation Center	$ 16,635	1
Open Mess and Club Facility	$ 12,939	1
Working Animal Support Building	$ 8,907	3
General Administrative Building	$ 4,720	2
Wharf	$ 4,562	1
Boundary Fence and Wall	$ 4,266	1
Public Restroom/Shower	$ 3,185	1
Operations Support Lab	$ 3,128	1

Figure 13. Breakdown of Top 10 Costs for FCD Fence

Most of the Fencing records were not associated with a facility type directly however facilities that were close to water such as small craft berthing and recreation centers were common.

Predominant Current Use		Sum	Count
Electrical Power Distribution Line, Overhead	$	597,492	228
NULL	$	231,617	88
Exterior Lighting, Pole	$	49,625	1
General Administrative Building	$	3,205	1
Airfield Pavement Lighting	$	2,844	1
Electrical Power Distribution Line, Underground	$	1,003	1
Electrical Power Transformers	$	837	1

Figure 14. Breakdown of Top 10 Costs for FCD Lighting

Most of the fixture issues were associated with externally mounted components with the exception of ceiling light fixtures.

Predominant Current Use		Sum	Count
Utility Building	$	588,785	90
NULL	$	283,613	55
Sewage Treatment	$	48,993	36
Sewage Lift Stations	$	38,877	29
Public Restroom/Shower	$	29,743	11
General Administrative Building	$	13,956	2
Enlisted Unaccompanied Personnel Housing, Transient	$	12,513	1
Family Housing Dwelling	$	2,451	1
Sewer and Industrial Waste Line	$	2,275	1
Family Housing Carport	$	2,081	1

Figure 15. Breakdown of Top 10 Costs for FCD Wastewater

Facilities that exhibited corrosion issues for Waste Water were Utility Building, Sewage Treatment, Sewage Life Stations, and Public Restroom/Shower.

Predominant Current Use		Sum	Count
NULL	$	3,089,294	15
General Administrative Building	$	413,520	11
Enlisted Unaccompanied Personnel Housing	$	228,251	2
Aircraft Maintenance Shop, Depot	$	69,783	6
Covered Storage Building, Installation	$	64,637	19
Refrigeration and Air Conditioning Source	$	60,806	1
Miscellaneous Operations Support Building	$	33,775	1
Miscellaneous Training Facility	$	29,491	1
Photo/TV Production Building	$	18,658	8
Dispensary And Clinic	$	13,196	3

Figure 16. Breakdown of Top 10 Costs for FCD Cooling, Chiller

For the Cooling, Chiller FICE Cost Driver, the corrosion maintenance records did not indicate a strong correlation to a particular facility type. From the data it is assumed that most of the maintenance objects were installed on the exterior of buildings.

Predominant Current Use		Sum	Count
NULL	$	6,242,005	256
Taxiway, Surfaced	$	1,984,853	1
Aircraft Apron, Surfaced	$	227,127	61
Sidewalk and Walkway	$	175,297	1
Aircraft Washing Pad, Surfaced	$	28,795	7
Miscellaneous Paved Area	$	11,873	7
Car Wash Facility	$	965	2
Installation Gas Production Plant	$	296	2
Miscellaneous Airfield Pavement, Surfaced	$	203	1

Figure 17. Breakdown of Top 10 Costs for FCD Pavement, Concrete

As expected, the vast majority of pavement work is associated with a building use of NULL, which would correspond to general grounds maintenance.

6. Actionable Item Analysis

The Actionable Item Analysis involved sorting through the free-text detailed description fields of the maintenance records to identify the root causes of corrosion issues. For this analysis, only records that contained a detailed description were considered. Next, records with identical detailed descriptions were consolidated into single records. Finally, each combination of FICE's cost driver and maintenance

object records was manually sorted to identify the corrosion issues for each combination. The detailed analysis of the top ten cost drivers and each of the top maintenance objects is provided in Appendix C. A summary of the findings from this analysis is for the top ten FICE Cost Drivers is provided in Section 6.1. Additionally, a summary analysis of the top twenty-five maintenance objects is provided in Section 6.2.

6.1. Top Ten FICE Cost Drivers

This first Actionable Item Analysis focuses on the top ten FICE cost drivers and summarizes the types of facilities, maintenance objects, and corrosion factors for each driver. Finally a recommendation on next steps for analysis is provided.

6.1.1. Facilities, Structure

The number one FICE Cost Driver issue is Facilities, Structure. This group is made up of the components of a structure such as roof, walls, windows, doors, stairways, floors, etc. The corrosion cost for this cost driver category can be broken into two groups. The first group which is characterized by a small number of large cost jobs such as renovations and refurbishments. The facility types in the first group are Unit Headquarters Buildings, Electronic and Communication Maintenance Shops, Vehicle Maintenance Shops, Open Mess and Club Facility, Indoor Physical Fitness Facility, and Transient Lodging. The second group is characterized by smaller cost jobs that are much more frequent. These are classified as maintenance intensive buildings and include General Administrative Buildings, Enlisted Unaccompanied Personnel Housing, and Covered Storage Buildings.

Maintenance objects affected in the Facilities, Structure category represents the basic building structural elements, which includes both interior and exterior features. However, exterior features such as doors, windows, gutters, downspouts, and stairways are the components that dominate this category with doors vastly outnumbering all other components. Exterior overhead or rollup doors are the single largest maintenance object accounted for in the corrosion database.

These exterior components are affected by corrosion factors associated with high ESI areas which include high times of wetness (rain), high humidity, high heat (UV exposure), and exposure to contaminates (chlorides, sulfides, etc.).

It is recommended that a review of the materials specified for exterior components in ESI zones 11 and greater be conducted to ensure that materials resistant to corrosion are used. Most common issues related to corrosion of carbon steel components such as exterior doors, hinges, and window frames. Alternatives to carbon steel materials should be considered in high ESI zones such as aluminum, stainless steel, or composites. Finally, training should be conducted to ensure that current best practices for specifying components for exteriors are employed.

6.1.2. Plumbing

The number two FICE Cost Driver issue is Plumbing. This group represents the plumbing fixtures as well as plumbing support components found in building interiors. Facilities that typically have less frequent but relatively higher cost corrosion issues are General Administrative Buildings, Applied Instruction,

Prison/Confinement Facility, Marine Maintenance Shop, recruit/Trainee Barracks, Vehicle Maintenance Ship, and Enlisted Unaccompanied Personnel Housing, Transient. Facilities with low cost but frequent plumbing corrosion issues include Enlisted Unaccompanied Personnel Housing and Small Unit Headquarters Building. The vast majority of plumbing maintenance records are associated with bathrooms spaces and relate to components such as toilets, bath tubs, sinks, faucets, showers, fixtures, piping, and drains.

Corrosion Factors for plumbing maintenance objects include high humidity found in bathrooms leading to high times of wetness that deteriorate some materials especially carbon steel components. In addition to high humidity, local water chemistry can be a contributing corrosion factor to component failure such as hard water deposits. Finally, support components such as brackets, hinges, doors, and partitions constructed of carbon steel lead to significant corrosion cost in this category. It is recommended that components resistant to corrosion in high humidity and high time of wetness environments be specified for bathroom components and carbon steel should be avoided in all cases.

6.1.3. HVAC

Heating Ventilation Air Conditioning (HVAC) Components were the third largest FICE Cost Driver. The two facility types that have the largest HVAC corrosion issues include Covered Storage Building, Installation and Family Housing Dwelling. These two facility types account for greater than 75% of the FICE data in the HVAC cost driver. Other facilities with significant HVAC corrosion issues include Enlisted Unaccompanied Personnel Housing, General Administrative Building, Open Mess and Club, Flight Simulator, Medical research Laboratory, Vehicle Maintenance Shop, and Exchange Sales Facility. Components that makeup Heating Ventilation and Air Conditioning components can be broken in two main environments exterior and interior. For the components exposed the exterior of buildings the corrosion issues were associated with typical carbon steel corrosion. Components mounted in the external environment should be constructed of galvanized steel, aluminum, or stainless steel. For components in ESI zones greater than 11, stainless steel should be considered. The internally mounted components that failed were exposed to high times of wetness due to its function such as condensation coils, chillers, or outside air intakes. Internal HVAC components that function in areas with high times of wetness, carbon steel components should be replaced with corrosion resistant metal alloys and composites when possible. For both exterior and interior components the corrosion factors were high times of wetness.

6.1.4. Electrical

The vast majorities of the Electrical FICE Cost Driver records were not associated with a facility and are assumed to be exterior electrical components such as transformers and electrical transmission lines. Facilities that do exhibit some electrical corrosion costs from the FICE data include Communications Building, Ammunition Storage, Depot and Arsenal, Marine Maintenance Shop, Utility Building, Exchange Eating Facility, Large Unit Headquarters Building, General Administrative Building, Enlisted Unaccompanied Personnel Housing, and Family Housing Dwelling. Components that make up the majority of the electrical corrosion issues are Panel, Breaker, Conduit, Cabinet, and Transformer.

The corrosion issues with electrical panels, breakers, and cabinets can be attributed to interior components that are installed external to facilities or in interior bathrooms. The interior components are not constructed or designed to be exposed to the external environment or in high humidity conditions. Electrical components constructed for external environments should be specified in these situations. Specifications for external electrical boxes should be reviewed to ensure components specified are designed for corrosion protection. Training that provides instruction regarding the selection of proper electrical components should be created and distributed.

The majority of the transformer issues were associated with bases located in Hawaii. It is assumed that the corrosion factors associated with a high ESI zone contributed to the corrosion failure on these units. Transformers that are constructed of corrosion resistant alloys or non-metallic materials should be considered in high ESI zones.

Finally, metal conduit corrosion was a common issue. It is assumed that these were mounted external to a facility. Corrosion Factors for metal conduit corrosion include high humidity, high chlorides, and elevated rain fall.

6.1.5. Water Heater

The fifth largest FICE Cost Driver was associated with Water Heaters. Most of the records for water heaters were not associated with a particular type of facility. Water heaters exhibited many issues that ranged from the general holding tank leaks to individual component failures. Leaking water from water heaters can cause significant and costly damage. Potential corrosion factors include local water chemistry, older piping materials such as iron, and exposure to high humidity bathroom spaces. Standards for water heaters should be developed to ensure they are constructed of the proper materials and can be specified during procurement. Also, standards for the location of water heaters should ensure that they are not installed in spaces and not exposed to high humidity such as bathrooms and showers. Finally, maintenance on hot water heaters should include regularly changing the internal anodes to protect against internal tank corrosion.

6.1.6. Fence

For the Fence FICE Cost Driver, corrosion due to carbon steel deterioration was the most common issue. Fencing located at shore front facilities such as small craft berthing and recreation centers were common. Corrosion Factors for Fences are temperature, proximity to salt water, high humidity, wind, and sand erosion. It is recommended that the minimum standard for fencing would be galvanized steel and that alternative materials to galvanized steel should be considered for high ESI areas.

6.1.7. Lighting

The seventh FICE Cost Driver is Lighting. Corrosion issues within the lighting cost driver were fixtures and poles. Most of the fixture issues were associated with externally mounted components with the exception of ceiling light fixtures. Ceiling fixtures seemed to fail due to exposure to water leaks or high humidity environments such as bathrooms. Standards for externally mounted fixtures should be reviewed to ensure proper construction materials and designs are used for potentially corrosive environments. Electrical pole corrosion issues were concentrated in high ESI areas. Therefore it is

recommended that materials to construct external electrical lines and mounting poles should be reviewed to ensure they are designed for high ESI environments. Corrosion factors for Lighting include proximity to salt water, temperature, humidity, and rain fall.

6.1.8. Waste Water

Facilities that exhibited corrosion issues for Waste Water were Utility Building, Sewage Treatment, Sewage Life Stations, and Public Restroom/Shower. From waste water records it can be determined that waste water facilities are highly corrosive areas and the systems installed in these facilities should be designed for corrosion durability. Corrosion factors for these types of facilities would include water immersion, chemical exposures (hydrogen-sulfide, nitrides, chlorides, acid, caustic), ozone, varying Ph levels, and microbiologically Induced Corrosion (MIC). Most corrosion records related to deterioration of carbon steel components. Specifically, mounting hardware and attachment hardware were often constructed of carbon steel and required replacement. This support components can often be overlooked when specifying or installing components in a high corrosion environment. Records indicated components such as steel stairways were installed in immersion areas that wasted away and became a significant safety hazard.

A field survey of Waste Water facilities should be conducted to determine root cause for corrosion. From the root cause analysis the proper materials can be identified for components and general construction. Specifications should be reviewed to ensure that all components and mounting components be constructed of corrosion resistant materials. Finally, training should be developed to teach best practices for waste water systems design and construction.

6.1.9. Cooling, Chiller

For the Cooling, Chiller FICE Cost Driver, the corrosion maintenance records did not indicate a strong correlation to a particular facility type. From the data it is assumed that most of the maintenance objects were installed on the exterior of buildings. Potential corrosion factors are local water chemistry, older piping or component materials such as iron, and exposure to high humidity environments. There was not an inherent correlation to ESI for this cost driver.

Due to the lack of detail contained in the FICE records, it is recommended that a field survey of Cooling Towers and Chillers should be conducted to determine root cause for corrosion. From the root cause analysis the proper materials can be identified for components and general construction. Specifications should be reviewed to ensure that all components and mounting components be constructed of corrosion resistant materials, especially those exposed to high humidity environments.

6.1.10. Pavement, Concrete

The last of the top ten FICE Cost Drivers is for Pavement, Concrete. This category includes asphalt, concrete, curbs and associated painting. The pavement and concrete issues consisted of replacing or repairing runways, general pavement/concrete, and painting lines or markings.

It is not possible to determine the root cause from this data exercise. Information on the age and micro-environment are needed to determine if failures were a result of use, age, or the environment. In

general corrosion factors for pavement and concrete are temperature, load-use, rain fall, UV exposure, and freeze thaw cycles. It is recommended that a site survey be conduct to determine possible root causes with facility managers that maintain pavement, concrete systems. Certain maintenance practices such as surface sealing may offer life cycle cost savings.

6.2. Top Twenty-Five FICE Maintenance Objects

In addition to the top ten FICE cost drivers, an analysis of each of the top twenty-five maintenance objects was conducted. The top twenty-five maintenance objects were determined by summing the total corrosion costs of each maintenance object and dividing by the total corrosion costs to derive the overall percentage that object represents in reference to total cost. This percentage was then used to sort the maintenance objects for this top twenty-five list analysis. From this sorting the top twenty-five maintenance objects exhibited an overall corrosion cost of 1% or greater, all other maintenance objects were less than 1%. For each maintenance object an analysis of the maintenance records description to determine the corrosion issues and corresponding corrosion factor is conducted. Results are provided in Figure 18.

Maintenance Object	FICE Cost Driver	Corrosion Factors	Percent of Overall Corrosion Cost
Door	Facilities, Structure	ESI, UV, H, Cl, S, RF, SF	17%
Toilet	Plumbing	WC, TOW	7%
Valve	Plumbing	WC, TOW	5%
Ceiling	Facilities, Structure	TOW	5%
Faucet	Plumbing	WC, TOW	5%
Shower	Plumbing	WC, TOW	4%
Roof	Facilities, Structure	TOW, UV, RF, Temp	4%
Piping	Plumbing	WC, TOW, WI	3%
Stairway	Facilities, Structure	ESI, UV, H, Cl, S, RF, SF	3%
Sink	Plumbing	WC, TOW, WI	2%
Water Heater	Water Heater	WC, TOW	2%
Gutter	Facilities, Structure	TOW, RF, SF, Cl	2%
Fence	Fence	ESI, H, RF, SF, Cl, S	2%
Window	Facilities, Structure	ESI, UV, H, Cl, Su, RF, SF	2%
Ventilation	HVAC	ESI, H, RF, SF, Cl, S	2%
Air Handler	HVAC	TOW, H, Cl	2%
Fixture	Lighting	ESI, H, RF, SF, Cl, S	2%
Wastewater plant	Wastewater	WI, S, Cl, N, TOW, WC, pH	2%
Panel	Electrical	ESI, H, RF, SF, Cl, S	1%
Water fountain	Plumbing	WC, TOW	1%
Transformer	Electrical	ESI, H, RF, SF, Cl, S	1%
Breaker	Electrical	ESI, H, RF, SF, Cl, S	1%
Fixture	Plumbing	WC, TOW	1%
Floor	Facilities, Structure	TOW	1%
Boiler	HVAC	WC, TOW	1%

Figure 18. Top 25 FICE Maintenance Objects

6.2.1. Door

It is noted that “Doors” represent the largest group of maintenance objects in the Facilities, Structures group. Further reduction in the data to the detailed description associated with these records yields the specific corrosion issues associated with each maintenance object. This further reduction for “Doors” yields the following detailed corrosion issues:

Rollup door general corrosion and track and roller corrosion
Exterior entrance door coating failure, door corrosion, frame/jam corrosion, hinge corrosion
Interior/Bathroom door general corrosion, hinge corrosion

Figure 19. Door Corrosion Description

The number one issue concerns roll up or overhead doors. These records primarily reference corrosion issues with the panels and with the track and rollers. Next are the exterior doors which concern general coating failures and general corrosion, door frame or door jamb corrosion, and hinge corrosion issues. Finally, interior or bathroom doors exhibited issues with general corrosion and hinge corrosion.

Corrosion Factors: It is assumed that the majority of the “Door” corrosion issues are from carbon steel components. However, this is not conclusive and materials should be considered when improving door corrosion. Additionally, it is assumed that the exterior door corrosion is more likely to occur in high ESI environments. Therefore, the corrosion factors are proximity to salt water, rain fall, temperature, humidity, and UV exposure.

Recommendation: Conduct a review of the current state-of-the-art for overhead and rollup doors. Survey the industry for Overhead and Rollup doors to determine if corrosion resistant doors can be specified. Additionally, review external and entrance door specifications for corrosion control design and material use. Seek to specify doors that eliminate the use of carbon steel fasteners, hinges, and general components. If carbon steel is used in construction ensure that proper corrosion control coatings are specified.

6.2.2. Toilet

The vast majority of “Plumbing” maintenance objects are associated with bathrooms, specifically “Toilet.” High time of wetness in bathrooms can cause steel-based components to corrode and fail. Further analysis of detailed toilet maintenance records reveal the following specific corrosion issues:

Rusted Urinal
Rusted Spud
Rusted Bolts
Rusted Pipes
Rusted Sinks
Rusted Bath
Leaking Pipes
Rusted Drains
Corroded urinal handle
Rusted Flange
Valve corrosion
Broken toilet seat
Corroded Flush Rod
Water Contains Rust

Figure 20. Toilet Corrosion Descriptions

Corrosion Factors: Corrosion factors for Toilets are prolonged exposure to water and humidity, which lead to the deterioration of the toilet components.

Recommendation: Investigate toilet components materials that can effectively withstand exposure to water and humidity.

6.2.3. Valve

The next largest maintenance object for the Plumbing group is "Valve." The data reduction exercise for "Valve" yielded the following issues:

Sink valve corrosion
Shower valve corrosion
Corroded flush valves
Rusted propane tank shutoff valve
Corroded gate valves
Water main seal corrosion
Rusted drainage pipe
Corroded sink trap
Deteriorated water main valves
Deteriorated steam bypass valves
Valve Leakage
Corroded ball valves
Rusted valve cover
Shut off valve corrosion
Corroded chill water valve
Washer dryer valves corroded

Figure 21. Valve Corrosion Descriptions

The majority of the records in the Valve category were associated with bathrooms, such as sink, shower, and toilet valves. However, significant issues were also observed in water main piping valves, steam distribution valves, chilled water line valves, and finally washer machine shut offs.

Corrosion Factors: Corrosion factors are local water chemistry, older valve materials such as iron, and external valve components exposed to the environment.

Recommendation: Conduct a field survey of failed valves to determine root cause and follow-on recommendations.

6.2.4. Ceiling

The fourth largest maintenance object was Ceiling within the Facilities, Structure group. The data reduction exercise for "Ceiling" yielded the following issues:

Drop Ceiling Frame Corrosion
Deterioration from water leak from roof
Deterioration from water leak from piping

Figure 22. Ceiling Corrosion Description

Most "Ceiling" records expressed deterioration that required replacement of tiles or dry wall. Additionally, records described corrosion of the drop ceiling frame.

Corrosion Factors: Most records relate the deterioration to water leaks from either piping or roof leaks. The water damage caused the ceiling material to deteriorate to a point where repairs were required. The next most common issue was due to corrosion of drop ceiling frames. It is assumed that these were steel frames that corroded due to water leaks or exposure to high humidity in bathrooms.

Recommendation: The majority of these issues would be resolved if water leaks from piping systems and roofs were identified early, before major damage has occurred. It is recommended that studies into leak detection technologies be investigated in an effort to find a practical cost effective method to detect leaks at their onset. Finally, steel drop ceiling frames should be eliminated and replaced with aluminum where possible.

6.2.5. Faucet

Bathroom faucet corrosion
Pipe/hose corrosion
Corroded faucets for washers
Shower faucet corrosion
Corroded sink fixtures
Corroded Shower Faucet
Male head faucet corroded
Faucet leaks
Leaking sink
Broken faucet handles
Sink faucet deteriorating

Figure 23. Faucet Corrosion Descriptions

All faucet records related to bathrooms. Faucet issues ranged from hose issues to leaking sinks to damaged handles.

Corrosion Factors: Corrosion factors are local water chemistry, older faucet materials such as iron, and exposure to high humidity bathrooms.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

6.2.6. Shower

Corroded shower heads
Shower pipe leaking
Shower handle corrosion
Shower wall water damage
Deteriorating ceramic tile in shower
Rusted threads on shower head arm
Corroded shower drain
Corroded shower stall
Rusted emergency shower piping
Shower panel rust
Deteriorating plaster around shower
Metal trim rusted
Rusty shower water

Figure 24. Shower Corrosion Descriptions

Shower records issues ranged from fixtures such as the shower head and handles to supply water piping and water drainage piping to the wall/stall materials and trim.

Corrosion Factors: There is not enough information in the data to determine a root cause. Potential root causes are local water chemistry, carbon steel shower components, and exposure to high humidity head spaces.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

6.2.7. Roof

The seventh largest maintenance object was "Roof" and is within the Facilities structure group. The data reduction exercise for "Roof" yielded the following issues:

Metal roof corrosion
Metal flashing corrosion
General roof leaks

Figure 25. Roof Corrosion Descriptions

Most "Roof" records were connected with deterioration of the roofing material so that leaks were present. The materials associated with the roof were not noted on the majority of the records, however, some records indicated corrosion with metal roofs and metal flashing materials.

Corrosion Factors: A material investigation needs to be conducted to determine if corrosion prone materials are being specified. It is generally assumed that most leaks are due to poor installation or age.

Recommendation: Review roofing specifications and standards to eliminate corrosion prone materials.

6.2.8. Piping

Steam/condensate piping deteriorated
Washer pipe corrosion
corroded sink drain pipe
Flush arms leak
Corroded drainage pipe
Leaking rusted pipes
Corroded sink piping
Steam leak
Deteriorated water lines

Figure 26. Piping Corrosion Descriptions

Corrosion Factors: Most piping issues are related to bathrooms and drain pipes. It is assumed that these failures are due to clogged drain pipes that retain water and other contaminates that deteriorate the pipe. Other issues are associated with steam and water supply piping. Typical corrosion factors are local issues with water/steam chemistry and water immersion.

Recommendation: Using non-metallic materials where practical for drain lines is recommended. For supply lines a survey should be conducted to determine root cause. From the root cause recommendations should be made to specify proper materials for steam/water chemistries.

6.2.9. Stairway

The ninth largest maintenance object is “Stairway” and is within the Facilities structure group. The data reduction exercise for “Stairway” yielded the following issues:

Steel stairway corrosion
Stairway tread corrosion
Wood Stairway deterioration
Concrete stairway deterioration

Figure 27. Stairway Corrosion Descriptions

Most “Stairway” records were connected with deterioration of the stairway material. Records that indicated deterioration of metal, wood and concrete were identified. Additionally, stairway treads were identified as a corrosion issue.

Corrosion Factors: It is assumed that most corrosion issues were due to stairways on the exterior of buildings. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Ensure that specifications and standards consider the environment when specifying stairway materials. Certain materials are known to perform better in certain environments, such as fiberglass in chemical environments or galvanized steel in exterior environments.

6.2.10. Sink

Rusted Sinks
Corroded handles
Rust in water from sink
Corroded sink drain
Sink leaks

Figure 28. Sink Corrosion Descriptions

Corrosion Factors: Most sink issues are related to the sink bowl corroding. Corrosion factors are damaged porcelain/steel sinks that are exposed to high times of wetness leading to corrosion. Typically the porcelain chips and exposes the steel substrate, leading to corrosion.

Recommendation: Specify sink materials that are non-metal construction or stainless steel.

6.2.11. Water Heater

Water heater rusted
Water heater leaking
Deteriorated water heater
Corroded water heater pipes
Deteriorated wood door
Corroded supply and return hoses
Corroded valves
Instant water heater rusted
Corroded pipe under sink
Rusted gas water heater

Figure 29. Water Heater Corrosion Descriptions

Water heaters exhibited many issues that ranged from the general holding tank to individual components. Leaking water from water heaters can cause significant and costly damage.

Corrosion Factors: Corrosion factors are local water chemistry, older piping materials such as iron, and exposure to high humidity bathrooms.

Recommendation: Standards for water heaters should be developed to ensure they are constructed of the proper materials and can be specified during procurement. Additionally, maintenance on hot water heaters should include regularly changing the internal anodes to protect against internal tank corrosion.

6.2.12. Gutter

The next largest maintenance object is "Gutter." The data reduction exercise for "Gutter" yielded the following issue:

Corroded metal gutters

Figure 30. Gutter Corrosion Description

Most "Gutter" records were connected with deterioration of the metal gutters that were causing leaks.

Corrosion Factors: It is assumed that the root cause of corrosion is from steel or iron gutters and down spouts, where the material is lost due to pooling water. However, other materials such as aluminum or copper may be the issue. These materials can corrode especially in marine environments, albeit more slowly than steel. Therefore, the corrosion factors for gutters would include high time of wetness, rain fall, and saltfall.

Recommendation: Conduct inspections of corroded gutters and down spouts to determine an actual root cause. Follow-up the root cause analysis with updates to specifications and standards.

6.2.13. Fence

Deteriorated fence line
Fence post rusted
Corroded fencing
Corroded barbed wire
Hole caused by deterioration

Figure 31. Fence Corrosion Descriptions

Corrosion Factors: Fencing corrosion due to carbon steel deterioration was the most common issue. The data did not provide enough detail to determine if the issues were related to galvanized materials or if they were related to high ESI areas. Typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: It is assumed that the minimum standard for fencing would be galvanized materials. Alternatives to galvanized materials should be considered for high ESI areas.

6.2.14. Window

The next largest maintenance object is "Window." The data reduction exercise for "Window" yielded the following issues:

Wood frame deterioration
Metal frame rusting
Concrete around window deterioration

Figure 32. Window Corrosion Descriptions

Most "Window" records were connected with deterioration of the frame materials, with both metal and wood identified as frame materials. The frame deterioration typically led to leaks or window operation issues. Additionally, concrete and rebar surrounding windows were noted to have deterioration issues.

Corrosion Factors: It assumed that the root cause is connected to environmental factors associated with high ESI areas (i.e., high humidity, high heat, exposure to chlorides).

Recommendation: Review the materials specified for high ESI areas to ensure that materials resistant to corrosion are used.

6.2.15. Ventilation

AC air intake rusted
AC vent rusted/deteriorating
Rusted grill vent
ventillation fan corroded
Rust holes in fan housing
supply fan corrosion
Corroded metal brackets
Deteriorated hoses
Corroded ventalation mount
Deteriorated vent pipe
Corroded vent stack
Corroded screen
Fly wheel corrosion
Corroded ventilation turbine

Figure 33. Ventilation Corrosion Descriptions

The ventilation records encompassed a large range of components as observed in the above list. Components include hoses, ducting, fans, grills, and piping.

Corrosion Factors: It is assumed that the ventilation HVAC issues are in environments with high humidity and high ESI zones. The ventilation system in general is exhibiting corrosion because the components were not designed for these types of environments.

Recommendation: Conduct a field survey of ventilation systems to determine root cause and follow-on recommendations. Potential solution to duct corrosion would be selection of non-steel construction materials.

6.2.16. Air Handler

Discharge chamber floor rusting
Supply motor foundation rusting
Corroded housing
Chilled water return thermometer deteriorated
Deteriorated cw piping
Rusted condensate pan
Corroded valve
Deteriorated air handler
Broken steam supply line
Blower wheels rusted
Inoperable air conditioners
Box filters deteriorating
Rusted ducts
Corroded air handlers

Figure 34. Air Handler Corrosion Descriptions

The air handler records encompassed a large range of components as can be observed from the above list. Components include air handlers, foundations, thermometers, piping, condenser pans, and ducting.

Corrosion Factors: It is assumed that the ventilation HVAC issues are in environments with high humidity and high ESI zones. The air handler system in general is exhibiting corrosion because the components were not designed for these types of environments.

Recommendation: Conduct a field survey of air handler systems to determine root cause and follow-on recommendations. Again, potential solution to duct corrosion would be selection of non-steel construction materials for high ESI environments.

6.2.17. Fixture

Corroded ceiling light fixture
Deteriorated security light fixtures
Rusted weather proof light fixtures
Corroded light fixture covers
Rusted flood lights
Lighting swivel arm corroded
Rusted emergency light fixtures
Corroded motion detector
Corroded screws in light covers

Figure 35. Light Fixture Corrosion Descriptions

Corrosion Factors: Most of the fixture issues were associated with externally mounted components, with the exception of ceiling light fixtures. Ceiling fixtures seemed to fail due to exposure to water leaks or high humidity environments such as bathrooms.

Recommendation: Externally mounted fixtures should be reviewed to ensure proper construction materials are used for potentially corrosive environments.

6.2.18. Wastewater Plant

Lift station pump corroded
Corroded air line relief valve riser
Corroded piping
Corroded elbows
Rust damaged wheel-barrows
Rusted anchor links
Rusted chain
Corroded valve
Corroded bolts
Corroded Conduit
Corroded hose rib
Corroded Pressure Regulators
Air tank corrosion
Corrosion damaged guage mount
Corroded guide rail plugs
Corroded nuts and washers
Rusted angle mounts
Rusted Unistrut supports
Rusted Jib Crane

Figure 36. Wastewater Plant Corrosion Descriptions

Corrosion Factors: From these records it can be determined that wastewater facilities are highly corrosive areas and the systems installed in these facilities should be designed for corrosion durability. Corrosion factors for these types of facilities would include water immersion, chemical exposures (hydrogen-sulfide, nitrides, chlorides, acids, caustics), ozone, varying Ph levels, and microbiologically induced corrosion (MIC). Most corrosion records related to the deterioration of carbon steel components. Specifically, mounting hardware and attachment hardware were often constructed from carbon steel and required replacement. These support components can often be overlooked when specifying or installing components in a high corrosion environment. Records indicated components such as steel stairways were installed in immersion areas, wasted away and became significant safety hazards.

Recommendation: A field survey of wastewater facilities should be conducted to determine root cause for corrosion. From the root cause analysis, the proper materials can be identified for components and general construction. Specifications should be reviewed to ensure that all components and mounting components be constructed of corrosion resistant materials.

6.2.19. Panel

access panel rusting
Corroding panels
Rusted overhead panels
Rusted utilities box
Corroded pannel on stall in head
Corroded base panel under sink

Figure 37. Panel Corrosion Descriptions

Corrosion Factors: The above issues with electrical panels can be attributed to panels mounted externally to facilities and to panels mounted in bathrooms. It is assumed that these panels are not designed to be exposed to the external environment or high humidity conditions. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Panels constructed for external environments should be considered in these situations. Specifications for external electrical boxes should be reviewed to ensure components specified are designed for corrosion protection.

6.2.20. Water Fountain

Corroded drain pipe
Corroded water fountain
Replace water fountain filter
Water filter leaks
Corroded water fountain drain
Tap rusted out
Corroded water fountain spout

Figure 38. Water Fountain Corrosion Descriptions

Corrosion Factors: Water fountain corrosion issues ranged from drain pipes to filters to spouts. Corrosion factors are local water chemistry, carbon steel components, clogged drain lines (immersion), and exposure to high humidity spaces.

Recommendation: Conduct a field survey of failed water fountains to determine root cause and follow-on recommendations.

6.2.21. Transformer

Corroded transformer
Deteriorated pad-mounted transformer
Corrosion holes in transformer
Corroded transformer door hinges

Figure 39. Transformer Corrosion Descriptions

Corrosion Factors: The majority of the transformer issues were associated with bases located in Hawaii. It is assumed that the corrosive environment was the root cause on these units. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Transformers that are constructed of corrosion resistant alloys or non-metallic materials should be considered in high ESI environments.

6.2.22. Breaker

Breaker corroded
deteriorating breaker boxes
Circuit breaker door corroded
Rusted electrical outlets
Wooden breaker enclosure deteriorating

Figure 40. Breaker Corrosion Descriptions

Corrosion Factors: Breaker corrosion is very similar to the electrical panel issues mentioned previously. These were electrical boxes mounted externally to a facility and were not constructed of materials intended for external exposure. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Alternative construction materials for electrical enclosures and internal components should be considered for external exposures.

6.2.23. Fixture

Corroded bathtub and shower fixtures
Rusted fitting
Rusted overhead vent
Corroded light fixtures

Figure 41. Fixture Corrosion Descriptions

Most fixture records related to bathrooms. Fixture issues ranged from hose issues to leaking sinks to damaged handles. The one exception being light fixtures, however these were light fixtures primarily in bathrooms.

Corrosion Factors: Corrosion factors are local water chemistry, older faucet materials such as iron, and exposure to high humidity bathrooms.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

6.2.24. Floor

The next largest maintenance object within the Facilities structure group is "Floor." The data reduction exercise for "Floor" yielded the following issues:

Bathroom floor tile deterioration
Floor tile deterioration
Floor coating deteroration

Figure 42. Floor Corrosion Descriptions

Most "Floor" records were connected with deterioration of the tile and coatings. The majority of the flooring issues were associated with bathrooms.

Corrosion Factors: From the data, is it assumed that prolonged exposure to water and humidity lead to the deterioration of the floor materials.

Recommendation: Investigate flooring materials that can effectively withstand exposure to water and humidity.

6.2.25. Boiler

Corroded boiler
Bottom rusted out
Corroded tank top
Rusted circ pump line
Corroded pipe fitting
Boiler leaking
Coils deteriorated
Corroded pumps
Corroded flow switch
Corroded temperatute sensor
Corroded valve

Figure 43. Boiler Corrosion Descriptions

Corrosion Factors: The boiler records seemed to describe most components contained in boiler systems. Therefore, it is assumed that these systems operate in inherently harsh conditions. Corrosion factors include water immersion, elevated temperatures, and combustion exhaust contamination leading to corrosion failures.

Recommendation: A site survey of current boiler conditions should be conducted to assess boiler root causes. The survey should be followed up by a thorough review of boiler design and construction materials needs to be conducted to determine specifications.

7. Relating FICE Study Data Analysis to Potential Applications within UFCs/USGSs

One target outcome of the subject research is determination of factors for corrosion that drive the major cost factors for DoD facilities corrosion. The analysis to-date has focused efforts on a list of items that have the largest impact on overall facilities corrosion cost as output from the FICE Study. The list of the top ten items appears below:

1) Facilities, Structure
2) HVAC
3) Plumbing
4) Building Exterior, Painting
5) Waterfront
6) Exterior Electric
7) Pavement, Concrete
8) Roof
9) Cooling, Chiller
10) Wastewater

While this list has value in focusing efforts to reduce or eliminate corrosion impact going forward on items with the highest potential payoff, direct application of this list to refine present design guidance is limited in that it does not follow a naming and numbering convention consistent with the CSI Masterformat. That is, a further exercise is necessary to relate these top impacting items to the present UFC specification structure so that a list of working actions for UFC and UFGS improvements can be developed, planned and executed.

A proposed approach to adding corrosion protection value to facilities infrastructure would be to enhance the guidance provided to the design process by the UFCs which directly impact the high corrosion cost items as determined by the FICE study. This process involves two primary actions:

- First, a focused list of UFCs and UFGSs that provide guidance impacting the top cost items must be defined; and,
- Second, the guidance in each of these UFCs UFCs/UFGSs must be analyzed and compared to available, proven industry best practices. Once these best practices are defined, they can be added, as appropriate to the UFCs and UFGSs.

7.1. Target UFCs/UFGSs for Corrosion Lead Actors

Relating the top ten corrosion cost items to specific UFCs/UFGSs results in the following list of UFCs as potential targets for improvement, or at least, review and examination. This matching of items produces a manageable list of target UFCs/UFGSs for insertion of corrosion hardening language. UFCs/UFGSs that either appear multiple times or are directly tied to the corrosion item in left column are bolded as an

initial screen for prioritization. Other, non-bolded, items on the list are UFCs that appear to be closely related, or possibly impact the corrosion item, but further, detailed review of each document would be needed to determine specific needs for that document.

Corrosion Lead Actors	Applicable UFC/UFGS
Facilities, structure	>UFC 3-190-06 Protective Coatings and Paints >UFC 3-270-04 Concrete Repair >UFC 3-301-01 Structural Engineering >UFC 3-310-08 Non-Expeditionary Bridge Inspection, Maintenance and Repair, with Change 1 >UFC 3-220-06 Grouting Methods and Equipment >UFC 3-440-05N Tropical Engineering, with Changes 1-2 >UFGS 08 34 63 Detention Hollow Metal Frames, Doors, and Door Frames >UFGS 08 34 53 Security Doors and Frames >UFGS 08 33 23 Overhead Coiling Doors >UFGS 08 34 16.10 Steel Sliding Hangar Doors >UFGS 08 34 19.10 20 Rolling Service and Fire Doors >UFGS 08 34 16 Corrosion Control Hangar Doors >UFGS 08 11 16 Aluminum Doors and Frames >UFGS 08 39 53 Blast Resistant Doors >UFGS 08 36 13 Sectional Overhead Doors >UFGS 08 32 13 Aluminum Sliding Glass Doors >UFGS 08 91 00 Metal Louvers >UFGS 08 11 73 Sliding Fire Doors >UFGS 08 11 13 Steel Doors and Frames >UFGS 08 39 54 Blast Resistant Doors >UFGS 08 71 00 Door Hardware >UFGS 08 11 69 Metal Storm Doors >UFGS 08 36 19 Vertical Lift Doors >UFGS 08 13 73 Sliding Metal Doors >UFGS 08 33 13 Metal Rolling Counter Doors
HVAC	>UFC 3-410-01 Heating, Ventilating, and Air Conditioning Systems >UFC 3-410-04N Industrial Ventilation >UFC 3-430-01FA Heating and Cooling Distribution Systems >UFC 3-440-05N Tropical Engineering, with Changes 1-2 >UFC 3-430-02FA Central Steam Boiler Plants, with Change 1 >UFC 3-430-07 Inspection and Certification of Boilers and Unfired Pressure Vessels, with Changes 1-3 >UFC 3-430-08N Central Heating Plants >UFC 3-430-09 Exterior Mechanical Utility Distribution, with Change 1 >UFC 3-440-01 Active Solar Preheat Systems, with Change 1 >UFC 3-440-04N Solar Heating of Buildings and Domestic Hot Water >UFGS 23 00 00 Air Supply, Distribution, Ventilation, and Exhaust Systems >UFGS 33 63 13 Exterior Underground Steam Distribution Systems

Corrosion Lead Actors	Applicable UFC/UFGS
Plumbing	>UFC 3-230-01 Water Storage, Distribution, and Transmission >UFC 3-230-02 O&M: Water Supply Systems >UFC 3-420-01 Plumbing Systems, with Changes 1-8 >UFC 3-420-02FA Compressed Air, with Change 1 >UFC 3-130-05 Utilities - Arctic and Subarctic Construction >UFGS 10 28 13 Toilet Accessories >UFC 4-720-01 Lodging Facilities >UFGS 10 21 13 Toilet Compartments
Building exterior – Paint	>UFC 3-190-06 Protective Coatings and Paints >UFC 3-130-07 Buildings - Arctic and Subarctic Construction >UFC 3-440-05N Tropical Engineering, with Changes 1-2
Exterior electric	>UFC 3-550-01 Exterior Electrical Power Distribution >UFC 3-130-05 Utilities - Arctic and Subarctic Construction >UFC 3-440-05N Tropical Engineering, with Changes 1-2 >UFC 3-530-01 Design: Interior and Exterior Lighting and Controls, with Change 3 (Revised) >UFC 3-535-01 Visual Air Navigation Facilities >UFC 3-555-01N 400 Hertz Medium Voltage Conversion/Distribution and Low Voltage Utilization Systems >UFC 3-570-02A Cathodic Protection >UFC 3-570-02N Electrical Engineering Cathodic Protection >UFC 3-570-06 O&M: Cathodic Protection Systems >UFC 3-575-01 Lightning and Static Electricity Protection Systems >UFC 3-580-01 Telecommunications Building Cabling Systems Planning and Design >UFGS 26 11 14.00 10 Main Electric Supply Station and Substation

Corrosion Lead Actors	Applicable UFC/UFGS
Pavement, concrete	>UFC 3-250-01FA Pavement Design for Roads, Streets, Walks, and Open Storage Areas >UFC 3-250-04 Standard Practice for Concrete Pavements, with Change 2 >UFC 3-250-06 Repair of Rigid Pavements Using Epoxy Resin Grouts, Mortars and Concretes >UFC 3-250-08FA Standard Practice for Sealing Joints and Cracks in Rigid and Flexible Pavements >UFC 3-260-02 Pavement Design for Airfields >UFC 3-260-03 Airfield Pavement Evaluation >UFC 3-260-16FA Airfield Pavement Condition Survey Procedures Pavements >UFC 3-270-03 Concrete Crack and Partial-Depth Spall Repair >UFC 3-270-04 Concrete Repair >UFC 3-270-07 O&M: Airfield Damage Repair >UFC 3-440-05N Tropical Engineering, with Changes 1-2 >UFC 3-270-08 Pavement Maintenance Management >UFGS 03 31 29 Marine Concrete >UFGS 03 31 01.00 10 Cast-in-place Structural Concrete for Civil Works >UFGS 03 45 00 Precast Architectural Concrete >UFGS 03 23 00 Steel Stressing Tendons and Accessories for Prestressed Concrete >UFGS 03 41 33Precast Structural Pretensioned Concrete >UFGS 03 01 30.71 Concrete Rehabilitation >UFGS 03 47 13 Tilt-Up Concrete
Waterfront	>UFC 4-150-07 Maintenance and Operation: Maintenance of Waterfront Facilities, with Change 1 >UFC 4-151-10 General Criteria for Waterfront Construction >UFC 3-440-05N Tropical Engineering, with Changes 1-2 >UFC 4-150-02 Dockside Utilities for Ship Service, with Change 5 >UFC 4-152-01 Design: Piers and Wharves; with Change 1 >UFC 4-152-07 Design: Small Craft Berthing Facilities; with Change 1 >UFC 4-159-03 Design: Moorings, with Change 1 >UFC 4-213-10 Design: Graving Drydocks, with Change 1 >UFC 4-213-12 Drydocking Facilities Characteristics >UFGS 09 97 13.26 Coating of Steel Waterfront Structures
Roof	>UFC 3-110-03 Roofing >UFC 3-110-04 Roofing Maintenance and Repair >UFC 3-440-05N Tropical Engineering, with Changes 1-2 >UFGS 03 51 01 Precast Roof Decks >UFGS 07 41 13 Metal Roof Panels >UFGS 07 51 13 Built up Asphalt Roofing >UFGS 07 57 13 Sprayed Polyurethane Foam (SPF) Roofing
Cooling, chiller	>UFC 4-826-10 Design: Refrigeration Systems for Cold Storage

Corrosion Lead Actors	Applicable UFC/UFGS
Wastewater	>UFC 3-230-03 Water Treatment >UFC 3-240-01 Wastewater Collection >UFC 3-240-02 Domestic Wastewater Treatment >UFC 3-240-03N Wastewater Treatment System >UFC 3-240-13FN Industrial Water Treatment Operation and Maintenance Augmenting Handbook Operation and Maintenance >UFC 4-832-01N Design: Industrial and Oily Wastewater Control
Lighting	>UFC 3-530-01 Design: Interior and Exterior Lighting and Controls, with Change 3 >UFC 3-535-01 Visual Air Navigation Facilities >UFC 3-575-01 Lightning and Static Electricity Protection Systems >UFGS 26 56 00 Exterior Lighting
Fence	>UFC 4-010-03 Security Engineering: Physical Security Measures for High-Risk Personnel >UFC 4-020-01 DoD Security Engineering Facilities Planning Manual >UFC 4-022-03 Security Fences and Gates >UFGS 32 31 26 Wire Fences and Gates >UFGS 32 31 13.53 High-security Chain Link Fences and Gates >UFGS 32 31 13 Chain Link Fences and Gates
Water Heater	>UFGS 22 00 70 Plumbing, Healthcare Facilities >UFGS 22 00 00 Plumbing General Purpose
Sign	>UFGS 26 53 00.00 40 Exit Signs >UFC 3-120-01 Design: Sign Standards, with Change 1
Compressor	>UFGS 23 52 33.02 20 Steam Heating Plant Watertube (Field Erected) Coal/Oil or Coal >UFGS 23 64 10 Water Chillers, Vapor Compression Type >UFGS 22 15 19.13 20 Large Nonlubricated Reciprocating Air Compressors >UFGS 23 82 02.00 10 Unitary Heating and Cooling Equipment >UFGS 22 16 19.26 20 Large Centrifugal Air Compressors >UFGS 43 15 00.00 20 Low Pressure Compressed Air Piping
Generator	>UFGS 26 32 15.00 10 Diesel Generator Set Stationary 100-2500 KW, with Auxilliaries >UFGS 26 32 14.00 10 Diesel Generator Set, Stationary 15-300 KW, Standby Application >UFGS 26 32 26 Motor Generator Sets, 44 HZ >UFGS 2632 13.00 20 Single Operation Generator Sets
Tank, tower	>UFGS 09 97 13.25 Maintenance, Repair, and Coating of Tall Antenna Towers >UFC 2-000-05N Facility Planning for Navy and Marine Corps Shore Installations >Central Vehicle Wash Facilities

Figure 44. Target UFCs/UFGSs for Corrosion Lead Actors

In-depth review and analysis of each of the highlighted UFCs/UFGSs indicated above is beyond the scope of the subject effort; however, a selected review was made of several of these documents to point to

some priority areas where known, technically valid solutions are available or can be readily developed. This effort is intended to point to a selected list of high value, relatively low effort changes that can add significant corrosion protection value to the existing practices and to demonstrate a potential methodology for updating these documents in future corrosion enhancement efforts.

7.1.1. UFC 3-190-06 Protective Coatings and Paints

This document is now ten years old, with a date of JAN2004. This document is a comprehensive guide for corrosion protection and building durability enhancement using protective coatings. It includes sections of the various components of coatings, advantages and disadvantages of various coating types, health and safety issues, coating selection guidelines, and even failure analysis guidance. Section 1.3, Deterioration of Facilities, is a brief section providing some of the causes and mitigation techniques for corrosion and deterioration of various common building materials. The information contained in this section appears to be informative and technically correct; however, it would likely be of significant value to review, update and enhance this section. Of particular use would be the development and inclusion of some figures to append to paragraph 1.3.4, Design Factors Affecting Deterioration. This paragraph can lead designers to understand how to better understand the detailing required to ensure high quality painting application and long term performance.

Additionally, Section 4: Selection of Coatings, and Section 5: Coatings Systems for Specific Uses, could be updated to include information developed in the industrial coatings industry within the past decade. Of particular interest would be the application of high build, solvent-free and plural component applied coatings. Coatings with rapid dry properties could be of particular use in many applications that require repair and rapid return to service. Also, the extension of some of the very high performance materials (ultra-weatherable topcoats, single and two coat high durability systems) and systems that have come into use in the industrial coating sector could be selectively inserted into this guidance.

7.1.2. UFC 4-150-07 Maintenance and Operation: Maintenance of Waterfront Facilities, with Change 1

This document is an excellent collection of guidance on design and construction of waterfront structures and facilities. It was recently updated (2012) and the content shows that the update captured a significant amount of guidance regarding proper corrosion protection practice. Section 3: Materials for Preventive Maintenance, is particularly good and much of this guidance could likely be used throughout other UFCs that have not been updated recently. For example, the guidance on the proper selection and use of low water/cement ratio (pozzalanic) concretes is very good and up to date. Such use of “High Performance Concrete” has proven beneficial to mitigating corrosion in other industries over the past two decades.

There are a few areas that could still be strengthened. For example, the wording regarding the use of stainless steels refers to “300 series” rather than specific alloys. There is certainly a proven difference in resistance to pitting among the various 300 series alloys, so calling out of 316 SS may be of benefit for high durability requirements like those found on the waterfront. An additional area that could be covered in Chapter 3 to a greater extent is the effect of UV radiation from the sun on the deterioration

of waterfront materials. Particularly of concern would be the effect of UV on deterioration of non-metallic materials like plastics, coatings, foams, etc.

7.1.3. UFC 4-151-10 General Criteria for Waterfront Construction

UFC-4-150-10 was also updated in 2012 and has much of the same general enhancement as UFC 4-150-07. In fact, this UFC directly references the Maintenance and Operation UFC for its information on material deterioration. There is one item to note in this UFC. It is the service life default of 25 years for design given in 5.1. This design service life should be reviewed for adequacy. The trend for other public infrastructure has been to push design standards out for longer periods. For example, the long standing highway bridge design service life was 50 years until about 10 years ago when it was increased to 75 years. Many structure owners are now using a design service life of 100+ years. This change has had a significant effect on the bridge design community and forced attention to be paid to durable materials and methods.

The present study also analyzed the relationship between corrosion cost and Environmental Severity Index (ESI). Although the findings are not definitive given the current data set, the data point to some correlation between the ESI of a particular site and the corrosion cost. However, this relationship is certainly not linear and increasing from the data analyzed. Rather, there is an apparent increase in overall facility corrosion costs for ESI rated facilities that are in the range of 11-14 ESI. This result indicates that facilities with moderate to just above moderate corrosivity ratings have a significant corrosion cost impact. One hypothesis for this result is that these environments are not obviously "highly corrosive" (i.e., they are not directly near the coast) so they do not receive construction specifications that have enhanced corrosion control investment. The ironic result of lower apparent cost associated with sites of the highest corrosivity index (e.g., ESI=15-18) could be the result of upfront design investment in enhanced corrosion protection during the construction of these facilities.

7.1.4. UFC 3-440-05N Tropical Engineering

One example of these design standards is the UFC for Tropic Engineering (UFC 3-440-05N). This standard contains enhanced corrosion control materials selection and design standards that require an investment in corrosion protection. They are called out for geographically "tropical" facility locations. The results of the current study indicate that the extension of these enhanced corrosion protection design practices may be of significant value for facilities located beyond geographical tropical locations (i.e., extension of corrosion enhancement to facilities in ESI 11-14 areas).

It is informative to consider the "purpose" definition contained in the Tropical Engineering UFC:

> *"...to upgrade the quality of design and construction and thereby extend the economic life of shore facilities in an environment considered aggressive because of constant sun, rain, salt, and humidity; frequent high winds, wind-blown sand, and salt spray; High Solar Radiation, High Humidity (Above 70% most of the year), Extreme Events (Intense Rain Periods, Tsunamis, Storm Surges, Earthquakes, Monsoons, Volcanoes), Prolonged Elevated Temperatures and Salt Laden Air."*

These environmental characteristics are certainly not limited to tropical latitudes, and where they occur outside of the Tropics, these environments can certainly have similar effects at Northern and Southern latitudes. The corrosion effects of these extreme and regular environmental events can be seen in as a key contributor to corrosive sites worldwide.

Extension of these provisions should be done in a judicious manner so as to contain and manage additional resources expended. This targeted extension should use the FICE study top impacting items list as a starting point.

A review of the current language in the UFC for Tropical Engineering produces a significant list of guidance that can be useful in reducing corrosion costs if translated to construction of facilities beyond the narrow definition of tropical, but known to be in areas that produce corrosion related costs as indicated by the FICE study.

The following examples show promise in enhancing the corrosion hardening of some of the top corrosion cost items.

Much of the document is qualitative and is written with a purpose of awareness for the designer, but several highlight sections point to the need for either enhancement of this document or translation of the corrosion hardening guidance given for Tropical Engineering toward effect corrosion enhancement for corrosive, non-tropical installations.

Specific examples from UFC 3-440-05N Tropical Engineering, with Changes 1-2, are:

7.1.4.1. Section 3: Concrete

This section could be greatly enhanced by referring to the specific guidance associated with the current widespread use of High Performance Concrete (HPC). HPC is a low water/cement ratio concrete that develops high early strength and low permeability. It has been adopted by the highway and other concrete construction industries as a material form with high strength to weight ratio and excellent durability.

7.1.4.2. Section 5: Metals

This section has a lot of very good general guidance and qualitative language to make the designer aware of the pitfalls in design that frequently lead to corrosion. The wording of many of these sections could be made more specific and the language could easily be modified from referencing “tropical” to referencing a corrosivity category or index (e.g., ESI) in order to properly apply this guidance. An example of the beneficial language follows:

> *5.7.1. Corrosion Exposure. The areas adjacent to miscellaneous metal items are often more susceptible to corrosion than their component parts, due partly because of damage during installation. This condition is worse when dissimilar metals are used. When exposed to aggressive elements, these areas become the most corrosive locations on any project. Exposed architectural items are likewise subject to significant corrosion; these include items such as handrails, protective guards, and wire screens.*

5.7.2. Corrosive Environment. In a corrosive environment, even with the proper selection of materials, the careless installation procedures of components can completely negate the quality of the designed project.

5.7.3. Dissimilar Metals. Galvanic corrosion, where dissimilar metals are encountered, creates major problem areas when not properly protected. Where dissimilar metals are specified, provide protective coating (insulation) between the items.

7.1.4.3. Section 8: Doors and Windows

This section provides specific guidance to the designer to take care of details of building envelope openings because of the tendency of these structures to be initiation points for corrosion and deterioration. The FICE study cited doors and windows in this regard many times over. Translating some of the existing best practice language from this Tropical Engineering UFC to a more generic document targeting structures in moderate to corrosive locations (based on a corrosivity metric rather than geographical latitude) would certainly have a measureable benefit to reduce corrosion related cost.

7.1.4.4. Section 14: Mechanical

This section holds guidance on durable construction that would certainly impact the HVAC, wastewater, and cooler/chiller categories at a minimum.

7.1.4.5. Section 15: Electrical

This section cites specific examples of corrosion and durability enhancement that cover almost all of the top 10 FICE Study items directly.

7.1.4.6. Additional Possible Enhancements

Additionally, the present content of the Tropical Engineering UFC should be reviewed and updated with state of the practice corrosion protection materials and methods. For example, the use of epoxy-coated rebar, stainless and stainless clad rebar, and high performance concrete mixes is a practice that has had significant corrosion control benefits for U.S. highway infrastructure. These practices are well-known and defined, and could be inserted into the UFCs for Tropical Engineering and Waterfront Structures and Marine Concrete with relative ease.

8. Conclusions

1) From analysis of the FICE Study data is can be concluded that Facilities, Structure is the number one Cost Driver for corrosion costs. This category, as expected, contains the external building elements such as doors, windows, roofing, gutters, downspouts, stairs, and attachments which typically are exposed to the most severe corrosive conditions. However, by far Doors are the largest maintenance object corrosion costs for facilities.
2) There exist UFCs and UFGSs for all maintenance items and cost drivers. These criteria documents identify a minimum level of material performance including corrosion protection

over a wide range of available materials. However, corrosion durability is not emphasized in most cases nor is enhanced corrosion protection required for more severe environments and higher ESI zones. Typically the choice of material and any corrosion enhancement is the designer's choice based on experience and best practices and is often limited by budget constraints.

3) Facilities that are constructed in ESI zones of 11 or greater demonstrate higher costs due to corrosion. Therefore, Facilities in ESI Zones great than or equal to 11 should consider corrosion durability during design, construction, and maintenance.
4) The majority of the interior maintenance objects corrosion factors were from two sources 1) roof and plumbing leaks and 2) high humidity bathroom spaces. The majority of the roof and plumbing leaks affected maintenance objects such as ceilings, floors, walls, and light fixtures. The majority of the high humidity bathroom spaces were plumbing related maintenance objects such as facets, valves, piping, drains, and plumbing fixtures.
5) The facility types that are characterized by a small number of large cost jobs such as renovations and refurbishments include Unit Headquarters Buildings, Electronic and Communication Maintenance Shops, Vehicle Maintenance Shops, Open Mess and Club Facility, Indoor Physical Fitness Facility, and Transient Lodging. For these facilities renovation\refurbishment guidelines and training are needed.
6) The facility types characterized by smaller cost jobs that are much more frequent include General Administrative Buildings, Enlisted Unaccompanied Personnel Housing, and Covered Storage Buildings. For these facilities maintenance guidelines and training for corrosion durability are needed.
7) Large portions of the corrosion cost were due to installing interior components in exterior environments. Most of these components are covered within current UFC/UFGS standards and guidelines in the proper manner. Training is needed to ensure the proper standards are used during renovation and repair/maintenance operations at the local level.

9. Data Gaps

1) Currently there is a significant data gap in root cause analysis. The FICE data does not adequately provide enough information to determine root cause. Specifically, the FICE data does not contain information on facility age, component material, local environment, component use, or maintenance performed.
2) There is a gap in comparing the corrosion maintenance objects to the project drawings and specifications used in the construction of the facilities. The design and construction documents would need to be compared to the maintenance objects to determine the root cause of problems, i.e. whether the component or system was installed correctly in accordance with the project specification, or if the project specification did not specify installation standard or method. This would determine if there was a design deficiency or a construction quality control deficiency.

3) There is a data gap on the current state-of-the-art in facility component design for corrosion control. There is not a military design guide dedicated to corrosion resistant components or designs for harsh environments. Therefore, maintainers do not have proper guidance regarding replacement parts for corrosion control.
4) There is a data gap on facility location. The RPAD data contains GIS coordinates for entire base sites, but it is not specific to individual facilities. All facilities at a base are given the same location.
5) There is a data gap regarding material deterioration based on environment for non-carbon-steel materials. Carbon steel has been used to identify high ESI areas; however, non-carbon-steel materials such as copper, aluminum, concrete, wood, coatings, fiberglass, roofing, vinyl siding, and asphalt have not been characterized. For example, vinyl siding is known to be degraded by UV light exposure, however, the ESI rating does not including UV exposure as a parameter.
6) There is a data gap regarding material deterioration in internal spaces. Specifically, there is currently no data on environmental conditions in wet spaces such as heads and showers.
7) There is no expected life or design life data for facilities or components.

10. Recommendations

1) Current best practices for corrosion control in new construction (design) and maintenance should be codified, documented, and indoctrinated into the DoD facilities community. Most of the corrosion issues in the FICE data were due to installation of improper components or materials for the local environment. For example, unsealed interior electrical junction boxes installed in the exterior environment. The correct components are known but those implementing or repairing facilities are not trained on the current best practices.
2) For ESI zones 11 and higher, consider enhanced corrosion protection for the top maintenance objects sensitive to ESI. In addition, consider enhanced construction quality control for those maintenance objects.
3) It is recommended that a corrosion team conduct site surveys of the top ten FICE cost drivers. The purpose of these surveys would be to confirm or to establish root causes of the corrosion cost drivers. The team should consist of Facility Managers, UFGS/UFC specialists, and Corrosion SMEs. The team should visit at least two bases in two different services to determine core corrosion issues.
4) It is recommended that the corrosion team develop specific facility/maintenance object inspection survey forms. These forms can then be used to gather specific data from facility managers from several bases for analysis.
5) It is recommended that a Facility Corrosion Control test program be established to test, evaluate, and demonstrate viable corrosion control technologies and components in real world situations. Additionally, the facilities management community will obtain valuable data on the "should" costs associated with facility corrosion maintenance.

6) It is recommended that a data call to industry be conducted for the top maintenance objects for corrosion resistant components with their associated cost data. These technologies should be evaluated in the T, E, & D program.
7) It is recommended that business cases for the top maintenance objects be created to determine the most cost effective implantation of corrosion resistant components.

11. Suggested Technology Demonstrations

1) Leak sensors for piping systems: Install leak detection for piping systems during new construction. Significant corrosion costs were associated with repairs after water damage due to leaking pipes. If these leaks can be detected early, before major damage occurs, significant cost savings can be realized.
2) Fabric ducting: Several corrosion records under the HVAC FICE cost driver referred to rusted ducting. A technology demonstration using fabric ducting for HVAC systems should be considered in environments where steel or galvanized ducting can fail.
3) Electroless nickel-plated sprinkler heads: Several sprinkler corrosion records leaked due to corrosion in high humidity head spaces. A technology demonstration to install electroless nickel sprinkler heads in high humidity head spaces with known corrosion issues should be considered.
4) Fiberglass transformer box pad: Several exterior electrical records expressed corrosion of electrical transformer boxes in tropical environments. A technology demonstration to install fiberglass box enclosures for transformers should be considered.
5) Corrosion resistant overhead/roll-up door: The number one corrosion issue was exterior and roll-up doors. Several door manufacturers claim roll-up doors with corrosion resistant and low maintenance components. A technology demonstration of these doors should be considered.

Appendix A. Data Definitions

The following fields comprise the database provided by LMI, a private, not-for-profit corporation that provides management consulting, research, and analysis to governments and other nonprofit organizations:

- AccountCode
- CalcLaborCorroCost: Calculated labor cost multiplied by corrosion percentage
- CalcLaborCost: Calculated labor cost (man hours multiplied by labor rate)
- CalcMatlCorroCost: Calculated material cost multiplied by corrosion percentage
- CalcMatlCost: Sum of material costs
- CivilianHours: Labor hours attributed to civilians
- CalcContractCorroCost: Calculated corrosion cost attributed to contractors
- CorrectiveCorroCost: Total calculated corrosion cost multiplied by 1 if action is corrective
- CorrectiveMaintCost: Total calculated cost multiplied by 1 if action is corrective
- CorroCostFlag: Yes or no identifier of whether or not the record is associated with corrosion
- CorroKeyword: The word or code that caused the record to be flagged for corrosion
- CorroPerc: Corrosion percentage based upon corrosion algorithm (algorithm proprietary to LMI)
- CorrosionAdjective: The adjective, If present, associated with the corrosion maintenance record
- DataSource: Database from which records were obtained
- FAC: Facility Asset Category Code; some created by LMI
- FacilityClassification: Major structure based on FAC
- FacilityIDCode: Code service uses to ID facility
- FacilityName: Facility name; usually the same as FacilityIDCode
- FacilityNumber: Facility number specific to installation
- FamilyHousingInd: Yes or no identifier of whether or not the facility is typed as family housing
- FaultCauseCD: Fault code (most missing)
- FaultDetailDesc: A detailed description of the fault
- FaultSummaryDesc: A more generalized description of the fault
- InstallationMasterName: Normalized installation name
- JobControlNumber: Job Control Number
- LMICraftCode: Master craft identifier (e.g. HVAC)
- MaintActionFY: Fiscal year for a given record
- MainCompletionDate: Date of maintenance completion
- MaintDLH: Number of man hours to complete maintenance action
- MaintObject: The object associated with the corrosion maintenance record (if present)
- MaintOperationDetailDesc: The detailed description of the maintenance operation
- MaintOperationKeyword: The verb associated with the corrosion maintenance record (if present)
- MaintStartDate: Date of maintenance start

- MaintSubWorkCt: Sub-work center performing maintenance action
- MaintWorkCtr: Code for work center performing maintenance action
- MaintWorkCtrDesc: Text description of MaintWorkCtr
- MilitaryLaborHours: Labor hours attributed to military
- PreventiveCorrective: Preventive or corrective identifier
- PreventiveMaintCost: Total calculated cost multiplied by 1 if action is preventive
- Service: Service identifier (e.g. Army, Marine Corps, etc.)
- SubJCN: Sub-Job Control Number
- TotalCalcCorroCost: Total calculated corrosion cost multiplied by 1 if action is preventive
- TotalCalcCost: Total maintenance cost after scaling
- LMI_ID: Unique number identifier for every record
- WPC: Work performance category code; identifies general category of work
- Source_ID: Unique counter contained in source file
- xxxfices_cost_driver: FICE's cost driver identifier

Appendix B. ESI Analysis

B.1. Boiler

Percent of Corrosion Cost	ESI							
FCW	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Bilge	0.00%	0.00%	0.00%	0.43%	0.00%	0.00%	0.00%	0.36%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.95%	0.25%
Corrosion	0.00%	0.00%	0.00%	0.07%	8.64%	0.00%	5.01%	0.90%
Deterioration	0.00%	56.24%	0.00%	0.00%	2.46%	0.00%	0.00%	0.85%
Inspect	0.00%	15.69%	53.44%	6.53%	70.33%	35.84%	38.42%	13.86%
Install	0.00%	0.00%	0.00%	0.53%	0.19%	1.20%	0.94%	0.53%
Insulate	0.00%	0.00%	0.00%	1.15%	0.00%	0.00%	0.00%	0.96%
Order	0.00%	0.00%	0.00%	17.50%	0.00%	0.16%	0.00%	14.67%
Overhaul	0.00%	0.00%	0.00%	30.70%	0.00%	0.00%	0.00%	25.72%
Paint	0.00%	0.00%	46.56%	0.63%	18.29%	29.04%	8.09%	3.42%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.99%	0.19%
Remove	0.00%	0.00%	0.00%	1.18%	0.00%	0.50%	0.11%	1.01%
Repair	100.00%	27.96%	0.00%	15.13%	0.00%	22.25%	29.03%	14.78%
Replace	0.00%	0.10%	0.00%	19.54%	0.09%	11.01%	4.46%	16.95%
Service	0.00%	0.00%	0.00%	6.61%	0.00%	0.00%	0.00%	5.54%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 45. Boiler, Percent Cost of Corrosion Total by Column FCW by ESI

The most significant FCWs for Boiler are:

1) Overhaul
2) Replace
3) Repair
4) Order
5) Inspect
6) Service
7) Paint
8) Remove

Percent of Corrosion Cost	ESI							
FCW	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Bilge	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	6.97%	75.78%	0.00%	17.26%	100.00%
Deterioration	0.00%	77.08%	0.00%	0.00%	22.92%	0.00%	0.00%	100.00%
Inspect	0.00%	1.32%	0.39%	39.47%	40.04%	10.18%	8.60%	100.00%
Install	0.00%	0.00%	0.00%	82.86%	2.77%	8.88%	5.49%	100.00%
Insulate	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Order	0.00%	0.00%	0.00%	99.96%	0.00%	0.04%	0.00%	100.00%
Overhaul	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Paint	0.00%	0.00%	1.39%	15.52%	42.26%	33.48%	7.34%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Remove	0.00%	0.00%	0.00%	97.72%	0.00%	1.95%	0.33%	100.00%
Repair	0.05%	2.20%	0.00%	85.73%	0.00%	5.93%	6.09%	100.00%
Replace	0.00%	0.01%	0.00%	96.58%	0.04%	2.56%	0.82%	100.00%
Service	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Grand Total	**0.01%**	**1.16%**	**0.10%**	**83.79%**	**7.89%**	**3.94%**	**3.10%**	**100.00%**

Figure 46. Boiler, Percent Cost of Corrosion Total by Row FCW by ESI

None of the FCWs for Boiler trend with ESI.

B.2. Bridge

Percent of Corrosion Cost	ESI					
FCW	8	11	14	18	19	Grand Total
Bilge	0.00%	0.00%	0.00%	14.71%	0.00%	8.38%
Deterioration	0.00%	0.00%	0.00%	0.00%	100.00%	33.18%
Inspect	50.88%	100.00%	100.00%	0.00%	0.00%	6.21%
Paint	49.12%	0.00%	0.00%	81.72%	0.00%	50.20%
Preservation	0.00%	0.00%	0.00%	3.57%	0.00%	2.03%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 47. Bridge, Percent Cost of Corrosion Total by Column FCW by ESI

The most significant FCWs for Bridge are:

1) Paint
2) Deterioration
3) Bilge
4) Inspect
5) Preservation

Percent of Corrosion Cost	ESI					
FCW	8	11	14	18	19	Grand Total
Bilge	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Inspect	60.80%	17.18%	22.02%	0.00%	0.00%	100.00%
Paint	7.26%	0.00%	0.00%	92.74%	0.00%	100.00%
Preservation	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Grand Total	**7.42%**	**1.07%**	**1.37%**	**56.97%**	**33.18%**	**100.00%**

Figure 48. Bridge, Percent Cost of Corrosion Total by Row FCW by ESI

ESI does not trend with the FCWs for Bridge. However, the majority of the cost for the FCD is focused in ESIs 18 and 19 for all FCW with the exception of Inspect.

B.3. Compressor

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	6.35%	0.00%	5.28%	0.00%	0.48%	1.91%	0.03%	0.69%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.89%	0.00%	0.00%	0.19%
Corrosion	0.00%	0.00%	0.00%	0.64%	0.00%	4.92%	1.18%	20.18%	4.33%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.00%	0.00%	0.01%
Deterioration	0.00%	0.00%	0.00%	0.00%	38.15%	0.00%	2.22%	0.92%	15.55%
Inspect	19.68%	22.14%	38.93%	15.69%	3.04%	23.20%	8.52%	27.14%	13.37%
Install	0.00%	0.14%	1.24%	2.10%	0.61%	3.40%	0.10%	0.69%	1.19%
Order	0.00%	0.00%	0.00%	0.04%	0.00%	0.06%	0.29%	0.08%	0.08%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
Paint	0.00%	0.00%	5.60%	2.24%	0.00%	2.23%	0.02%	2.91%	1.13%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	26.81%	0.00%	0.01%	5.66%
Remove	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
Repair	38.77%	27.46%	29.52%	49.57%	10.60%	13.74%	43.53%	19.89%	20.44%
Replace	41.02%	41.95%	24.71%	24.06%	47.37%	23.95%	42.00%	28.14%	37.14%
Service	0.53%	1.96%	0.00%	0.39%	0.23%	0.28%	0.22%	0.00%	0.22%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 49. Compressor, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Compressor are:

1) Replace
2) Repair
3) Deterioration
4) Inspect
5) Preservation
6) Corrosion
7) Install

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	8.26%	0.00%	28.48%	0.17%	14.58%	47.94%	0.57%	100.00%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	0.55%	0.00%	23.97%	4.75%	70.73%	100.00%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	96.62%	0.00%	2.48%	0.89%	100.00%
Inspect	0.05%	1.49%	6.60%	4.39%	8.95%	36.63%	11.07%	30.82%	100.00%
Install	0.00%	0.11%	2.37%	6.59%	20.22%	60.41%	1.50%	8.80%	100.00%
Order	0.00%	0.00%	0.00%	1.95%	0.00%	17.37%	65.02%	15.66%	100.00%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Paint	0.00%	0.00%	11.27%	7.45%	0.00%	41.76%	0.31%	39.21%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	99.97%	0.00%	0.03%	100.00%
Remove	0.00%	0.00%	0.00%	0.00%	85.75%	0.00%	0.00%	14.25%	100.00%
Repair	0.06%	1.21%	3.27%	9.07%	20.42%	14.19%	37.01%	14.78%	100.00%
Replace	0.04%	1.02%	1.51%	2.42%	50.24%	13.62%	19.65%	11.50%	100.00%
Service	0.08%	8.06%	0.00%	6.65%	40.81%	27.04%	17.29%	0.08%	100.00%
Grand Total	**0.03%**	**0.90%**	**2.27%**	**3.74%**	**39.39%**	**21.11%**	**17.38%**	**15.18%**	**100.00%**

Figure 50. Compressor, Percent Cost of Corrosion Total by Column FCW by ESI

FCW Corrosion trends with ESI.

B.4. Conveyance Line, etc.

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.90%	3.43%	0.00%	0.00%	0.91%	0.15%	0.00%	0.20%	0.59%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.01%	0.00%	0.17%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.66%	0.00%	0.06%
Corrosion	0.00%	2.77%	0.00%	2.79%	0.00%	8.96%	0.00%	4.36%	3.90%
Deterioration	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.05%	0.00%	0.09%
Inspect	4.74%	79.80%	5.72%	13.08%	2.51%	26.39%	13.11%	14.55%	21.51%
Install	4.53%	0.00%	0.18%	0.80%	28.48%	6.11%	0.00%	0.97%	7.04%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.25%	0.00%	0.02%
Paint	7.41%	4.84%	0.00%	53.94%	0.00%	36.34%	58.88%	49.59%	31.60%
Preservation	0.00%	0.00%	60.80%	0.00%	0.00%	0.00%	0.00%	0.00%	2.42%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.39%	0.00%	0.03%
Remove	0.27%	0.20%	0.00%	0.22%	0.00%	0.00%	0.00%	0.07%	0.07%
Repair	68.22%	3.27%	8.45%	24.48%	57.85%	11.62%	13.75%	12.93%	21.72%
Replace	13.94%	4.66%	24.86%	4.69%	10.24%	10.17%	8.19%	17.33%	10.48%
Service	0.00%	1.03%	0.00%	0.00%	0.00%	0.27%	1.71%	0.00%	0.32%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 51. Conveyance Line, etc., Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Conveyance Line, etc. are:

1) Paint
2) Repair
3) Inspect
4) Replace
5) Install
6) Corrosion
7) Preservation

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	1.88%	58.54%	0.00%	0.00%	27.08%	6.92%	0.00%	5.58%	100.00%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Corrosion	0.00%	7.17%	0.00%	10.34%	0.00%	64.08%	0.00%	18.41%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Inspect	0.27%	37.41%	1.06%	8.79%	2.05%	34.19%	5.12%	11.12%	100.00%
Install	0.79%	0.00%	0.10%	1.64%	71.01%	24.18%	0.00%	2.27%	100.00%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Paint	0.29%	1.54%	0.00%	24.66%	0.00%	32.05%	15.66%	25.80%	100.00%
Preservation	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remove	4.92%	30.49%	0.00%	47.48%	0.00%	0.00%	0.00%	17.11%	100.00%
Repair	3.87%	1.52%	1.55%	16.29%	46.75%	14.92%	5.32%	9.79%	100.00%
Replace	1.64%	4.48%	9.43%	6.47%	17.15%	27.06%	6.57%	27.20%	100.00%
Service	0.00%	32.36%	0.00%	0.00%	0.00%	23.08%	44.56%	0.00%	100.00%
Grand Total	**1.23%**	**10.08%**	**3.97%**	**14.45%**	**17.55%**	**27.87%**	**8.41%**	**16.44%**	**100.00%**

Figure 52. Conveyance Line, etc., Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs seem to trend with ESI for Conveyance Line, etc.

B.5. Cooling, Chiller

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	0.58%	0.15%	27.37%	0.04%	0.24%	0.00%	0.00%	1.24%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.01%
Corrosion	0.00%	0.00%	0.00%	11.24%	0.00%	3.29%	2.87%	0.32%	1.34%
Deterioration	0.00%	0.00%	0.00%	0.00%	4.27%	22.11%	5.98%	24.76%	15.22%
Inspect	5.66%	92.41%	18.41%	21.98%	3.37%	24.85%	22.11%	4.42%	10.48%
Install	0.00%	0.00%	0.73%	0.90%	0.28%	1.18%	0.37%	0.05%	0.29%
Insulate	0.00%	0.00%	0.06%	0.00%	0.11%	0.00%	0.00%	0.01%	0.03%
Order	0.00%	0.00%	0.01%	0.03%	0.00%	0.12%	0.00%	0.00%	0.01%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.28%	0.00%	0.20%
Paint	0.00%	3.72%	4.40%	0.04%	0.74%	1.06%	0.87%	0.07%	0.59%
Preservation	0.00%	0.00%	8.41%	0.00%	0.19%	1.59%	0.43%	0.00%	0.51%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.08%	0.00%	0.00%	0.01%
Remove	0.00%	0.00%	0.07%	1.42%	0.00%	0.00%	0.00%	0.00%	0.06%
Repair	40.94%	1.27%	51.39%	26.38%	20.53%	29.99%	43.53%	3.45%	17.90%
Replace	53.40%	2.02%	16.32%	9.83%	68.33%	14.69%	22.52%	66.90%	51.55%
Service	0.00%	0.00%	0.05%	0.79%	2.16%	0.80%	0.04%	0.00%	0.55%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 53. Cooling, Chiller, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Cooling, Chiller are:

1) Replace
2) Repair
3) Deterioration
4) Inspect
5) Corrosion
6) Assemble

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	0.38%	0.41%	96.96%	0.63%	1.45%	0.00%	0.17%	100.00%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	36.83%	0.00%	18.66%	33.38%	11.13%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	5.85%	11.06%	6.13%	76.97%	100.00%
Inspect	0.00%	7.25%	5.96%	9.21%	6.70%	18.04%	32.88%	19.95%	100.00%
Install	0.00%	0.00%	8.38%	13.44%	19.70%	30.48%	19.81%	8.20%	100.00%
Insulate	0.00%	0.00%	7.54%	0.00%	75.65%	0.00%	0.00%	16.81%	100.00%
Order	0.00%	0.00%	1.83%	13.88%	0.00%	84.29%	0.00%	0.00%	100.00%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.07%	0.00%	99.93%	0.00%	100.00%
Paint	0.00%	5.22%	25.46%	0.32%	26.31%	13.72%	23.21%	5.77%	100.00%
Preservation	0.00%	0.00%	55.65%	0.00%	7.70%	23.52%	13.13%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Remove	0.00%	0.00%	3.55%	96.42%	0.00%	0.03%	0.00%	0.00%	100.00%
Repair	0.01%	0.06%	9.75%	6.48%	23.92%	12.75%	37.92%	9.12%	100.00%
Replace	0.00%	0.03%	1.08%	0.84%	27.65%	2.17%	6.81%	61.42%	100.00%
Service	0.00%	0.00%	0.32%	6.29%	81.32%	10.98%	1.06%	0.04%	100.00%
Grand Total	**0.00%**	**0.82%**	**3.40%**	**4.39%**	**20.86%**	**7.61%**	**15.59%**	**47.32%**	**100.00%**

Figure 54. Cooling, Chiller, Percent Cost of Corrosion Total by Row FCW by ESI

ESI trends with FCW Deterioration for FCD Cooling, Chiller.

B.6. Culvert, Ditch

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	21.88%	0.00%	0.92%	0.00%	0.90%	0.00%	3.21%	0.96%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	3.84%	0.00%	0.99%
Inspect	9.59%	21.82%	34.13%	51.92%	18.91%	16.65%	65.50%	11.22%	30.25%
Install	0.00%	0.16%	0.00%	1.63%	0.72%	1.35%	0.18%	0.23%	0.82%
Paint	90.23%	6.23%	0.00%	14.01%	0.00%	13.08%	14.55%	5.76%	9.94%
Remove	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	9.88%	1.39%
Repair	0.17%	19.19%	23.90%	30.90%	44.38%	8.29%	3.19%	42.11%	21.23%
Replace	0.00%	30.71%	41.97%	0.62%	33.95%	2.27%	12.75%	27.35%	14.68%
Service	0.00%	0.00%	0.00%	0.00%	2.05%	56.86%	0.00%	0.25%	19.73%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 55. Culvert, Ditch, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Culvert, Ditch are:

1) Inspect
2) Repair
3) Service
4) Replace
5) Paint
6) Remove

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	12.03%	0.00%	9.46%	0.00%	31.73%	0.00%	46.77%	100.00%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	20.49%	79.51%	0.00%	100.00%
Inspect	0.10%	0.38%	2.73%	16.93%	11.44%	18.70%	44.52%	5.21%	100.00%
Install	0.00%	0.10%	0.00%	19.61%	15.94%	55.99%	4.39%	3.97%	100.00%
Paint	2.79%	0.33%	0.00%	13.91%	0.00%	44.72%	30.11%	8.14%	100.00%
Remove	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	99.98%	100.00%
Repair	0.00%	0.48%	2.72%	14.36%	38.25%	13.26%	3.09%	27.84%	100.00%
Replace	0.00%	1.11%	6.91%	0.41%	42.31%	5.24%	17.86%	26.15%	100.00%
Service	0.00%	0.00%	0.00%	0.00%	1.90%	97.93%	0.00%	0.18%	100.00%
Grand Total	**0.31%**	**0.53%**	**2.42%**	**9.87%**	**18.30%**	**33.98%**	**20.57%**	**14.04%**	**100.00%**

Figure 56. Culvert, Ditch, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs for Culvert, Ditch trend with ESI.

B.7. Distribution

Percent of Corrosion Cost	ESI					
FCW	7	11	14	18	19	Grand Total
Cathode	0.00%	84.18%	0.00%	0.00%	0.00%	11.73%
Corrosion	0.00%	0.00%	0.00%	49.85%	89.77%	39.67%
Inspect	100.00%	15.82%	100.00%	3.78%	3.16%	24.86%
Paint	0.00%	0.00%	0.00%	0.00%	4.23%	0.73%
Preservation	0.00%	0.00%	0.00%	46.37%	0.00%	22.53%
Repair	0.00%	0.00%	0.00%	0.00%	2.84%	0.49%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 57. Distribution, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Distribution are:

1) Corrosion
2) Inspect
3) Preservation
4) Cathode

Percent of Corrosion Cost	ESI					
FCW	7	11	14	18	19	Grand Total
Cathode	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	61.03%	38.97%	100.00%
Inspect	79.05%	8.86%	2.52%	7.38%	2.19%	100.00%
Paint	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Preservation	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Repair	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Grand Total	**19.65%**	**13.93%**	**0.63%**	**48.57%**	**17.22%**	**100.00%**

Figure 58. Distribution, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs for Distribution trend with ESI. However, if you remove "Inspect" the majority of the costs are for an ESI of 11 or higher for FCD Distribution.

B.8. Electrical

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.20%	0.00%	0.00%	0.05%
Assemble	0.00%	0.57%	0.56%	0.86%	2.65%	10.52%	0.74%	0.54%	3.43%
Bilge	0.00%	0.21%	0.00%	0.00%	0.03%	0.00%	0.02%	0.00%	0.02%
Blast	0.04%	0.01%	0.21%	0.00%	0.05%	0.13%	0.40%	0.02%	0.13%
Cathode	0.00%	0.17%	4.74%	3.07%	0.02%	0.00%	2.56%	1.30%	1.29%
Corrosion	0.12%	1.02%	1.30%	0.46%	1.89%	4.20%	2.72%	9.93%	3.76%
Describe	0.00%	0.01%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%
Deterioration	0.00%	0.79%	1.32%	0.04%	0.04%	1.76%	0.28%	1.87%	0.92%
Faded	0.00%	0.84%	0.15%	0.06%	0.01%	0.00%	0.32%	0.13%	0.13%
ICCP	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.18%	0.03%
Inspect	6.92%	12.08%	33.12%	42.89%	18.90%	39.49%	9.12%	19.56%	25.34%
Install	1.08%	1.10%	5.44%	1.73%	10.47%	2.51%	9.14%	2.67%	5.30%
Insulate	0.00%	0.00%	0.00%	0.00%	0.05%	0.01%	0.07%	0.00%	0.02%
Order	0.00%	0.03%	0.03%	0.02%	0.09%	0.03%	0.04%	0.31%	0.09%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	1.13%	0.01%	0.20%
Paint	78.81%	55.58%	6.14%	5.04%	3.59%	12.57%	27.43%	12.98%	14.39%
Preservation	0.00%	0.42%	1.16%	0.27%	0.00%	0.18%	0.02%	0.29%	0.21%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	2.43%	0.00%	0.42%
Remove	0.04%	0.00%	0.38%	0.25%	0.17%	0.09%	0.08%	0.47%	0.20%
Repair	5.30%	14.83%	17.66%	30.66%	39.99%	11.49%	25.19%	23.32%	24.12%
Replace	7.55%	11.19%	17.86%	14.27%	20.65%	16.60%	17.60%	23.28%	18.29%
Service	0.14%	1.16%	0.06%	0.38%	1.34%	0.19%	0.69%	2.95%	1.04%
Spalling	0.00%	0.00%	9.86%	0.00%	0.04%	0.00%	0.00%	0.19%	0.61%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 59. Electrical Enclosure, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Electrical are:

1) Inspect
2) Repair
3) Paint
4) Install

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	98.95%	1.05%	0.00%	100.00%
Assemble	0.00%	0.61%	0.95%	2.70%	15.44%	73.83%	3.72%	2.75%	100.00%
Bilge	0.00%	44.82%	0.00%	0.00%	38.86%	0.00%	16.32%	0.00%	100.00%
Blast	0.28%	0.32%	9.87%	0.00%	7.46%	24.19%	54.60%	3.27%	100.00%
Cathode	0.00%	0.49%	21.41%	25.71%	0.34%	0.07%	34.40%	17.58%	100.00%
Corrosion	0.03%	1.01%	2.02%	1.32%	10.06%	26.88%	12.54%	46.15%	100.00%
Describe	0.00%	5.05%	0.00%	0.00%	0.00%	93.82%	0.00%	1.13%	100.00%
Deterioration	0.00%	3.20%	8.33%	0.50%	0.96%	46.22%	5.30%	35.48%	100.00%
Faded	0.00%	24.39%	6.65%	5.09%	1.65%	0.36%	43.96%	17.89%	100.00%
ICCP	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Inspect	0.23%	1.78%	7.60%	18.28%	14.90%	37.51%	6.23%	13.48%	100.00%
Install	0.17%	0.78%	5.97%	3.54%	39.46%	11.43%	29.86%	8.79%	100.00%
Insulate	0.00%	0.00%	0.00%	0.00%	40.97%	5.27%	53.76%	0.00%	100.00%
Order	0.00%	1.21%	2.06%	2.33%	18.80%	8.81%	8.06%	58.73%	100.00%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.66%	0.07%	98.44%	0.83%	100.00%
Paint	4.58%	14.39%	2.48%	3.79%	4.99%	21.04%	32.98%	15.76%	100.00%
Preservation	0.00%	7.43%	32.27%	13.88%	0.32%	20.76%	1.32%	24.02%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.47%	99.53%	0.00%	100.00%
Remove	0.15%	0.00%	11.02%	13.45%	17.17%	10.96%	6.89%	40.36%	100.00%
Repair	0.18%	2.29%	4.26%	13.73%	33.12%	11.47%	18.07%	16.88%	100.00%
Replace	0.35%	2.28%	5.68%	8.43%	22.55%	21.84%	16.65%	22.23%	100.00%
Service	0.11%	4.18%	0.34%	3.95%	25.79%	4.44%	11.57%	49.62%	100.00%
Spalling	0.00%	0.00%	93.30%	0.00%	1.24%	0.00%	0.00%	5.46%	100.00%
Grand Total	**0.84%**	**3.73%**	**5.82%**	**10.80%**	**19.98%**	**24.07%**	**17.30%**	**17.47%**	**100.00%**

Figure 60. Electrical Enclosure, Percent Cost of Corrosion Total by Row FCW by ESI

ESI for the cost driver does trend with Electrical Enclosure. Additionally, FCW Remove trends with ESI.

B.9. Facilities, Structure

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	1.09%	3.13%	0.48%	0.00%	0.01%	1.56%	0.25%	0.14%	0.48%
Assemble	0.09%	1.25%	0.24%	0.99%	0.86%	0.83%	0.60%	0.31%	0.62%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Blast	0.00%	0.12%	0.12%	0.03%	0.10%	0.39%	0.03%	0.01%	0.09%
Cathode	0.00%	0.00%	0.00%	0.00%	0.10%	0.02%	0.00%	0.00%	0.02%
Corrosion	0.12%	1.77%	4.10%	0.38%	0.99%	3.76%	6.05%	2.81%	2.88%
Describe	0.00%	0.00%	0.00%	0.02%	0.26%	0.03%	0.00%	0.26%	0.13%
Deterioration	0.01%	0.34%	2.15%	1.09%	1.40%	3.01%	4.34%	59.44%	21.09%
Faded	0.00%	0.69%	0.02%	0.13%	0.01%	0.56%	0.19%	0.50%	0.32%
Inspect	1.05%	27.95%	11.30%	3.32%	4.39%	6.35%	3.28%	3.76%	5.31%
Install	0.34%	1.36%	10.93%	1.46%	4.28%	2.53%	0.80%	0.37%	1.88%
Insulate	0.00%	0.01%	0.01%	0.00%	0.17%	0.03%	0.00%	0.00%	0.03%
Order	0.01%	0.02%	0.03%	0.01%	0.04%	0.29%	0.02%	0.12%	0.09%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
Paint	55.02%	37.73%	32.05%	72.88%	23.93%	39.25%	23.52%	20.87%	31.38%
Preservation	0.01%	0.24%	0.03%	0.00%	0.08%	0.21%	0.50%	0.08%	0.17%
Remediate	0.00%	0.00%	0.00%	0.00%	0.02%	0.02%	1.84%	0.45%	0.47%
Remove	0.09%	-0.02%	0.41%	0.10%	0.97%	0.24%	0.20%	0.09%	0.28%
Repair	37.52%	13.89%	24.13%	13.21%	33.81%	24.90%	48.83%	5.86%	22.84%
Replace	4.64%	7.34%	13.82%	6.27%	27.29%	14.05%	7.86%	4.10%	10.66%
Service	0.02%	4.17%	0.18%	0.06%	1.22%	1.86%	1.57%	0.31%	1.02%
Spalling	0.00%	0.01%	0.00%	0.02%	0.06%	0.13%	0.13%	0.53%	0.22%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 61. Facilities, Structure, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Facilities, Structure are:

1) Paint
2) Repair
3) Deterioration
4) Replace

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	4.99%	27.95%	3.13%	0.05%	0.33%	44.63%	9.02%	9.89%	100.00%
Assemble	0.30%	8.58%	1.21%	15.90%	23.08%	18.24%	16.44%	16.25%	100.00%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Blast	0.03%	5.79%	4.03%	3.48%	18.31%	59.17%	4.90%	4.29%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	84.96%	13.15%	0.00%	1.89%	100.00%
Corrosion	0.09%	2.63%	4.44%	1.34%	5.73%	17.94%	35.84%	31.98%	100.00%
Describe	0.00%	0.15%	0.01%	1.76%	32.53%	2.64%	0.00%	62.91%	100.00%
Deterioration	0.00%	0.07%	0.32%	0.52%	1.11%	1.96%	3.51%	92.51%	100.00%
Faded	0.00%	9.24%	0.22%	4.15%	0.58%	24.25%	10.27%	51.28%	100.00%
Inspect	0.43%	22.58%	6.65%	6.26%	13.86%	16.44%	10.54%	23.23%	100.00%
Install	0.39%	3.12%	18.21%	7.78%	38.20%	18.54%	7.27%	6.49%	100.00%
Insulate	0.08%	1.01%	0.47%	0.29%	83.24%	12.85%	0.00%	2.06%	100.00%
Order	0.23%	0.89%	1.02%	1.41%	6.34%	42.34%	4.30%	43.45%	100.00%
Overhaul	0.00%	0.00%	0.00%	0.00%	94.49%	2.84%	0.00%	2.67%	100.00%
Paint	3.84%	5.16%	3.19%	23.23%	12.76%	17.20%	12.80%	21.82%	100.00%
Preservation	0.11%	6.29%	0.57%	0.00%	8.53%	17.47%	51.48%	15.55%	100.00%
Remediate	0.00%	0.00%	0.00%	0.04%	0.62%	0.60%	67.26%	31.49%	100.00%
Remove	0.73%	-0.29%	4.49%	3.54%	57.50%	11.47%	12.28%	10.27%	100.00%
Repair	3.60%	2.61%	3.30%	5.79%	24.77%	14.99%	36.52%	8.42%	100.00%
Replace	0.95%	2.95%	4.05%	5.88%	42.84%	18.11%	12.59%	12.62%	100.00%
Service	0.03%	17.54%	0.54%	0.56%	20.10%	25.09%	26.29%	9.84%	100.00%
Spalling	0.00%	0.16%	0.00%	0.94%	4.23%	7.93%	9.52%	77.22%	100.00%
Grand Total	**2.19%**	**4.29%**	**3.12%**	**10.00%**	**16.74%**	**13.75%**	**17.09%**	**32.82%**	**100.00%**

Figure 62. Facilities, Structure, Percent Cost of Corrosion Total by Row FCW by ESI

FCWs Corrosion, Faded, Inspect, and Spalling trend with ESI for Facilities, Structure.

B.10. Fence

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	0.58%	0.00%	1.24%	0.03%	2.00%	1.21%	0.01%	0.80%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.15%	0.00%	0.00%	0.02%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	2.90%	3.78%	18.37%	4.16%
Deterioration	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	8.98%	5.03%	4.22%
Faded	0.00%	4.01%	0.00%	0.00%	0.00%	0.23%	2.58%	0.00%	1.33%
Inspect	0.00%	1.70%	34.04%	28.00%	2.27%	1.85%	5.55%	12.76%	5.59%
Install	0.00%	4.52%	2.32%	0.50%	0.00%	2.52%	1.44%	0.00%	1.23%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.00%	0.02%
Paint	0.00%	52.08%	2.96%	20.62%	2.09%	19.01%	13.39%	36.16%	16.51%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	42.03%	0.00%	16.83%
Remove	0.00%	0.00%	0.00%	1.49%	0.00%	0.49%	0.04%	0.00%	0.10%
Repair	69.49%	34.29%	59.96%	42.09%	58.38%	53.91%	15.53%	25.85%	34.87%
Replace	30.51%	2.16%	0.72%	6.07%	37.23%	16.38%	5.17%	1.59%	14.10%
Service	0.00%	0.66%	0.00%	0.00%	0.00%	0.55%	0.22%	0.24%	0.23%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 63. Fence, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Fence are:

1) Repair
2) Remediate
3) Paint
4) Replace
5) Inspect
6) Deterioration
7) Corrosion
8) Faded
9) Install

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	4.78%	0.00%	1.84%	1.01%	31.51%	60.75%	0.11%	100.00%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	8.80%	36.43%	54.78%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	85.24%	14.76%	100.00%
Faded	0.00%	19.94%	0.00%	0.00%	0.00%	2.22%	77.85%	0.00%	100.00%
Inspect	0.00%	2.01%	9.42%	5.94%	10.40%	4.17%	39.78%	28.29%	100.00%
Install	0.00%	24.21%	2.91%	0.48%	0.00%	25.67%	46.68%	0.04%	100.00%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Paint	0.00%	20.86%	0.28%	1.48%	3.25%	14.50%	32.48%	27.16%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remove	0.00%	0.00%	0.00%	18.36%	0.00%	64.63%	17.00%	0.00%	100.00%
Repair	0.01%	6.50%	2.66%	1.43%	42.91%	19.46%	17.83%	9.19%	100.00%
Replace	0.01%	1.01%	0.08%	0.51%	67.67%	14.63%	14.69%	1.40%	100.00%
Service	0.00%	18.88%	0.00%	0.00%	0.00%	29.81%	38.54%	12.77%	100.00%
Grand Total	**0.00%**	**6.61%**	**1.55%**	**1.19%**	**25.63%**	**12.59%**	**40.04%**	**12.40%**	**100.00%**

Figure 64. Fence, Percent Cost of Corrosion Total by Row FCW by ESI

FCWs Inspect and Paint trend with ESI for Fence.

B.11. Fire Suppression

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	2.43%	0.63%	0.57%	0.00%	0.89%
Assemble	3.62%	0.49%	0.00%	0.28%	0.63%	0.82%	0.00%	0.00%	0.50%
Cathode	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.00%	0.00%	0.18%
Corrosion	0.00%	7.43%	0.00%	0.00%	0.32%	1.36%	0.10%	51.26%	6.50%
Deterioration	0.00%	0.60%	0.00%	0.00%	0.00%	1.46%	1.30%	0.00%	0.54%
Faded	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.67%	0.06%
Inspect	4.27%	8.18%	8.53%	2.17%	20.83%	14.83%	7.59%	21.18%	13.69%
Install	7.37%	5.76%	0.97%	0.55%	1.47%	1.44%	5.98%	0.25%	2.63%
Insulate	0.00%	0.00%	0.00%	0.36%	0.00%	0.00%	0.00%	0.00%	0.03%
Order	0.00%	0.32%	0.00%	0.00%	0.00%	1.09%	0.00%	0.00%	0.27%
Paint	46.67%	1.03%	18.09%	44.22%	4.70%	36.68%	39.24%	10.80%	18.81%
Preservation	0.00%	3.80%	0.00%	0.00%	0.05%	0.00%	0.19%	0.00%	0.76%
Remove	0.00%	0.00%	0.88%	0.01%	0.42%	0.08%	0.00%	0.00%	0.16%
Repair	14.29%	58.86%	58.48%	39.01%	27.27%	26.17%	35.26%	10.90%	34.11%
Replace	23.66%	12.57%	13.05%	11.38%	35.55%	14.14%	8.31%	4.65%	18.41%
Service	0.12%	0.94%	0.00%	2.02%	5.72%	1.29%	1.47%	0.30%	2.47%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 65. Fire Suppression, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Fire Suppression are:

1) Repair
2) Paint
3) Replace
4) Inspect
5) Corrosion
6) Install
7) Service

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	79.55%	13.44%	7.00%	0.00%	100.00%
Assemble	7.56%	18.87%	0.00%	5.15%	37.22%	31.19%	0.00%	0.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	21.79%	0.00%	0.00%	1.45%	3.97%	0.16%	72.63%	100.00%
Deterioration	0.00%	21.46%	0.00%	0.00%	0.00%	51.75%	26.79%	0.00%	100.00%
Faded	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Inspect	0.32%	11.39%	1.43%	1.46%	44.52%	20.52%	6.13%	14.24%	100.00%
Install	2.91%	41.66%	0.85%	1.90%	16.33%	10.39%	25.11%	0.86%	100.00%
Insulate	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Order	0.00%	22.94%	0.00%	0.00%	0.00%	77.06%	0.00%	0.00%	100.00%
Paint	2.58%	1.04%	2.20%	21.59%	7.31%	36.93%	23.07%	5.28%	100.00%
Preservation	0.00%	95.42%	0.00%	0.00%	1.76%	0.00%	2.82%	0.00%	100.00%
Remove	0.00%	0.00%	12.67%	0.65%	77.21%	9.47%	0.00%	0.00%	100.00%
Repair	0.43%	32.86%	3.93%	10.50%	23.39%	14.52%	11.43%	2.94%	100.00%
Replace	1.33%	13.01%	1.62%	5.67%	56.50%	14.54%	4.99%	2.32%	100.00%
Service	0.05%	7.27%	0.00%	7.51%	67.64%	9.86%	6.56%	1.11%	100.00%
Grand Total	**1.04%**	**19.05%**	**2.29%**	**9.18%**	**29.25%**	**18.93%**	**11.06%**	**9.20%**	**100.00%**

Figure 66. Fire Suppression, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs trend with ESI for Fire Suppression.

B.12. Fuel Distribution

Percent of Corrosion Cost	ESI						
FCW	2	6	7	8	14	19	Grand Total
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	555.62%	-2.30%
Faded	0.00%	0.00%	0.00%	25.03%	0.00%	0.00%	10.45%
Inspect	27.63%	100.00%	100.00%	74.97%	100.00%	-455.62%	84.31%
Replace	72.37%	0.00%	0.00%	0.00%	0.00%	0.00%	7.54%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 67. Fuel Distribution, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Fuel Distribution are:

1) Inspect
2) Replace
3) Faded

Percent of Corrosion Cost	ESI						
FCW	2	6	7	8	14	19	Grand Total
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Faded	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Inspect	3.41%	0.18%	49.97%	37.13%	7.06%	2.24%	100.00%
Replace	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Grand Total	**10.42%**	**0.15%**	**42.13%**	**41.76%**	**5.95%**	**-0.41%**	**100.00%**

Figure 68. Fuel Distribution, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs trend with ESI for Fuel Distribution.

B.13. Generator

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.12%	0.04%
Assemble	0.00%	0.00%	0.30%	0.36%	0.07%	0.16%	0.08%	0.03%	0.08%
Corrosion	0.00%	0.00%	0.00%	10.41%	0.93%	2.43%	0.29%	19.23%	1.16%
Deterioration	0.00%	0.00%	0.00%	0.00%	0.00%	8.56%	0.00%	0.00%	0.08%
Faded	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Inspect	20.37%	90.53%	9.90%	38.34%	71.67%	36.67%	3.45%	6.47%	7.39%
Install	0.65%	0.06%	3.94%	0.43%	0.28%	0.50%	0.02%	0.41%	0.10%
Order	0.00%	0.00%	0.03%	0.00%	0.00%	0.64%	0.00%	7.46%	0.30%
Paint	7.39%	8.84%	41.43%	21.10%	0.73%	16.08%	3.98%	14.49%	5.24%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.22%	0.00%	0.00%	0.00%
Repair	55.90%	0.13%	40.13%	23.63%	19.89%	10.68%	91.84%	26.14%	83.86%
Replace	15.69%	0.02%	4.13%	5.46%	4.02%	24.06%	0.33%	24.41%	1.67%
Service	0.00%	0.40%	0.10%	0.27%	2.41%	0.00%	0.01%	0.23%	0.07%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 69. Generator, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Generator are:

1) Repair
2) Inspect
3) Paint
4) Replace
5) Corrosion

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Assemble	0.00%	0.00%	4.58%	4.51%	1.27%	1.93%	86.14%	1.57%	100.00%
Corrosion	0.00%	0.00%	0.00%	9.38%	1.15%	2.07%	22.18%	65.21%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Faded	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Inspect	0.09%	28.87%	1.71%	5.43%	13.96%	4.93%	41.56%	3.45%	100.00%
Install	0.20%	1.51%	50.26%	4.49%	3.97%	4.96%	18.57%	16.03%	100.00%
Order	0.00%	0.00%	0.13%	0.00%	0.00%	2.10%	0.00%	97.77%	100.00%
Paint	0.04%	3.98%	10.11%	4.22%	0.20%	3.05%	67.51%	10.90%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Repair	0.02%	0.00%	0.61%	0.30%	0.34%	0.13%	97.37%	1.23%	100.00%
Replace	0.29%	0.04%	3.17%	3.43%	3.47%	14.34%	17.52%	57.72%	100.00%
Service	0.00%	14.01%	1.83%	4.19%	51.04%	0.00%	15.37%	13.56%	100.00%
Grand Total	**0.03%**	**2.36%**	**1.28%**	**1.05%**	**1.44%**	**0.99%**	**88.92%**	**3.94%**	**100.00%**

Figure 70. Generator, Percent Cost of Corrosion Total by Row FCW by ESI

FCWs for Corrosion and Replace trend with ESI for Generator.

B.14. High Voltage

Percent of Corrosion Cost	ESI						
FCW	6	7	8	14	18	19	Grand Total
Corrosion	0.00%	0.00%	0.00%	44.69%	42.46%	66.23%	42.57%
Deterioration	0.00%	0.00%	0.00%	0.00%	5.92%	0.00%	3.32%
Inspect	100.00%	100.00%	100.00%	12.79%	13.89%	33.77%	17.13%
Paint	0.00%	0.00%	0.00%	42.52%	4.59%	0.00%	18.38%
Repair	0.00%	0.00%	0.00%	0.00%	5.71%	0.00%	3.21%
Spalling	0.00%	0.00%	0.00%	0.00%	27.42%	0.00%	15.39%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 71. High Voltage, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for High Voltage are:

1) Corrosion
2) Paint
3) Inspect
4) Spalling
5) Deterioration
6) Repair

Percent of Corrosion Cost	ESI						
FCW	6	7	8	14	18	19	Grand Total
Corrosion	0.00%	0.00%	0.00%	39.02%	55.98%	4.99%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Inspect	3.96%	1.89%	14.57%	27.75%	45.50%	6.33%	100.00%
Paint	0.00%	0.00%	0.00%	85.98%	14.02%	0.00%	100.00%
Repair	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Spalling	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Grand Total	**0.68%**	**0.32%**	**2.50%**	**37.17%**	**56.12%**	**3.21%**	**100.00%**

Figure 72. High Voltage, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs trend with ESI for High Voltage.

B.15. Hot Water Tank

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.98%	0.00%	0.00%	0.09%
Assemble	0.00%	0.39%	0.00%	0.00%	0.69%	0.62%	0.00%	0.45%	0.59%
Cathode	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%	0.02%
Corrosion	0.00%	30.20%	0.00%	0.00%	0.51%	9.46%	17.50%	0.00%	4.97%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%
Inspect	0.22%	27.84%	43.53%	0.00%	3.56%	7.30%	2.13%	14.53%	6.79%
Install	0.00%	0.12%	0.00%	0.00%	1.11%	0.49%	2.64%	4.49%	1.14%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.18%	0.00%	0.00%	0.02%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.84%	0.94%	0.39%
Paint	0.00%	0.00%	0.00%	0.00%	0.15%	0.00%	0.00%	0.00%	0.10%
Remove	0.00%	0.00%	0.00%	0.00%	0.08%	0.02%	0.00%	0.12%	0.06%
Repair	98.50%	8.93%	56.47%	100.00%	28.16%	57.82%	38.80%	44.82%	32.40%
Replace	1.29%	32.51%	0.00%	0.00%	65.48%	23.04%	29.42%	33.89%	53.15%
Service	0.00%	0.00%	0.00%	0.00%	0.24%	0.05%	1.67%	0.77%	0.28%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 73. Hot Water Tank, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Hot Water Tank are:

1) Replace
2) Repair
3) Inspect
4) Corrosion
5) Install

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Assemble	0.00%	6.49%	0.00%	0.00%	80.15%	9.87%	0.00%	3.50%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	59.37%	0.00%	0.00%	7.07%	17.91%	15.66%	0.00%	100.00%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Inspect	0.06%	40.03%	2.64%	0.00%	35.94%	10.11%	1.39%	9.81%	100.00%
Install	0.00%	1.07%	0.00%	0.00%	66.57%	4.05%	10.28%	18.04%	100.00%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	88.96%	11.04%	100.00%
Paint	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Remove	0.00%	0.00%	0.00%	0.00%	86.98%	3.93%	0.00%	9.09%	100.00%
Repair	6.18%	2.69%	0.72%	2.35%	59.62%	16.78%	5.32%	6.34%	100.00%
Replace	0.05%	5.97%	0.00%	0.00%	84.52%	4.08%	2.46%	2.92%	100.00%
Service	0.00%	0.00%	0.00%	0.00%	59.36%	1.75%	26.39%	12.51%	100.00%
Grand Total	**2.03%**	**9.76%**	**0.41%**	**0.76%**	**68.60%**	**9.40%**	**4.44%**	**4.59%**	**100.00%**

Figure 74. Hot Water Tank, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs trend with ESI for Hot Water Tank.

B.16. HVAC

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.30%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.05%	0.02%
Assemble	0.03%	0.36%	0.26%	12.05%	0.60%	1.24%	0.47%	1.13%	1.64%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.03%	0.00%	0.01%
Blast	0.06%	0.09%	0.98%	0.01%	0.00%	0.06%	0.00%	0.01%	0.07%
Cathode	0.00%	0.00%	0.00%	0.00%	0.08%	0.00%	0.00%	0.04%	0.03%
Corrosion	0.17%	0.75%	1.30%	0.77%	0.32%	2.10%	1.74%	5.54%	1.97%
Describe	0.00%	0.00%	0.00%	0.02%	0.00%	0.03%	0.00%	0.00%	0.01%
Deterioration	0.36%	0.02%	0.56%	0.46%	0.32%	0.87%	20.28%	35.31%	10.29%
Faded	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.25%	0.02%	0.04%
Inspect	5.39%	66.98%	25.02%	15.72%	9.59%	19.62%	6.49%	11.84%	14.45%
Install	13.96%	0.74%	1.49%	7.83%	1.86%	2.59%	0.91%	0.65%	2.07%
Insulate	0.00%	0.00%	0.01%	0.00%	0.08%	0.04%	0.04%	0.00%	0.04%
Order	0.00%	0.01%	0.74%	0.17%	11.45%	11.71%	0.05%	0.24%	5.79%
Overhaul	0.00%	0.01%	0.03%	0.00%	0.16%	0.02%	0.11%	0.07%	0.09%
Paint	1.53%	6.21%	16.13%	10.04%	0.48%	7.63%	2.22%	2.38%	4.03%
Preservation	0.31%	0.02%	0.82%	0.01%	0.04%	0.24%	0.61%	0.06%	0.20%
Remediate	0.00%	0.00%	0.00%	0.14%	0.02%	0.01%	0.63%	0.00%	0.11%
Remove	0.34%	0.01%	0.21%	0.17%	0.20%	0.18%	0.11%	0.21%	0.18%
Repair	70.10%	9.72%	34.55%	37.90%	36.40%	28.35%	45.34%	14.35%	31.17%
Replace	7.38%	9.20%	17.78%	12.63%	35.75%	23.64%	19.73%	27.75%	26.11%
Service	0.08%	5.88%	0.11%	2.08%	2.62%	1.66%	0.86%	0.34%	1.68%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.09%	0.00%	0.01%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 75. HVAC, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for HVAC are:

1) Repair
2) Replace
3) Inspect
4) Deterioration
5) Order
6) Paint
7) Install
8) Corrosion
9) Service
10) Assemble

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	9.15%	0.00%	0.00%	0.00%	0.00%	2.44%	36.30%	52.11%	100.00%
Assemble	0.01%	0.73%	0.80%	55.85%	11.85%	12.85%	4.07%	13.84%	100.00%
Bilge	0.00%	0.00%	0.00%	0.00%	5.26%	39.13%	55.61%	0.00%	100.00%
Blast	0.47%	4.68%	72.64%	0.95%	1.87%	14.49%	1.04%	3.87%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	73.35%	0.00%	0.00%	26.65%	100.00%
Corrosion	0.05%	1.27%	3.30%	2.97%	5.18%	18.12%	12.54%	56.57%	100.00%
Describe	0.00%	0.58%	0.00%	25.78%	0.00%	63.81%	0.34%	9.49%	100.00%
Deterioration	0.02%	0.01%	0.27%	0.34%	1.00%	1.43%	27.93%	69.00%	100.00%
Faded	0.00%	0.00%	0.00%	1.41%	4.62%	0.15%	84.33%	9.49%	100.00%
Inspect	0.20%	15.52%	8.69%	8.28%	21.41%	23.06%	6.36%	16.48%	100.00%
Install	3.59%	1.20%	3.62%	28.78%	28.95%	21.27%	6.24%	6.35%	100.00%
Insulate	0.02%	0.00%	1.43%	0.18%	67.26%	15.94%	13.41%	1.76%	100.00%
Order	0.00%	0.00%	0.64%	0.22%	63.81%	34.37%	0.13%	0.84%	100.00%
Overhaul	0.02%	0.38%	1.75%	0.19%	58.97%	4.66%	17.13%	16.89%	100.00%
Paint	0.20%	5.16%	20.07%	18.94%	3.85%	32.11%	7.81%	11.85%	100.00%
Preservation	0.84%	0.40%	20.99%	0.40%	6.45%	20.43%	44.37%	6.12%	100.00%
Remediate	0.00%	0.00%	0.23%	9.83%	6.54%	1.28%	82.12%	0.00%	100.00%
Remove	1.01%	0.19%	5.92%	7.12%	36.61%	16.79%	8.52%	23.85%	100.00%
Repair	1.20%	1.04%	5.56%	9.25%	37.65%	15.44%	20.61%	9.25%	100.00%
Replace	0.15%	1.18%	3.42%	3.68%	44.13%	15.37%	10.71%	21.36%	100.00%
Service	0.02%	11.72%	0.33%	9.45%	50.40%	16.82%	7.24%	4.02%	100.00%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Grand Total	**0.53%**	**3.35%**	**5.02%**	**7.61%**	**32.24%**	**16.98%**	**14.17%**	**20.11%**	**100.00%**

Figure 76. HVAC, Percent Cost of Corrosion Total by Row FCW by ESI

FCWs Abate and Bilge trend with ESI for HVAC.

B.17. Hydrant

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.22%	0.01%
Assemble	0.00%	0.00%	0.00%	0.00%	0.00%	2.15%	0.00%	0.00%	0.64%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	20.11%	2.73%	5.41%	6.34%
Deterioration	0.00%	97.72%	0.00%	0.68%	0.00%	0.00%	0.00%	0.00%	53.51%
Inspect	0.00%	0.00%	41.19%	4.35%	1.23%	1.71%	35.62%	8.21%	2.28%
Install	0.00%	0.00%	0.00%	0.00%	0.00%	1.16%	4.36%	0.00%	0.43%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.07%	0.00%	0.00%	0.02%
Paint	0.00%	1.71%	38.67%	47.65%	13.47%	3.77%	17.64%	55.00%	7.63%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	5.58%	0.00%	0.00%	1.67%
Remove	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	0.00%
Repair	100.00%	0.33%	20.00%	8.10%	70.23%	16.14%	29.75%	21.99%	10.17%
Replace	0.00%	0.24%	0.14%	38.24%	15.05%	49.31%	9.90%	8.61%	17.24%
Service	0.00%	0.00%	0.00%	0.99%	0.02%	0.00%	0.00%	0.50%	0.06%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 77. Hydrant, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Hydrant are:

1) Deterioration
2) Replace
3) Repair
4) Paint
5) Corrosion
6) Inspect
7) Preservation

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Assemble	0.00%	0.00%	0.00%	0.00%	0.00%	99.96%	0.00%	0.04%	100.00%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	94.72%	0.86%	4.42%	100.00%
Deterioration	0.00%	99.96%	0.00%	0.04%	0.00%	0.00%	0.00%	0.00%	100.00%
Inspect	0.00%	0.00%	19.91%	5.51%	2.27%	22.38%	31.22%	18.70%	100.00%
Install	0.00%	0.00%	0.00%	0.00%	0.00%	79.96%	20.04%	0.00%	100.00%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Paint	0.00%	12.27%	5.58%	18.02%	7.40%	14.74%	4.62%	37.37%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Remove	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Repair	0.34%	1.76%	2.17%	2.30%	28.97%	47.40%	5.84%	11.22%	100.00%
Replace	0.00%	0.75%	0.01%	6.40%	3.66%	85.44%	1.15%	2.59%	100.00%
Service	0.00%	2.53%	0.00%	50.17%	1.58%	0.00%	0.00%	45.72%	100.00%
Grand Total	**0.03%**	**54.74%**	**1.10%**	**2.89%**	**4.19%**	**29.86%**	**2.00%**	**5.19%**	**100.00%**

Figure 78. Hydrant, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs trend ESI for Hydrant.

B.18. Insulation

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	3.67%	0.00%	4.79%	0.00%	0.00%	1.98%
Assemble	0.00%	0.00%	1.13%	0.00%	0.00%	0.58%	0.00%	6.06%	1.09%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.37%	0.00%	0.05%
Corrosion	0.00%	0.00%	0.00%	0.59%	0.25%	0.00%	11.76%	0.00%	1.83%
Deterioration	0.00%	0.00%	0.00%	1.34%	3.02%	7.46%	6.69%	1.67%	4.55%
Inspect	15.17%	6.93%	34.93%	12.66%	0.00%	4.67%	2.14%	23.25%	7.57%
Install	0.00%	0.00%	0.09%	0.84%	0.00%	0.70%	2.12%	5.97%	1.48%
Insulate	53.27%	0.00%	13.64%	2.71%	42.67%	20.25%	0.25%	11.08%	18.90%
Paint	0.00%	71.34%	4.61%	46.82%	25.69%	7.05%	7.20%	0.85%	15.46%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	5.14%	0.00%	0.75%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.36%	0.70%	1.17%
Remove	0.00%	0.00%	0.00%	0.00%	2.10%	0.17%	0.00%	1.83%	0.80%
Repair	31.56%	13.85%	12.46%	18.18%	11.81%	51.76%	48.12%	31.00%	34.01%
Replace	0.00%	6.95%	33.14%	13.18%	13.65%	2.54%	7.53%	15.42%	9.64%
Service	0.00%	0.94%	0.00%	0.00%	0.81%	0.04%	1.33%	2.18%	0.72%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 79. Insulation, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Insulation are:

1) Repair
2) Insulate
3) Paint
4) Replace
5) Inspect
6) Deterioration
7) Abate
8) Corrosion
9) Install
10) Remediate
11) Assemble

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	18.34%	0.00%	81.66%	0.00%	0.00%	100.00%
Assemble	0.00%	0.00%	2.93%	0.00%	0.00%	18.00%	0.00%	79.06%	100.00%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	3.19%	3.16%	0.00%	93.65%	0.00%	100.00%
Deterioration	0.00%	0.00%	0.00%	2.92%	15.20%	55.22%	21.45%	5.21%	100.00%
Inspect	0.16%	1.64%	13.07%	16.53%	0.00%	20.78%	4.13%	43.68%	100.00%
Install	0.00%	0.00%	0.17%	5.61%	0.00%	15.92%	20.93%	57.37%	100.00%
Insulate	0.22%	0.00%	2.05%	1.42%	51.66%	36.13%	0.19%	8.34%	100.00%
Paint	0.00%	8.26%	0.85%	29.93%	38.02%	15.37%	6.80%	0.78%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	91.52%	8.48%	100.00%
Remove	0.00%	0.00%	0.00%	0.00%	60.21%	7.12%	0.00%	32.67%	100.00%
Repair	0.07%	0.73%	1.04%	5.28%	7.95%	51.31%	20.65%	12.96%	100.00%
Replace	0.00%	1.29%	9.74%	13.52%	32.41%	8.88%	11.40%	22.75%	100.00%
Service	0.00%	2.33%	0.00%	0.00%	25.64%	2.09%	26.90%	43.04%	100.00%
Grand Total	**0.08%**	**1.79%**	**2.83%**	**9.88%**	**22.88%**	**33.71%**	**14.60%**	**14.22%**	**100.00%**

Figure 80. Insulation, Percent Cost of Corrosion Total by Row FCW by ESI

FCWs Assemble and Install trend with ESI for Insulation.

B.19. Ladder

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	1.83%	0.00%	8.03%	1.27%	0.90%	1.55%	0.03%	1.79%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	2.41%	0.00%	15.71%	4.26%
Deterioration	0.00%	0.00%	0.00%	0.00%	8.42%	0.17%	0.00%	6.31%	3.60%
Inspect	13.11%	2.35%	4.84%	8.58%	1.80%	1.69%	7.42%	2.70%	3.47%
Install	83.54%	0.96%	9.79%	5.25%	0.00%	12.41%	10.46%	1.53%	4.76%
Paint	0.00%	90.78%	0.00%	12.65%	2.68%	59.83%	29.30%	64.22%	43.35%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.72%	0.00%	0.06%
Remove	1.80%	0.00%	9.87%	0.42%	2.11%	0.77%	0.48%	0.07%	0.79%
Repair	1.56%	2.07%	66.35%	28.66%	39.19%	9.51%	32.72%	5.98%	18.76%
Replace	0.00%	1.18%	9.15%	35.88%	41.46%	8.48%	16.19%	3.04%	17.52%
Service	0.00%	0.84%	0.00%	0.53%	3.07%	3.83%	1.16%	0.39%	1.66%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 81. Ladder, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Ladder are:

1) Paint
2) Repair
3) Replace
4) Install
5) Corrosion
6) Deterioration
7) Inspect
8) Assemble
9) Service

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	16.28%	0.00%	52.39%	16.95%	7.25%	6.68%	0.45%	100.00%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	8.13%	0.00%	91.87%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	55.69%	0.66%	0.00%	43.65%	100.00%
Inspect	4.39%	10.74%	0.76%	28.89%	12.37%	6.99%	16.49%	19.39%	100.00%
Install	20.37%	3.21%	1.12%	12.87%	0.00%	37.47%	16.94%	8.03%	100.00%
Paint	0.00%	33.21%	0.00%	3.40%	1.47%	19.81%	5.21%	36.90%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remove	2.63%	0.00%	6.76%	6.22%	63.47%	13.96%	4.68%	2.28%	100.00%
Repair	0.10%	1.75%	1.92%	17.82%	49.76%	7.28%	13.44%	7.94%	100.00%
Replace	0.00%	1.07%	0.28%	23.89%	56.37%	6.95%	7.12%	4.33%	100.00%
Service	0.00%	7.97%	0.00%	3.69%	44.01%	33.06%	5.36%	5.91%	100.00%
Grand Total	**1.16%**	**15.86%**	**0.54%**	**11.66%**	**23.82%**	**14.35%**	**7.70%**	**24.90%**	**100.00%**

Figure 82. Ladder, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs for Ladder trend with ESI.

B.20. Lighting, etc.

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	3.82%	0.00%	0.00%	0.88%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.19%	0.00%	0.12%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	17.82%	14.76%	3.92%	13.15%
Deterioration	0.00%	0.00%	16.63%	0.00%	0.00%	0.53%	0.00%	39.30%	1.33%
Faded	0.00%	0.00%	0.00%	4.82%	0.00%	0.30%	0.00%	0.00%	0.16%
Inspect	87.06%	2.16%	49.54%	79.29%	88.05%	52.55%	7.13%	20.70%	27.58%
Paint	0.00%	0.00%	33.82%	15.88%	0.00%	24.87%	0.68%	26.48%	8.21%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.12%	77.08%	0.00%	47.08%
Repair	0.00%	0.00%	0.00%	0.00%	11.78%	0.00%	0.02%	2.06%	1.00%
Replace	12.94%	97.84%	0.00%	0.00%	0.16%	0.00%	0.12%	7.55%	0.49%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 83. Lighting, etc., Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Lighting are:

1) Remediate
2) Inspect
3) Corrosion
4) Paint
5) Deterioration
6) Repair

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	0.00%	0.00%	31.09%	68.53%	0.38%	100.00%
Deterioration	0.00%	0.00%	53.46%	0.00%	0.00%	9.17%	0.00%	37.37%	100.00%
Faded	0.00%	0.00%	0.00%	57.52%	0.00%	42.48%	0.00%	0.00%	100.00%
Inspect	0.10%	0.02%	7.65%	5.62%	26.14%	43.73%	15.78%	0.95%	100.00%
Paint	0.00%	0.00%	17.55%	3.78%	0.00%	69.52%	5.08%	4.06%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.06%	99.94%	0.00%	100.00%
Repair	0.00%	0.00%	0.00%	0.00%	96.01%	0.00%	1.41%	2.58%	100.00%
Replace	0.83%	62.06%	0.00%	0.00%	2.71%	0.00%	15.16%	19.24%	100.00%
Grand Total	**0.03%**	**0.31%**	**4.26%**	**1.96%**	**8.19%**	**22.95%**	**61.04%**	**1.26%**	**100.00%**

Figure 84. Lighting, etc., Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs for Light trend with ESI.

B.21. Mold

Percent of Corrosion Cost	ESI						
FCW	6	7	8	14	18	19	Grand Total
Abate	100.00%	100.00%	100.00%	69.01%	38.77%	74.41%	75.44%
Deterioration	0.00%	0.00%	0.00%	0.16%	0.00%	0.00%	0.11%
Inspect	0.00%	0.00%	0.00%	0.02%	0.00%	9.55%	0.11%
Paint	0.00%	0.00%	0.00%	7.22%	16.06%	0.00%	5.72%
Remediate	0.00%	0.00%	0.00%	23.59%	45.17%	16.04%	18.62%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 85. Mold, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Mold are:

1) Abate
2) Remediate
3) Paint

Percent of Corrosion Cost	ESI						
FCW	6	7	8	14	18	19	Grand Total
Abate	30.99%	0.02%	0.06%	66.44%	1.51%	0.98%	100.00%
Deterioration	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Inspect	0.00%	0.00%	0.00%	15.28%	0.00%	84.72%	100.00%
Paint	0.00%	0.00%	0.00%	91.73%	8.27%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	92.00%	7.14%	0.86%	100.00%
Grand Total	**23.38%**	**0.01%**	**0.05%**	**72.63%**	**2.94%**	**0.99%**	**100.00%**

Figure 86. Mold, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs trend with ESI for Mold.

B.22. Pavement, Concrete

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.26%	0.00%	0.06%	0.00%	0.00%	0.03%
Assemble	0.00%	0.00%	0.02%	0.00%	0.00%	0.12%	0.00%	0.04%	0.05%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.41%	0.00%	0.00%	0.14%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.41%	0.00%	1.09%	0.30%
Corrosion	0.00%	0.17%	0.00%	0.00%	1.41%	4.84%	0.23%	2.81%	2.10%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.00%	0.14%
Deterioration	75.90%	0.00%	4.50%	39.69%	0.00%	0.74%	81.65%	6.36%	27.63%
Faded	0.00%	0.00%	0.89%	4.18%	0.00%	0.94%	3.44%	0.97%	1.51%
Inspect	0.00%	7.74%	2.98%	13.83%	22.32%	64.31%	0.73%	37.10%	28.68%
Install	0.00%	0.00%	0.00%	0.14%	0.08%	0.18%	0.10%	0.00%	0.09%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.11%	0.02%
Paint	0.09%	26.71%	5.91%	38.51%	68.44%	19.48%	11.63%	48.12%	20.05%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.21%	0.43%	0.04%	0.16%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.00%	0.00%	0.12%
Remove	0.00%	0.00%	0.00%	0.24%	0.00%	0.02%	0.00%	0.00%	0.02%
Repair	0.00%	0.00%	1.18%	2.04%	6.66%	0.28%	1.62%	1.75%	1.00%
Replace	2.55%	0.00%	0.00%	0.77%	0.91%	7.65%	0.05%	0.14%	2.88%
Service	0.00%	0.00%	0.00%	0.34%	0.19%	0.00%	0.02%	0.06%	0.03%
Spalling	21.46%	65.38%	84.51%	0.00%	0.00%	0.00%	0.10%	0.40%	15.04%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 87. Pavement, Concrete, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Pavement, Concrete are:

1) Inspect
2) Deterioration
3) Paint
4) Spalling
5) Replace
6) Corrosion
7) Faded
8) Repair

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	43.35%	0.00%	56.65%	0.00%	0.00%	100.00%
Assemble	0.00%	0.00%	4.74%	0.00%	0.00%	82.48%	0.00%	12.78%	100.00%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	46.88%	0.00%	53.12%	100.00%
Corrosion	0.00%	0.22%	0.00%	0.00%	0.52%	77.64%	2.30%	19.33%	100.00%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Deterioration	24.66%	0.00%	2.18%	7.84%	0.00%	0.90%	61.10%	3.32%	100.00%
Faded	0.00%	0.00%	7.88%	15.07%	0.00%	20.81%	47.00%	9.24%	100.00%
Inspect	0.00%	0.72%	1.39%	2.63%	0.60%	75.47%	0.53%	18.67%	100.00%
Install	0.00%	0.00%	0.00%	8.09%	0.67%	67.68%	23.55%	0.00%	100.00%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	13.77%	0.00%	86.23%	100.00%
Paint	0.04%	3.54%	3.94%	10.49%	2.64%	32.71%	12.00%	34.64%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	42.36%	54.40%	3.25%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Remove	0.00%	0.00%	0.29%	65.04%	0.00%	34.68%	0.00%	0.00%	100.00%
Repair	0.01%	0.00%	15.80%	11.15%	5.14%	9.39%	33.35%	25.17%	100.00%
Replace	7.95%	0.00%	0.00%	1.46%	0.24%	89.30%	0.34%	0.72%	100.00%
Service	0.00%	0.00%	0.00%	54.52%	4.40%	2.30%	12.07%	26.70%	100.00%
Spalling	12.80%	11.56%	75.12%	0.00%	0.00%	0.00%	0.13%	0.39%	100.00%
Grand Total	**8.97%**	**2.66%**	**13.37%**	**5.46%**	**0.77%**	**33.66%**	**20.67%**	**14.43%**	**100.00%**

Figure 88. Pavement, Concrete, Percent Cost of Corrosion Total by Row FCW by ESI

No FCWs trend with ESI for Pavement, Concrete.

B.23. Plumbing

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.59%	0.00%	0.00%	0.00%	0.02%	0.47%	0.00%	0.08%	0.13%
Assemble	0.03%	2.45%	0.66%	0.48%	0.52%	0.44%	0.05%	0.14%	0.42%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.38%	0.00%	0.00%	0.08%
Blast	0.00%	1.32%	0.00%	0.13%	12.80%	0.03%	0.12%	0.00%	5.73%
Cathode	0.00%	0.00%	0.00%	0.00%	0.13%	0.00%	0.00%	0.10%	0.07%
Corrosion	0.38%	5.08%	3.85%	1.04%	0.45%	6.02%	4.90%	4.27%	2.88%
Describe	0.04%	0.01%	0.00%	0.00%	0.00%	0.11%	0.00%	0.00%	0.02%
Deterioration	2.64%	0.26%	0.18%	0.11%	1.88%	1.55%	1.90%	0.25%	1.49%
Faded	0.00%	0.15%	0.01%	0.00%	0.00%	0.00%	0.32%	0.22%	0.08%
Inspect	1.14%	10.69%	16.85%	16.31%	2.52%	15.06%	5.30%	23.12%	9.08%
Install	4.35%	1.58%	2.41%	1.06%	0.36%	1.30%	0.34%	0.87%	0.76%
Insulate	0.00%	0.00%	0.03%	0.00%	0.03%	0.02%	0.00%	0.00%	0.02%
Order	0.04%	0.02%	0.01%	0.00%	0.00%	0.07%	0.02%	0.10%	0.03%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.09%	0.01%
Paint	0.75%	16.05%	12.96%	22.39%	4.86%	27.43%	31.47%	18.52%	15.69%
Preservation	0.08%	0.08%	0.09%	0.06%	0.03%	0.24%	0.15%	0.08%	0.10%
Remediate	0.00%	0.00%	0.00%	0.00%	0.02%	0.03%	0.02%	0.00%	0.02%
Remove	0.15%	0.00%	0.29%	0.09%	0.15%	0.07%	0.04%	0.10%	0.11%
Repair	83.81%	32.33%	49.99%	35.14%	55.39%	33.85%	44.66%	35.96%	46.14%
Replace	6.00%	25.29%	12.64%	12.94%	20.18%	12.55%	10.39%	16.02%	16.31%
Service	0.00%	4.67%	0.02%	10.24%	0.66%	0.37%	0.10%	0.07%	0.78%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.22%	0.00%	0.03%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 89. Plumbing, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Plumbing are:

1) Repair
2) Replace
3) Paint
4) Inspect
5) Blast
6) Corrosion
7) Deterioration

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	7.48%	0.00%	0.00%	0.00%	5.94%	77.38%	0.00%	9.20%	100.00%
Assemble	0.10%	12.61%	2.27%	3.25%	53.95%	21.83%	1.49%	4.50%	100.00%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Blast	0.00%	0.50%	0.00%	0.06%	99.04%	0.12%	0.27%	0.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	78.98%	1.15%	0.00%	19.87%	100.00%
Corrosion	0.21%	3.84%	1.94%	1.02%	6.94%	43.57%	22.16%	20.31%	100.00%
Describe	2.53%	0.86%	0.00%	0.00%	0.00%	95.10%	0.00%	1.51%	100.00%
Deterioration	2.84%	0.38%	0.18%	0.21%	55.86%	21.66%	16.57%	2.30%	100.00%
Faded	0.00%	4.40%	0.14%	0.00%	0.00%	0.00%	55.17%	40.29%	100.00%
Inspect	0.20%	2.56%	2.70%	5.11%	12.34%	34.57%	7.61%	34.91%	100.00%
Install	9.15%	4.52%	4.60%	3.97%	20.76%	35.57%	5.84%	15.59%	100.00%
Insulate	0.00%	0.00%	2.65%	0.31%	70.49%	25.07%	0.00%	1.48%	100.00%
Order	2.06%	1.43%	0.58%	0.01%	4.75%	45.87%	6.81%	38.50%	100.00%
Overhaul	0.00%	0.00%	0.00%	0.00%	12.24%	0.00%	0.00%	87.76%	100.00%
Paint	0.08%	2.23%	1.20%	4.06%	13.74%	36.42%	26.11%	16.17%	100.00%
Preservation	1.32%	1.65%	1.33%	1.78%	14.77%	48.86%	19.07%	11.21%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	54.66%	30.88%	14.47%	0.00%	100.00%
Remove	2.23%	0.02%	3.92%	2.24%	60.83%	14.17%	4.28%	12.31%	100.00%
Repair	2.92%	1.53%	1.58%	2.17%	53.24%	15.28%	12.61%	10.68%	100.00%
Replace	0.59%	3.38%	1.13%	2.26%	54.87%	16.03%	8.30%	13.46%	100.00%
Service	0.00%	12.96%	0.03%	37.16%	37.28%	9.79%	1.63%	1.14%	100.00%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Grand Total	**1.61%**	**2.18%**	**1.45%**	**2.85%**	**44.36%**	**20.84%**	**13.02%**	**13.70%**	**100.00%**

Figure 90. Plumbing, Percent Cost of Corrosion Total by Row FCW by ESI

FCWs Faded and Overhaul trend with ESI for Plumbing.

B.24. Roof

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	4.41%	0.06%	4.42%	0.28%	0.77%	0.30%	0.45%	0.56%
Blast	0.00%	2.42%	0.00%	0.00%	0.02%	2.80%	0.02%	0.19%	0.43%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.29%	0.00%	0.00%	0.04%
Corrosion	0.00%	0.18%	0.00%	0.49%	0.12%	1.62%	8.74%	1.41%	2.76%
Describe	0.00%	0.25%	0.00%	0.20%	0.00%	0.06%	0.00%	8.68%	1.20%
Deterioration	0.00%	0.00%	0.00%	0.09%	3.14%	0.81%	4.43%	1.22%	2.27%
Inspect	2.74%	8.08%	3.67%	3.72%	2.16%	2.88%	2.25%	23.78%	5.53%
Install	0.44%	0.00%	40.20%	1.18%	1.30%	0.65%	0.47%	0.83%	4.43%
Insulate	0.00%	0.00%	0.00%	0.00%	0.07%	0.01%	0.00%	0.00%	0.02%
Order	0.00%	0.00%	0.00%	0.00%	0.03%	0.05%	0.00%	0.04%	0.02%
Paint	0.02%	0.00%	1.03%	4.72%	0.25%	11.51%	9.04%	8.29%	5.39%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.12%	0.00%	0.03%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.20%	0.00%	0.05%
Remove	0.04%	0.08%	0.05%	0.01%	0.30%	0.14%	0.52%	0.08%	0.25%
Repair	80.24%	66.27%	31.76%	81.39%	43.77%	47.86%	67.02%	38.53%	52.62%
Replace	16.51%	5.91%	23.15%	3.60%	48.22%	29.31%	3.99%	8.74%	22.14%
Service	0.00%	12.38%	0.09%	0.17%	0.35%	1.23%	2.92%	0.26%	1.22%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.52%	1.02%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 91. Roof, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Roof are:

1) Repair
2) Replace
3) Inspect
4) Order
5) Install
6) Corrosion
7) Deterioration
8) Service
9) Describe
10) Spalling

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	9.62%	0.90%	33.92%	13.08%	17.93%	13.75%	10.80%	100.00%
Blast	0.00%	6.88%	0.02%	0.00%	1.02%	85.14%	0.94%	6.01%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	0.08%	0.00%	0.77%	1.12%	7.75%	83.32%	6.95%	100.00%
Describe	0.00%	0.26%	0.00%	0.73%	0.00%	0.68%	0.00%	98.33%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.18%	36.51%	4.71%	51.28%	7.32%	100.00%
Inspect	2.86%	1.80%	6.10%	2.91%	10.30%	6.86%	10.68%	58.48%	100.00%
Install	0.58%	0.00%	83.31%	1.15%	7.70%	1.95%	2.77%	2.54%	100.00%
Insulate	0.00%	0.00%	0.00%	0.00%	96.58%	3.42%	0.00%	0.00%	100.00%
Order	0.00%	0.00%	0.00%	0.00%	42.81%	31.63%	0.00%	25.56%	100.00%
Paint	0.02%	0.00%	1.75%	3.80%	1.22%	28.21%	44.07%	20.92%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	4.97%	95.03%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remove	0.84%	0.39%	1.75%	0.21%	30.87%	7.17%	54.26%	4.51%	100.00%
Repair	8.80%	1.55%	5.55%	6.71%	21.94%	12.01%	33.48%	9.96%	100.00%
Replace	4.31%	0.33%	9.61%	0.71%	57.45%	17.49%	4.74%	5.37%	100.00%
Service	0.00%	12.47%	0.65%	0.60%	7.47%	13.28%	62.69%	2.84%	100.00%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Grand Total	**5.77%**	**1.23%**	**9.19%**	**4.34%**	**26.37%**	**13.20%**	**26.28%**	**13.61%**	**100.00%**

Figure 92. Roof, Percent Cost of Corrosion Total by Row FCW by ESI

FCW Inspect trends with ESI for Roof.

B.25. Sign

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	2.73%	0.13%	0.45%	0.01%	0.96%	1.82%	0.01%	0.63%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.03%	0.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.17%	0.00%	0.00%	0.00%	0.01%
Corrosion	0.00%	0.00%	0.01%	0.24%	0.39%	0.90%	0.57%	14.99%	0.93%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Deterioration	0.00%	2.69%	0.00%	0.00%	0.00%	0.01%	2.73%	10.47%	0.95%
Faded	0.00%	9.86%	0.75%	6.18%	2.95%	16.54%	29.30%	33.54%	10.10%
Inspect	21.31%	13.42%	1.40%	6.72%	30.90%	8.74%	5.91%	9.67%	5.71%
Install	0.12%	2.22%	0.25%	0.89%	2.48%	4.00%	0.52%	0.11%	1.16%
Order	0.00%	0.00%	0.00%	0.04%	0.00%	0.03%	0.21%	0.00%	0.04%
Paint	67.79%	46.40%	95.41%	68.17%	18.29%	32.48%	27.74%	21.93%	64.07%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.44%	0.10%	0.00%	0.10%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.84%	0.00%	0.28%
Remove	0.00%	0.00%	0.02%	0.00%	0.00%	0.04%	0.48%	0.00%	0.09%
Repair	1.64%	6.26%	0.84%	5.69%	32.43%	12.25%	15.76%	3.34%	7.06%
Replace	9.14%	15.78%	1.18%	7.74%	12.38%	23.56%	11.93%	5.91%	8.44%
Service	0.00%	0.64%	0.01%	3.88%	0.00%	0.03%	0.14%	0.00%	0.30%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.95%	0.00%	0.14%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 93. Sign, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Sign are:

1) Paint
2) Faded
3) Replace
4) Repair
5) Inspect
6) Install

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Assemble	0.00%	12.93%	10.04%	4.57%	0.04%	28.14%	44.21%	0.07%	100.00%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	0.68%	1.68%	1.70%	17.71%	9.21%	69.02%	100.00%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Deterioration	0.00%	8.41%	0.00%	0.00%	0.00%	0.27%	43.77%	47.55%	100.00%
Faded	0.00%	2.90%	3.59%	3.93%	1.18%	29.98%	44.13%	14.29%	100.00%
Inspect	0.61%	6.97%	11.89%	7.57%	21.89%	28.02%	15.75%	7.29%	100.00%
Install	0.02%	5.66%	10.64%	4.94%	8.62%	62.91%	6.81%	0.40%	100.00%
Order	0.00%	0.00%	0.00%	6.45%	0.00%	14.23%	79.32%	0.00%	100.00%
Paint	0.17%	2.15%	72.34%	6.84%	1.15%	9.28%	6.59%	1.47%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	83.92%	16.08%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remove	0.00%	0.00%	10.65%	0.00%	0.00%	8.13%	81.18%	0.04%	100.00%
Repair	0.04%	2.63%	5.78%	5.19%	18.59%	31.76%	33.98%	2.03%	100.00%
Replace	0.18%	5.55%	6.82%	5.90%	5.94%	51.10%	21.51%	3.01%	100.00%
Service	0.00%	6.37%	1.12%	83.23%	0.00%	1.97%	7.30%	0.00%	100.00%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Grand Total	**0.16%**	**2.97%**	**48.58%**	**6.43%**	**4.04%**	**18.30%**	**15.21%**	**4.30%**	**100.00%**

Figure 94. Sign, Percent Cost of Corrosion Total by Row FCW by ESI

FCWs Corrosion and Deterioration trend with ESI for Sign.

B.26. Spillway

Percent of Corrosion Cost	ESI		
FCW	8	14	Grand Total
Corrosion	0.00%	26.81%	12.55%
Deterioration	2.28%	0.00%	1.21%
Inspect	8.51%	57.36%	31.38%
Paint	85.29%	15.83%	52.78%
Spalling	3.91%	0.00%	2.08%
Grand Total	**100.00%**	**100.00%**	**100.00%**

Figure 95. Spillway, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Spillway are:

1) Paint
2) Inspect
3) Corrosion
4) Spalling
5) Deterioration

Percent of Corrosion Cost	ESI		
FCW	8	14	Grand Total
Corrosion	0.00%	100.00%	100.00%
Deterioration	100.00%	0.00%	100.00%
Inspect	14.43%	85.57%	100.00%
Paint	85.96%	14.04%	100.00%
Spalling	100.00%	0.00%	100.00%
Grand Total	**53.20%**	**46.80%**	**100.00%**

Figure 96. Spillway, Percent Cost of Corrosion Total by Row FCW by ESI

There is not enough ESI data to determine a trend with FCWs.

B.27. Staircase

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.11%	0.00%	0.00%	0.00%	0.00%	0.01%
Assemble	0.00%	0.00%	0.59%	5.50%	0.31%	2.68%	0.35%	0.59%	1.02%
Blast	0.00%	0.53%	0.00%	0.00%	0.00%	0.49%	0.36%	0.04%	0.18%
Corrosion	0.00%	0.11%	0.00%	2.21%	28.85%	0.65%	13.82%	1.02%	11.47%
Deterioration	0.00%	12.05%	11.15%	7.07%	0.10%	0.84%	9.71%	2.84%	4.33%
Faded	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.26%	0.62%	0.19%
Inspect	0.00%	0.12%	13.64%	5.48%	0.49%	7.23%	1.98%	2.49%	2.76%
Install	0.00%	2.46%	0.32%	1.55%	0.61%	0.69%	0.17%	0.14%	0.59%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.00%
Paint	1.24%	78.72%	62.45%	46.44%	3.10%	72.91%	37.01%	75.88%	43.91%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.21%	0.00%	4.99%	1.11%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.07%	0.00%	0.01%
Remove	0.06%	0.00%	0.01%	0.00%	0.00%	0.15%	0.00%	0.00%	0.02%
Repair	96.72%	1.99%	5.22%	16.43%	24.80%	9.06%	27.40%	2.31%	16.66%
Replace	1.98%	3.21%	6.62%	15.13%	37.45%	3.90%	7.53%	3.25%	14.79%
Service	0.00%	0.81%	0.00%	0.08%	4.08%	1.12%	0.70%	0.98%	1.70%
Spalling	0.00%	0.00%	0.00%	0.00%	0.21%	0.00%	0.64%	4.86%	1.24%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 97. Staircase, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Staircase are:

1) Paint
2) Repair
3) Replace
4) Corrosion
5) Deterioration
6) Inspect
7) Service
8) Spalling
9) Preservation

10) Assemble

Percent of Corrosion Cost	ESI							
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Assemble	0.00%	0.00%	1.64%	37.88%	8.60%	32.28%	7.16%	12.44%	100.00%
Blast	0.00%	18.72%	0.00%	0.00%	0.00%	33.99%	42.35%	4.93%	100.00%
Corrosion	0.00%	0.06%	0.00%	1.36%	70.97%	0.70%	25.00%	1.92%	100.00%
Deterioration	0.00%	17.34%	7.34%	11.52%	0.66%	2.39%	46.58%	14.17%	100.00%
Faded	0.00%	0.00%	0.00%	0.00%	0.00%	3.32%	27.52%	69.15%	100.00%
Inspect	0.00%	0.28%	14.07%	13.98%	4.99%	32.33%	14.87%	19.49%	100.00%
Install	0.00%	25.89%	1.55%	18.43%	28.93%	14.39%	5.81%	5.00%	100.00%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Paint	0.03%	11.16%	4.05%	7.45%	1.99%	20.49%	17.49%	37.34%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	2.37%	0.00%	97.63%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remove	3.05%	0.00%	1.44%	0.00%	5.80%	89.71%	0.00%	0.00%	100.00%
Repair	5.59%	0.74%	0.89%	6.95%	41.99%	6.71%	34.12%	3.00%	100.00%
Replace	0.13%	1.35%	1.27%	7.21%	71.46%	3.26%	10.57%	4.74%	100.00%
Service	0.00%	2.97%	0.00%	0.34%	67.67%	8.14%	8.51%	12.38%	100.00%
Spalling	0.00%	0.00%	0.00%	0.00%	4.84%	0.00%	10.65%	84.51%	100.00%
Grand Total	**0.96%**	**6.23%**	**2.85%**	**7.05%**	**28.22%**	**12.34%**	**20.75%**	**21.61%**	**100.00%**

Figure 98. Staircase, Percent Cost of Corrosion Total by Row FCW by ESI

FCW Paint trends with ESI for Staircase.

B.28. Steam and Distribution

Percent of Corrosion Cost	ESI							
FCW	2	6	7	8	11	14	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.37%	0.00%	0.10%
Assemble	0.00%	0.00%	0.40%	4.62%	0.00%	4.64%	0.00%	1.49%
Deterioration	0.00%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.15%
Inspect	0.00%	0.00%	8.64%	8.34%	0.49%	18.38%	0.00%	7.46%
Install	0.00%	0.00%	3.10%	0.00%	0.27%	4.28%	0.00%	1.98%
Insulate	0.00%	0.00%	0.10%	0.00%	0.00%	0.00%	0.00%	0.02%
Order	0.00%	0.00%	3.51%	0.00%	0.00%	0.00%	0.00%	0.89%
Paint	0.00%	0.00%	0.05%	67.64%	0.00%	7.13%	0.00%	4.69%
Remove	0.00%	0.00%	0.15%	0.00%	0.00%	0.00%	0.00%	0.04%
Repair	99.43%	100.00%	64.13%	3.16%	14.50%	46.95%	0.00%	45.23%
Replace	0.57%	0.00%	19.92%	15.14%	80.43%	17.53%	100.00%	36.47%
Service	0.00%	0.00%	0.01%	1.10%	4.31%	0.12%	0.00%	1.48%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 99. Steam and Distribution, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Steam and Distribution are:

1) Repair
2) Replace
3) Inspect
4) Paint
5) Install
6) Assemble
7) Service

Percent of Corrosion Cost	ESI							
FCW	2	6	7	8	11	14	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Assemble	0.00%	0.00%	6.78%	12.94%	0.00%	80.28%	0.00%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Inspect	0.00%	0.00%	29.49%	4.68%	2.13%	63.70%	0.00%	100.00%
Install	0.00%	0.00%	39.81%	0.00%	4.41%	55.78%	0.00%	100.00%
Insulate	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Order	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Paint	0.00%	0.00%	0.29%	60.43%	0.00%	39.28%	0.00%	100.00%
Remove	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Repair	26.32%	0.06%	36.09%	0.29%	10.42%	26.82%	0.00%	100.00%
Replace	0.19%	0.00%	13.90%	1.74%	71.68%	12.42%	0.07%	100.00%
Service	0.00%	0.00%	0.09%	3.13%	94.62%	2.16%	0.00%	100.00%
Grand Total	**11.97%**	**0.03%**	**25.45%**	**4.19%**	**32.50%**	**25.84%**	**0.02%**	**100.00%**

Figure 100. Steam and Distribution, Percent Cost of Corrosion Total by Row FCW by ESI

ESI does not seem to trend with the FCWs for Steam and Distribution.

B.29. Storage

Percent of Corrosion Cost	ESI						
FCW	6	8	11	14	18	19	Grand Total
Cathode	0.00%	0.00%	12.14%	0.00%	0.00%	1.65%	2.16%
Corrosion	0.00%	0.00%	0.00%	0.00%	27.81%	2.42%	2.36%
Deterioration	0.00%	0.00%	0.00%	20.09%	0.00%	0.00%	1.31%
Inspect	46.90%	91.15%	87.86%	31.89%	45.00%	0.21%	16.28%
Paint	53.10%	8.85%	0.00%	48.02%	21.49%	95.72%	77.78%
Preservation	0.00%	0.00%	0.00%	0.00%	5.70%	0.00%	0.10%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 101. Storage, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Storage are:

1) Paint
2) Inspect
3) Corrosion
4) Cathode
5) Deterioration

Percent of Corrosion Cost	ESI						
FCW	6	8	11	14	18	19	Grand Total
Cathode	0.00%	0.00%	41.69%	0.00%	0.00%	58.31%	100.00%
Corrosion	0.00%	0.00%	0.00%	0.00%	21.19%	78.81%	100.00%
Deterioration	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Inspect	1.05%	40.13%	40.08%	12.78%	4.97%	0.99%	100.00%
Paint	0.25%	0.82%	0.00%	4.03%	0.50%	94.41%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Grand Total	**0.36%**	**7.17%**	**7.43%**	**6.52%**	**1.80%**	**76.72%**	**100.00%**

Figure 102. Storage, Percent Cost of Corrosion Total by Row FCW by ESI

ESI does not trend with the FCWs for Storage.

B.30. Tank, Tower

Percent of Corrosion Cost	ESI						
FCW	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	19.24%	0.00%	0.00%	2.84%
Blast	0.00%	14.22%	0.00%	3.98%	0.00%	0.00%	0.71%
Cathode	95.62%	0.00%	5.45%	0.41%	0.00%	0.00%	5.94%
Corrosion	0.00%	0.00%	0.96%	3.14%	0.00%	3.66%	1.36%
Deterioration	0.00%	0.00%	0.00%	0.00%	99.48%	0.00%	23.47%
Inspect	4.21%	57.69%	91.37%	44.41%	0.52%	16.11%	49.68%
Paint	0.17%	6.03%	2.12%	5.91%	0.00%	43.85%	7.61%
Repair	0.00%	0.00%	0.07%	22.92%	0.00%	35.65%	8.08%
Replace	0.00%	0.00%	0.04%	0.00%	0.00%	0.73%	0.11%
Service	0.00%	9.95%	0.00%	0.00%	0.00%	0.00%	0.09%
Spalling	0.00%	12.11%	0.00%	0.00%	0.00%	0.00%	0.11%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 103. Tank, Tower, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Tank, Tower are:

1) Inspect
2) Deterioration
3) Repair
4) Paint
5) Cathode
6) Abate
7) Corrosion

Percent of Corrosion Cost	ESI						
FCW	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Blast	0.00%	17.97%	0.00%	82.03%	0.00%	0.00%	100.00%
Cathode	58.61%	0.00%	40.38%	1.01%	0.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	30.95%	33.89%	0.00%	35.16%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Inspect	0.31%	1.05%	80.97%	13.18%	0.25%	4.25%	100.00%
Paint	0.08%	0.72%	12.27%	11.45%	0.00%	75.49%	100.00%
Repair	0.00%	0.00%	0.37%	41.82%	0.00%	57.81%	100.00%
Replace	0.00%	0.00%	15.20%	0.00%	0.00%	84.80%	100.00%
Service	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Spalling	0.00%	100.00%	0.00%	0.00%	0.00%	0.00%	100.00%
Grand Total	**3.64%**	**0.90%**	**44.03%**	**14.74%**	**23.60%**	**13.10%**	**100.00%**

Figure 104. Tank, Tower, Percent Cost of Corrosion Total by Row FCW by ESI

ESI does not seem to trend with the FCWs for Tank, Tower.

B.31. Valve

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.42%	0.22%
Assemble	0.00%	1.32%	1.53%	1.30%	0.37%	1.03%	0.00%	0.03%	0.64%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.68%	0.20%	0.36%
Blast	0.00%	0.00%	0.00%	0.00%	0.20%	0.00%	0.00%	0.08%	0.06%
Corrosion	5.77%	4.97%	2.35%	10.48%	0.63%	2.80%	10.00%	5.85%	4.05%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.01%
Deterioration	0.00%	0.00%	0.22%	0.30%	8.88%	4.17%	0.00%	1.16%	3.81%
Faded	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.13%	0.00%	0.02%
Inspect	5.24%	12.33%	15.36%	39.59%	5.63%	14.28%	32.62%	31.76%	18.25%
Install	2.65%	2.93%	6.17%	2.58%	2.77%	3.04%	0.66%	0.88%	2.47%
Insulate	0.00%	0.00%	0.00%	0.00%	0.02%	0.09%	0.00%	0.00%	0.04%
Order	0.00%	0.64%	0.05%	0.00%	0.00%	0.08%	0.00%	0.09%	0.06%
Overhaul	0.00%	0.00%	0.00%	0.00%	0.24%	0.00%	0.02%	0.01%	0.06%
Paint	7.63%	0.00%	0.31%	0.53%	0.05%	3.11%	1.08%	7.15%	2.45%
Preservation	0.00%	9.41%	0.00%	0.00%	0.00%	0.06%	0.00%	0.00%	0.31%
Remove	0.02%	0.05%	0.07%	0.00%	0.15%	0.04%	0.00%	0.17%	0.08%
Repair	44.48%	32.46%	29.49%	27.02%	35.30%	34.04%	43.16%	32.60%	34.71%
Replace	34.03%	31.22%	44.29%	12.91%	44.61%	36.77%	9.34%	17.85%	31.43%
Service	0.18%	4.68%	0.14%	5.28%	1.15%	0.48%	0.31%	0.76%	0.99%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 105. Valve, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Valve are:

1) Repair
2) Replace
3) Inspect
4) Corrosion
5) Deterioration
6) Install
7) Paint

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Assemble	0.00%	6.37%	10.13%	9.28%	13.30%	60.28%	0.00%	0.63%	100.00%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	91.38%	8.62%	100.00%
Blast	0.00%	0.00%	0.00%	0.00%	79.56%	0.00%	0.00%	20.44%	100.00%
Corrosion	0.63%	3.79%	2.45%	11.83%	3.60%	25.80%	30.02%	21.89%	100.00%
Describe	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Deterioration	0.00%	0.00%	0.25%	0.36%	53.95%	40.84%	0.00%	4.59%	100.00%
Faded	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Inspect	0.13%	2.09%	3.56%	9.90%	7.13%	29.16%	21.70%	26.33%	100.00%
Install	0.47%	3.67%	10.58%	4.78%	25.97%	45.87%	3.23%	5.42%	100.00%
Insulate	0.00%	0.00%	0.38%	0.00%	13.62%	86.00%	0.00%	0.00%	100.00%
Order	0.00%	31.25%	3.16%	0.00%	0.00%	44.81%	0.00%	20.78%	100.00%
Overhaul	0.00%	0.00%	0.00%	0.00%	94.15%	0.00%	3.79%	2.05%	100.00%
Paint	1.37%	0.00%	0.54%	0.98%	0.45%	47.26%	5.33%	44.06%	100.00%
Preservation	0.00%	92.93%	0.04%	0.00%	0.00%	7.03%	0.00%	0.00%	100.00%
Remove	0.08%	1.92%	3.88%	0.00%	42.78%	18.75%	0.00%	32.58%	100.00%
Repair	0.56%	2.89%	3.59%	3.55%	23.53%	36.56%	15.10%	14.22%	100.00%
Replace	0.48%	3.07%	5.95%	1.87%	32.83%	43.60%	3.61%	8.59%	100.00%
Service	0.08%	14.56%	0.61%	24.32%	26.88%	18.15%	3.77%	11.63%	100.00%
Grand Total	**0.44%**	**3.09%**	**4.23%**	**4.56%**	**23.13%**	**37.28%**	**12.14%**	**15.13%**	**100.00%**

Figure 106. Valve, Percent Cost of Corrosion Total by Row FCW by ESI

ESI does not seem to trend with FCWs for Valve.

B.32. Wash Rack

Percent of Corrosion Cost	ESI							
FCW	2	6	8	11	14	18	19	Grand Total
Assemble	0.00%	0.00%	0.00%	6.07%	0.00%	0.00%	0.00%	0.92%
Corrosion	0.00%	0.00%	0.00%	0.00%	2.48%	0.00%	0.00%	1.08%
Inspect	0.00%	12.16%	100.00%	15.38%	0.17%	7.12%	2.47%	3.76%
Install	0.00%	0.00%	0.00%	0.56%	2.29%	1.23%	0.00%	1.25%
Paint	0.00%	4.26%	0.00%	0.91%	0.00%	3.46%	75.61%	1.23%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	1.08%	0.00%	0.15%
Repair	100.00%	83.58%	0.00%	54.00%	5.72%	47.26%	21.92%	43.60%
Replace	0.00%	0.00%	0.00%	23.09%	89.34%	39.86%	0.00%	48.01%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 107. Wash Rack, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Wash Rack are:

1) Replace
2) Repair
3) Inspect
4) Install
5) Paint
6) Corrosion

Percent of Corrosion Cost	ESI							
FCW	2	6	8	11	14	18	19	Grand Total
Assemble	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Inspect	0.00%	2.38%	7.34%	62.03%	2.00%	25.74%	0.52%	100.00%
Install	0.00%	0.00%	0.00%	6.73%	79.93%	13.34%	0.00%	100.00%
Paint	0.00%	2.55%	0.00%	11.15%	0.00%	38.18%	48.12%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Repair	58.91%	1.41%	0.00%	18.80%	5.74%	14.75%	0.39%	100.00%
Replace	0.00%	0.00%	0.00%	7.30%	81.41%	11.29%	0.00%	100.00%
Grand Total	**25.68%**	**0.74%**	**0.28%**	**15.18%**	**43.74%**	**13.60%**	**0.78%**	**100.00%**

Figure 108. Wash Rack, Percent Cost of Corrosion Total by Row FCW by ESI

ESI trends with Paint for Wash Rack.

B.33. Wastewater

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.57%	0.03%	0.50%
Assemble	0.00%	0.87%	0.05%	2.69%	0.01%	0.40%	0.64%	0.00%	0.39%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.35%	0.00%	0.07%
Blast	0.00%	2.53%	0.00%	0.00%	0.00%	0.19%	0.00%	0.00%	0.09%
Cathode	0.00%	0.00%	0.00%	0.00%	0.05%	0.00%	0.00%	0.00%	0.01%
Corrosion	5.70%	0.00%	0.29%	0.38%	0.22%	3.27%	7.06%	5.54%	3.66%
Deterioration	0.00%	0.00%	5.07%	0.19%	0.00%	0.03%	0.30%	0.54%	0.68%
Faded	0.80%	0.00%	0.30%	0.00%	0.07%	0.46%	0.00%	0.00%	0.15%
Inspect	13.13%	47.32%	39.37%	20.16%	52.66%	25.02%	15.32%	7.56%	24.00%
Install	3.47%	0.60%	3.17%	1.76%	1.00%	3.83%	1.32%	1.99%	2.25%
Insulate	0.00%	0.00%	0.01%	0.00%	0.68%	0.00%	0.00%	0.00%	0.10%
Order	0.00%	0.00%	0.01%	0.00%	0.00%	0.02%	0.00%	0.11%	0.03%
Overhaul	0.02%	0.94%	0.00%	0.00%	0.53%	0.04%	0.03%	0.00%	0.11%
Paint	17.62%	10.66%	3.72%	14.55%	2.77%	3.98%	24.89%	13.17%	10.86%
Preservation	0.00%	0.18%	0.24%	0.56%	0.02%	0.11%	1.56%	0.00%	0.39%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.51%	0.02%	0.10%
Remove	0.26%	0.02%	0.38%	0.00%	1.42%	0.26%	0.17%	0.00%	0.33%
Repair	41.36%	9.34%	31.52%	46.80%	21.96%	26.46%	29.98%	9.71%	23.54%
Replace	16.24%	26.54%	15.68%	12.61%	16.02%	35.31%	13.30%	40.40%	26.47%
Service	1.41%	1.00%	0.19%	0.30%	2.60%	0.62%	1.17%	0.39%	0.89%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.84%	20.53%	5.37%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 109. Wastewater, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Wastewater are:

1) Replace
2) Inspect
3) Repair
4) Paint
5) Spalling
6) Corrosion
7) Install

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.09%	98.56%	1.35%	100.00%
Assemble	0.00%	4.13%	1.16%	37.65%	0.40%	25.17%	31.32%	0.17%	100.00%
Bilge	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Blast	0.00%	50.10%	0.00%	0.00%	0.00%	49.90%	0.00%	0.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	98.29%	0.00%	0.00%	1.71%	100.00%
Corrosion	0.14%	0.00%	0.74%	0.57%	0.82%	22.24%	37.09%	38.41%	100.00%
Deterioration	0.00%	0.00%	68.50%	1.51%	0.00%	1.13%	8.54%	20.32%	100.00%
Faded	0.48%	0.00%	18.38%	0.00%	6.34%	74.81%	0.00%	0.00%	100.00%
Inspect	0.05%	3.66%	15.10%	4.60%	30.36%	25.97%	12.27%	7.99%	100.00%
Install	0.14%	0.50%	12.97%	4.27%	6.12%	42.38%	11.23%	22.38%	100.00%
Insulate	0.00%	0.00%	0.74%	0.00%	98.33%	0.00%	0.00%	0.93%	100.00%
Order	0.00%	0.00%	2.38%	0.00%	0.00%	14.47%	0.00%	83.15%	100.00%
Overhaul	0.02%	16.41%	0.00%	0.00%	69.13%	9.40%	5.05%	0.00%	100.00%
Paint	0.15%	1.82%	3.15%	7.34%	3.54%	9.14%	44.08%	30.79%	100.00%
Preservation	0.00%	0.88%	5.61%	7.95%	0.64%	7.22%	77.69%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	94.02%	5.98%	100.00%
Remove	0.07%	0.11%	10.68%	0.01%	59.36%	19.78%	9.89%	0.09%	100.00%
Repair	0.16%	0.74%	12.33%	10.89%	12.91%	28.01%	24.49%	10.47%	100.00%
Replace	0.06%	1.86%	5.45%	2.61%	8.37%	33.23%	9.66%	38.75%	100.00%
Service	0.14%	2.09%	1.97%	1.84%	40.36%	17.22%	25.24%	11.15%	100.00%
Spalling	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	2.99%	97.01%	100.00%
Grand Total	**0.09%**	**1.86%**	**9.21%**	**5.48%**	**13.84%**	**24.91%**	**19.23%**	**25.38%**	**100.00%**

Figure 110. Wastewater, Percent Cost of Corrosion Total by Row FCW by ESI

FCWs Corrosion, Order, and Paint trend with ESI for Wastewater.

B.34. Water Heater

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.29%	0.00%	0.00%	0.08%
Assemble	0.00%	0.40%	3.04%	9.23%	0.89%	1.00%	0.00%	0.05%	1.27%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.75%	0.09%
Corrosion	0.00%	3.76%	0.00%	2.02%	0.93%	8.05%	5.15%	12.55%	4.88%
Deterioration	0.00%	0.00%	0.00%	0.00%	1.76%	0.00%	0.00%	16.75%	2.78%
Inspect	4.50%	6.68%	18.84%	19.90%	0.93%	20.02%	13.12%	12.28%	10.65%
Install	0.07%	5.15%	5.90%	1.72%	1.18%	6.08%	0.00%	0.20%	2.71%
Order	0.00%	0.00%	0.00%	1.49%	0.00%	0.36%	0.00%	0.76%	0.28%
Paint	0.00%	0.00%	7.83%	0.05%	37.50%	18.48%	10.04%	2.67%	21.22%
Preservation	0.00%	0.00%	0.00%	0.00%	0.17%	0.00%	0.00%	1.29%	0.23%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.11%	1.63%	0.00%	0.15%
Remove	0.00%	0.00%	0.00%	0.00%	0.00%	0.05%	0.00%	0.08%	0.03%
Repair	68.70%	41.84%	26.60%	32.89%	31.79%	19.38%	61.08%	41.12%	31.81%
Replace	18.30%	30.45%	37.80%	29.36%	24.26%	24.90%	8.97%	11.51%	22.65%
Service	8.44%	11.73%	0.00%	3.35%	0.59%	1.30%	0.00%	0.00%	1.18%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 111. Water Heater, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Water Heater are:

1) Repair
2) Replace
3) Paint
4) Inspect
5) Corrosion
6) Deterioration
7) Install
8) Assemble
9) Service

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Assemble	0.00%	1.00%	8.24%	40.34%	27.12%	22.85%	0.00%	0.45%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Corrosion	0.00%	2.43%	0.00%	2.29%	7.41%	47.96%	7.76%	32.14%	100.00%
Deterioration	0.00%	0.00%	0.00%	0.00%	24.58%	0.00%	0.00%	75.42%	100.00%
Inspect	0.12%	1.98%	6.07%	10.34%	3.40%	54.62%	9.06%	14.41%	100.00%
Install	0.01%	6.00%	7.47%	3.51%	16.82%	65.25%	0.00%	0.94%	100.00%
Order	0.00%	0.00%	0.00%	29.34%	0.00%	36.94%	0.00%	33.73%	100.00%
Paint	0.00%	0.00%	1.27%	0.01%	68.37%	25.30%	3.48%	1.57%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	28.55%	0.00%	0.00%	71.45%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	20.51%	79.49%	0.00%	100.00%
Remove	0.00%	0.00%	0.00%	0.00%	0.00%	61.46%	0.00%	38.54%	100.00%
Repair	0.63%	4.15%	2.87%	5.72%	38.66%	17.70%	14.12%	16.15%	100.00%
Replace	0.24%	4.24%	5.73%	7.17%	41.43%	31.94%	2.91%	6.35%	100.00%
Service	2.07%	31.26%	0.00%	15.66%	19.19%	31.82%	0.00%	0.00%	100.00%
Grand Total	**0.29%**	**3.16%**	**3.43%**	**5.53%**	**38.69%**	**29.06%**	**7.35%**	**12.49%**	**100.00%**

Figure 112. Water Heater, Percent Cost of Corrosion Total by Row FCW by ESI

FCW Preservation trends with ESI for water heater.

B.35. Water Pipe

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.14%	0.00%	0.00%	0.08%
Assemble	0.00%	0.00%	0.96%	7.61%	0.00%	1.70%	0.93%	0.00%	1.41%
Bilge	0.00%	0.00%	0.00%	0.00%	0.12%	0.00%	0.00%	0.00%	0.01%
Corrosion	0.00%	0.00%	0.00%	3.16%	0.00%	0.70%	11.23%	8.43%	2.35%
Deterioration	0.00%	0.00%	0.63%	0.00%	0.00%	18.44%	0.00%	0.00%	10.62%
Inspect	3.12%	25.06%	20.90%	33.74%	98.80%	31.12%	13.45%	32.41%	33.68%
Install	0.00%	0.00%	0.76%	1.43%	0.00%	1.27%	0.10%	0.00%	0.88%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	0.02%	0.00%	0.00%	0.01%
Paint	0.00%	74.94%	14.02%	21.32%	0.00%	7.52%	8.87%	38.39%	9.73%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.80%	0.04%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.28%	0.00%	0.00%	0.16%
Remove	0.00%	0.00%	0.37%	0.00%	0.00%	0.03%	0.00%	0.00%	0.07%
Repair	96.26%	0.00%	57.00%	27.03%	1.08%	26.19%	57.79%	16.71%	31.75%
Replace	0.62%	0.00%	5.19%	2.69%	0.00%	9.69%	1.20%	3.02%	6.58%
Service	0.00%	0.00%	0.17%	3.02%	0.00%	2.92%	6.43%	0.25%	2.63%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 113. Water Pipe, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Water Pipe are:

1) Inspect
2) Repair
3) Deterioration
4) Paint
5) Replace
6) Service
7) Assemble

Percent of Corrosion Cost	ESI								
FCW	2	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Assemble	0.00%	0.00%	8.80%	13.70%	0.00%	68.76%	8.74%	0.00%	100.00%
Bilge	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Corrosion	0.00%	0.00%	0.00%	3.42%	0.00%	16.93%	63.53%	16.13%	100.00%
Deterioration	0.00%	0.00%	0.76%	0.00%	0.00%	99.24%	0.00%	0.00%	100.00%
Inspect	0.02%	0.16%	8.05%	2.54%	26.76%	52.83%	5.31%	4.33%	100.00%
Install	0.00%	0.00%	11.24%	4.16%	0.00%	83.12%	1.48%	0.00%	100.00%
Order	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Paint	0.00%	1.62%	18.71%	5.57%	0.00%	44.22%	12.13%	17.76%	100.00%
Preservation	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%
Remove	0.00%	0.00%	73.12%	0.00%	0.00%	26.88%	0.00%	0.00%	100.00%
Repair	0.51%	0.00%	23.30%	2.16%	0.31%	47.16%	24.20%	2.37%	100.00%
Replace	0.02%	0.00%	10.24%	1.04%	0.00%	84.21%	2.43%	2.07%	100.00%
Service	0.00%	0.00%	0.86%	2.91%	0.00%	63.34%	32.46%	0.42%	100.00%
Grand Total	**0.17%**	**0.21%**	**12.98%**	**2.54%**	**9.12%**	**57.19%**	**13.30%**	**4.50%**	**100.00%**

Figure 114. Water Pipe, Percent Cost of Corrosion Total by Row FCW by ESI

ESI does not trend with the FCWs for Water Pipe.

B.36. Waterfront

Percent of Corrosion Cost	ESI							
FCW	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%
Assemble	0.03%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.01%
Bilge	0.00%	0.00%	0.00%	2.33%	0.00%	86.80%	0.00%	29.04%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%
Corrosion	3.83%	0.00%	0.00%	0.52%	2.90%	1.67%	86.93%	2.44%
Deterioration	0.00%	0.00%	100.00%	3.77%	2.21%	0.99%	0.05%	2.27%
Faded	0.41%	0.00%	0.00%	0.00%	0.00%	0.05%	0.00%	0.08%
Inspect	2.16%	0.00%	0.00%	1.51%	3.60%	1.20%	5.29%	1.57%
Install	0.39%	0.00%	0.00%	15.04%	0.00%	0.20%	0.00%	7.86%
Insulate	0.00%	0.00%	0.00%	0.01%	0.00%	0.00%	0.00%	0.00%
Paint	59.61%	0.00%	0.00%	3.28%	3.93%	1.44%	1.66%	10.83%
Preservation	0.00%	0.00%	0.00%	0.01%	0.92%	0.01%	0.00%	0.01%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	0.45%	0.00%	0.14%
Remove	0.01%	0.00%	0.00%	0.12%	0.00%	0.06%	0.00%	0.08%
Repair	31.04%	100.00%	0.00%	55.96%	30.68%	5.70%	3.99%	35.39%
Replace	1.18%	0.00%	0.00%	17.23%	55.73%	0.73%	1.91%	9.72%
Service	0.03%	0.00%	0.00%	0.23%	0.01%	0.09%	0.16%	0.15%
Spalling	1.32%	0.00%	0.00%	0.00%	0.00%	0.60%	0.00%	0.38%
Grand Total	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**	**100.00%**

Figure 115. Waterfront, Percent Cost of Corrosion Total by Column FCW by ESI

The most prevalent FCWs for Waterfront are:

1) Bilge
2) Repair
3) Paint
4) Replace
5) Install
6) Corrosion
7) Deterioration
8) Inspect

Percent of Corrosion Cost	ESI							
FCW	6	7	8	11	14	18	19	Grand Total
Abate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Assemble	52.30%	0.00%	0.00%	24.47%	0.00%	23.23%	0.00%	100.00%
Bilge	0.00%	0.00%	0.00%	4.13%	0.00%	95.87%	0.00%	100.00%
Blast	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Cathode	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
Corrosion	22.73%	0.00%	0.00%	10.90%	0.93%	21.90%	43.54%	100.00%
Deterioration	0.00%	0.00%	0.06%	85.21%	0.76%	13.94%	0.03%	100.00%
Faded	77.21%	0.00%	0.00%	0.00%	0.00%	22.79%	0.00%	100.00%
Inspect	19.90%	0.00%	0.00%	49.59%	1.79%	24.60%	4.12%	100.00%
Install	0.71%	0.00%	0.00%	98.47%	0.00%	0.81%	0.00%	100.00%
Insulate	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	0.00%	100.00%
Paint	79.71%	0.00%	0.00%	15.56%	0.28%	4.26%	0.19%	100.00%
Preservation	0.00%	0.00%	0.00%	32.45%	51.79%	15.76%	0.00%	100.00%
Remediate	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	100.00%
Remove	2.20%	0.00%	0.00%	74.99%	0.00%	22.80%	0.01%	100.00%
Repair	12.70%	0.00%	0.00%	81.32%	0.68%	5.17%	0.14%	100.00%
Replace	1.75%	0.00%	0.00%	91.13%	4.48%	2.40%	0.24%	100.00%
Service	2.74%	0.00%	0.00%	76.46%	0.06%	19.50%	1.25%	100.00%
Spalling	49.88%	0.00%	0.00%	0.00%	0.00%	50.12%	0.00%	100.00%
Grand Total	**14.48%**	**0.00%**	**0.00%**	**51.43%**	**0.78%**	**32.08%**	**1.22%**	**100.00%**

Figure 116. Waterfront, Percent Cost of Corrosion Total by Row FCW by ESI

ESI trends with FCW Corrosion for Waterfront.

Appendix C. Actionable Item Analysis

C.1. Facilities, Structure

The number one FICE cost driver issue is Facilities, Structures. This group represents the basic building structural elements, which includes both interior and exterior features. From the data reduction exercise, the maintenance objects with their corresponding count of relevant maintenance records representing this group can be found in Figure 117 below:

Facilities, Structure	723
Door	314
Ceiling	85
Roof	71
Stairway	52
Gutter	40
Window	37
Floor	19
Downspout	15
Bracket	14
Wall	11

Figure 117. Facilities, Structure Maintenance Objects Breakdown

C.1.1. Doors

It is noted that "Doors" represent the largest group of maintenance objects in the Facilities, Structures group. Further reduction in the data to the detailed description associated with these records yields the specific corrosion issues associated with each maintenance object. This further reduction for "Doors" yields the following detailed corrosion issues:

Rollup door general corrosion and track and roller corrosion
Exterior entrance door coating failure, door corrosion, frame/jam corrosion, hinge corrosion
Interior/Bathroom door general corrosion, hinge corrosion

Figure 118. Door Corrosion Description

The number one issue concerns roll up or overhead doors. These records primarily reference corrosion issues with the panels and with the track and rollers. Next are the exterior doors which concern general coating failures and general corrosion, door frame or door jamb corrosion, and hinge corrosion issues. Finally, interior or bathroom doors exhibited issues with general corrosion and hinge corrosion.

Corrosion Factors: It is assumed that the majority of the "Door" corrosion issues are from carbon steel components. However, this is not conclusive and materials should be considered when improving door corrosion. Additionally, it is assumed that the exterior door corrosion is more likely to occur in high ESI

environments. Therefore, the corrosion factors are proximity to salt water, rain fall, temperature, humidity, and UV exposure.

Recommendation: Conduct a review of the current state-of-the-art for overhead and rollup doors. Survey the industry for Overhead and Rollup doors to determine if corrosion resistant doors can be specified. Additionally, review external and entrance door specifications for corrosion control design and material use. Seek to specify doors that eliminate the use of carbon steel fasteners, hinges, and general components. If carbon steel is used in construction ensure that proper corrosion control coatings are specified.

C.1.2. Ceiling

The next maintenance within the Facilities, Structure group is "Ceiling." The data reduction exercise for "Ceiling" yielded the following issues:

Drop Ceiling Frame Corrosion
Deterioration from water leak from roof
Deterioration from water leak from piping

Figure 119. Ceiling Corrosion Description

Most "Ceiling" records expressed deterioration that required replacement of tiles or dry wall. Additionally, records described corrosion of the drop ceiling frame.

Corrosion Factors: Most records relate the deterioration to water leaks from either piping or roof leaks. The water damage caused the ceiling material to deteriorate to a point where repairs were required. The next most common issue was due to corrosion of drop ceiling frames. It is assumed that these were steel frames that corroded due to water leaks or exposure to high humidity in bathrooms.

Recommendation: The majority of these issues would be resolved if water leaks from piping systems and roofs were identified early, before major damage has occurred. It is recommended that studies into leak detection technologies be investigated in an effort to find a practical cost effective method to detect leaks at their onset. Finally, steel drop ceiling frames should be eliminated and replaced with aluminum where possible.

C.1.3. Roof

The third largest maintenance object within the Facilities structure group is "Roof." The data reduction exercise for "Roof" yielded the following issues:

Metal roof corrosion
Metal flashing corrosion
General roof leaks

Figure 120. Roof Corrosion Descriptions

Most "Roof" records were connected with deterioration of the roofing material so that leaks were present. The materials associated with the roof were not noted on the majority of the records, however, some records indicated corrosion with metal roofs and metal flashing materials.

Corrosion Factors: A material investigation needs to be conducted to determine if corrosion prone materials are being specified. It is generally assumed that most leaks are due to poor installation or age.

Recommendation: Review roofing specifications and standards to eliminate corrosion prone materials.

C.1.4. Stairway

The fourth largest maintenance object within the Facilities structure group is "Stairway." The data reduction exercise for "Stairway" yielded the following issues:

Steel stairway corrosion
Stairway tread corrosion
Wood Stairway deterioration
Concrete stairway deterioration

Figure 121. Stairway Corrosion Descriptions

Most "Stairway" records were connected with deterioration of the stairway material. Records that indicated deterioration of metal, wood and concrete were identified. Additionally, stairway treads were identified as a corrosion issue.

Corrosion Factors: It is assumed that most corrosion issues were due to stairways on the exterior of buildings. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Ensure that specifications and standards consider the environment when specifying stairway materials. Certain materials are known to perform better in certain environments, such as fiberglass in chemical environments or galvanized steel in exterior environments.

C.1.5. Gutter

The next largest maintenance object within the Facilities structure group is "Gutter." The data reduction exercise for "Gutter" yielded the following issue:

Corroded metal gutters

Figure 122. Gutter Corrosion Description

Most "Gutter" records were connected with deterioration of the metal gutters that were causing leaks.

Corrosion Factors: It is assumed that the root cause of corrosion is from steel or iron gutters and down spouts, where the material is lost due to pooling water. However, other materials such as aluminum or copper may be the issue. These materials can corrode especially in marine environments, albeit more slowly than steel. Therefore, the corrosion factors for gutters would include high time of wetness, rain fall, and saltfall.

Recommendation: Conduct inspections of corroded gutters and down spouts to determine an actual root cause. Follow-up the root cause analysis with updates to specifications and standards.

C.1.6. Window

The next largest maintenance object within the Facilities structure group is “Window.” The data reduction exercise for “Window” yielded the following issues:

Wood frame deterioration
Metal frame rusting
Concrete around window deterioration

Figure 123. Window Corrosion Descriptions

Most “Window” records were connected with deterioration of the frame materials, with both metal and wood identified as frame materials. The frame deterioration typically led to leaks or window operation issues. Additionally, concrete and rebar surrounding windows were noted to have deterioration issues.

Corrosion Factors: It assumed that the root cause is connected to environmental factors associated with high ESI areas (i.e., high humidity, high heat, exposure to chlorides).

Recommendation: Review the materials specified for high ESI areas to ensure that materials resistant to corrosion are used.

C.1.7. Floor

The next largest maintenance object within the Facilities structure group is “Floor.” The data reduction exercise for “Floor” yielded the following issues:

Bathroom floor tile deterioration
Floor tile deterioration
Floor coating deteroration

Figure 124. Floor Corrosion Descriptions

Most “Floor” records were connected with deterioration of the tile and coatings. The majority of the flooring issues were associated with bathrooms.

Corrosion Factors: From the data, is it assumed that prolonged exposure to water and humidity lead to the deterioration of the floor materials.

Recommendation: Investigate flooring materials that can effectively withstand exposure to water and humidity.

C.1.8. Downspout

The next largest maintenance object within the Facilities structure group is “Down Spout.” The data reduction exercise for “Down Spout” yielded the following issue:

Metal downspout corrosion

Figure 125. Downspout Corrosion Description

Most “Down Spout” records were connected with deterioration of the metal down spouts that were causing leaks. Refer to the gutter section for root cause and recommendation.

C.1.9. Bracket

The next largest maintenance object within the Facilities structure group is “Bracket.” The data reduction exercise for “Bracket” yielded the following issues:

Steel bracket corrosion
Steel bolt corrosion

Figure 126. Bracket Corrosion Descriptions

Most “Bracket” records were connected with deterioration of the steel brackets and fastener materials on the building exterior and in bathrooms.

Corrosion Factors: Corrosion seems to occur from carbon steel hardware that is not intended for exterior environments. These brackets and bolts are typically designed for interior service and are not plated or coated to withstand the exterior environment. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Specify that all materials mounted to the exterior of facilities meet a minimum corrosion standard.

C.1.10. Wall

The next largest maintenance object within the Facilities structure group is “Wall.” The data reduction exercise for “Wall” yielded the following issues:

General Deterioration
Damaged Plaster
Damaged/Decaying Sheetrock
Repainting Needed

Figure 127. Wall Corrosion Descriptions

Most “Wall” records were connected with deterioration of the Plaster and Sheetrock and led to material repair and repainting.

Corrosion Factors: From these records, deterioration is from age and general use.

Recommendation: Review wall materials for best practices.

C.2. Plumbing

The number two FICE Cost Driver issue is Plumbing. This group represents the plumbing components found in buildings. From the data reduction exercise the maintenance objects with their corresponding count of relevant maintenance records representing this group can be found in Figure 128 below:

Plumbing	586
Toilet	129
Valve	96
Faucet	84
Shower	74
Piping	55
Sink	43
Water fountain	26
Water line	20
Fixture	14
Plumbing	13
Fitting	11
Sprinkler	11
Bathtub	10

Figure 128. Plumbing Maintenance Objects Breakdown

C.2.1. Toilet

The vast majority of "Plumbing" maintenance objects are associated with bathrooms, specifically "Toilet." High time of wetness in bathrooms can cause steel-based components to corrode and fail. Further analysis of detailed toilet maintenance records reveal the following specific corrosion issues:

Rusted Urinal
Rusted Spud
Rusted Bolts
Rusted Pipes
Rusted Sinks
Rusted Bath
Leaking Pipes
Rusted Drains
Corroded urinal handle
Rusted Flange
Valve corrosion
Broken toilet seat
Corroded Flush Rod
Water Contains Rust

Figure 129. Toilet Corrosion Descriptions

Corrosion Factors: Corrosion factors for Toilets are prolonged exposure to water and humidity, which lead to the deterioration of the toilet components.

Recommendation: Investigate toilet components materials that can effectively withstand exposure to water and humidity.

C.2.2. Valve

The next largest maintenance object for the Plumbing group is “Valve.” The data reduction exercise for “Valve” yielded the following issues:

Sink valve corrosion
Shower valve corrosion
Corroded flush valves
Rusted propane tank shutoff valve
Corroded gate valves
Water main seal corrosion
Rusted drainage pipe
Corroded sink trap
Deteriorated water main valves
Deteriorated steam bypass valves
Valve Leakage
Corroded ball valves
Rusted valve cover
Shut off valve corrosion
Corroded chill water valve
Washer dryer valves corroded

Figure 130. Valve Corrosion Descriptions

The majority of the records in the Valve category were associated with bathrooms, such as sink, shower, and toilet valves. However, significant issues were also observed in water main piping valves, steam distribution valves, chilled water line valves, and finally washer machine shut offs.

Corrosion Factors: Corrosion factors are local water chemistry, older valve materials such as iron, and external valve components exposed to the environment.

Recommendation: Conduct a field survey of failed valves to determine root cause and follow-on recommendations.

C.2.3. Faucet

Bathroom faucet corrosion
Pipe/hose corrosion
Corroded faucets for washers
Shower faucet corrosion
Corroded sink fixtures
Corroded Shower Faucet
Male head faucet corroded
Faucet leaks
Leaking sink
Broken faucet handles
Sink faucet deteriorating

Figure 131. Faucet Corrosion Descriptions

All faucet records related to bathrooms. Faucet issues ranged from hose issues to leaking sinks to damaged handles.

Corrosion Factors: Corrosion factors are local water chemistry, older faucet materials such as iron, and exposure to high humidity bathrooms.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

C.2.4. Shower

Corroded shower heads
Shower pipe leaking
Shower handle corrosion
Shower wall water damage
Deteriorating ceramic tile in shower
Rusted threads on shower head arm
Corroded shower drain
Corroded shower stall
Rusted emergency shower piping
Shower panel rust
Deteriorating plaster around shower
Metal trim rusted
Rusty shower water

Figure 132. Shower Corrosion Descriptions

Shower records issues ranged from fixtures such as the shower head and handles to supply water piping and water drainage piping to the wall/stall materials and trim.

Corrosion Factors: There is not enough information in the data to determine a root cause. Potential root causes are local water chemistry, carbon steel shower components, and exposure to high humidity head spaces.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

C.2.5. Piping

Steam/condensate piping deteriorated
Washer pipe corrosion
corroded sink drain pipe
Flush arms leak
Corroded drainage pipe
Leaking rusted pipes
Corroded sink piping
Steam leak
Deteriorated water lines

Figure 133. Piping Corrosion Descriptions

Corrosion Factors: Most piping issues are related to bathrooms and drain pipes. It is assumed that these failures are due to clogged drain pipes that retain water and other contaminates that deteriorate the pipe. Other issues are associated with steam and water supply piping. Typical corrosion factors are local issues with water/steam chemistry and water immersion.

Recommendation: Using non-metallic materials where practical for drain lines is recommended. For supply lines a survey should be conducted to determine root cause. From the root cause recommendations should be made to specify proper materials for steam/water chemistries.

C.2.6. Sink

Rusted Sinks
Corroded handles
Rust in water from sink
Corroded sink drain
Sink leaks

Figure 134. Sink Corrosion Descriptions

Corrosion Factors: Most sink issues are related to the sink bowl corroding. Corrosion factors are damaged porcelain/steel sinks that are exposed to high times of wetness leading to corrosion. Typically the porcelain chips and exposes the steel substrate, leading to corrosion.

Recommendation: Specify sink materials that are non-metal construction or stainless steel.

C.2.7. Water Fountain

Corroded drain pipe
Corroded water fountain
Replace water fountain filter
Water filter leaks
Corroded water fountain drain
Tap rusted out
Corroded water fountain spout

Figure 135. Water Fountain Corrosion Descriptions

Corrosion Factors: Water fountain corrosion issues ranged from drain pipes to filters to spouts. Corrosion factors are local water chemistry, carbon steel components, clogged drain lines (immersion), and exposure to high humidity spaces.

Recommendation: Conduct a field survey of failed water fountains to determine root cause and follow-on recommendations.

C.2.8. Fixture

Corroded bathtub and shower fixtures
Rusted fitting
Rusted overhead vent
Corroded light fixtures

Figure 136. Fixture Corrosion Descriptions

Most fixture records related to bathrooms. Fixture issues ranged from hose issues to leaking sinks to damaged handles. The one exception being light fixtures, however these were light fixtures primarily in bathrooms.

Corrosion Factors: Corrosion factors are local water chemistry, older faucet materials such as iron, and exposure to high humidity bathrooms.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

C.2.9. Waterline

Water line corrosion
Deteriorated cast iron pipe
Leaking and corroded cold water pipes
Rusted brackets on waterline
Waterline broken/rusted off

Figure 137. Waterline Corrosion Descriptions

Corrosion Factors: Most waterline records related to supply water piping and related support brackets. Supply pipe corrosion factors are local water chemistry, older piping materials such as iron, and exposure to high humidity bathrooms. Corrosion factors for the support brackets are exposure of carbon steel components to a high humidity environment.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

C.2.10. Plumbing

Corroded drain leaking
Rusted plumbing
Deteriorated plumbing
Plumbing leaks
Corroded sink drains/traps

Figure 138. Plumbing Corrosion Descriptions

Corrosion Factors: Most plumbing records related to components such as sinks in bathrooms. Corrosion factors are local water chemistry, older plumbing materials such as iron, and exposure to high humidity bathrooms.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

C.2.11. Fitting

Fittings deteriorated/rotted
Rusted hoist fittings

Figure 139. Fittings Corrosion Descriptions

Corrosion Factors: Most fitting records related to bathrooms. Corrosion factors are local water chemistry, older fitting materials such as iron, and exposure to high humidity head spaces.

Recommendation: Conduct a field survey of bathrooms to determine root cause and follow-on recommendations.

C.2.12. Bathtub

Corroded Bathtub
Bathtub cracked
Holes in bathtubs
Bathtub wall rusted
Re-caulk bathtubs

Figure 140. Bathtub Corrosion Descriptions

Corrosion Factors: Most bathtub issues are related to the tub corroding. It is assumed that these are damaged porcelain/steel tubs that are exposed to high times of wetness leading to corrosion. Typically the porcelain chips and exposes the steel substrate leading to corrosion.

Recommendation: Specify bathtub materials that are non-metal construction or stainless steel.

C.2.13. Sprinkler

Corroded sprinkler head
Sprinkler system leaking
Corroded female couplings
Corroded sprinkler piping

Figure 141. Sprinkler Corrosion Descriptions

Corrosion Factors: Most of the sprinkler issues concerned leaking components such as sprinkler heads or couplings. Additionally, it seemed that the majority of these issues were in high humidity spaces such as bathrooms. Corrosion factors are exposure of steel components to high times of wetness leading to corrosion.

Recommendation: Investigate corrosion resistant materials (stainless steel, Monel, etc.) for sprinkler heads and couplings that can be specified in high humidity spaces.

C.3. HVAC

The number three FICE Cost Driver issue is HVAC.

⊟ **HVAC**	**174**
⊞ **Ventilation**	**37**
⊞ **Air Handler**	**33**
⊞ **Boiler**	**18**
⊞ **Air Conditioner**	**17**
⊞ **Exhaust**	**15**
⊞ **Duct**	**12**
⊞ **Condenser**	**11**
⊞ **Blower**	**8**
⊞ **Heater**	**7**
⊞ **Air Compressor**	**6**
⊞ **Coil**	**4**
⊞ **Line**	**2**
⊞ **Chiller**	**2**
⊞ **Door**	**1**
⊞ **Controller**	**1**

Figure 142. HVAC Maintenance Objects Breakdown

C.3.1. Ventilation

AC air intake rusted
AC vent rusted/deteriorating
Rusted grill vent
ventillation fan corroded
Rust holes in fan housing
supply fan corrosion
Corroded metal brackets
Deteriorated hoses
Corroded ventalation mount
Deteriorated vent pipe
Corroded vent stack
Corroded screen
Fly wheel corrosion
Corroded ventilation turbine

Figure 143. Ventilation Corrosion Descriptions

The ventilation records encompassed a large range of components as observed in the above list. Components include hoses, ducting, fans, grills, and piping.

Corrosion Factors: It is assumed that the ventilation HVAC issues are in environments with high humidity and high ESI zones. The ventilation system in general is exhibiting corrosion because the components were not designed for these types of environments.

Recommendation: Conduct a field survey of ventilation systems to determine root cause and follow-on recommendations. Potential solution to duct corrosion would be selection of non-steel construction materials.

C.3.2. Air Handler

Discharge chamber floor rusting
Supply motor foundation rusting
Corroded housing
Chilled water return thermometer deteriorated
Deteriorated cw piping
Rusted condensate pan
Corroded valve
Deteriorated air handler
Broken steam supply line
Blower wheels rusted
Inoperable air conditioners
Box filters deteriorating
Rusted ducts
Corroded air handlers

Figure 144. Air Handler Corrosion Descriptions

The air handler records encompassed a large range of components as can be observed from the above list. Components include air handlers, foundations, thermometers, piping, condenser pans, and ducting.

Corrosion Factors: It is assumed that the ventilation HVAC issues are in environments with high humidity and high ESI zones. The air handler system in general is exhibiting corrosion because the components were not designed for these types of environments.

Recommendation: Conduct a field survey of air handler systems to determine root cause and follow-on recommendations. Again, potential solution to duct corrosion would be selection of non-steel construction materials for high ESI environments.

C.3.3. Boiler

Corroded boiler
Bottom rusted out
Corroded tank top
Rusted circ pump line
Corroded pipe fitting
Boiler leaking
Coils deteriorated
Corroded pumps
Corroded flow switch
Corroded temperatute sensor
Corroded valve

Figure 145. Boiler Corrosion Descriptions

Corrosion Factors: The boiler records seemed to describe most components contained in boiler systems. Therefore, it is assumed that these systems operate in inherently harsh conditions. Corrosion factors include water immersion, elevated temperatures, and combustion exhaust contamination leading to corrosion failures.

Recommendation: A site survey of current boiler conditions should be conducted to assess boiler root causes. The survey should be followed up by a thorough review of boiler design and construction materials needs to be conducted to determine specifications.

C.3.4. Air Conditioner

Corroded AC unit
Drain pan is rusted
Rusted AC duct
Deteriorating Condensor
Corroded cooling fins
AC pipe leaking

Figure 146. Air Conditioner Corrosion Descriptions

The air conditioner records encompassed a large range of components as can be observed from the above list. Components include AC units, drain pans, condenser tubes, cooling fans, piping and ducting.

Corrosion Factors: It is assumed that the air conditioner HVAC issues are in environments with high humidity and high ESI values. The air handler system in general is exhibiting corrosion because the components were not designed for these types of environments.

Recommendation: Conduct a field survey of air handler systems to determine root cause and follow-on recommendations. Solicit industry input on specifying corrosion resistant air conditioning systems for high ESI environments. Again, potential solution to duct corrosion would be selection of non-steel construction materials for high ESI environments.

C.3.5. Exhaust

Corroded exhaust pipe
Corroded exhaust fan
Rusted grill
Corroded exhaust vent
Screws rusted

Figure 147. Exhaust Corrosion Descriptions

See C.3.1. Ventilation and C.3.2. Air Handler.

C.3.6. Duct

Rusted ducts
Corroded screws
Deteriorated AHU's and ducting
Rusted vents

Figure 148. Duct Corrosion Descriptions

See C.3.1. Ventilation and C.3.2. Air Handler.

C.3.7. Condenser

Deteriorated fins
Deteriorating condensor coils
Deteriorated brackets
Condensor Rusted out
Corroded condensor pipe causes freon leak

Figure 149. Condenser Corrosion Descriptions

See C.3.4. Air Conditioner.

C.3.8. Blower

Corroded blower
Electrical connection corrosion
Rusted metal clips

Figure 150. Blower Corrosion Descriptions

See C.3.2. Air Handler.

C.3.9. Heater

Rusted heater bleed valves
Corroded fan coils
Corroded pipes
Leaking pipes
Corroded unions

Figure 151. Heater Corrosion Descriptions

See C.3.4. Air Conditioner.

C.3.10. Air Compressor

Rusted air compressor
Defective compressor
Deteriorating coils
Air vent rusted

Figure 152. Compressor Corrosion Descriptions

See C.3.4. Air Conditioner.

C.3.11. Coil

Deteriorated fan coil
Rusted fan coil

Figure 153. Coil Corrosion Descriptions

See C.3.4. Air Conditioner.

C.3.12. Line

Corroded gas line
Deteriorated combustion tube

Figure 154. Line Corrosion Descriptions

C.3.13. Chiller

Deteriorated Chiller

Figure 155. Chiller Corrosion Description

See C.9.1. Chiller.

C.3.14. Controller

Corrosion control

Figure 156. Controller Corrosion Description

C.4. Electrical

The fourth FICE Cost Driver issue is Electrical.

Electrical	**91**
Panel	**27**
Transformer	**24**
Breaker	**21**
Conduit	**15**
Cabinet	**2**
Electrical	**1**
Connection	**1**

Figure 157. Electrical Maintenance Objects Breakdown

C.4.1. Panel

access panel rusting
Corroding panels
Rusted overhead panels
Rusted utilities box
Corroded pannel on stall in head
Corroded base panel under sink

Figure 158. Panel Corrosion Descriptions

Corrosion Factors: The above issues with electrical panels can be attributed to panels mounted externally to facilities and to panels mounted in bathrooms. It is assumed that these panels are not designed to be exposed to the external environment or high humidity conditions. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Panels constructed for external environments should be considered in these situations. Specifications for external electrical boxes should be reviewed to ensure components specified are designed for corrosion protection.

C.4.2. Transformer

Corroded transformer
Deteriorated pad-mounted transformer
Corrosion holes in transformer
Corroded transformer door hinges

Figure 159. Transformer Corrosion Descriptions

Corrosion Factors: The majority of the transformer issues were associated with bases located in Hawaii. It is assumed that the corrosive environment was the root cause on these units. Therefore, the typical

corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Transformers that are constructed of corrosion resistant alloys or non-metallic materials should be considered in high ESI environments.

C.4.3. Breaker

Breaker corroded
deteriorating breaker boxes
Circuit breaker door corroded
Rusted electrical outlets
Wooden breaker enclosure deteriorating

Figure 160. Breaker Corrosion Descriptions

Corrosion Factors: Breaker corrosion is very similar to the electrical panel issues mentioned previously. These were electrical boxes mounted externally to a facility and were not constructed of materials intended for external exposure. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Alternative construction materials for electrical enclosures and internal components should be considered for external exposures.

C.4.4. Conduit

Rusted riser conduits
Conduit pipe corroded

Figure 161. Conduit Corrosion Descriptions

Corrosion Factors: Metal conduit corrosion was a common issue. It is assumed that these were mounted externally to a facility. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Conduct site survey to determine the connection between conduit materials and their environment.

C.4.5. Cabinet

Rusted electrical cabinet

Figure 162. Cabinet Corrosion Descriptions

Cabinet corrosion issues were the same as for the panels and breakers previously mentioned.

C.4.6. Electrical

Deteriorating wires

Figure 163. Electrical Corrosion Description

Corrosion Factors: It is assumed that these are wires exposed to the environment that caused deterioration. It is not known whether the wire sheathing was damaged or if general wire deterioration occurred. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: It is suggested that wiring exposed to the environment be enclosed in conduit to protect it from the environment.

C.4.7. Connection

Truck fill stand control valve corroded
Corroded dead man hose connection

Figure 164. Connection Corrosion Descriptions

Corrosion Factors: These connection issues seem to be associated with components unique to a system. Typically, components such as these corrode because they are not designed to be continually exposed to the outdoor environment. Therefore, the typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: In general all components exposed to the environment should be reviewed to ensure proper materials are used for construction to prevent corrosion issues.

C.5. Water Heater

The fifth FICE Cost Driver is Water Heater.

⊟ **water heater**	**42**
⊞ **Water Heater**	**42**

Figure 165. Water Heater Maintenance Objects Breakdown

C.5.1. Water Heater

Water heater rusted
Water heater leaking
Deteriorated water heater
Corroded water heater pipes
Deteriorated wood door
Corroded supply and return hoses
Corroded valves
Instant water heater rusted
Corroded pipe under sink
Rusted gas water heater

Figure 166. Water Heater Corrosion Descriptions

Water heaters exhibited many issues that ranged from the general holding tank to individual components. Leaking water from water heaters can cause significant and costly damage.

Corrosion Factors: Corrosion factors are local water chemistry, older piping materials such as iron, and exposure to high humidity bathrooms.

Recommendation: Standards for water heaters should be developed to ensure they are constructed of the proper materials and can be specified during procurement. Additionally, maintenance on hot water heaters should include regularly changing the internal anodes to protect against internal tank corrosion.

C.6. Fence

The sixth FICE Cost Driver is Fence.

⊟ **Fence**	**38**
⊞ **Fence**	**38**

C.6.1. Fence

Deteriorated fence line
Fence post rusted
Corroded fencing
Corroded barbed wire
Hole caused by deterioration

Figure 167. Fence Corrosion Descriptions

Corrosion Factors: Fencing corrosion due to carbon steel deterioration was the most common issue. The data did not provide enough detail to determine if the issues were related to galvanized materials or if they were related to high ESI areas. Typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: It is assumed that the minimum standard for fencing would be galvanized materials. Alternatives to galvanized materials should be considered for high ESI areas.

C.7. Lighting

The seventh FICE Cost Driver is Lighting.

Lighting, etc	**34**
Fixture	**31**
Pole	**2**
Track	**1**

C.7.1. Fixture

Corroded ceiling light fixture
Deteriorated security light fixtures
Rusted weather proof light fixtures
Corroded light fixture covers
Rusted flood lights
Lighting swivel arm corroded
Rusted emergency light fixtures
Corroded motion detector
Corroded screws in light covers

Figure 168. Light Fixture Corrosion Descriptions

Corrosion Factors: Most of the fixture issues were associated with externally mounted components, with the exception of ceiling light fixtures. Ceiling fixtures seemed to fail due to exposure to water leaks or high humidity environments such as bathrooms.

Recommendation: Externally mounted fixtures should be reviewed to ensure proper construction materials are used for potentially corrosive environments.

C.7.2. Pole

Deteriorated electrical lines
Deteriorated/rotting electrical poles

Figure 169. Pole Corrosion Descriptions

Corrosion Factors: The pole issues were concentrated in high ESI areas.

Recommendation: Materials used to construct external electrical lines and mounting poles should be reviewed to ensure they are designed for high ESI environments.

C.7.3. Track

Rusted Track

Figure 170. Track Corrosion Description

Corrosion Factors: These records indicated that the track mounting systems for lights had deteriorated. Typical corrosion factors associated with the external environment apply, such as humidity, rain fall, temperature, salt fall, and UV.

Recommendation: Again the environment should be considered during specification of mounting materials in high ESI areas.

C.8. Wastewater

The eighth FICE Cost Driver is Wastewater.

Wastewater	**32**
Wastewater plant	**30**
Piping	**1**
Stairway	**1**

Figure 171. Wastewater Maintenance Objects Breakdown

C.8.1. Wastewater Plant

Lift station pump corroded
Corroded air line relief valve riser
Corroded piping
Corroded elbows
Rust damaged wheel-barrows
Rusted anchor links
Rusted chain
Corroded valve
Corroded bolts
Corroded Conduit
Corroded hose rib
Corroded Pressure Regulators
Air tank corrosion
Corrosion damaged guage mount
Corroded guide rail plugs
Corroded nuts and washers
Rusted angle mounts
Rusted Unistrut supports
Rusted Jib Crane

Figure 172. Wastewater Plant Corrosion Descriptions

C.8.2. Piping

Rusted water pipe

Figure 173. Piping Corrosion Description

C.8.3. Stairway

Rusted out step

Figure 174. Stairway Corrosion Description

Corrosion Factors: From these records it can be determined that wastewater facilities are highly corrosive areas and the systems installed in these facilities should be designed for corrosion durability. Corrosion factors for these types of facilities would include water immersion, chemical exposures (hydrogen-sulfide, nitrides, chlorides, acids, caustics), ozone, varying Ph levels, and microbiologically induced corrosion (MIC). Most corrosion records related to the deterioration of carbon steel components. Specifically, mounting hardware and attachment hardware were often constructed from carbon steel and required replacement. These support components can often be overlooked when specifying or installing components in a high corrosion environment. Records indicated components such as steel stairways were installed in immersion areas, wasted away and became significant safety hazards.

Recommendation: A field survey of wastewater facilities should be conducted to determine root cause for corrosion. From the root cause analysis, the proper materials can be identified for components and general construction. Specifications should be reviewed to ensure that all components and mounting components be constructed of corrosion resistant materials.

C.9. Cooling, Chiller

The ninth FICE Cost Driver is Cooling, Chiller.

⊟ **Cooling, Chiller**	**23**
⊞ **Chiller**	**15**
⊞ **Cooling Tower**	**8**

Figure 175. Cooling, Chiller Maintenance Objects Breakdown

C.9.1. Chiller

Rusted fittings on chillwater expansion tank
Rusted piping (Freon leaks)
Rusted dialectric fittings
Deteriorating/Rusted AC chiller unit
corrosion on chiller panel

Figure 176. Chiller Corrosion Descriptions

C.9.2. Cooling Tower

Electrical disconnects corroded
Chill water return pipe corroded
Deteriorated cooling tower
Corroded pump suction screen
Chemical check valve deteriorated

Figure 177. Cooling Tower Corrosion Descriptions

Corrosion Factors: Potential corrosion factors are local water chemistry, older piping or component materials such as iron, and exposure to high humidity environments. There was not an inherent correlation to ESI for this cost driver.

Recommendation: A field survey of Cooling Towers and Chillers should be conducted to determine root cause for corrosion. From the root cause analysis, the proper materials can be identified for components and general construction. Specifications should be reviewed to ensure that all components and mounting components be constructed of corrosion resistant materials, especially those exposed to high humidity environments.

C.10. Pavement, Concrete

The tenth FICE Cost Driver is Pavement, Concrete.

Pavement, Concrete	21
Pavement	7
Concrete	7
Apron	3
Piping	1
Paint	1
Curb	1
Fire Hydrant	1

Figure 178. Pavement, Concrete Maintenance Objects Breakdown

C.10.1. Pavement

Asphalt deteriorated
Pavement deteriorated
Shoulder area deteriorated
Taxiway deteriorated

Figure 179. Pavement Corrosion Descriptions

C.10.2. Concrete

Sidewalk deteriorated
Concrete deteriorated
Corroded concrete at base of ramp

Figure 180. Concrete Corrosion Descriptions

C.10.3. Apron

Apron parking pavement deteriorated
Taxiway aircraft parking apron deteriorated

Figure 181. Apron Corrosion Descriptions

C.10.4. Piping

Rusted piping

Figure 182. Piping Corrosion Description

C.10.5. Paint

Restripe old paint

Figure 183. Paint Corrosion Description

C.10.6. Curb

Deteriorated sidewalk

Figure 184. Curb Corrosion Description

C.10.7. Fire Hydrant

Fire Hydrant coroded causing concrete repair

Figure 185. Fire Hydrant Corrosion Description

The pavement and concrete issues can be broken into three sections:

1) Runways
2) General pavement concrete
3) Painting

Corrosion Factors: It is not possible to determine the root cause from the FICE data. Information on the age and local environment are needed to determine if failures were a result of use or the environment. In general, corrosion factors for pavement and concrete are temperature, load-use, rain fall, UV exposure, and freeze thaw cycles.

Recommendation: Conduct site surveys and discuss possible root causes with facility managers that maintain pavement, concrete systems.

Appendix D. Installation Corrosion Factors

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Al Dhafra AF Base	AE	00	τ1	No	1	1.065
AL UDEID AIR BASE	QA	00	τ1	No	1	1.065
Arizona National Guard	US	04	τ1	No	1	1.06
Arizona Reserves	US	04	τ1	No	1	1.06
Camp Lemonier Djibouti	DJ	00	τ1	No	1	1.065
Davis-Monthan AF Base	US	04	τ1	No	1	1.06
Dugway Proving Ground	US	49	τ1	No	1	1.06
Fort Bliss	US	48	τ1	No	1	1.06
Fort Huachuca	US	04	τ1	No	1	1.06
Holloman AF Base	US	35	τ1	No	1	1.06
Kirtland AF Base	US	35	τ1	No	1	1.06
Luke AF Base	US	04	τ1	No	1	1.06
Mcas Yuma Az	US	04	τ1	No	1	1.06
Naf El Centro Ca	US	06	τ1	No	1	1.06
Nellis AF Base	US	32	τ1	No	1	1.06
Nevada National Guard	US	32	τ1	No	1	1.06
Nsa Bahrain	BA	00	τ1	No	1	1.065
Thule Air Base	GL	00	τ1	Yes	1	1.065
White Sands Missile Range	US	35	τ1	No	1	1.06
Yuma Proving Ground	US	04	τ1	No	1	1.06
Nevada Reserves	US	32	τ1	No	1	1.06
AF PLANT 44 ARMED FORCES PLANT	US	04	τ1	No	1	1.06
United Arab Emirates	AE	00	τ1	No	1	1.065
Navcommsta H E Holt Exmouth As	AS	00	τ1	No	2	1.065
Naf Adak Ak	US	02	τ2	Yes	2	1.06
Alaska National Guard	US	02	τ2	Yes	2	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Alaska Reserves	US	02	τ2	Yes	2	1.06
Beale AF Base	US	06	τ3	No	2	1.06
Buckley AF Base	US	08	τ2	No	2	1.06
Cannon AF Base	US	35	τ2	No	2	1.06
Cheyenne Mountain AF Station	US	08	τ2	No	2	1.06
Clear AF Station	US	02	τ2	No	2	1.06
Colorado National Guard	US	08	τ2	No	2	1.06
Colorado Reserves	US	08	τ2	No	2	1.06
Eielson AF Base	US	02	τ2	No	2	1.06
Ellsworth AF Base	US	30	τ2	No	2	1.06
F E Warren AF Base	US	56	τ2	No	2	1.06
Fort Carson	US	08	τ2	No	2	1.06
Fort Greely	US	02	τ2	No	2	1.06
Fort Wainwright	US	02	τ2	No	2	1.06
Hawthorne AR Depot	US	32	τ2	No	2	1.06
Joint Base Elmendorf-Richardson	US	02	τ2	Yes	2	1.06
Laughlin AF Base	US	48	τ2	No	2	1.06
Malmstrom AF Base	US	30	τ2	No	2	1.06
Mcagcc Twentynine Palms Ca	US	06	τ1	No	2	1.06
Mclb Barstow Ca	US	06	τ1	No	2	1.06
Montana National Guard	US	30	τ2	No	2	1.06
Montana Reserves	US	30	τ2	No	2	1.06
Nas Fallon Nv	US	32	τ2	No	2	1.06
National Training Center And Fort Irwin	US	06	τ1	No	2	1.06
Navmedrschu Three Cairo Egypt	EG	00	τ3	No	2	1.065
Naws China Lake	US	06	τ3	No	2	1.06
New Mexico National Guard	US	35	τ2	No	2	1.06
New Mexico Reserves	US	35	τ2	No	2	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Peterson AF Base	US	08	τ2	No	2	1.06
Pueblo Chemical Depot	US	08	τ2	No	2	1.06
Schriever AF Base	US	08	τ2	No	2	1.06
Sierra AR Depot	US	06	τ2	No	2	1.06
Tooele AR Depot	US	35	τ2	No	2	1.06
Usaf Academy	US	08	τ2	No	2	1.06
Wyoming National Guard	US	56	τ2	No	2	1.06
Wyoming Reserves	US	56	τ2	No	2	1.06
Rocky Mountain Arsenal	US	08	τ2	No	2	1.06
Unknown	US	02	τ2	Yes	2	1.06
Fairchild AF Base	US	53	τ2	No	3	1.06
Hill AF Base	US	49	τ2	Yes	3	1.06
Idaho National Guard	US	16	τ2	No	3	1.06
Idaho Reserves	US	16	τ2	No	3	1.06
Mountain Home AF Base	US	16	τ2	No	3	1.06
Nsa Midsouth Memphis Tn	US	47	τ3	No	3	1.06
South Dakota National Guard	US	46	τ3	No	3	1.06
South Dakota Reserves	US	46	τ3	No	3	1.06
Utah National Guard	US	49	τ2	No	3	1.06
Utah Reserves	US	49	τ2	No	3	1.06
Defense Depot Memphis	US	47	τ3	No	3	1.06
Deseret Chemical Depot	US	49	τ2	No	3	1.06
Aviano Air Base	IT	00	τ3	No	4	1.065
Cavalier AF Station	US	38	τ3	No	4	1.06
Grand Forks AF Base	US	38	τ3	No	4	1.06
Minnesota National Guard	US	27	τ3	No	4	1.06
Minnesota Reserves	US	27	τ3	No	4	1.06
Minot AF Base	US	38	τ3	No	4	1.06
North Dakota National Guard	US	38	τ3	No	4	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
North Dakota Reserves	US	38	τ3	No	4	1.06
Nsa Athens	US	13	τ3	No	4	1.06
Umatilla Chemical Depot	US	41	τ2	No	4	1.06
Usag Benelux	BE	00	τ3	No	4	1.065
Usag Vicenza	IT	00	τ3	No	4	1.065
Altus AF Base	US	40	τ4	No	5	1.06
Area 4, Korea	KS	00	τ3	No	5	1.065
Fort Leonard Wood	US	29	τ4	No	5	1.06
Fort Mccoy	US	55	τ3	No	5	1.06
Fort Sill	US	40	τ4	No	5	1.06
Germersheim AR Depot	GM	00	τ3	No	5	1.065
Joint Base Anacostia-Bolling	US	11	τ4	No	5	1.06
Landstuhl	GM	00	τ3	No	5	1.065
Marbks Washington Dc	US	11	τ4	No	5	1.06
Mcsptact Kansas City Mo	US	29	τ4	No	5	1.06
Nas Meridian Ms	US	29	τ4	No	5	1.06
Navsta Rota Sp	SP	00	τ3	Yes	5	1.065
Nebraska National Guard	US	31	τ3	No	5	1.06
Nebraska Reserves	US	31	τ3	No	5	1.06
New Boston AF Station	US	33	τ3	No	5	1.06
Offutt AF Base	US	31	τ3	No	5	1.06
Oklahoma National Guard	US	40	τ4	No	5	1.06
Oklahoma Reserves	US	40	τ4	No	5	1.06
Oregon National Guard	US	41	τ3	No	5	1.06
Oregon Reserves	US	41	τ3	No	5	1.06
Taylor Barracks	GM	00	τ3	No	5	1.065
Tinker AF Base	US	40	τ4	No	5	1.06
Usag Ansbach	GM	00	τ3	No	5	1.065
Usag Bamberg	GM	00	τ3	No	5	1.065

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Usag Baumholder	GM	00	τ3	No	5	1.065
Usag Grafenwoehr	GM	00	τ3	No	5	1.065
Usag Heidelberg	GM	00	τ3	No	5	1.065
Usag Hohenfels	GM	00	τ3	No	5	1.065
Usag Kaiserslautern	GM	00	τ3	No	5	1.065
Usag Mannheim	GM	00	τ3	No	5	1.065
Usag Schinnen	GM	00	τ3	No	5	1.065
Usag Schweinfurt	GM	00	τ3	No	5	1.065
Usag Stuttgart	GM	00	τ3	No	5	1.065
Usag Wiesbaden	GM	00	τ3	No	5	1.065
Vance AF Base	US	40	τ4	No	5	1.06
Wisconsin National Guard	US	55	τ3	No	5	1.06
Wisconsin Reserves	US	55	τ3	No	5	1.06
Badger AR Ammunition Plant	US	55	τ3	No	5	1.06
Camp Bedrock	BK	00	τ3	No	5	1.065
Camp Bondsteel	RB	00	τ3	No	5	1.065
Camp McGovern	BK	00	τ3	No	5	1.065
Camp Monteith	RB	00	τ3	No	5	1.065
Cornhusker AR Ammunition Plant	US	31	τ3	No	5	1.06
Taegu Air Base	KS	00	τ3	No	5	1.065
USAG Darmstadt	GM	00	τ3	No	5	1.065
Usag Franconia	GM	00	τ3	No	5	1.065
Usag Giessen	GM	00	τ3	No	5	1.065
Usag Hessen	GM	00	τ3	No	5	1.065
Wuerzburg Tng Areas	GM	00	τ3	No	5	1.065
Davisville Ri Cbc	US	44	τ3	No	6	1.06
Mcas Tustin Ca	US	06	τ3	No	6	1.06
Nas Alameda Ca	US	06	τ3	No	6	1.06
Alconbury Royal Af Station	UK	00	τ3	No	6	1.065

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Brooks City Base	US	48	τ4	No	6	1.06
California National Guard	US	06	τ3	No	6	1.06
California Reserves	US	06	τ3	No	6	1.06
Carlisle Barracks	US	42	τ3	No	6	1.06
Croughton Royal Af Station	UK	00	τ3	No	6	1.065
Defense Distribution Depot San Joaquin	US	06	τ3	No	6	1.06
Defense Distribution Depot Susquehanna	US	42	τ3	No	6	1.06
Delaware National Guard	US	10	τ4	No	6	1.06
Delaware Reserves	US	10	τ4	No	6	1.06
Dyess AF Base	US	48	τ4	No	6	1.06
Edwards AF Base	US	06	τ3	No	6	1.06
Fairford Royal Af Station	UK	00	τ3	No	6	1.065
Fort Hood	US	48	τ4	No	6	1.06
Fort Hunter Liggett	US	06	τ3	No	6	1.06
Goodfellow AF Base	US	48	τ4	No	6	1.06
Lakenheath Royal Af Station	UK	00	τ3	No	6	1.065
Letterkenny AR Depot	US	42	τ3	No	6	1.06
Los Angeles AF Base	US	06	τ3	No	6	1.06
Mcalester AR Ammunition Plant	US	48	τ4	No	6	1.06
Mcas El Toro Santa Ana Ca	US	06	τ3	No	6	1.06
Mcas Miramar	US	06	τ3	Yes	6	1.06
Mildenhall Royal Af Station	UK	00	τ3	No	6	1.065
Nas Lemoore Ca	US	06	τ3	No	6	1.06
Nas Sigonella It	IT	00	τ3	No	6	1.065
Naval Base Ventura City Pt Mugu Ca	US	06	τ3	Yes	6	1.06
Nsa Mechanicsburg Pa	US	42	τ3	No	6	1.06
Pennsylvania National Guard	US	42	τ3	No	6	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Pennsylvania Reserves	US	42	τ3	No	6	1.06
Philadelphia Pa Ns	US	42	τ3	No	6	1.06
Ramstein Air Base	GM	00	τ3	No	6	1.065
Red River AR Depot	US	48	τ4	No	6	1.06
Rhode Island National Guard	US	44	τ3	No	6	1.06
Sheppard AF Base	US	48	τ4	No	6	1.06
Spangdahlem Air Base	GM	00	τ3	No	6	1.065
Texas National Guard	US	48	τ4	No	6	1.06
Texas Reserves	US	48	τ4	No	6	1.06
Tobyhanna AR Depot	US	42	τ3	No	6	1.06
Travis AF Base	US	06	τ3	No	6	1.06
Usag Livorno	IT	00	τ3	No	6	1.065
Vermont National Guard	US	50	τ3	No	6	1.06
Vermont Reserves	US	50	τ3	No	6	1.06
Rhode Island Reserves	US	44	τ3	No	6	1.06
Warminster Pa Nawc-Ad	US	42	τ3	No	6	1.06
AF PLANT 42 ARMED FORCES PLANT	US	06	τ3	No	6	1.06
Applied Research Lab Austin Tx	US	48	τ4	No	6	1.06
Defense Supply Center Philadelphia	US	42	τ3	No	6	1.06
Fort Indiantown Gap	US	42	τ3	No	6	1.06
Longhorn AR Ammunition Plant	US	48	τ4	No	6	1.06
Military Ocean Terminal Concord	US	06	τ3	No	6	1.06
Nrc Stockton Ca	US	06	τ3	No	6	1.06
Nwirp Dallas Tx	US	48	τ4	No	6	1.06
Nwirp Mcgregor Tx	US	48	τ4	No	6	1.06
Ord Research Lab Univ Park Pa	US	42	τ3	No	6	1.06
Sacramento AR Depot	US	06	τ3	No	6	1.06
Sagami Depot	JA	00	τ3	No	6	1.065

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Scranton AR Ammunition Plant	US	42	τ3	No	6	1.06
Aberdeen Proving Ground	US	24	τ4	No	7	1.06
Area 3, Korea	KS	00	τ4	No	7	1.065
Arkansas National Guard	US	05	τ4	No	7	1.06
Arkansas Reserves	US	05	τ4	No	7	1.06
Arnold AF Base	US	47	τ4	No	7	1.06
Connecticut National Guard	US	09	τ3	No	7	1.06
Connecticut Reserves	US	09	τ3	No	7	1.06
Defense Supply Center Columbus	US	39	τ3	No	7	1.06
District Of Columbia National Guard	US	11	τ4	No	7	1.06
Fort Detrick	US	24	τ4	No	7	1.06
Fort George G Meade	US	24	τ4	No	7	1.06
Incirlik Air Base	TU	00	τ3	No	7	1.065
Joint Base Andrews	US	24	τ4	No	7	1.06
Joint Base San Antonio	US	48	τ4	No	7	1.06
Kaena Point Sattelite Tracking Station	US	15	τ3	No	7	1.06
Lake City AR Ammunition Plant	US	29	τ3	No	7	1.06
Little Rock AF Base	US	05	τ4	No	7	1.06
Marcorps Dist 1 Garden City Ny	US	36	τ3	No	7	1.06
Maryland National Guard	US	24	τ4	No	7	1.06
Maryland Reserves	US	24	τ4	No	7	1.06
Missouri National Guard	US	29	τ3	No	7	1.06
Missouri Reserves	US	29	τ3	No	7	1.06
Moron Air Base	SP	00	τ3	No	7	1.065
Navsuppu Saratoga Springs Ny	US	36	τ3	No	7	1.06
New York National Guard	US	36	τ3	No	7	1.06
New York Reserves	US	36	τ3	No	7	1.06
Nsa Thurmont	US	24	τ4	No	7	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Ohio National Guard	US	39	τ3	No	7	1.06
Ohio Reserves	US	39	τ3	No	7	1.06
Pine Bluff Arsenal	US	05	τ4	No	7	1.06
Rome Laboratory	US	36	τ3	No	7	1.06
Seymour Johnson AF Base	US	37	τ4	No	7	1.06
Tennessee National Guard	US	47	τ4	No	7	1.06
Tennessee Reserves	US	47	τ4	No	7	1.06
Us AR Research Laboratory Adelphi	US	24	τ4	No	7	1.06
Usma	US	36	τ3	No	7	1.06
Walter Reed National Military Medical Center	US	24	τ4	No	7	1.06
Watervliet Arsenal	US	36	τ3	No	7	1.06
Whiteman AF Base	US	29	τ3	No	7	1.06
Washington DC National Guard	US	24	τ4	No	7	1.06
Washington DC Reserves	US	11	τ4	No	7	1.06
Attache Israel	IS	0	τ3	No	7	1.065
Holston AR Ammunition Plant	US	47	τ4	No	7	1.06
Jfc North	NL	0	τ3	No	7	1.065
Joint System Manufacturing Center Lima	US	39	τ3	No	7	1.06
Milan AR Ammunition Plant	US	47	τ4	No	7	1.06
NAS Barbers Pt Hi	US	15	τ5	Yes	7	1.06
Nswc Carderock Md	US	24	τ4	No	7	1.06
Nwirp Bethpage Ny	US	36	τ3	No	7	1.06
Nwirp Bloomfield Ct	US	09	τ3	No	7	1.06
Nwirp Calverton Ny	US	36	τ3	No	7	1.06
Seneca AR Depot Activity	US	36	τ3	No	7	1.06
Washington Headquarters	US	24	τ4	No	7	1.06
Anniston AR Depot	US	01	τ4	No	8	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Arlington National Cemetery	US	51	τ4	No	8	1.06
Cape Cod AF Station	US	25	τ3	Yes	8	1.06
CRANE AR AMMUNITION ACTIVITY	US	18	τ3	No	8	1.06
Defense Supply Center Richmond	US	51	τ4	No	8	1.06
Detroit Arsenal	US	26	τ3	No	8	1.06
Dover AF Base	US	10	τ4	Yes	8	1.06
Fort Ap Hill	US	51	τ4	No	8	1.06
Fort Belvoir	US	51	τ4	No	8	1.06
Fort Drum	US	36	τ3	No	8	1.06
Fort Hamilton	US	36	τ3	Yes	8	1.06
Fort Lee	US	51	τ4	No	8	1.06
Fort Mcclellan	US	01	τ4	No	8	1.06
Fort Riley	US	20	τ3	No	8	1.06
Fort Rucker	US	01	τ4	No	8	1.06
Hanscom AF Base	US	25	τ3	No	8	1.06
Hqbn Hqmc Arlington Va	US	51	τ4	No	8	1.06
Illinois National Guard	US	17	τ3	No	8	1.06
Illinois Reserves	US	17	τ3	No	8	1.06
Indiana National Guard	US	18	τ3	No	8	1.06
Indiana Reserves	US	18	τ3	No	8	1.06
Iowa AR Ammunition Plant	US	19	τ3	No	8	1.06
Iowa National Guard	US	19	τ3	No	8	1.06
Iowa Reserves	US	19	τ3	No	8	1.06
Joint Base Mcguire-Dix-Lakehurst	US	34	τ3	No	8	1.06
Joint Base Myer-Henderson Hall	US	51	τ4	No	8	1.06
Massachusetts National Guard	US	25	τ3	Yes	8	1.06
Massachusetts Reserves	US	25	τ3	Yes	8	1.06
Maxwell AF Base	US	01	τ4	No	8	1.06
Mcb Quantico Va	US	51	τ4	No	8	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Mcconnell AF Base	US	20	τ3	No	8	1.06
Mclb Albany Ga	US	13	τ4	No	8	1.06
Michigan National Guard	US	26	τ3	No	8	1.06
Michigan Reserves	US	26	τ3	No	8	1.06
Nas Kingsville Tx	US	48	τ4	No	8	1.06
Naval Weapons Station Yorktown	US	51	τ4	No	8	1.06
Navmedrschcen Det Lima Peru	PE	00	τ3	No	8	1.065
Navsta Great Lakes Il	US	17	τ3	No	8	1.06
Navsta Newport Ri	US	44	τ3	Yes	8	1.06
New Jersey National Guard	US	34	τ3	No	8	1.06
New Jersey Reserves	US	34	τ3	No	8	1.06
Nsa Crane	US	18	τ3	No	8	1.06
Nsa Naples It	IT	00	τ3	Yes	8	1.065
NSA South Potomac	US	24	τ4	No	8	1.06
Nsa Wash	US	11	τ3	Yes	8	1.06
Picatinny Arsenal	US	34	τ3	No	8	1.06
Radford AR Ammunition Plant	US	51	τ4	No	8	1.06
Redstone Arsenal	US	01	τ4	No	8	1.06
Rock Island Arsenal	US	17	τ3	No	8	1.06
Scott AF Base	US	17	τ3	No	8	1.06
Soldier Systems Center	US	25	τ3	No	8	1.06
South Weymouth Ma Nas	US	25	τ3	No	8	1.06
Fort Benjamin Harrison	US	18	τ3	No	8	1.06
Fort Devens	US	25	τ3	Yes	8	1.06
Fort Meyer	US	51	τ4	No	8	1.06
Newport Chemical Depot	US	18	τ3	No	8	1.06
NOSTRA Yorktown	US	51	τ4	No	8	1.06
Nwirp Bedford Ma	US	25	τ3	No	8	1.06
USAG Selfridge	US	26	τ3	No	8	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Hdqtrs 4Th Maw New Orleans La	US	22	τ3	No	9	1.06
Barksdale AF Base	US	22	τ4	No	9	1.06
Blue Grass AR Depot	US	21	τ4	No	9	1.06
Camp Zama	JA	00	τ3	Yes	9	1.065
Comfleact Sasebo Ja	JA	00	τ4	Yes	9	1.065
Fort Campbell	US	21	τ4	No	9	1.06
Fort Jackson	US	45	τ4	No	9	1.06
Fort Knox	US	21	τ4	No	9	1.06
Fort Leavenworth	US	20	τ4	No	9	1.06
Fort Polk	US	22	τ4	No	9	1.06
Joint Base Lewis-Mcchord	US	53	τ3	No	9	1.06
Kadena Air Base	JA	00	τ4	Yes	9	1.065
Kansas National Guard	US	20	τ4	No	9	1.06
Kansas Reserves	US	20	τ4	No	9	1.06
Kentucky National Guard	US	21	τ4	No	9	1.06
Kentucky Reserves	US	21	τ4	No	9	1.06
Mcas Iwakuni Ja	JA	00	τ4	Yes	9	1.065
Misawa Air Base	JA	00	τ3	Yes	9	1.065
Naf Atsugi Ja	JA	00	τ4	No	9	1.065
Naf Misawa Ja	JA	00	τ4	No	9	1.065
Navsuppfac Diego Garcia Io	IO	00	τ4	Yes	9	1.065
Nsa Souda Bay Gr	GR	00	τ3	Yes	9	1.065
Nsa Sugar Grove	US	54	τ3	No	9	1.06
Shaw AF Base	US	45	τ4	No	9	1.06
South Carolina National Guard	US	45	τ4	No	9	1.06
South Carolina Reserves	US	45	τ4	No	9	1.06
West Virginia National Guard	US	54	τ3	No	9	1.06
West Virginia Reserves	US	54	τ3	No	9	1.06
Wright-Patterson AF Base	US	39	τ3	No	9	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Yokota Air Base	JA	00	τ4	No	9	1.065
Allegany Ballistics Lab	US	54	τ3	No	9	1.06
Fort Ord	US	06	τ3	Yes	9	1.06
Izmir Air Station	TU	00	τ3	Yes	9	1.065
Louisiana AR Ammunition Plant	US	22	τ4	No	9	1.06
New Orleans Nas Annex	US	22	τ4	No	9	1.06
Alabama National Guard	US	01	τ4	Yes	10	1.06
Alabama Reserves	US	01	τ4	Yes	10	1.06
Columbus AF Base	US	28	τ4	No	10	1.06
Florida National Guard	US	12	τ4	No	10	1.06
Florida Reserves	US	12	τ4	No	10	1.06
Fort Benning	US	13	τ4	No	10	1.06
Fort Gordon	US	13	τ4	No	10	1.06
Fort Mcpherson	US	13	τ4	No	10	1.06
Fort Monmouth	US	34	τ3	Yes	10	1.06
Fort Stewart	US	13	τ4	No	10	1.06
Georgia National Guard	US	13	τ4	No	10	1.06
Georgia Reserves	US	13	τ4	No	10	1.06
Joint Base Charleston	US	45	τ4	Yes	10	1.06
Mcas Beaufort Sc	US	45	τ4	Yes	10	1.06
Mcrd Beaufort Pi Sc	US	45	τ4	Yes	10	1.06
Mississippi National Guard	US	28	τ4	No	10	1.06
Mississippi Reserves	US	28	τ4	No	10	1.06
Moody AF Base	US	13	τ4	No	10	1.06
Naval Weapons Station Earle Nj	US	34	τ3	Yes	10	1.06
Robins AF Base	US	13	τ4	No	10	1.06
Ft Mcpherson Brac/Excess Sites	US	13	τ4	No	10	1.06
Cbc Gulfport Ms	US	28	τ4	Yes	11	1.06
Keesler AF Base	US	28	τ4	Yes	11	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Louisiana National Guard	US	22	τ4	Yes	11	1.06
Louisiana Reserves	US	22	τ4	Yes	11	1.06
Nas Keflavik	IC	0	τ3	Yes	11	1.065
Navsta Norfolk Va	US	51	τ4	Yes	11	1.06
New Hampshire National Guard	US	33	τ4	Yes	11	1.06
NS PASCAGOULA MS	US	28	τ4	Yes	11	1.06
Nsa New Orleans La	US	22	τ4	Yes	11	1.06
Nsa Norfolk Nsy	US	51	τ4	Yes	11	1.06
Nsy Portsmouth Nh	US	33	τ4	Yes	11	1.06
Stratford AR Engine Plant	US	09	τ3	Yes	11	1.06
Subase New London Ct	US	09	τ3	Yes	11	1.06
New Hampshire Reserves	US	33	τ4	Yes	11	1.06
Nsa Northwest	US	51	τ4	Yes	11	1.06
Fort Bragg	US	37	τ4	No	12	1.06
Mcb Camp Lejeune Nc	US	37	τ4	No	12	1.06
Military Ocean Terminal Sunny Point	US	37	τ4	No	12	1.06
Nas Patuxent River Md	US	24	τ4	No	12	1.06
Naval Base Kitsap	US	53	τ3	Yes	12	1.06
North Carolina National Guard	US	37	τ4	No	12	1.06
North Carolina Reserves	US	37	τ4	No	12	1.06
NSA Annapolis	US	24	τ4	No	12	1.06
Nsa Orlando	US	12	τ4	No	12	1.06
Pope AF Base	US	37	τ4	No	12	1.06
Washington National Guard	US	53	τ3	No	12	1.06
Washington Reserves	US	53	τ3	No	12	1.06
Cecil Field Fl Nas	US	12	τ4	No	12	1.06
Orlando Fl Ntc	US	12	τ4	No	12	1.06
Applied Physics Lab Seattle Wa	US	53	τ3	Yes	12	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Louisville Ky Nswc	US	21	τ4	No	12	1.06
Mcrc Yakima	US	53	τ3	No	12	1.06
Maine National Guard	US	23	τ3	No	13	1.06
Maine Reserves	US	23	τ3	No	13	1.06
Nas Brunswick Me	US	23	τ3	No	13	1.06
Pwc San Francisco Ca	US	06	τ3	Yes	14	1.06
FRC North Island	US	06	τ3	Yes	14	1.06
Hurlburt Field	US	12	τ4	Yes	14	1.06
Mcb Camp Pendleton Ca	US	06	τ3	Yes	14	1.06
Mcrd San Diego Ca	US	06	τ3	Yes	14	1.06
Naval Activity Puerto Rico	RQ	72	τ5	No	14	1.065
Naval Base Point Loma	US	06	τ3	Yes	14	1.06
Naval Weapons Station Seal Beach	US	06	τ3	Yes	14	1.06
Navregcontrctr Singapore	SN	00	τ5	Yes	14	1.065
Navsta Guantanamo Bay	CU	00	τ4	Yes	14	1.065
Navsta San Diego Ca	US	06	τ3	Yes	14	1.06
Ns Long Beach Ca	US	06	τ3	Yes	14	1.06
Nsa Monterey	US	06	τ3	Yes	14	1.06
Presidio Of Monterey	US	06	τ3	No	14	1.06
Hunters Point Annex	US	06	τ3	Yes	14	1.06
Ns Treasure Island Ca	US	06	τ3	Yes	14	1.06
Nsy Mare Island Ca	US	06	τ3	Yes	14	1.06
Eglin AF Base	US	12	τ4	Yes	15	1.06
Joint Base Langley–Eustis	US	51	τ4	Yes	15	1.06
Joint Expeditionary Base Little Creek-Fort Story	US	51	τ4	Yes	15	1.06
Macdill AF Base	US	12	τ4	Yes	15	1.06
Navsta Mayport Fl	US	12	τ4	Yes	15	1.06
Nsa Panama City	US	12	τ4	Yes	15	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Tyndall AF Base	US	12	τ4	Yes	15	1.06
Usag Miami	US	12	τ4	Yes	15	1.06
Navmedcen Portsmouth Va	US	51	τ4	Yes	15	1.06
Blount Island Command	US	12	τ4	Yes	16	1.06
Comfleact Yokosuka Ja	JA	00	τ4	Yes	16	1.065
Frc Jacksonville	US	12	τ4	Yes	16	1.06
Lajes Field	PO	00	τ3	Yes	16	1.065
Nas Pensacola Fl	US	12	τ4	Yes	16	1.06
Nas Whiting Fld Milton Fl	US	12	τ4	Yes	16	1.06
Vandenberg AF Base	US	06	τ5	Yes	16	1.06
NOMI Pensacola	US	12	τ4	Yes	16	1.06
Area 1, Korea	KS	00	τ4	Yes	17	1.065
Area 2, Korea	KS	00	τ4	Yes	17	1.065
Nas Atlanta Ga	US	13	τ4	No	17	1.06
Patrick AF Base	RQ	72	τ4	Yes	17	1.065
Subase Kings Bay Ga	US	13	τ4	No	17	1.06
Eareckson AF Station	US	02	τ2	Yes	18	1.06
Fort Shafter	US	15	τ5	Yes	18	1.06
Frc/Mcas Cherry Point	US	37	τ4	Yes	18	1.06
Hawaii National Guard	US	15	τ5	Yes	18	1.06
Hawaii Reserves	US	15	τ5	Yes	18	1.06
Joint Base Pearl Harbor-Hickam	US	15	τ5	Yes	18	1.06
Nas Oceana Va	US	51	τ4	Yes	18	1.06
Nas Whidbey Island Wa	US	53	τ3	Yes	18	1.06
Navmag Indian Island Wa	US	53	τ3	Yes	18	1.06
Navsta Everett Wa	US	53	τ3	Yes	18	1.06
Ns Puget Sound Wa	US	53	τ3	Yes	18	1.06
Pacmisranfac Hawaiian Area	US	15	τ5	Yes	18	1.06
Schofield Barracks	US	15	τ5	Yes	18	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Virginia National Guard	US	51	τ4	Yes	18	1.06
Virginia Reserves	US	51	τ4	Yes	18	1.06
Wheeler AR Airfield	US	15	τ5	Yes	18	1.06
Comfleact Kadena Okinawa Ja	JA	00	τ4	Yes	19	1.065
Corpus Christi AR Depot	US	48	τ4	Yes	19	1.06
Fort Buchanan	RQ	72	τ5	Yes	19	1.065
Guam National Guard	GQ	66	τ5	Yes	19	1.065
Guam Reserves	GQ	66	τ5	Yes	19	1.065
Joint Region Marianas	GQ	66	τ5	Yes	19	1.065
Mcb Camp S D Butler Okinawa Ja	JA	00	τ4	Yes	19	1.065
Mcb Hawaii Kaneohe	US	15	τ5	Yes	19	1.06
Nas Corpus Christi Tx	US	48	τ4	Yes	19	1.06
Nas Key West Fl	US	12	τ4	Yes	19	1.06
Navsta Ingleside Tx	US	48	τ4	No	19	1.06
Puerto Rico National Guard	RQ	72	τ5	Yes	19	1.065
Puerto Rico Reserves	RQ	72	τ5	Yes	19	1.065
Us AR Kwajalein Atoll	RM	00	τ5	Yes	19	1.065
Virgin Islands National Guard	VQ	00	τ5	Yes	19	1.06
Agana Guam Nas	GQ	66	τ5	Yes	19	1.065
Virgin Islands Reserves	VQ	00	τ5	Yes	19	1.06
Fort Buckner	JA	00	τ4	Yes	19	1.065
Soto Cano AF Base	HO	00	τ5	Yes	19	1.065
USS Constitution	US	25	τ5	Yes	20	1.06
Abraham Lincoln	US	53	τ5	Yes	20	1.06
Alabama	US	53	τ5	Yes	20	1.06
Alaska	US	51	τ5	Yes	20	1.06
Albany	US	51	τ5	Yes	20	1.06
Albuquerque	US	09	τ5	Yes	20	1.06
Alexandria	US	09	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Annapolis	US	33	τ5	Yes	20	1.06
Antietam	US	06	τ5	Yes	20	1.06
Anzio	US	51	τ5	Yes	20	1.06
Ardent	BA	00	τ5	Yes	20	1.065
Arleigh Burke	US	51	τ5	Yes	20	1.06
Asheville	US	06	τ5	Yes	20	1.06
Ashland	US	51	τ5	Yes	20	1.06
Augusta	US	09	τ5	Yes	20	1.06
Austin	US	51	τ5	Yes	20	1.06
Avenger	US	48	τ5	Yes	20	1.06
Bainbridge	US	51	τ5	Yes	20	1.06
Barry	US	51	τ5	Yes	20	1.06
Bataan	US	51	τ5	Yes	20	1.06
Belleau Wood	US	06	τ5	Yes	20	1.06
Benfold	US	06	τ5	Yes	20	1.06
Black Hawk	US	48	τ5	Yes	20	1.06
Blue Ridge	JA	00	τ5	Yes	20	1.065
Boise	US	51	τ5	Yes	20	1.06
Bonhomme Richard	US	06	τ5	Yes	20	1.06
Boone	US	12	τ5	Yes	20	1.06
Boxer	US	06	τ5	Yes	20	1.06
Bremerton	US	15	τ5	Yes	20	1.06
Bridge	JA	00	τ5	Yes	20	1.065
Briscoe	US	00	τ5	Yes	20	1.06
Buffalo	US	66	τ5	Yes	20	1.06
Bulkeley	US	51	τ5	Yes	20	1.06
Bunker Hill	US	06	τ5	Yes	20	1.06
Camden	US	00	τ5	Yes	20	1.06
Cape St. George	US	51	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Cardinal	BA	00	τ5	Yes	20	1.065
Carl Vinson	US	51	τ5	Yes	20	1.06
Carney	US	12	τ5	Yes	20	1.06
Carr	US	51	τ5	Yes	20	1.06
Carter Hall	US	51	τ5	Yes	20	1.06
Chafee	US	15	τ5	Yes	20	1.06
Champion	US	48	τ5	Yes	20	1.06
Chancellorsville	US	06	τ5	Yes	20	1.06
Charlotte	US	15	τ5	Yes	20	1.06
Cheyenne	US	15	τ5	Yes	20	1.06
Chicago	US	15	τ5	Yes	20	1.06
Chief	US	48	τ5	Yes	20	1.06
Chinook	US	51	τ5	Yes	20	1.06
Chosin	US	15	τ5	Yes	20	1.06
Chung-Hoon	US	15	τ5	Yes	20	1.06
Cleveland	US	06	τ5	Yes	20	1.06
Cole	US	51	τ5	Yes	20	1.06
Columbia	US	15	τ5	Yes	20	1.06
Columbus	US	15	τ5	Yes	20	1.06
Comstock	US	06	τ5	Yes	20	1.06
Connecticut	US	53	τ5	Yes	20	1.06
Cormorant	US	48	τ5	Yes	20	1.06
Coronado	US	06	τ5	Yes	20	1.06
Corpus Christi	US	66	τ5	Yes	20	1.06
Cowpens	JA	00	τ5	Yes	20	1.065
Crommelin	US	15	τ5	Yes	20	1.06
Curtis Wilbur	JA	00	τ5	Yes	20	1.065
Curts	US	06	τ5	Yes	20	1.06
Cushing	JA	00	τ5	Yes	20	1.065

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Dallas	US	09	τ5	Yes	20	1.06
De Wert	US	12	τ5	Yes	20	1.06
Decatur	US	06	τ5	Yes	20	1.06
Defender	US	48	τ5	Yes	20	1.06
Denver	US	06	τ5	Yes	20	1.06
Detroit	US	00	τ5	Yes	20	1.06
Devastator	US	48	τ5	Yes	20	1.06
Dewey	US	06	τ5	Yes	20	1.06
Dextrous	BA	00	τ5	Yes	20	1.065
Deyo	US	00	τ5	Yes	20	1.06
Donald Cook	US	51	τ5	Yes	20	1.06
Doyle	US	12	τ5	Yes	20	1.06
Dubuque	JA	00	τ5	Yes	20	1.065
Duluth	US	06	τ5	Yes	20	1.06
Dwight D. Eisenhower	US	51	τ5	Yes	20	1.06
Elliott	US	00	τ5	Yes	20	1.06
Elrod	US	51	τ5	Yes	20	1.06
Emory S Land	US	53	τ5	Yes	20	1.06
Enterprise	US	51	τ5	Yes	20	1.06
Essex	US	06	τ5	Yes	20	1.06
Falcon	US	48	τ5	Yes	20	1.06
Farragut	US	12	τ5	Yes	20	1.06
Firebolt	US	51	τ5	Yes	20	1.06
Fitzgerald	JA	00	τ5	Yes	20	1.065
Fletcher	US	00	τ5	Yes	20	1.06
Florida	US	13	τ5	Yes	20	1.06
Ford	US	53	τ5	Yes	20	1.06
Forrest Sherman	US	51	τ5	Yes	20	1.06
Fort Mchenry	US	51	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Frank Cable	US	66	τ5	Yes	20	1.06
Gary	US	06	τ5	Yes	20	1.06
George H W Bush	US	51	τ5	Yes	20	1.06
George Washington	US	51	τ5	Yes	20	1.06
Georgia	US	13	τ5	Yes	20	1.06
Germantown	US	06	τ5	Yes	20	1.06
Gettysburg	US	12	τ5	Yes	20	1.06
Gladiator	BA	00	τ5	Yes	20	1.065
Gonzalez	US	51	τ5	Yes	20	1.06
Grapple	US	51	τ5	Yes	20	1.06
Grasp	US	51	τ5	Yes	20	1.06
Green Bay	US	06	τ5	Yes	20	1.06
Greeneville	US	33	τ5	Yes	20	1.06
Gridley	US	06	τ5	Yes	20	1.06
Guardian	JA	00	τ5	Yes	20	1.065
Gunston Hall	US	51	τ5	Yes	20	1.06
Halsey	US	06	τ5	Yes	20	1.06
Halyburton	US	12	τ5	Yes	20	1.06
Hampton	US	06	τ5	Yes	20	1.06
Harpers Ferry	US	06	τ5	Yes	20	1.06
Harry S. Truman	US	51	τ5	Yes	20	1.06
Hartford	US	09	τ5	Yes	20	1.06
Hawaii	US	15	τ5	Yes	20	1.06
Hawes	US	51	τ5	Yes	20	1.06
Helena	US	06	τ5	Yes	20	1.06
Henry M. Jackson	US	53	τ5	Yes	20	1.06
Heron	US	48	τ5	Yes	20	1.06
Higgins	US	06	τ5	Yes	20	1.06
Honolulu	US	15	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Hopper	US	15	τ5	Yes	20	1.06
Houston	US	66	τ5	Yes	20	1.06
Howard	US	06	τ5	Yes	20	1.06
Hue City	US	12	τ5	Yes	20	1.06
Hurricane	US	51	τ5	Yes	20	1.06
Hyman G. Rickover	US	33	τ5	Yes	20	1.06
Ingraham	US	53	τ5	Yes	20	1.06
Iwo Jima	US	51	τ5	Yes	20	1.06
Jacksonville	US	51	τ5	Yes	20	1.06
James E. Williams	US	51	τ5	Yes	20	1.06
Jarrett	US	06	τ5	Yes	20	1.06
Jefferson City	US	06	τ5	Yes	20	1.06
Jimmy Carter	US	53	τ5	Yes	20	1.06
John C. Stennis	US	53	τ5	Yes	20	1.06
John F. Kennedy	US	12	τ5	Yes	20	1.06
John L. Hall	US	12	τ5	Yes	20	1.06
John Mccain	JA	00	τ5	Yes	20	1.065
John Paul Jones	US	06	τ5	Yes	20	1.06
Juneau	US	06	τ5	Yes	20	1.06
Kauffman	US	51	τ5	Yes	20	1.06
Kearsarge	US	51	τ5	Yes	20	1.06
Kentucky	US	53	τ5	Yes	20	1.06
Key West	US	15	τ5	Yes	20	1.06
Kidd	US	06	τ5	Yes	20	1.06
Kingfisher	US	48	τ5	Yes	20	1.06
Kitty Hawk	JA	00	τ5	Yes	20	1.065
Klakring	US	12	τ5	Yes	20	1.06
La Jolla	US	15	τ5	Yes	20	1.06
La Salle	US	00	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Laboon	US	51	τ5	Yes	20	1.06
Lake Champlain	US	06	τ5	Yes	20	1.06
Lake Erie	US	15	τ5	Yes	20	1.06
Lassen	JA	00	τ5	Yes	20	1.065
Leyte Gulf	US	51	τ5	Yes	20	1.06
Los Angeles	US	15	τ5	Yes	20	1.06
Louisiana	US	53	τ5	Yes	20	1.06
Louisville	US	33	τ5	Yes	20	1.06
Mahan	US	51	τ5	Yes	20	1.06
Maine	US	53	τ5	Yes	20	1.06
Makin Island	US	06	τ5	Yes	20	1.06
Maryland	US	13	τ5	Yes	20	1.06
Mason	US	51	τ5	Yes	20	1.06
Mccampbell	JA	00	τ5	Yes	20	1.065
Mcclusky	US	06	τ5	Yes	20	1.06
Mcfaul	US	51	τ5	Yes	20	1.06
Mcinerney	US	12	τ5	Yes	20	1.06
Memphis	US	33	τ5	Yes	20	1.06
Mesa Verde	US	51	τ5	Yes	20	1.06
Miami	US	09	τ5	Yes	20	1.06
Michigan	US	53	τ5	Yes	20	1.06
Milius	US	06	τ5	Yes	20	1.06
Minneapolis-Saint Paul	US	15	τ5	Yes	20	1.06
Missouri	US	09	τ5	Yes	20	1.06
Mitscher	US	51	τ5	Yes	20	1.06
Mobile Bay	US	06	τ5	Yes	20	1.06
Momsen	US	53	τ5	Yes	20	1.06
Monsoon	US	51	τ5	Yes	20	1.06
Monterey	US	51	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Montpelier	US	51	τ5	Yes	20	1.06
Mount Whitney	IT	00	τ5	Yes	20	1.065
Mustin	JA	00	τ5	Yes	20	1.065
Nashville	US	51	τ5	Yes	20	1.06
Nassau	US	51	τ5	Yes	20	1.06
Nebraska	US	53	τ5	Yes	20	1.06
Nevada	US	53	τ5	Yes	20	1.06
New Hampshire	US	09	τ5	Yes	20	1.06
New Mexico	US	09	τ5	Yes	20	1.06
New Orleans	US	06	τ5	Yes	20	1.06
New York	US	51	τ5	Yes	20	1.06
Newport News	US	51	τ5	Yes	20	1.06
Nicholas	US	51	τ5	Yes	20	1.06
Nimitz	US	53	τ5	Yes	20	1.06
Nitze	US	51	τ5	Yes	20	1.06
Norfolk	US	51	τ5	Yes	20	1.06
Normandy	US	51	τ5	Yes	20	1.06
North Carolina	US	15	τ5	Yes	20	1.06
Oak Hill	US	51	τ5	Yes	20	1.06
O'Bannon	US	12	τ5	Yes	20	1.06
Ogden	US	06	τ5	Yes	20	1.06
Ohio	US	53	τ5	Yes	20	1.06
O'Kane	US	15	τ5	Yes	20	1.06
Oklahoma City	US	51	τ5	Yes	20	1.06
Olympia	US	15	τ5	Yes	20	1.06
Oriole	US	48	τ5	Yes	20	1.06
Oscar Austin	US	51	τ5	Yes	20	1.06
Osprey	US	48	τ5	Yes	20	1.06
Pasadena	US	15	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Patriot	JA	00	τ5	Yes	20	1.065
Paul Hamilton	US	15	τ5	Yes	20	1.06
Pearl Harbor	US	06	τ5	Yes	20	1.06
Peleliu	US	06	τ5	Yes	20	1.06
Pelican	US	48	τ5	Yes	20	1.06
Pennsylvania	US	53	τ5	Yes	20	1.06
Philadelphia	US	33	τ5	Yes	20	1.06
Philippine Sea	US	12	τ5	Yes	20	1.06
Pinkney	US	06	τ5	Yes	20	1.06
Pioneer	US	48	τ5	Yes	20	1.06
Pittsburgh	US	09	τ5	Yes	20	1.06
Ponce	US	51	τ5	Yes	20	1.06
Port Royal	US	15	τ5	Yes	20	1.06
Porter	US	51	τ5	Yes	20	1.06
Portsmouth	US	51	τ5	Yes	20	1.06
Preble	US	06	τ5	Yes	20	1.06
Princeton	US	06	τ5	Yes	20	1.06
Providence	US	09	τ5	Yes	20	1.06
Ramage	US	51	τ5	Yes	20	1.06
Raven	BA	00	τ5	Yes	20	1.065
Rentz	US	06	τ5	Yes	20	1.06
Reuben James	US	15	τ5	Yes	20	1.06
Rhode Island	US	13	τ5	Yes	20	1.06
Robert G. Bradley	US	12	τ5	Yes	20	1.06
Robin	US	48	τ5	Yes	20	1.06
Rodney M. Davis	US	06	τ5	Yes	20	1.06
Ronald Reagan	US	06	τ5	Yes	20	1.06
Roosevelt	US	12	τ5	Yes	20	1.06
Ross	US	51	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Rushmore	US	06	τ5	Yes	20	1.06
Russell	US	15	τ5	Yes	20	1.06
Sacramento	US	00	τ5	Yes	20	1.06
Safeguard	US	15	τ5	Yes	20	1.06
Saipan	US	51	τ5	Yes	20	1.06
Salt Lake City	US	06	τ5	Yes	20	1.06
Salvor	US	15	τ5	Yes	20	1.06
Sampson	US	06	τ5	Yes	20	1.06
Samuel B. Roberts	US	12	τ5	Yes	20	1.06
San Antonio	US	51	τ5	Yes	20	1.06
San Francisco	US	53	τ5	Yes	20	1.06
San Jacinto	US	51	τ5	Yes	20	1.06
San Juan	US	09	τ5	Yes	20	1.06
Santa Fe	US	33	τ5	Yes	20	1.06
Scout	BA	00	τ5	Yes	20	1.065
Scranton	US	51	τ5	Yes	20	1.06
Seattle	US	00	τ5	Yes	20	1.06
Seawolf	US	53	τ5	Yes	20	1.06
Sentry	US	48	τ5	Yes	20	1.06
Shiloh	JA	00	τ5	Yes	20	1.065
Shoup	US	53	τ5	Yes	20	1.06
Shreveport	US	51	τ5	Yes	20	1.06
Shrike	US	48	τ5	Yes	20	1.06
Simpson	US	12	τ5	Yes	20	1.06
Sirocco	US	51	τ5	Yes	20	1.06
Springfield	US	09	τ5	Yes	20	1.06
Spruance	US	12	τ5	Yes	20	1.06
Squall	US	51	τ5	Yes	20	1.06
Stephen W. Groves	US	12	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Sterett	US	06	τ5	Yes	20	1.06
Stethem	JA	00	τ5	Yes	20	1.065
Stockdale	US	06	τ5	Yes	20	1.06
Stout	US	51	τ5	Yes	20	1.06
Stump	US	00	τ5	Yes	20	1.06
Tarawa	US	06	τ5	Yes	20	1.06
Taylor	US	12	τ5	Yes	20	1.06
Tempest	US	51	τ5	Yes	20	1.06
Tennessee	US	13	τ5	Yes	20	1.06
Texas	US	15	τ5	Yes	20	1.06
Thach	US	06	τ5	Yes	20	1.06
The Sullivans	US	12	τ5	Yes	20	1.06
Theodore Roosevelt	US	51	τ5	Yes	20	1.06
Thomas S. Gates	US	06	τ5	Yes	20	1.06
Thorn	US	00	τ5	Yes	20	1.06
Thunderbolt	US	51	τ5	Yes	20	1.06
Ticonderoga	US	29	τ5	Yes	20	1.06
Toledo	US	51	τ5	Yes	20	1.06
Topeka	US	06	τ5	Yes	20	1.06
Tortuga	US	51	τ5	Yes	20	1.06
Trenton	US	51	τ5	Yes	20	1.06
Truxtun	US	51	τ5	Yes	20	1.06
Tucson	US	51	τ5	Yes	20	1.06
Typhoon	US	51	τ5	Yes	20	1.06
Underwood	US	12	τ5	Yes	20	1.06
Valley Forge	US	06	τ5	Yes	20	1.06
Vandegrift	US	06	τ5	Yes	20	1.06
Vella Gulf	US	51	τ5	Yes	20	1.06
Vicksburg	US	12	τ5	Yes	20	1.06

InstallationMasterName	CountryCD	StateorProvinceCD	Time of Wetness	Saline Envr Measure	ESI Zone	SIOH
Vincennes	JA	00	τ5	Yes	20	1.065
Virginia	US	33	τ5	Yes	20	1.06
Warrior	US	48	τ5	Yes	20	1.06
Wasp	US	51	τ5	Yes	20	1.06
Wayne E Meyer	US	06	τ5	Yes	20	1.06
West Virginia	US	13	τ5	Yes	20	1.06
Whidbey Island	US	51	τ5	Yes	20	1.06
Whirlwind	US	51	τ5	Yes	20	1.06
Winston S. Churchill	US	51	τ5	Yes	20	1.06
Wyoming	US	13	τ5	Yes	20	1.06
Yorktown	US	51	τ5	Yes	20	1.06