

# APPLICATION OF ASSET MANAGEMENT PRINCIPLES FOR DAMAGE ASSESSMENT AND RECOVERY PLANNING

Esteban Azagra | May 25, 2018

# Overview

**Financial Impacts/Financial Benefits Case Study**

**Asset Management Principles**

**Application of Principles to Disaster Recovery**

# Overview

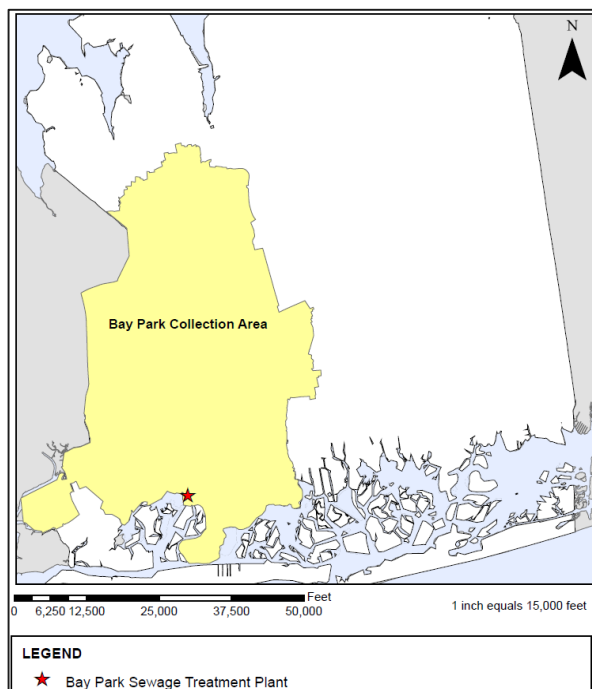
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# Hurricane Sandy and Bay Park STP, Nassau County

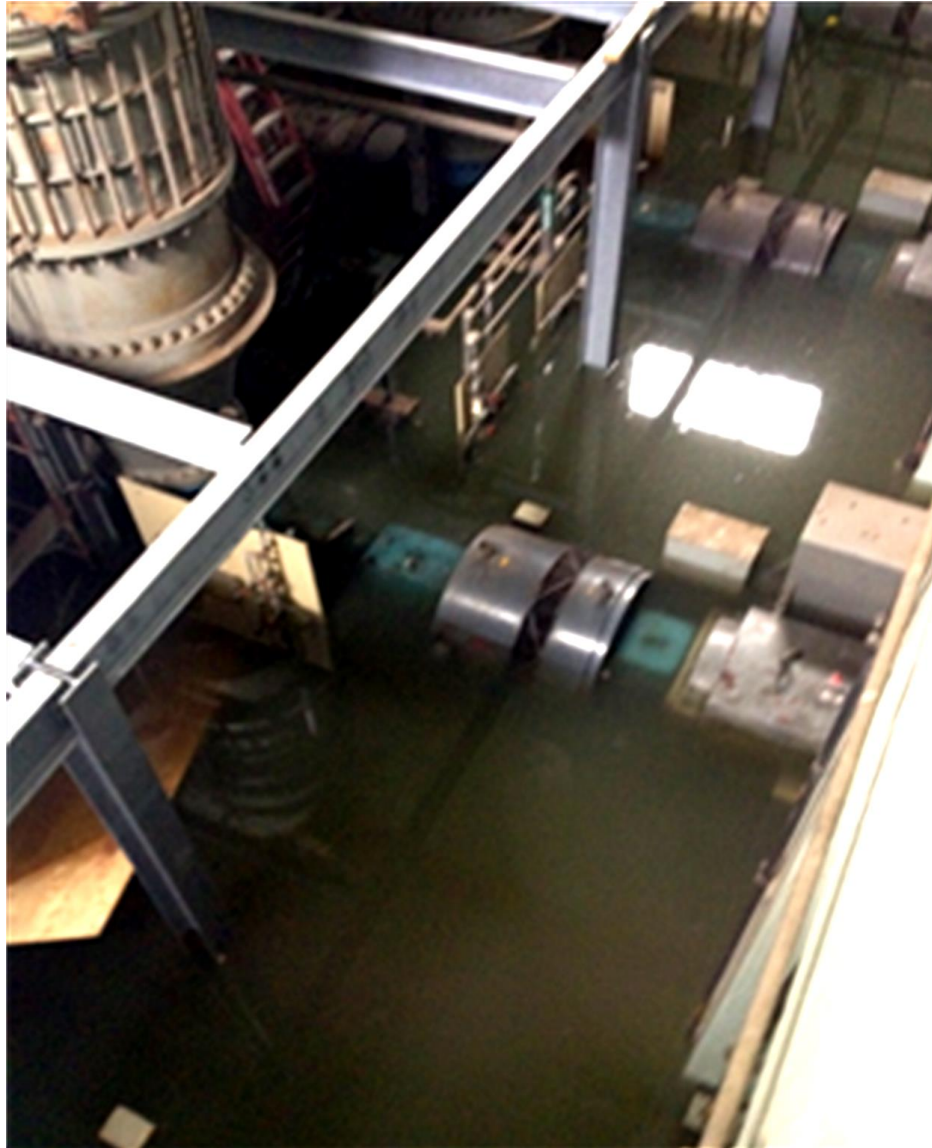
- Hurricane Sandy's high winds, severe flooding, and power outages cause widespread damage to Bay Park Sewage Treatment Plant (STP)
  - ~50 structures, numerous mechanical and electrical systems and operating equipment damaged



# North to South View

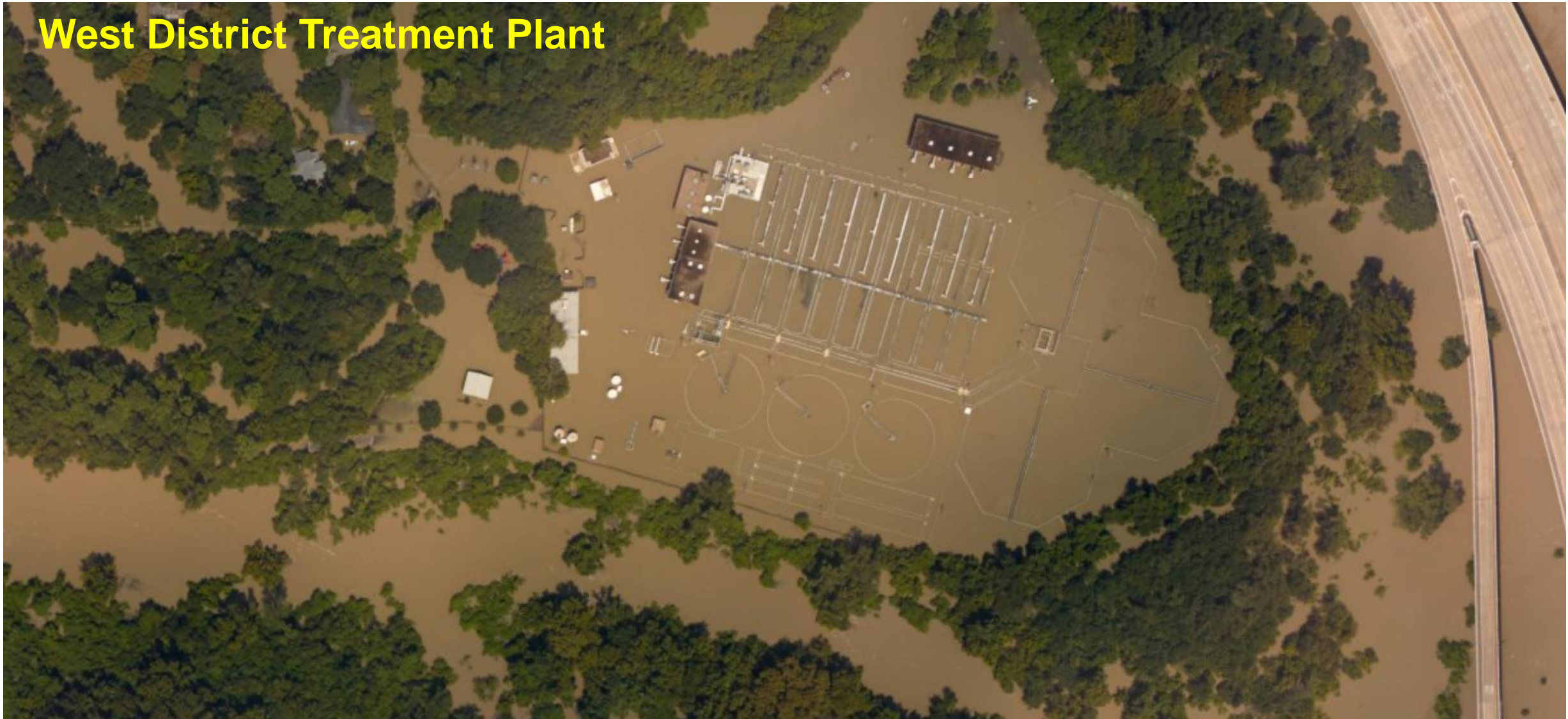


# Hurricane Sandy Impacts



# Hurricane Harvey Parallel

## West District Treatment Plant



# Hurricane Harvey Parallel

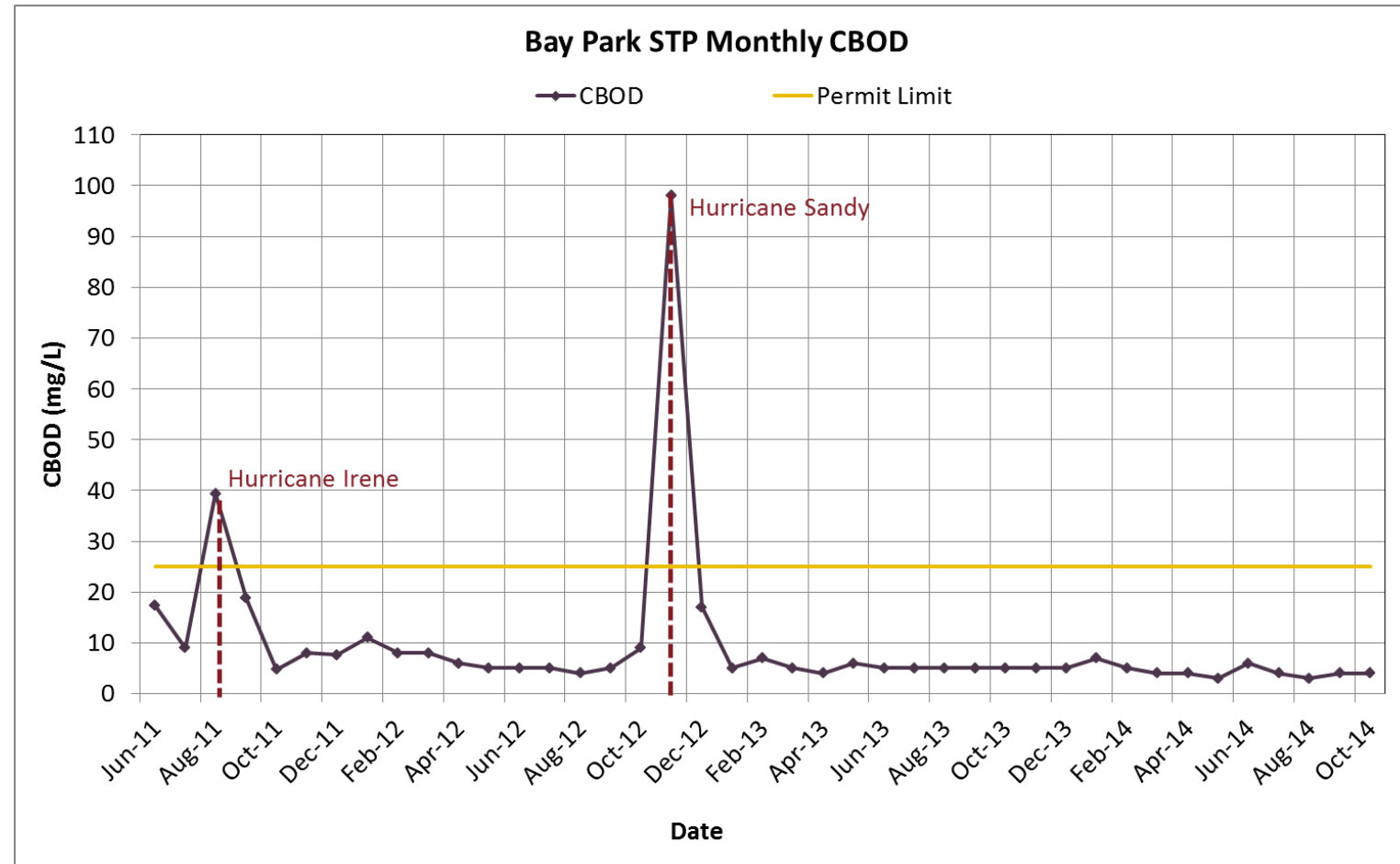
## Turkey Creek Treatment Plant





## Major Equipment and System Failure:

- ~ 3 Days Total Shutdown & ~ 45 Days Partial Treatment
- ~ 100 million gallons of untreated sewage overflowing into the streets
- ~ 2 Billion Gallons Raw & Partially Treated Waste into Reynolds Channel
- Over \$400M in facility damages



## FEMA awarded **\$810 million** in funding for *repair and mitigation measures* at Bay Park STP

- Includes **\$383 million** in Section 406 hazard mitigation costs to reduce risk for all systems and equipment within the plant to maintain operation during a 500-year flood event
  - Includes constructing a flood boundary protection system around the entire plant, protecting critical systems and equipment within the plant by elevating equipment, providing updated and submersible equipment and dry flood-proofing enclosures
- Includes **\$427 million** for Hurricane Sandy damage repair/restoration, through a Section 428 Capped Grant
  - Repairs to Bay Park architectural, mechanical, and electrical systems, satellite pump stations, effluent facilities, settling tanks, fire protection building, and utility tunnel

Damage assessment teams need to look holistically at damage and required restoration, and a framework for this assessment is critical to success

Funds are available to *improve* facilities against future damage, but documentation is critical to success

An Asset Management approach provides the fundamentals for the assessment framework and documentation

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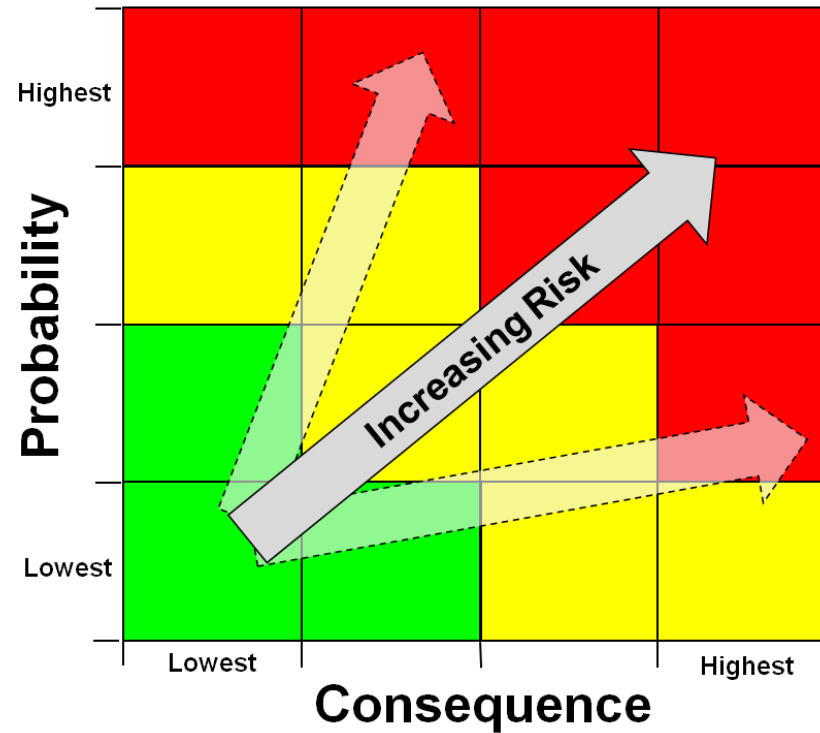
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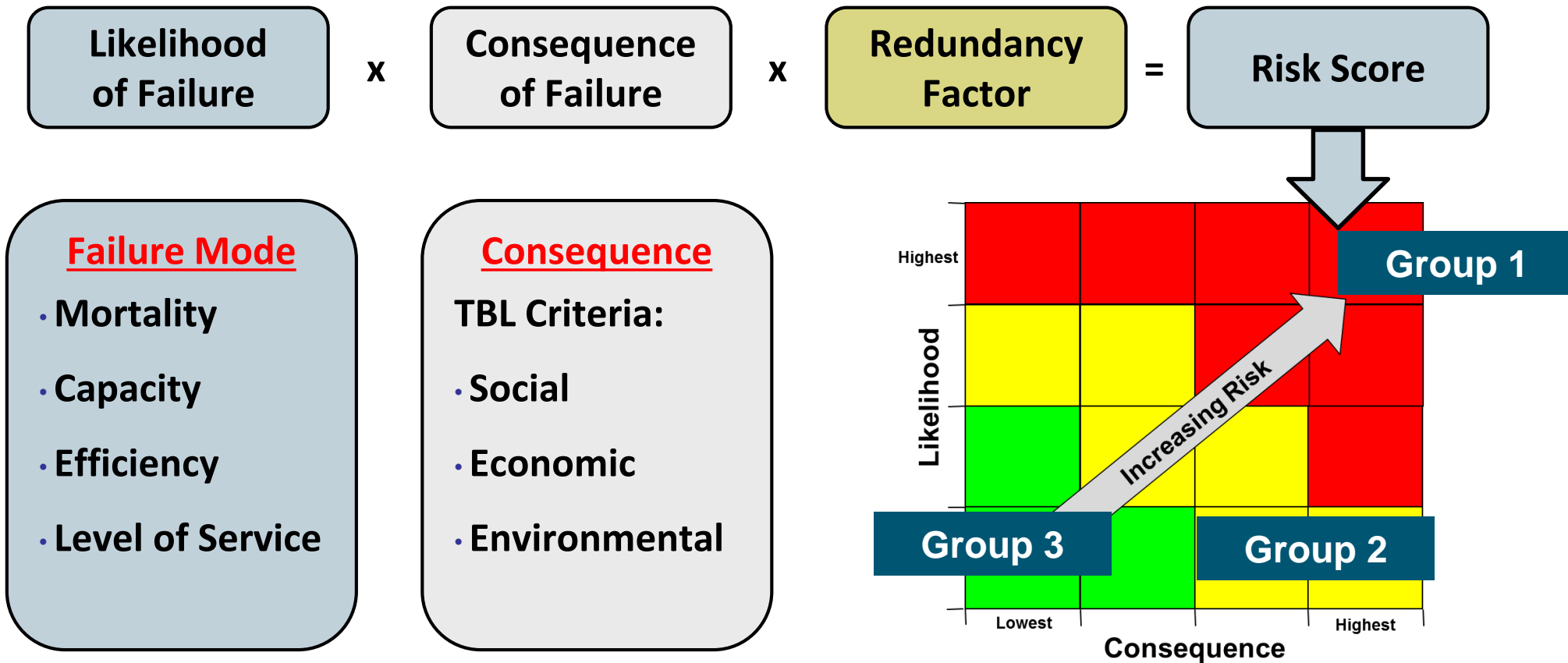
## Risk based asset management improves understanding



$$\text{Risk} = \text{Probability}(\text{failure}) \times \text{Consequence}(\text{failure})$$



## Industry Standard Risk Assessment Analyzes Likelihood (failure) and C(failure) with redundancy to determine Business Risk



## IIMM Standardizes Condition Scoring Across Asset Types

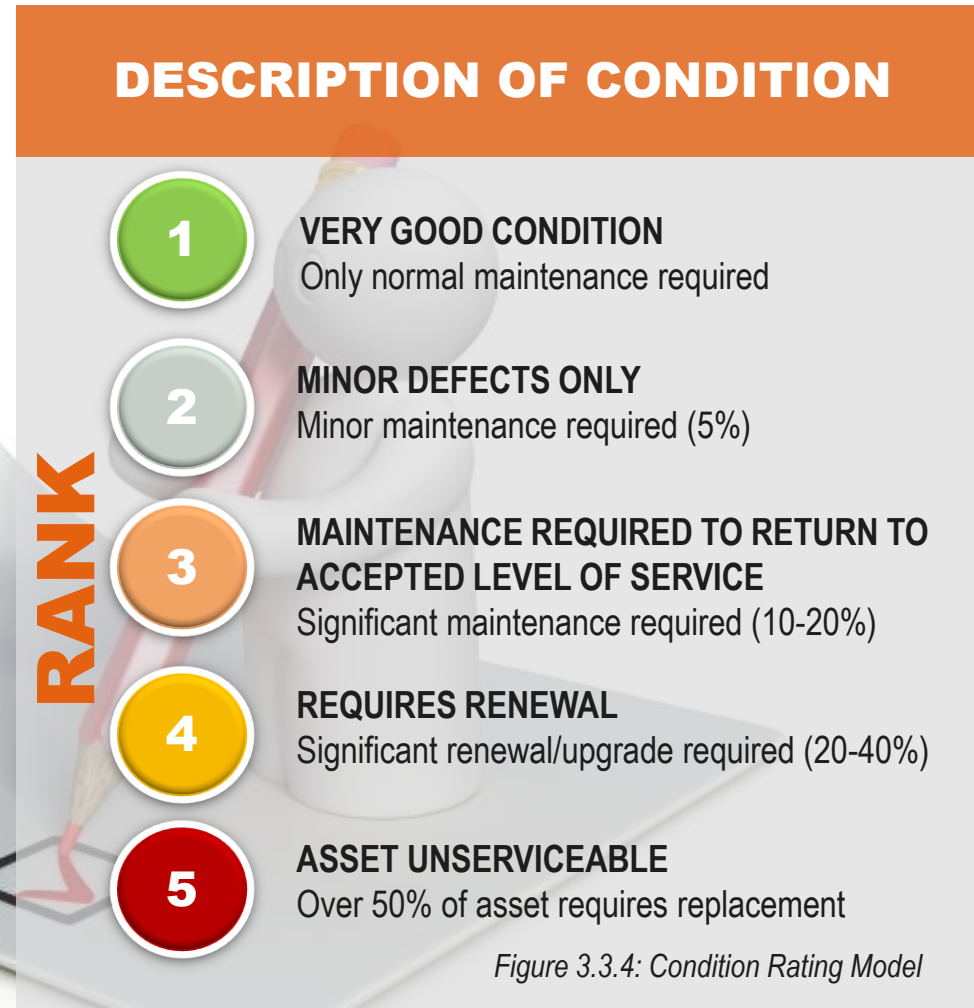
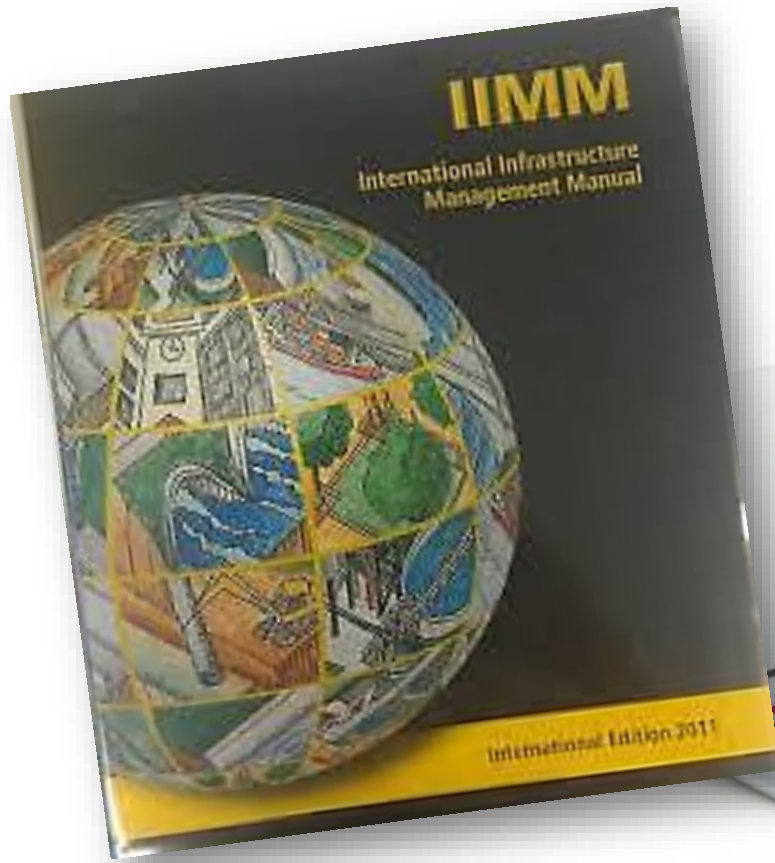


Figure 3.3.4: Condition Rating Model



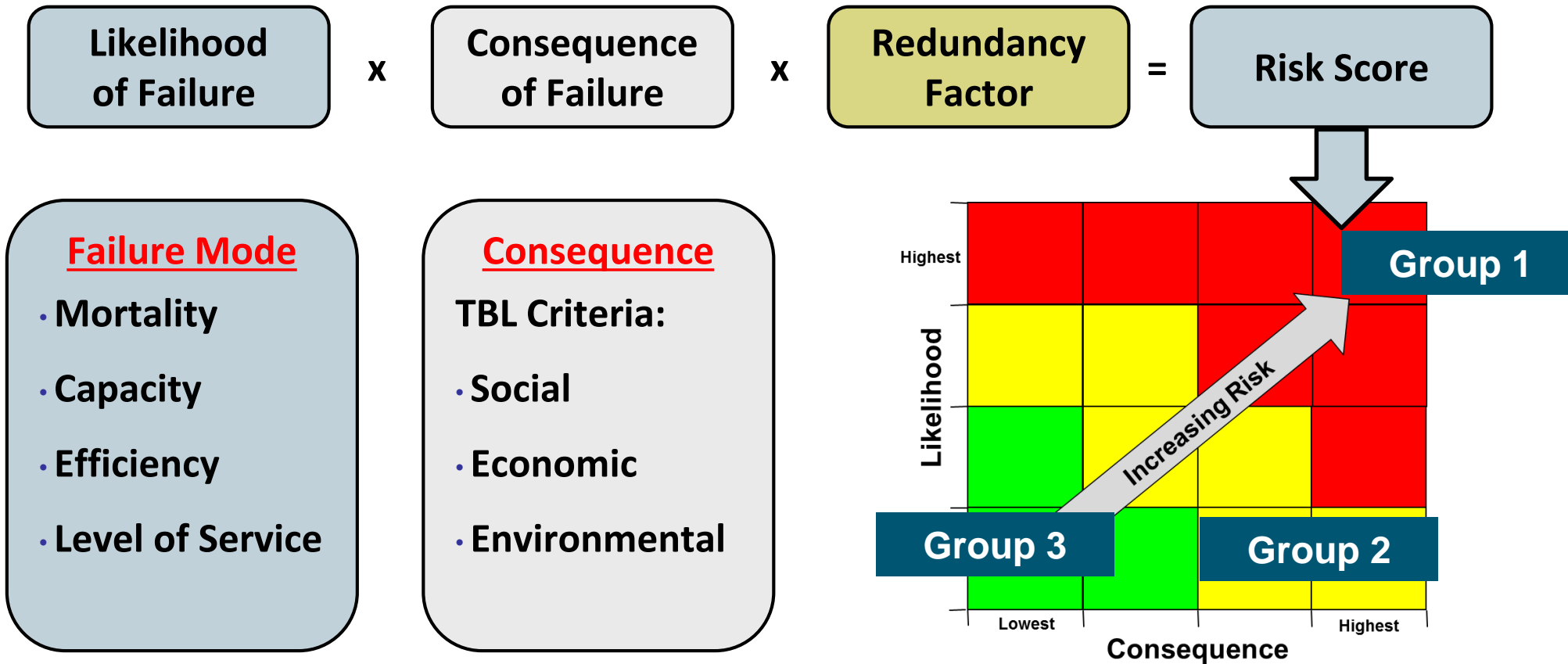
## Visual Assessment is Key for Determining Mortality (also key for determining damage post disaster)

Mechanical Process and HVAC Equipment (includes motor) Visual Condition Assessment						
Criteria	Evaluation	1	2	3	4	5
<b>CORE CRITERIA</b>						
Corrosion	Surface only	None	<10%	10% - <25%	25% - 50%	>50%
	Structural (loss of metal)	None	-	-	1 location	>1 location
Leakage	Gaskets / Connections	None	Historic only	Drip only	Stream 1 location	Stream >1 location
	Holes / Failures	None	-	-	1 location	>1 location
Vibration / Noise	Vibration Apparent with Noise	None	<10% normal	10% to 20% normal	>20% to 30% normal	>30% normal
	Non-Structural Damage	None	-	-	Yes	-
	Structural Damage	None	-	-	-	Yes
Concrete Supports	Surface Cracking / Loose Grout	None	<10%	10% - <25%	25% - 50%	>50%
	Through Cracks	None	-	<10%	10% - 25%	>25%
	Damaged / Missing Anchors	None	-	<5% / 1	5% - 20% / 2	>20% / >2
Steel Supports	Surface Corrosion	None	<10%	10% - <25%	25% - 50%	>50%
	Structural Corrosion	None	-	<10%	10% -25%	>=25%
	Damaged / Missing Anchors	None	-	<5% / 1	5% - 20% / 2	>=20% / >2
<b>ANCILLARY CRITERIA</b>						
Piping / Valves	Leaks – gaskets	None	-	Drips only	Stream – 1 location	Stream - >1 location
	Leaks – holes / failures	None	-	-	1 location	>1 location
	Corrosion - surface	None	<10%	10% - <25%	25% - 50%	>50%
	Corrosion - structural	None	-	<10%	10% -25%	>25%
	Support damage	None	-	<5%	5% - 20%	>20%
Local Panels	Surface corrosion	None	<10%	10% - <25%	25% - 50%	>50%
	Structural damage	None	-	-	1 location	>1 location
	Internal corrosion / leakage	None	<10% / none	10% - <25% / none	>=25% / 1 location	>=25% / >1 location
	Panel Instruments – non-function	None	-	-	1 device or 20%	>1 device or >20%
Field Instruments	Damaged / non-functional devices	None	-	-	1 device or 20%	>1 device or >20%
Electrical Connections	Conduit / J. Box - surface corrosion	None	<10%	10% - <25%	25% - 50%	>50%
	Damage - gaps / missing gaskets	None	-	-	1 location	>1 location
	Exposed wiring	None	-	-	1 location	>1 location

### Assessment Types:

- Mechanical
- Structural
- Electrical

## Industry Standard Risk Assessment Analyzes Likelihood (failure) and C(failure) with redundancy to determine Business Risk



## Consequence of Failure – Triple Bottom Line Analysis



**Direct cost**  
**Indirect cost or impact**



**Health & safety**  
**Levels of service**  
**Public image (taste & odor, water quality, etc.)**



**Regulatory compliance**  
**Regulatory violations**  
**Environmental impact**

**Documentation of Environmental and Social Impacts *can supplement* Financial Recovery funds requests post disaster...**

# Example: Consequence of Failure Scoring Matrix

Social/Community/Customers (at Location)					
<b>Public Image</b>	No Impact	Alert posted on website but no media attention	Local coverage	State coverage	National coverage
<b>Loss of service to fulfill customer contract</b>	Can be out of service for extended period	Can be out of service for less than a month	Can be out of service for 1 week	Can be out of service for 1 day	Critical - cannot lose service
<b>Health &amp; Safety</b>	No impact	N/A	Moderate injury and some sickness (water quality)	N/A	Potential for fatalities (chlorine gas)
	1	2	3	4	5
Financial (at Sub-Location)					
<b>Financial impact</b>	\$2,000 - Supervisory approval	\$20,000 - Department Head approval	\$75,000 - Assistant General Manager approval	\$1M to \$5M - Less than available reserves	>\$5M - Greater than available reserves
<b>Operational/resource impact</b>	Negligible impact	Low impact	High impact (scheduled work is delayed)	High impact & diverts funds	Triggers Use of Reserve Fund
	1	2	3	4	5
Environment/Regulatory - (at Sub-Location)					
<b>Water loss/discharge</b>	<1,000 gallons	1,000 gallons < 49,999	50,000 gallons < 1,000,000	1,000,000 gallons < 100,000,000	> 100,000,000 gallons
<b>Regulatory (permit) compliance</b>	No consequence	Warning with no fines	Single violation with fines	Multiple violation with fines	Cease and Desist
	1	2	3	4	5

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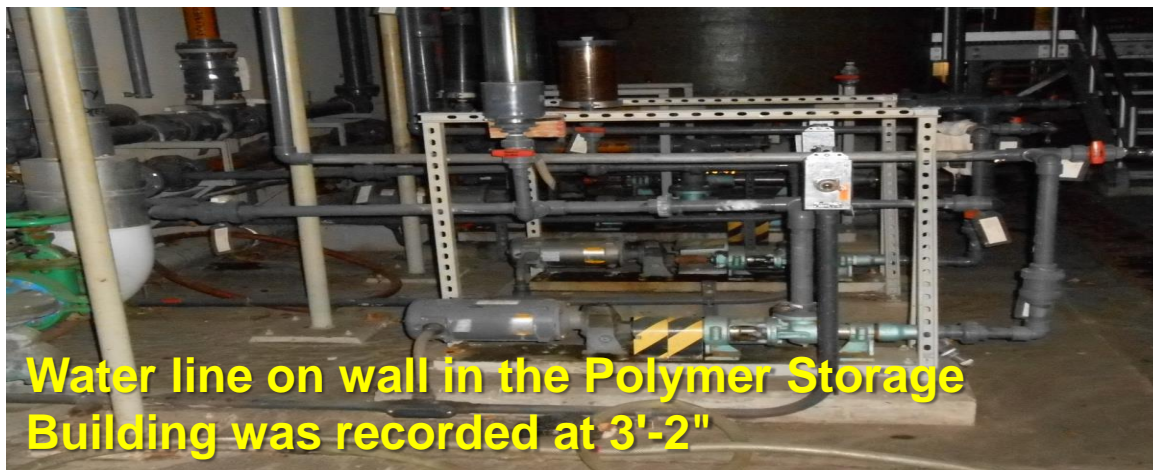
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# Damage Assessment Tools

## Mirror Condition Assessment Tools



**FLOOD RISK TEMPLATE**  
**Building Name: Sample Building A**

Note: It does not matter what units are used in the below template as long as units are consistent throughout. This template was constructed specifically for coastal flooding. Additionally, the same vertical datum must be used throughout. In this sample, feet are used as well as the North American Vertical Datum of 1988 (NAVD83).

Building Characterization			
Flood Zone	AE	Flood Floor Elevation (ft)	11.0
Type of Flooding (coastal, riverine, overland)	Coastal	Approx. Grade Elevation (ft)	8.0-12
Flood Floor Area	62,000sf	# of Basements	6
Building Occupancy Type	Commercial	# of Stories	42
Building Capacity	8,400	Year of Construction	2004
Foundation Type	Steel/Concrete		

Flood Elevation Data					
Recurrence Interval	100-Year Flood Elevation (ft)	Wave Height*	Total (100-Year Flood Elevation + Wave Height)	Sea Level Rise**	Total
10-Year Flood	6.5	0.0	6.5	1.0	7.5
50-Year Flood	10.0	0.5	10.5	1.0	11.5
100-Year Flood	11.5	1.0	12.5	1.0	13.5
500-Year Flood	13.0	3.0	16.0	1.0	17.0

\*Optional

Vulnerability					
Recurrence Interval	Flood Depth (ft)	# of Vulnerable Entrance Points	# of Vulnerable Service Lines	Foundation (ft/Story)	Ranking
10-Year Flood	2.5	0	0	N	4
50-Year Flood	11.5	25	10	N	2
100-Year Flood	13.5	40	20	N	1
500-Year Flood	16.0	60	20	N	1

**Determining Recurrence Intervals**

$y = 2.833(x)^{0.2168}$   
 $R^2 = 0.9938$

$y = f(x) = 6$	$x = 2.833(6)^{4.6147}$	**Recurrence Interval (yr)	87.47
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Note: While there is only one past event on this worksheet, if there is information on multiple events it is helpful to evaluate them all. The same methodology can be used for each event.

Consequences: Service Loss					
Recurrence Interval	Loss of Electricity (Days)	Loss of Potable Water (Days)	Loss of Heat/Water (Days)	Total Loss (\$)	Ranking
10-Year Flood	0	0	0	\$ -	4
50-Year Flood	0	0	0	\$ -	4
100-Year Flood	7	0	0	\$ 7,408,800.00	1
500-Year Flood	7	0	0	\$ 7,408,800.00	1

Comments: Evaluate expected loss of service using information from past events and site analysis. Loss of service for facilities with critical infrastructure located in basements or at elevations below the above flood levels can be expected.

Building Value***			
Basement(s)	First Floor	Second Floor (N/A)	
Structural Value \$ 24,000,000.00	Structural Value \$ 1,200,000.00	Structural Value \$ -	
Contents Value \$ 15,000,000.00	Contents Value \$ 8,000,000.00	Contents Value \$ -	
STRUCTURAL TOTAL \$ 49,000,000.00	STRUCTURAL TOTAL \$ 24,000,000.00	Basement (3 = yes, 0 = no)	3

Consequences: Physical Damage					
Recurrence Interval	Flood Depth Above (ft FM (ft))	% Structure Damage	% Contents Damage	Total Loss (\$)	Ranking
10-Year Flood	-0.5	-62.0%	-112.5%	\$ -	5
50-Year Flood	0.5	10.0%	21.5%	\$ 9,025,770.04	4
100-Year Flood	2.5	25.2%	44.0%	\$ 28,811,626.80	2
500-Year Flood	6.0	48.5%	66.7%	\$ 36,158,961.60	1

FINAL RANKING					
Recurrence Interval	Hazard	Vulnerability	Service Loss	Physical Damage	TOTAL
10-Year Flood	5	4	4	5	14
50-Year Flood	2	2	4	4	12
100-Year Flood	4	5	1	2	7
500-Year Flood	4	5	1	1	7
TOTAL					48

\*\*\*Notes:

- Structural Values Include:
  - Foundations and walls
  - Basement floors
  - HVAC
  - Electric equipment
  - Electric wiring
  - Plumbing and equipment
  - Insulation
  - Floors, stairs, partitions
  - Doors, windows, woodwork
  - Welder and lifts
  - Painting, decorations
  - Hardware etc...
- Contents Values Include:
  - Furniture
  - Electronics
  - Appliances
  - Office supplies
  - Vehicle etc...

# Assessment Tools

**Public Facility Record of Historical Flood Loss**

Facility Name: \_\_\_\_\_  
 Address: \_\_\_\_\_  
 Information provided by: \_\_\_\_\_  
 Contact information: \_\_\_\_\_  
 Flood insurance policy? Y / N Contents covered? Y / N  
 Date of Flood event: \_\_\_/\_\_\_/\_\_\_ Name of Event / Declaration: \_\_\_\_\_  
 Flood source (local drainage, river/stream flooding, coastal flood): \_\_\_\_\_  
 Flood depth: Outside, immediately adjacent to building: \_\_\_\_\_  
 How did water get into the building? \_\_\_\_\_  
 Was there evidence the water moving rapidly? Y / N Evidence: \_\_\_\_\_  
 Did the floodwater contain a lot of mud, oil/chemicals or debris? \_\_\_\_\_  
 How long did water stay inside building: \_\_\_\_\_  
 Did water drain or have to be pumped from the building? Drain: \_\_\_\_\_  
 How much warning did you have before the flooding? \_\_\_\_\_  
 Site access interrupted? Y / N How long? \_\_\_\_\_  
 Were employees prevented from coming to work by the event? \_\_\_\_\_  
 Was service provided by the facility interrupted (e.g., public electric power)? \_\_\_\_\_  
 For how long? \_\_\_\_\_  
 Injuries or casualties? Y / N \_\_\_\_\_

**ARCADIS** Infrastructure - Water - Environment - Buildings

**POST-DISASTER ASSET INSPECTION FORM**

PROJECT: \_\_\_\_\_ DATE: \_\_\_\_\_

Asset Name: \_\_\_\_\_ Asset ID: \_\_\_\_\_  
 Tier: \_\_\_\_\_ Inspector: \_\_\_\_\_  
 PW System: \_\_\_\_\_ Time Spent Insp: \_\_\_\_\_  
 Location: \_\_\_\_\_ System Type: \_\_\_\_\_  
 Sublocation: \_\_\_\_\_ Process Type: \_\_\_\_\_  
 Capacity / Size: \_\_\_\_\_ Asset Type: \_\_\_\_\_  
 Pre-Storm Elevation of Asset: \_\_\_\_\_ Discipline: \_\_\_\_\_

Asset Impact Score: \_\_\_\_\_  
 Corrosion: \_\_\_\_\_  
 Damage: \_\_\_\_\_  
 Heat: \_\_\_\_\_  
 Cause of Damage: \_\_\_\_\_  
 Source of Damage: \_\_\_\_\_  
 Flood Depth: \_\_\_\_\_  
 Depth at which Asset will First be Impacted: \_\_\_\_\_  
 Asset Future Risk Score: \_\_\_\_\_  
 Asset Status: \_\_\_\_\_  
 Disposition of Asset: \_\_\_\_\_  
 Action By: \_\_\_\_\_  
 Comments: \_\_\_\_\_

(5) Destroyed (4) Damaged (3) Impacted/Unk, Damage (2) Suspected Impact/Unk, Damage (1) No Impact

(e.g., wind, flood, cascading impacts, such as power surge)

(e.g., flooding through conduit, doors)

(4) Asset will be impacted at or Below Sandy elevation  
 (3) Asset will be impacted at or below min. level of protection  
 (2) Asset will be impacted at/below desired level of protection  
 (1) Asset will be impacted above desired level of protection

**ARCADIS** Infrastructure - Water - Environment - Buildings

**Structure Assessment Master Form**

**Inspector Information**

Date: \_\_\_\_\_ Inspector Area: \_\_\_\_\_  
 Inspector Name: \_\_\_\_\_ Inspector Sub-Area: \_\_\_\_\_  
 Elevation:  Yes  No Acquisition:  Yes  No PPDR:  Yes  No De: \_\_\_\_\_

**Right of Entry (ROE) \*\*\*DO NOT ENTER PROPERTY\*\*\***

Is there an ROE on File for Property?  Yes  No if no, was an ROE sig: \_\_\_\_\_  
 Comments: \_\_\_\_\_

**Location Information**

Owner (Last Name, First Name): \_\_\_\_\_ Reference ID: \_\_\_\_\_  
 Street Address: \_\_\_\_\_ Zip Code: \_\_\_\_\_  
 Latitude: \_\_\_\_\_ Longitude: \_\_\_\_\_  
 \*\*\*Take photos of structure and title them appropriately. Minimum of four photos\*\*\*

**Structure General Information**

Original Year Built: \_\_\_\_\_ Is the structure historic?  \_\_\_\_\_  
 Building Use: \_\_\_\_\_ Building Sub-Use: \_\_\_\_\_ Construction Type: \_\_\_\_\_  
 Commercial  Construction  Steel  
 Education  Food/Drugs/Chemical  Concrete  
 Agricultural  Heavy  Masonry  
 Industrial  High Technology  Wood  
 Government  Light  Manufactured Housing  
 Religion  Metals/Minerals Processing

Basement Present?  Yes  No  Unknown  
 Number of Stories:  1  1.5  2  2.5  3  
 Dominant Roof Covering Type:  Shingles - Asphalt, Wood (Standard)  Clay Tile  
 Exterior Finish:  Siding or Stucco (Standard)  Brick Veneer  EIFS  
 HVAC System:  Heating and/or Cooling  None  
 Structure Quality:  Low  Budget  Average  High  
 Heated Square Footage (sf): \_\_\_\_\_ Structure Footprint (sf): \_\_\_\_\_  
 Elevation of Lowest Finished Floor, above grade (feet): \_\_\_\_\_  
 Are there any structure additions post original construction date?  Yes  
 If yes, describe nature of additions: \_\_\_\_\_

**Structure General Information (continued)**

Does the structure have deck(s)?  Yes  No  N  
 Does the structure have Porch(es)?  Yes  No  N  
 Does the structure have exterior stairs?  Yes  No  N  
 Is there a potential ADA occupant?  Yes  No  N  
 Is there ADA written certification?  Yes  No  N  
 Are there any other habitable structures? Explain: \_\_\_\_\_

Complete and attach Structure Wind Details Sub-Form, Structure Details for Elevation Sub-Form, Information Sub-Form



**PROPOSED FORM FIELDS - INFRASTRUCTURE ASSESSMENT**

**INFRASTRUCTURE ASSESSMENT FIELDS**

**Damage**

PW Category  pulldown  
 Asset Type  pulldown  
 Asset Name   
 Location   
 Sublocation   
 GPS Coordinates   
 Photos   
 Damage Description   
 Damage Measurements   
 Service Interruption?  Pulldown  
 Duration of Interruption   
 Was damage a result of Sandy impacts?   
 Cause of Damage   
 Damage Category  Pulldown - based on BSG damage assessment  
 Condition Notes   
 Status of Restoration  Pulldown  
 Required Restoration Measures   
 Potential Mitigation Measures

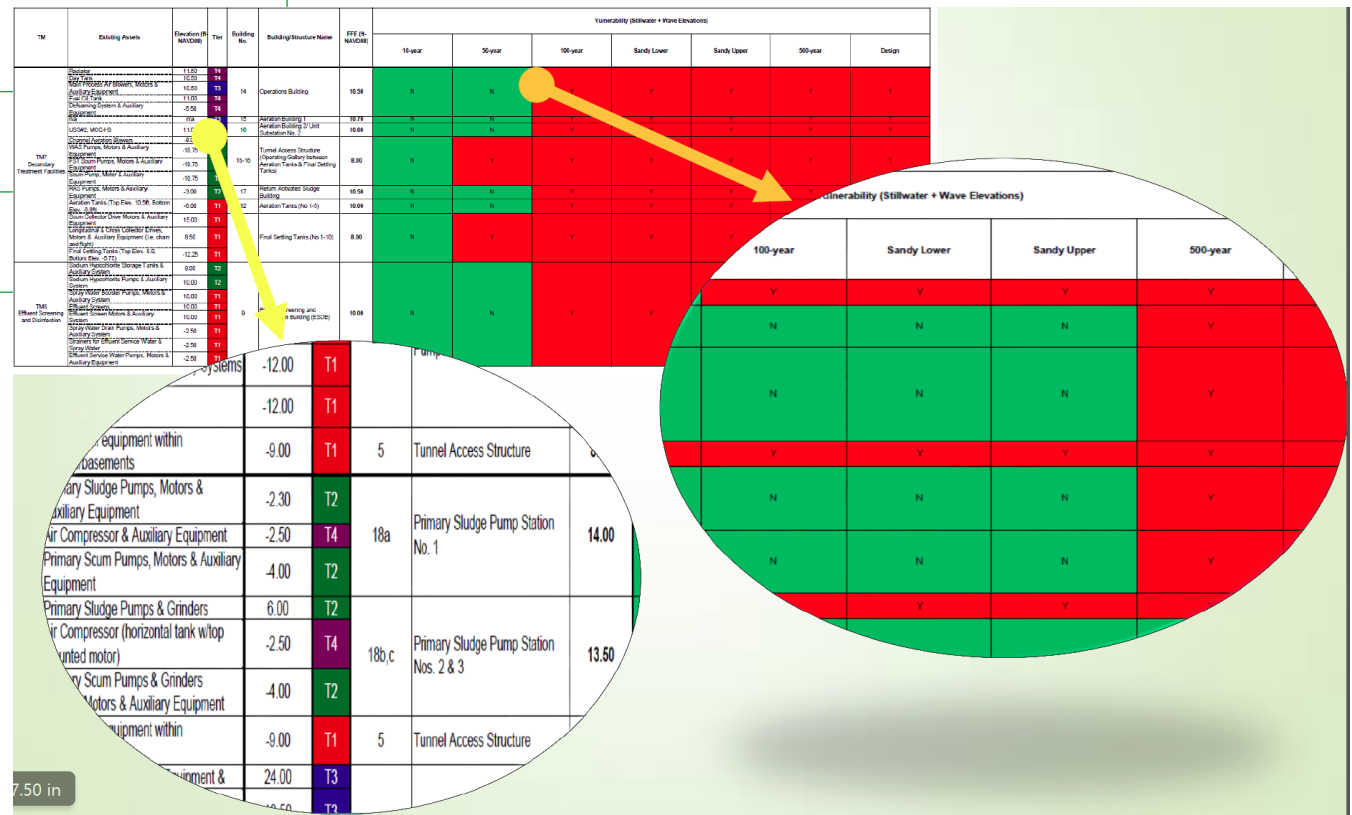
**Observed Hazards**

Hazard Type   
 Location Description   
 Potential Mitigation Action   
 Photographs



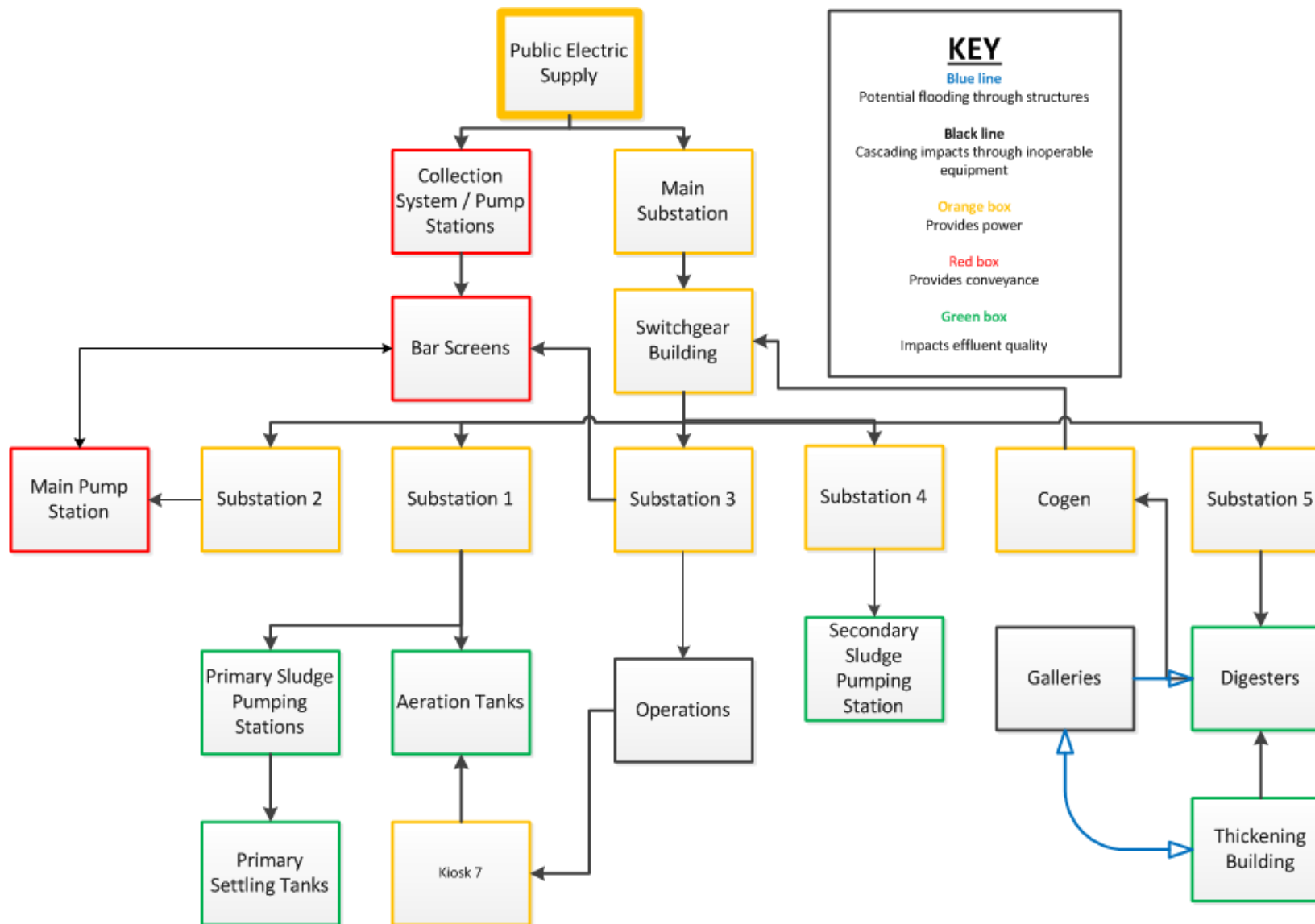
# Criticality Connect Assets to Risk

Tier	Essential Function
1	Conveyance
2	Solids Removal/ Handling
3A	Treatment – Minimal
3B	Treatment – Permit
4	Other Plant Services





# Risk from Criticality Supports Mitigation Measures



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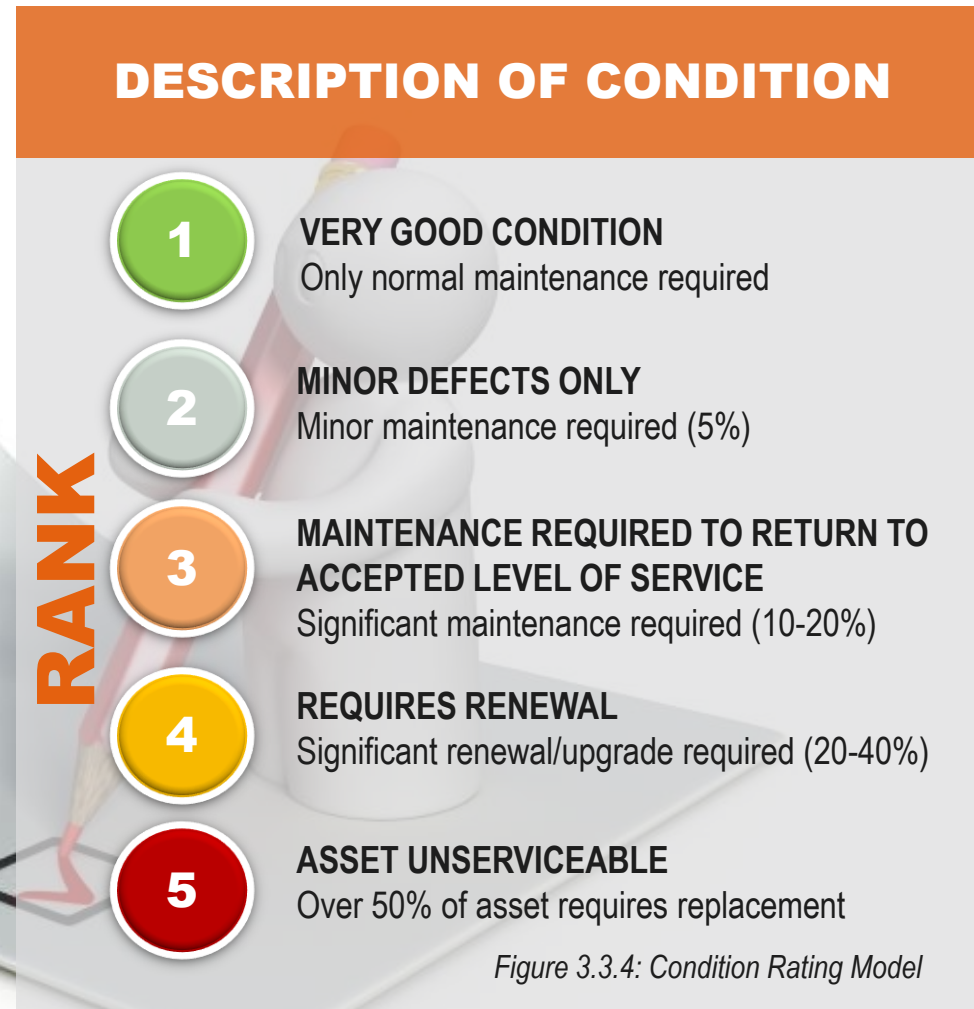
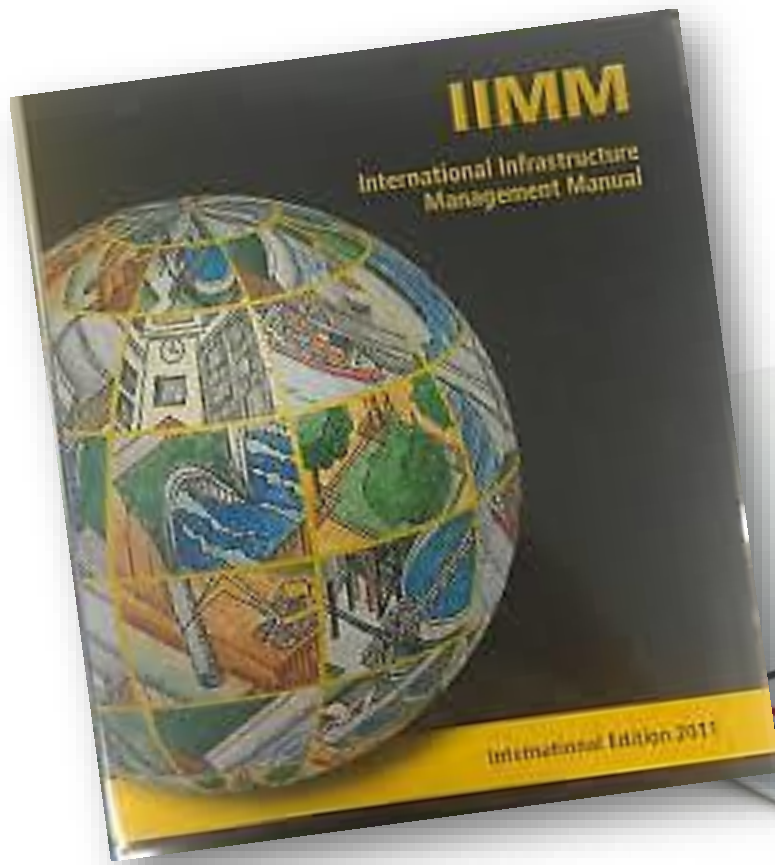


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- Electrical

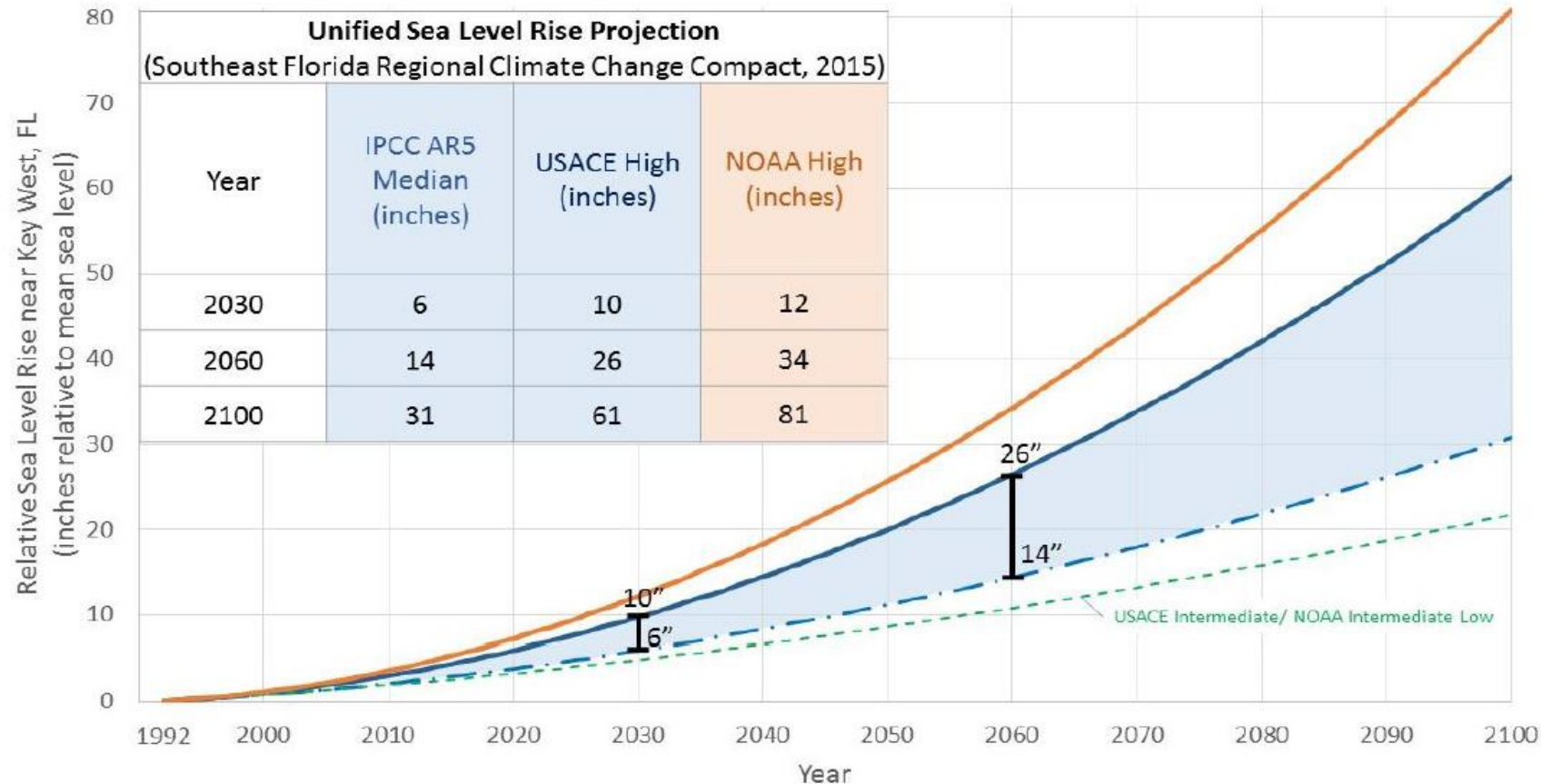
# Performance Condition Scoring

Performance Condition Assessment						
Criteria	Evaluation	1 (best)	2	3	4	5
Capacity	Ability to meet future and current capacity	Meets requirements for >20 years	Meets requirements for next 11 to 19 years	Meets requirements for next 5 to 9 years	Will not meet requirements in < 5 years	Does not meet current requirements
Regulatory	Ability to meet future and current regulations	Meets requirements for >10 years	Meets requirements for next 10 years	Meets requirements for next 5 to 9 years	Will not meet requirements in < 5 years	Does not meet current requirements
Reliability	Average time equipment is available when needed	99-100%	95-99%	90-94%	85-89%	< 85%
O&M Issues	Frequency of O&M Issues beyond regular maintenance (excluding breakdowns)	None	Very Infrequently (Quarterly)	Infrequently (Monthly)	Frequently (Weekly)	Very Frequently (>Weekly)
Obsolescence	Status of Equipment Technology, Operating Efficiency, Spare Parts Availability, Energy Efficiency	Best Available Operating cost optimal Obsolescence expected >10 years	Technology Industry Standard/ "Tried and True" Obsolescence expected >5 years	Technology Considered Appropriate Obsolescence expected within 5 years	Technology Nearing Obsolescence Spare parts still available	Technology Obsolete Spare parts not available
Resilience	Year to sea level rise impact with projected USACE High curve	No impact >= Year 2100	Impact by Year 2060	Impact by Year 2040	Impact by Year 2030	Impact < Year 2030
	Storm vulnerability with and without SLR (USACE High curve)	No impacts from 100-year with SLR	Impacts from: 100-year without SLR 50-year with SLR	Impacts from: 50-year without SLR 25-year with SLR	Impacts from: 25-year without SLR 5-year with SLR	Current impacts with 2-year storm

## Performance Categories:

- Capacity
- Regulatory
- Reliability
- O&M Issues
- Obsolescence
- Resilience

# Resilience Scoring: SLR and Storm Surge



## Sea Level Rise:

- Chronic flooding:
  - Depth and frequency of recurring flooding

## Storm Surge:

- Acute flooding event:
  - Storm return with and without SLR influence

Performance Condition Assessment						
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Capacity	Ability to meet future and current capacity	Meets requirements for >20 years	Meets requirements for next 10 to 19 years	Meets requirements for next 5 to 9 years	Will not meet requirements in < 5 years	Does not meet current requirements
Regulatory	Ability to meet future and current regulations	Meets requirements for >10 years	Meets requirements for next 10 years	Meets requirements for next 5 to 9 years	Will not meet requirements in < 5 years	Does not meet current requirements
Reliability	Average time equipment is available when needed	99-100%	95-99%	90-94%	85-89%	< 85%
O&M Issues	Frequency of O&M Issues beyond regular maintenance (excluding breakdowns)	None	Very Infrequently (Quarterly)	Infrequently (Monthly)	Frequently (Weekly)	Very Frequently (>Weekly)
Obsolescence	Status of Equipment Technology, Operating Efficiency, Spare Parts Availability, Energy Efficiency	Best Available Operating cost optimal Obsolescence expected >10 years	Technology Industry Standard/ "Tried and True" Obsolescence expected >5 years	Technology Considered Appropriate Obsolescence expected within 5 years	Technology Nearing Obsolescence Spare parts still available	Technology Obsolete Spare parts not available
Resilience	Year to sea level rise impact with projected USACE High curve	No impact $\geq$ Year 2100	Impact by Year 2060	Impact by Year 2040	Impact by Year 2030	Impact < Year 2030
	Storm vulnerability with and without SLR (USACE High curve)	No impacts from 100-year with SLR	Impacts from: 100-year without SLR OR 50-year with SLR	Impacts from: 50-year without SLR OR 25-year with SLR	Impacts from: 25-year without SLR OR 5-year with SLR	Current impacts with 2-year storm

# Asset Management/Disaster Recovery Convergence

**Use asset management principles to improve access to disaster recovery/mitigation funds**

**Use disaster recovery/mitigation conditions assessments to jump start an asset management program**

**Ensure your asset management program incorporates a LoS specific to resiliency**

# Questions/Discussion





# Thank you!



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