

City of New Orleans Stormwater Drainage System Root Cause Analysis of July-August 2017 Flooding

ABS Group
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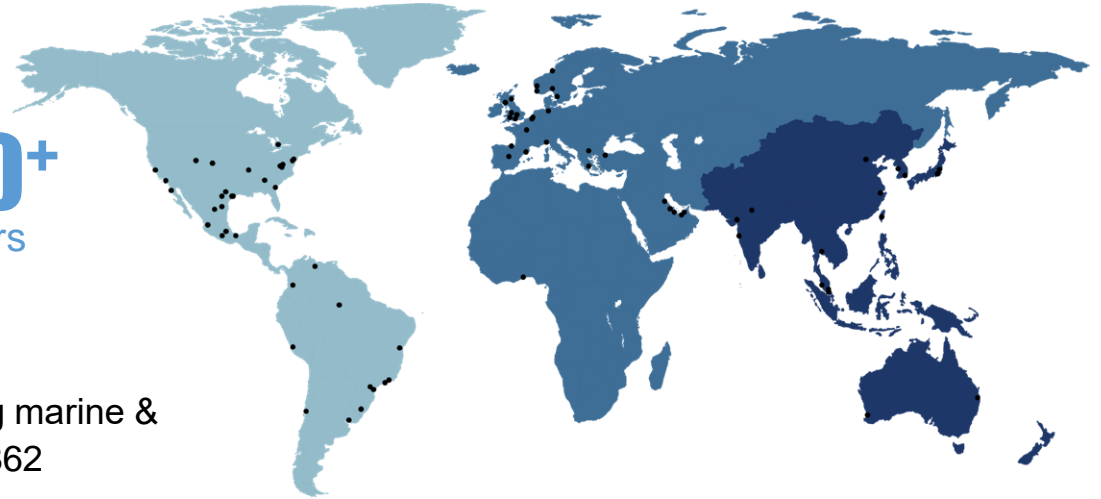
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1800+
Employees

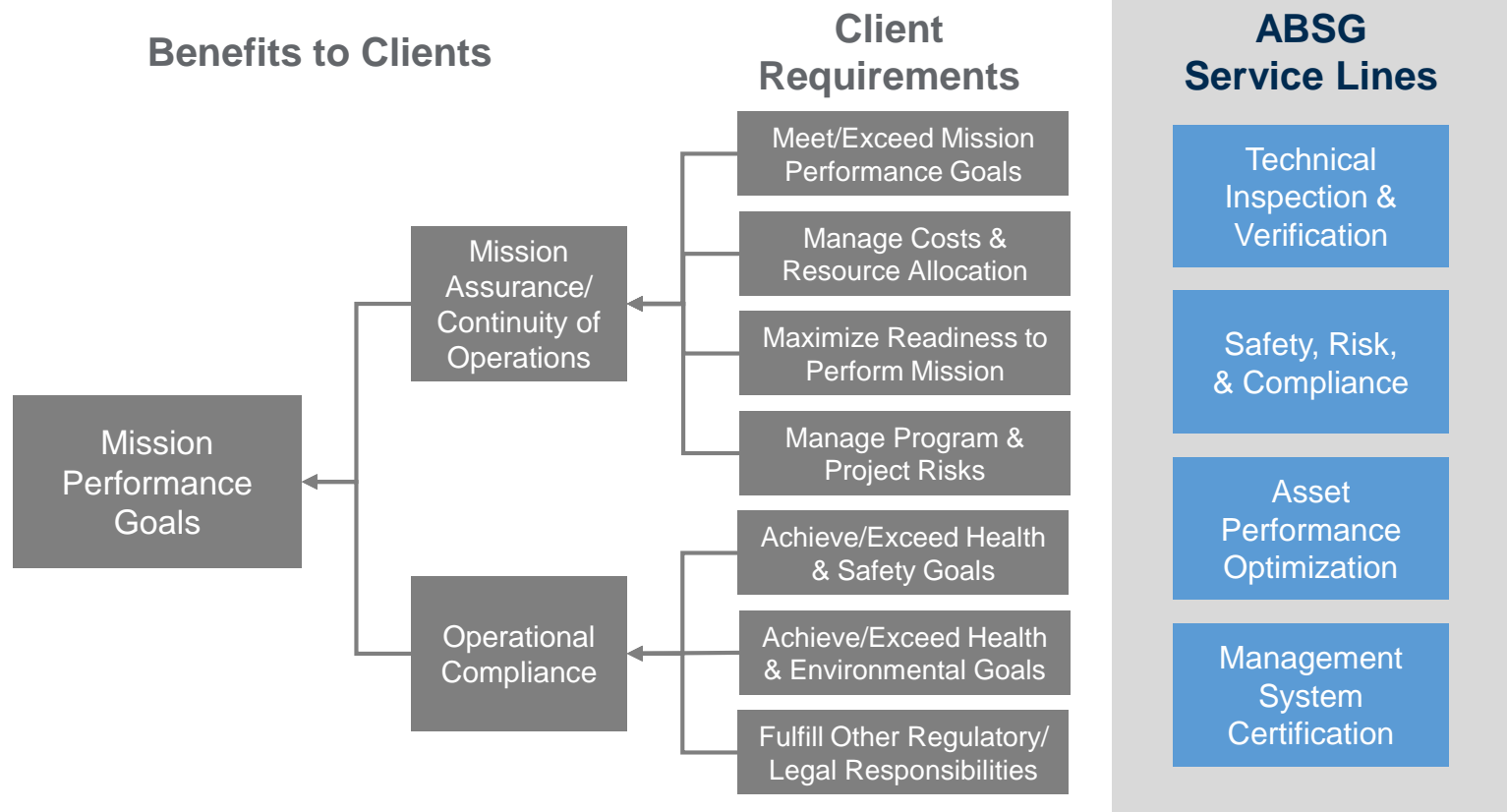
30+
Countries

40+
Years



Parent company, ABS, is the world's leading marine & offshore classification society, founded in 1862

Our Value Proposition



Scope of Analysis

A Root Cause Analysis with recommendations for addressing identified causal Factors and root causes was conducted for the following “Loss Events”:

- Flooding
 - July 22, 2017
 - August 5, 2017
 - August 8, 2017
- Turbine Generator #1 Electrical Fault
 - August 9, 2017

Root Cause Analysis Process

- Causal Factors
 - Front-line personnel performance gaps
 - Equipment performance gaps
- Intermediate Causes
 - Contributing factors to existence of Causal Factors
- Root Causes
 - Governance, policy, and management deficiencies allowing Causal Factors to occur or exist
- Recommendations
 - Suggested development, modification or enhancement of governance, policy, management, or operational systems

Assessment of Combined Stormwater Drainage System (S&WB & City Controlled Assets)

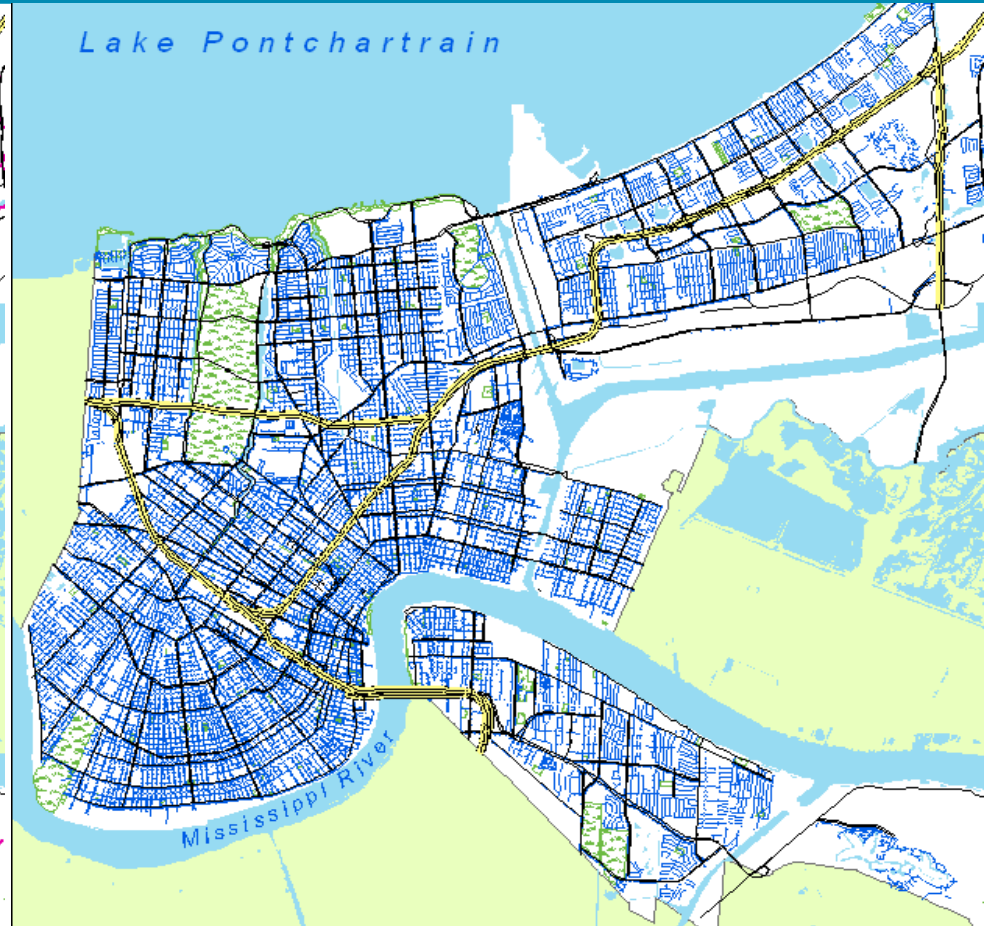
NOLA Stormwater Drainage System - Combined

- Responsibility for stormwater drainage is divided between separate governmental entities:
 - City
 - Catch basins
 - Piping less than 36-in. diameter
 - S&WB
 - Piping 36-in. diameter or greater
 - Pumping system
 - Power System
 - Underground Culverts & Outfall Canals

By the Numbers: S&WB and City Portions & Budgets for Combined NOLA Drainage System



S&WB: 235 miles of Pipe, Canals & Culverts; 23 Pump Stations; Power Plant
2017 O&M Budget: \$66,994,749



City: 1,288 Miles of Drainage Pipe & Over 68,000 catch basins, ditches, and inlets
2017 O&M Budget: Portion of \$6,496,623

NOLA Stormwater Drainage System - Combined

- Causal Factors and Root Causes of the flood related Loss Events involved both portions of the city's drainage system
- Consequences of divided responsibility:
 - No single point of responsibility
 - Inconsistencies between S&WB and City performance standards and management

Relevant Inconsistencies between S&WB & City Controlled Portions of NOLA Drainage System

- S&WB & City use different performance standards by which to establish service goals and measure success.
- S&WB pumping system capacity is not designed for full output from City drain lines.
- S&WB and City use separate governance, funding sources, budgeting processes, and maintenance programs to manage their portions of single system

Assessment of S&WB
Controlled Portion of
Stormwater Drainage System
Root Causes

S&WB/City Leadership Deficiencies as Root Causes

- **Insufficient Oversight**: Neither Board of Directors, Mayor, or City Council had controls in place to regularly assess and monitor power and pump system condition, performance issues, and related emergency measures
- **Lack of Situational & Risk Awareness**: S&WB Board and Executives failed to recognize impact that offline pumps and turbines would have in draining city and did not pursue adequate measures to mitigate performance risks
- **Failure to Adequately Fund**: City Leadership did not address known funding shortfalls related to drainage operations and capital improvements

S&WB Funding Deficiencies as Root Causes

- **Insufficient Funding Relative to Need:** Funding levels in years leading to Loss Events were insufficient to meet unmet maintenance needs and priority capital asset repairs.
- **Reduced Maintenance/Capital Spending:** One of S&WB's three drainage millages set to expire in Dec. 2016 w/out certainty of renewal, compelled 2015/2016 reduction in maintenance and capital spending to reserve funding.
- **Insufficient Monitoring of Needs:** Board's budgeting process lacked ongoing analysis of changing operational and capital needs during fiscal year.
- **Hesitancy to Enact Drainage Service Fee:** City Leadership choice to not pursue drainage service fee upon commissioning a proposed rate structure prevented pursuit of bond financing for major turbine and pump asset related improvements.

S&WB Funding Deficiencies as Root Causes

- Funding deficiencies identified 2015 Report on Operations
 - Insufficient funding available for capital improvements
 - \$13.3 million available
 - \$24.9 million required for anticipated capital improvements in 2016
 - 2016-2020 – S&WB does not have the capacity to issue additional bonds or fund the major capital improvement program
 - Future costs associated with SELA projects
 - Repayment of S&WB portion to begin 2019, payment rises to \$8.8 million/year in 2022
 - Additional \$1.2 million in annual costs will be incurred for operations and maintenance
 - Additional costs
 - \$4 million for deferred maintenance
 - \$2 million for groundwater management and green infrastructure
 - ***“The analysis indicates that the current revenue sources are not adequate to meet operation and maintenance expenses and total debt service on existing bond issues beginning in 2020”***

Assessment of City Controlled Portion of Stormwater Drainage System

City Controlled Portion of NOLA Drainage: Operational Deficiencies as Root Causes of Loss Events

Significantly Compromised Pre-Flood System: 38% of 68,092 catch basins; unknown amount of drain lines compromised.

Failure to Implement 2011 Stormwater Plan Maintenance Goal: Annually clean and inspect 8% of City drainage assets, including 15% of problem assets (103 mi pipes inspected; 7-8K catch basins cleaned). Clean system in 9 years.

Actual Operations (2011-2017): Average 4,751 catch basins cleaned annually – citizen complaint based; no camera inspections.

Failure to Remedy Known Pre-Flood Compromised Catch Basins: Post-Hurricane Isaac (2012), City aware of thousands of blocked catch basins and pipes. Received FEMA funding to address. Action not meaningfully begun until after August flood.

City Controlled Portion of NOLA Drainage: Governance Deficiencies as Root Causes of Loss Events

Incompatible Standard Relative to Need: Complaint based annual target number of catch basin/drain line cleanings does not assure sufficient performance baseline relative to known risks.

Insufficient Funding Relative to Need: Between 2011-2017, City drainage maintenance used portion of \$4.2 average annual budget for “roadway maintenance.” Post-Loss Event, City spent and acknowledged more than \$20MM is needed annually to achieve sufficient performance baseline.

Lack of Dedicated Funding & Overreliance on Regulated One-time Funds: Absent drainage service fee or other regular source, City over relies on one-time and federal funding with use limits delay due to regulatory compliance inefficiencies.

Root Causes of Loss Events

Root Cause Summary

Flooding

Entity	Description
S&WB	Inconsistent leadership oversight of power and pumping operations
S&WB	Failure to establish and maintain minimum conditions of operations
S&WB	Insufficient planning and risk awareness of assets conditions
S&WB	Inadequate pump asset maintenance planning
S&WB, City	Inadequate budgeted funding for inspection and repairs
S&WB, City	Inadequate long-term capital improvement planning
City	Bureaucratic inefficiencies and limitations
S&WB, City	Precipitation greater than design level of service

Electrical Fault

Entity	Description
S&WB	Detailed procedures for repair of critical equipment were not developed
S&WB	Configuration management for brushes and springs was not maintained

Improvement Recommendations City Leadership and City Council

Recommendations – City Leadership and City Council

- Maintain more consistent and probing situational awareness of the readiness of the city's drainage assets
- Prepare and implement strategies to ensure adequate, sustainable, and coordinated funding for operations, maintenance, and capital improvements within the entire city drainage system
- Require a monthly status update on any emergency repairs projects involving S&WB power and pumps assets
- Advance S&WB's ongoing studies of alternative power sourcing options that would provide more reliable commercially rated electrical service for drainage operations
- Institute a more proactive approach to maintaining City controlled drainage system assets

Recommendations – City Leadership and City Council

- Develop a proactive approach to replacing deteriorated and undersized drainage assets within city control, while investing in increased storm water storage and detention on both public and private property
- Establish drainage asset replacement measures
- Develop capital investment funding and incentives
- Consider implementing incentives to reduce stormwater runoff and promote retention
- Determine and communicate the risk of flooding with the city's various drainage basins that will remain within that design capacity goal; determine additional investments and restructuring that would be needed to further reduce such risk; and prepare contingency plans for reducing the risk

Improvement Recommendations S&WB

Recommendations –S&WB

- Develop and implement a *Power Resiliency Plan*
- Establish minimum design configuration and operational performance requirements should be established for drainage-dependent pumping and power assets
- Significantly improve the frequency and effectiveness of its oversight activity
- Require more stringent follow-up project status reporting requirements for emergency authorizations
- Require a project status update for any work involving turbines at monthly general board meetings
- Monitor and evaluate the impact of maintaining increased reliance on internally generated power
- Complete inspection of all system electrical feeders and prioritize replacements and repairs

Recommendations – City Leadership, City Council, S&WB

- Redirect available capital and maintenance funds to resolve prioritized repair needs and establish a proactive timeline and budget strategy
- Institute a more proactive inspection and maintenance program
- Establish a critical systems maintenance prioritization and tracking system
- Develop an integrated (S&WB/City) drainage asset capital improvement strategy to assure that catch basins, minor and major lines, pumps, related power assets, and planned storm water retention projects are designed, scaled in capacity, coordinated in operation and repair, and sustainably funded
- Enact policies and procedures that trigger coordination and communication measures whenever a “rain load” events has been designated

Detailed Corrective Action Recommendations

Corrective Action Recommendations

S&WB management team should develop a ***Power Resiliency Plan*** that establishes minimum performance requirements and operational plans to ensure backup power is provided for all drainage operations.

Causal Factors & Root Causes Addressed:

Causal Factor: There was insufficient 25 Hz power to supply all required pumps due to Turbines 1, 3, 4, and 5 being out of service for restoration or maintenance.

Root Causes: Insufficient Planning & Risk Awareness of Power Generation Systems; Increased Reliance & Demand on Aging Turbines for Daily Non-Drainage Related Systems

Corrective Action Recommendations

New Orleans City Leadership (City, S&WB, City Council) should ***maintain more consistent and probing situational awareness*** of the readiness of the city's drainage-dependent turbines and pump system assets.

- Monthly S&WB reports to Board, Mayor, Council, and public summarizing power/pump system readiness; status of offline assets; and contingency plans.
- Protocols for assessing and reporting risks and alternative solutions if major repairs are not begun or completed within three months of scheduled timelines.

Causal Factors & Root Causes Addressed:

Causal Factors: Insufficient 25 Hz power to pumps; Pumps not moving water efficiently and ran backwards for long durations due to mechanical integrity issues.

Root Causes: Insufficient risk awareness and planning to address Power System problems; Inconsistent oversight of Pump System repairs and capacity limits.

Corrective Action Recommendations

City Leadership (Mayor, S&WB, City Council) should ***enact strategies to ensure adequate, sustainable, and coordinated funding*** for operations, maintenance, and capital improvements within the entire city drainage system.

- Jointly create a single long-term funding source for entire city drainage system.
- Enact a joint drainage system capital planning and maintenance process
- Employ service delivery focused “budgeting for outcomes” process to establish annual joint budgets, maintenance goals, and performance metrics.

Causal Factors & Root Causes Addressed:

Causal Factors: Insufficient 25 Hz power; Continuous power from redundant sources not available; Insufficient pumps due to maintenance; Pumps not moving water efficiently and ran backwards for long durations; City pipes and catch basins blocked; City portion of drainage system lacked sufficient design drainage capacity.

Root Causes: Inadequate SWB/City long-term funding strategies, sources, policy support, and planning for inspections, repairs, and capital improvements.

Corrective Action Recommendations

City Leadership (Mayor, S&WB, City Council) should ***maintain more effective situational awareness of the impact that daily use of onsite turbines for non-drainage system needs has on readiness and functionality*** in meeting drainage system needs. This heightened awareness should include regular monitoring, analysis, and reporting to City Leadership.

Causal Factors & Root Causes Addressed:

Causal Factor: Insufficient 25 Hz power to pumps due to Turbines 1, 3, 4, 5 out of service for restoration/ maintenance.

Root Cause: Steady increase since at least 2011 in the use of S&WB turbines for non-drainage related system needs.

Corrective Action Recommendations

City Leadership should ***improve oversight of drainage power/pump matters***:

- S&WB Board should require monthly reports by staff on operating, offline, and repair status of critical drainage systems (turbines, pumps, frequency converters)
- Pump/power performance gauged using single drainage rate benchmark.
- Amend state law authorizing S&WB emergency repairs (La R.S. 33.4084) to require more stringent status reporting requirements to City Council and Board.
- Amend S&WB Board procedures to require a project status update for any work involving turbines at monthly general board meetings.
- Include updates on turbine related repairs and readiness as part of information reports to City Council and regular Mayoral briefings.

Causal Factors & Root Causes Addressed:

Causal Factors: Insufficient 25 Hz power to pumps due to known offline turbines and insufficient number of operable pumps due to maintenance issues.

Root Causes: Inconsistent oversight of turbine and pump repairs; Inadequate awareness of consequence of known offline turbines during severe rain events.

Corrective Action Recommendations

S&WB Leadership should establish ***proactive protocols to maintain critical threshold of functioning drainage system electrical feeders.***

- Institute proactive inspection and maintenance program to assure feeders deliver sufficient power to meet demands based on modeled rain storm scenarios.
- Complete inspection of all system electrical feeders and prioritize replacements and repairs based on confirmed degrees of deterioration or malfunction.
- Redirect funds if needed to resolve prioritized repair needs and set forth a proactive timeline and budget strategy to assure all system feeders are functioning.
- Institute a proactive inspection and maintenance program using benchmarks for gauging asset performance health (e.g., functional, problematic, eminent failure, failure) to better communicate system criticality within S&WB and to the public.

Causal Factors & Root Causes Addressed:

Causal Factors: Insufficient 25 Hz power to pumps due to lack of electrical feeders; Continuous power from non-turbine sources not adequately relayed to online pumps.

Root Causes: Inadequate budget and planning to assure inspections and repairs of feeders; and alternative power sourcing/conveyance options.

Corrective Action Recommendations

City Leadership (Mayor, S&WB, City Council) should ***collaborate jointly to negotiate a long-term power generation solution that involves reliable onsite power sourcing*** (e.g., the long-proposed power utility substation based at S&WB's East Bank Water Plant); and reduces or eliminates reliance on unreliable overhead distribution lines to convey power to critical water systems.

Causal Factors & Root Causes Addressed:

Causal Factor: Continuous power from redundant sources was not reliably conveyed to online pumps causing them to trip offline and cease functioning.

Root Cause: The use of distribution lines which are not commercially rated to convey Entergy power to S&WB is highly prone to disruption.

Corrective Action Recommendations

S&WB should consider the following to ***improve project prioritization and tracking***:

- Uniform analysis to establish feasible performance goals and asset needs for each drainage pumping station based on modeled rain storm scenarios.
- Centralize the assessment of the system's pump stations.
- Institute a fast-track project delivery system and unit to procure, perform, and monitoring repair and maintenance projects.
- Train personnel to use computerized maintenance management system to integrate job creation, prioritizing, procurement, and performance monitoring.
- Uniform procedures across all pump stations related to operations, inspections, “rain load” event checks, communications, repairs, and project tracking.

Causal Factors & Root Causes Addressed:

Causal Factors: Insufficient operable pumps due to maintenance issues; Pumps were not moving water efficiently due to mechanical integrity issues.

Root Causes: Inadequate pump asset maintenance planning; reactive maintenance.

Corrective Action Recommendations

S&WB and City Leadership should consider establishing ***minimum design and performance requirements for drainage-dependent pumping and power assets based on realistic goals for minimizing standing water during 5, 10, and 25-year rain events***, considering the combined S&WB/City drainage system as presently designed and configured. Specific examples include:

- Baseline for minimum 25 Hz power that must be able to be self-generated at any time to achieve the pumping capacity needed to meet those minimized standing water depth aims.
- Minimum pump station flow rates required to prevent flooding during rain event scenarios and baseline self-generated power needs to achieve those rates.

Causal Factors & Root Causes Addressed:

Causal Factor: Pump system had inadequate design capacity to remove water from drainage basins.

Root Causes: Pumping performance standards for modeled rain events are not used nor did S&WB establish and maintain minimum conditions of operations.

Corrective Action Recommendations

S&WB and City Leadership should ***implement an integrated drainage asset improvement plan*** to assure that catch basins, minor and major lines, culverts, pumps, power assets, and storm water retention projects are designed, coordinated in operation, and sustainably funded to assure that the city's combined drainage system limit standing water to 6 inches or less amid a 10-year rain event (approximately 8.5 inches over 24 hours).

Causal Factors & Root Causes Addressed:

Causal Factor: The drainage pumping system had inadequate design capacity to remove water from drainage basins.

Root Cause: Inadequate drainage related capital improvement assessment and implementation strategy.

Corrective Action Recommendations

City Leadership (Mayor, CAO/DPW, City Council) should ***maintain City controlled drainage assets based on rain event modeling and inspection data*** in lieu of a complaint-driven strategy.

- Establish a maximum standing water depth goal in each of the City's drainage basins for 5, 10, and 25-year rain events.
- Establish an adequate catch basin/drain line performance baseline by inspecting and cleaning all assets within 3-5 years and 8% of the system annually thereafter.
- Increase training along with performance incentives among contracted entities performing inspection and maintenance.
- Avoid use of one-time, highly regulated fund sources to the extent feasible.
- Implement cost-sharing or asset-sharing cooperatives between City and S&WB and neighboring Parishes to better meet maintenance goals.

Causal Factors & Root Causes Addressed:

Causal Factors: City drainage assets in flooded basins were clogged or broken.

Root Causes: Inadequate funding, planning, maintenance, and capital improvements relative to need and risk.

Corrective Action Recommendations

City Leadership (Mayor, CAO/DPW, City Council) should consider the following to improve the design and function of its portion of the drainage system:

- Institute capital improvement plan to replace compromised catch basins and undersize minor drain lines over 10-15 year period.
- Modify existing contracting and procurement rules to allow for “Design-Build-Finance-Maintain” contracting to better enable public-private funding options.
- Enact developer fees for major storm water infrastructure improvements servicing their project and/or based on runoff to already constructed finite drainage systems.
- Link zoning incentives to storm water control features above existing mandates.
- Enact ordinances and/or executive orders establishing target percentages for storm water investment among capital projects; and pervious surface area among planned street, roadway, and curb improvements between 2018-2028.

Causal Factors & Root Causes Addressed:

Causal Factors: City drainage assets in flooded basins were clogged or broken.

Root Causes: Inadequate funding, planning, maintenance, and capital improvements relative to need and risk.

Corrective Action Recommendations

S&WB and City Leadership should ***ascertain and communicate the risk of flooding with the city's various drainage basins based on a various modeled rain event scenarios***; what additional investments and restructuring would be needed to reduce such risk; and prepare contingency plans for reducing the risk of human endangerment, property damage, business interruption, and compromised transportation mobility during rainfall exceeding the present drainage system design capacity.

Root Causes Addressed:

Rainfall in three drainage basins during the Loss Events exceeded the “design storm” capacity of City’s controlled portion of the drainage system; and four drainage basins based on the “design storm” capacity of the S&WB controlled portion of the overall drainage system.

Corrective Action Recommendations

City Leadership (S&WB, City, City Council) should ***enact policies and procedures that trigger coordination and communication measures whenever a “rain load” events is declared*** by S&WB based on the severity of an anticipated storm. This designation should activate underpass flood alert signals and multi-media public communications on safeguards to minimize property damage. City should also streamline protocols for issuing public flood advisories.

Causal Factors & Items of Note Addressed:

Causal Factor: The public was not warned in a timely manner about street flooding causing traffic to enter flooded streets.

Items of Note: City Office of Communications procedures prevented City Emergency Operations personnel from issuing flood advisories to the public without prior approval.