Root Cause Analysis Report

West Point Treatment Plant Sewage Released, Injury

Problem Statement

Report Number	RCA-26-10-2017-214	**RCA Owner**	Chris Eckert
Report Date	10/26/2017	**RCA Facilitator**	Brian Hughes

Focal Point: West Point Treatment Plant Incident

When

Start Date: 2/9/2017	End Date: 2/9/2017
Unique Timing	During heavy rainfall in the Seattle area, while operating at peak hydraulic capacity, when a partial interruption of power supply occurred.

Where

Facility	West Point Treatment Plant (WPTP), Primary 440 mgd, Secondary = 300 mgd

Actual Impact

Safety	One employee was injured (first aid injury)	
Environmental	NPDES permit exceedance Estimated 235 million gallons of combined sewage released	
Cost	Estimated damage to equipment ($49 - $57 million)	$57,000,000.00
Cost	Fines and improvements required by authorities (Estimated)	$1,361,000.00
Investigation Costs	Multiple outside investigations conducted (CH2M & AECOM) (Estimated)	$1,000,000.00
		Actual Impact Total: $59,361,000.00
Frequency Note	The WPTP has experienced five emergency bypass events since 2000. Three events (2000, 2006, and 2009) were due to plant failure.	

Potential Impact

Safety	Potential for multiple serious injuries and/or fatalities.

Report Summaries

Executive Summary

LISTEN UP! SOLOGIC DID NOT INVESTIGATE THIS INCIDENT IN ANY OFFICIAL OR PROFESSIONAL CAPACITY. THE SOLE PURPOSE OF THIS EXAMPLE IS TO BE USED AS A LEARNING OPPORTUNITY TO DEMONSTRATE HOW A HIGH-VALUE, HIGH-RISK INCIDENT *COULD* BE ANALYZED USING THE SOLOGIC METHOD OF ROOT CAUSE ANALYSIS AND CAUSELINK SOFTWARE. PRIMARY SOURCES OF INFORMATION FOR THIS EXAMPLE RCA ARE THE (EXCELLENT AND DETAILED) INDEPENDENT AECOM REPORT COMMISSIONED BY KING COUNTY AND SEATTLE TIMES REPORTING. WE HAVE SIMPLY RESTATED INFORMATION PREVIOUSLY PUBLISHED BY OTHERS. ENJOY!

This is a challenging RCA, to say the least, because so many things happened in such a short amount of time. Essentially, the system was at capacity when it experienced a few failures that, under normal circumstances, would have been relatively easy to manage and likely would not have resulted in such a catastrophic outcome. And although one employee was injured, thankfully no one was killed. Note that the four Solutions listed are directly from the AECOM report referenced above. Sologic did not propose additional solutions. But you may have some ideas... feel free to send them on to us and we will add them to this analysis. Email us here: info@sologic.com

Cause and Effect Summary

On February 9th, 2017, the Seattle area was experiencing a significant amount of precipitation. Much of Seattle relies on a combined storm/waste sewage system. This means that during heavy rains, the wastewater treatment facilities experience significant volumes. In such events, roughly 90% of volume is attributed to storm water and the other 10% sewage. The West Point Treatment Facility is located on the Puget Sound in the Magnolia neighborhood. It has a capacity of approximately 440 million gallons per day (mgd).

On this night, the plant was operating near capacity when an electrical fault shut power down to part of the plant, including Effluent Discharge Pumps 1 & 2 as well as a hydraulic system which was the single source of hydraulic power to Effluent Flow Control valves. The plant uses a total of four Effluent Discharge Pumps, but only at high tide. At low tide, the pumps are not needed. When the hydraulic system lost power, the valves (by design) failed to the closed position. Of the four total Effluent Discharge Pumps, at the time of the power loss, pumps 2, 3, & 4 were operating while pump 1 was in standby mode. Effluent Pump 2 shut down when it lost power. And Effluent Pumps 3 & 4, pumping against the closed flow control valves, experienced high vibration, which caused them to shut down shortly thereafter. At this point, very little effluent is able to flow out of the plant. Yet millions of gallons are still flowing in.

When the Effluent Flow Pumps shut down, effluent began building up immediately upstream in the Effluent Pump Station (EPS) wet well until the EPS high-high indicator triggered. This caused weir gates to close upstream in the Primary Sedimentation tanks, stopping flow at that point. But then the Primary Sedimentation Tanks began to fill. These tanks are equiped with two high-high float switches which shut down the upstream Raw Sewage Pumps and open the system bypass. However, one of them did not function properly due to a bent float rod. These switches have a history of failure. The rods are easily bent, which then prevents the floats from tripping the switch.

The operators on shift at the time had a difficult time accurately troubleshooting exactly what was happening. They

were unaware that the flow control valves downstream from the Effluent Discharge Pumps had failed closed due to no hydraulic power. And they also did not realize that the weir gates on the Primary Sedimentation Tanks had been closed (and locked in place) by the high-high safety switch in the Effluent Pump Station wet well. And there were so many alarms (2,100 in an hour) that the operators in the Control Room were simply overwhelmed with information.

As the sewage continued to be pumped in (and not out), the Primary Sediment Tanks overtopped and began flooding the plant. Operators realized that they were in danger and quickly evacuated the area. However one operator partially fell into a tank through a grating that had been forced out of place and became injured. Other operators helped extract her and move her to safety where they were then able to provide first aid.

Operators then were able to correctly troubleshoot the fact that the flow control valves were failed closed due to the common hydraulic system. They then installed a backup hydraulic system which allowed them to open the valves and restart the Effluent Pumps.

Operators were also able to manually shut down the Raw Sewage Pumps. This caused the raw sewage wet well levels to rise, which then triggered the plant bypass. Downstream levels began to fall. And raw sewage began flowing directly into Puget Sound.

Solutions

SO-0001	**Solution**	Implement a Life Safety Management system. (From AECOM report)		
	Cause(s)	Proximity of multiple employees		
	Note	See AECOM report attached for additional details.		
	Assigned	Brian Hughes	**Criteria**	Passed
	Due	2/25/2018	**Status**	Approved
	Term	medium	**Cost**	
SO-0002	**Solution**	Conduct comprehensive emergency response training. (From AECOM report)		
	Cause(s)	Speed of rising waters		
	Note	See AECOM report attached for additional details.		
	Assigned	Brian Hughes	**Criteria**	Passed
	Due	2/25/2018	**Status**	Approved
	Term	medium	**Cost**	
SO-0003	**Solution**	Conduct an integrated evaluation to address plant constraints and improve redundancy. (From AECOM report)		
	Cause(s)	1 of 2 high-high float switches failed		
	Note	See AECOM report attached for additional details.		
	Assigned	Brian Hughes	**Criteria**	Passed
	Due	2/25/2018	**Status**	Approved
	Term	medium	**Cost**	
SO-0004	**Solution**	Optimize a capital improvement plan to maximize redundancy. (From AECOM report)		
	Cause(s)	Pumps 1 & 2 pumps had no power		
	Note	See AECOM report attached for additional details.		
	Assigned	Brian Hughes	**Criteria**	Passed
	Due	2/25/2018	**Status**	Approved
	Term	medium	**Cost**	

Team

Facilitator

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Owner

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Participants

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West Point Treatment Plant Sewage Released, Injury

Timezone: America/Los_Angeles

2/9/2017 02:21:00 AM

ACC-3 Operator reset and restarted EPS Pumps 3 & 4.

2/9/2017 02:20:00 AM

Main Control completed RSP slowdown to 50%, flow ~220 mgd

2/9/2017 02:19:00 AM

ACC-1 Operators placed PE gates in manual, but they failed to open.

2/9/2017 02:18:00 AM

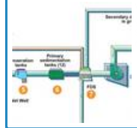
EPS level above elevation 115' interlock prevents manual PE gate movement.

2/9/2017 02:16:00 AM

Flow in the Flow Diversion Structure dropped below 300 mgd.

2/9/2017 02:14:59 AM

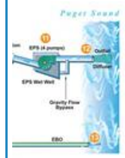
The EPS high-high tethered float signaled the Primary Sediment tank weir gates to raise (close).



When the Primary Effluent gates closed, effluent stopped flowing to systems downstream.

2/9/2017 02:14:40 AM

The EPS wet well water level begins to rise.



With the Effluent Pumps shut down, water begins to rise immediately upstream in the EPS wet well.

2/9/2017 02:14:20 AM

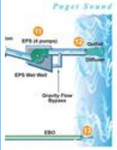
Effluent Pumps 3 & 4 shut down.

2/9/2017 02:13:00 AM

Hydraulic discharge valves of all 4 Effluent Pumps close

2/9/2017 02:12:30 AM

Electrical fault occurred



Effluent Pumps 1 & 2 immediately shut down

2/9/2017 02:26:00 AM

Water rises above grating on the way back to ACC-1.

2/9/2017 02:25:30 AM

1 of 2 High-high float switches in Primary Sediment Tanks failed to engage.

The float arm was bent, preventing the float from engaging. This would have triggered an automatic bypass of the plant and prevented the Primary Sediment Tanks from overtopping.

2/9/2017 02:25:00 AM

The water level in the primary sedimentation tanks began to rise.

2/9/2017 02:30:00 AM

Main Control slowed RSPs to 45% speed, ~200 mgd

2/9/2017 02:31:00 AM

ACC-3 Operators again try to restart EPS pumps 3 & 4.

2/9/2017 02:41:00 AM

ACC-3 Operators attach standby hydraulic unit to power the effluent valves.

2/9/2017 02:40:00 AM

ACC-3 Operators become aware that the pump effluent valves are not opening.

2/9/2017 02:40:00 AM

Main Control informed operators to check effluent valve hydraulic control power.

2/9/2017 02:39:00 AM

ACC-1 Operators began first aid on injured operator.

2/9/2017 02:59:00 AM

ACC-3 Operators finish installing standby hydraulic unit.

2/9/2017 03:00:00 AM

ACC-3 Operators observed water coming down the stairs and evacuated the area.

2/9/2017 03:00:00 AM

At grade, wastewater flowed into the parking lot and down into the truck tunnel area.

2/9/2017 03:03:00 AM

ACC-1 Operators succeed in manually stopping Raw Sewage Pumps.

2/9/2017 03:04:00 AM

Raw Sewage Pump wet well level rises.

2/9/2017 03:05:00 AM

Levels in both Primary Sedimentation Tanks dropped.

2:13 AM

2:19 AM

2/9/2017 02:30:00 AM

2/9/2017 02:31:00 AM

2:59:01 AM

2:59:51 AM

3:00 AM

3:00:41 AM

3:01 AM

3:01:31 AM

3:02 AM

3:02:21 AM

3:03 AM

3:03:11 AM

3:04 AM

3:04:01 AM

3:04:51 AM

West Point Treatment Plant Incident

- Adverse environmental impact
  - Release of up to 235 million gallons of sewage to Puget Sound
    - Sewage bypass required
      - Plant too damaged to function
        - Connects to: Section of the plant was severely flooded
    - Sewage load continued to the plant
      - END — Terminated because: Other causal paths more productive
    - Time required to repair equipment = ?
- Adverse safety impact: Injury, risk of additional injuries/fatalities
  - Employee injury
    - Employee fell through a floor grating
      - Running for higher ground in ACC-1
        - END — Terminated because: Desired State
      - Grating had become dislodged
        - Rising flood waters
          - Connects to: Primary Sediment tanks overtopped
        - Grating held in place by gravity
          - ?
      - Employee did not see missing grating
        - Waters were brown and turbid... could not see through
          - END — Terminated because: Other causal paths more productive
    - Sufficient force to injure
      - END — Terminated because: Other causal paths more productive
  - Potential multiple employee injuries/fatalities
    - Speed of rising waters
      - END — Terminated because: Other causal paths more productive

      Solutions

      Conduct comprehensive emergency response training. (From AECOM report)

      Criteria Pass Status Approved

      See AECOM report attached for additional details.
    - Proximity of multiple employees
      - Attempting to troubleshoot the problem(s)
        - END — Terminated because: Desired State

      Solutions

      Implement a Life Safety Management system. (From AECOM report)

      Criteria Pass Status Approved

      See AECOM report attached for additional details.
- Adverse operational impact: Plant offline for several days
  - Section of the plant was severely flooded (d)
    - Primary Sediment tanks overtopped (c)
      - Sewage continued to enter Primary Sediment tanks
        - Upstream Raw Sewage Pump continued to operate
          - 1 of 2 high-high float switches failed

            Solutions

            Conduct an integrated evaluation to address plant constraints and improve redundancy. (From AECOM report)

            Criteria Pass Status Approved

            See AECOM report attached for additional details.
            - Float rod bent
              - History of damage to float rods
                - END — Terminated because: Other causal paths more productive
              - Float rods are small, easily damaged
                - END — Terminated because: Other causal paths more productive
            - Bend was sufficient to prevent engagement
              - ?
          - High-high float switches shutdown upstream flow, open plant bypass
            - END — Terminated because: Desired State
      - Outflow weirs for Primary Sediment Tanks closed
        - Four downstream Effluent Pumps were offline
          - Pumps 1 & 2 pumps had no power

            Solutions

            Optimize a capital improvement plan to maximize redundancy. (From AECOM report)

            Criteria Pass Status Approved

            See AECOM report attached for additional details.

            Connects to: Electric Switchgear A powers a common hydraulic system, Pumps 1 & 2 (b)
          - Pumps 3 & 4 pumps had the exit pathway blocked... vibration
            - Downstream flow control valves failed in the closed position
              - Electric Switchgear A failed
                - ?
              - Electric Switchgear A powers a common hydraulic system, Pumps 1 & 2 (b)
                - END — Terminated because: Other causal paths more productive
              - Hydraulic system powers all flow control valves
                - END — Terminated because: Other causal paths more productive
    - Series of holding tanks exist upstream from flooded area
      - END — Terminated because: Desired State
  - Required several days to recover
    - ?