Case Study

Connecting Asset Management to Maintenance & Reliability

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Rancho California Water District

Hierarchy Consulting | Criticality Analysis Facilitation | Asset Management Coaching

Summary

In 2005 the Rancho California Water District in Temecula, California began planning for the substantial redesign and expansion of its sole water reclamation facility. The plant expansion was put on hold for legal reasons and declining flows in 2008. The District reduced its repair and maintenance budget by deferring repairs and capital improvements pending the plant expansion. By 2012 the District and its contributory partners began examining other options. The amount of deferred maintenance accumulated over the preceding seven years and the anticipated delay for any new option presented a challenge for the facility staff. With limited funds for repair and the uncertainty of the Board of Directors supporting major capital improvements, it became very clear that any funds for repair would need to be spent on critical assets first.

In late fall of 2012 a criticality analysis was initiated with the aid of Uberlytics. The unique approach and tool set was originally developed over the course of a decade and successfully applied at numerous plants across the US, and is specifically developed to be transferable to in-house staff. A recent CMMS upgrade had just been completed and was the starting point of the analysis. The overall criticality ranking was developed using a unique ‘failure scenario’ analysis at the functional system level. Several new and previously unrecognized critical systems were identified as well as several new risk mitigating opportunities at various levels of commitment. One of the key objectives with assuming this unique approach and the specific outside consultant was to pass on the necessary skill set and facilitation tools to the in-house Rancho staff for follow-on analyses.

As a result of the criticality analysis, several additional initiatives are under way including condition assessment and failure mode analysis (FMA) development plans for both the wastewater and water departments.

Introduction

In 2005, the Rancho California Water District in Temecula, California began planning for the substantial redesign and expansion of its sole water reclamation facility. When the economic downturn began in 2008, flow projections began to decline and the existing flow stabilized. For this and other reasons, the plant expansion was put on hold. As the delays moved from month to years, the District deferred repairs and capital improvements pending the plant expansion. By 2012, it became apparent that the flows would not reach the design levels in the foreseeable future. For this reason, the District and its contributory partners began examining options other than the planned expansion. While the facility staff waited for direction, the amount of deferred maintenance that had accumulated over the preceding seven years presented a challenge for the facility staff. With limited funds for repair and the uncertainty of support for major capital improvements, it became very clear, and critical, that any funds for repair would need to be spent on critical assets first and foremost.

In late fall of 2012 a criticality analysis was initiated with the aid of an outside consultant. The unique approach and tool set was originally developed over the course of a decade and successfully applied at numerous plants across the US, and is specifically developed to be transferable to in-house staff.

The discipline needed to prevent any Criticality Analysis discovery phase from devolving into a solution mode and capital planning discussion found its value in a key follow-up exercise: that of a condition assessment. At times there could be a tendency to act too quickly once systems and assets were verifiably known as having a high risk ranking; and that was typically to shift into solution mode and capital planning. However a key component of capital planning is to actually know why you would engage in a capital plan and for what assets. Is the 'as-built' asset or system insufficient or just has a history of needing maintenance given a bad design?

The decidedly better approach was a follow-up to initiate and plan for a detailed condition assessment of the higher risk systems, and particularly the assets within those systems. In this way the capital planning would have a sharper focus to what actually needs doing. Further, the condition assessment would provide a basis for the ongoing maintenance activities:

- Do they need adjustment?
- Do they need more on certain asset?
- Do they need additional types of testing to track wear and incipient failure?

It was recognized that a considered and thoughtful follow-up would save money in both the short or near term as well as the long term. As a result of the Criticality Analysis, Rancho California Water District is part way through a condition assessment on the top 20 % of the systems, or those it deems at sufficiently high risk to warrant expenditure in this way. Completed Condition Analysis on the critical systems is forming the basis for the initial capital plan.

Building upon the follow-up items from the Criticality Analysis at the wastewater plant is a Failure Mode Analysis (FMA) that is centered on discovering the failure modes of the assets within the high-risk ranked systems. The advantage with this approach is to drive maintenance towards understanding exactly how the assets exhibit failure modes and thus tailor the maintenance and monitoring programs towards those failures. Non-critical pumps, for example, would not require expensive thermography and vibration analysis. Differences between pump types, vertical centrifugal versus horizontal rotary lobe, would also exhibit signs of failure differently based on their internal design and construction. As such, the monitoring would reflect those differences and the actual ability to detect signs of failure. With the criticality analysis foundation set, plans are under way to break down the critical assets in the critical systems according to their failure modes.

The initial success of the wastewater experience is translating to the water side with plans to replicate the criticality analysis, and the follow-up evaluations for that side of the District. This paper will describe the overall process used, the unique results, and some key lessons along the way to attain a meaningful criticality analysis.

Methodology

Overview

The criticality analysis began in January of 2013, conducted with in-house staff as available and completed in July of 2013. The first step was to review the existing asset register for completeness and accuracy. Once the asset register was finalized, the registry was organized into a hierarchy structure using third party software, Criticality Analyzer™, described below. The hierarchy followed strict guidelines for type coding and hierarchy parent–child structures. The hierarchy representing the plant was successively divided into smaller groupings of area, process, and eventually the functional systems in the facility. This organization resulted in a total of 117 functional systems to be analyzed, comprising the entirety of the plant.

The next step was to identify the categories for evaluation, such as safety, environment, etc. The specific categories are a reflection of the District's mission statement and the associated objectives of the facility to be analyzed. It reflects what is important to the District and the facility operation. The analysis was conducted with in-house subject matter experts represented by operations, maintenance, electrical, engineering, and plant e, with facilitation and guidance provided by experienced outside consultants.

The analysis ranked the 117 systems in order of relative risk ranking, that is, the severity of the consequences in the categories identified of each of systems failing to deliver their designed service and the likelihood of that occurring based on historical occurrences and related near misses.

As the analysis continued and the bulk of the systems were evaluated, the overall profile began to take shape and the systems of concern distilled to the top.

During the analysis several follow-up items were identified that could mitigate the risks that negatively affected the functionality of the system. The process of functional system failure evaluation fostered many discussions on the design of the systems and the comprising assets 'as built'.

Specific Approach: Functional System Failure Scenario

The use of the Functional System Failure Scenario approach was developed and refined over a decade by Terrence Nelson while Director of Asset Management for a global water utility management company. The approach was field tested at hundreds of plants across the United States with the objective to develop an accurate means of determining criticality ranking of facility assets across a wide variety of plant technologies, operating cultures, local context and needs of the clients involved. Two of the unique features used in combination are

- The rapidly developed focus on the critical assets by means of identifying the critical functional systems, and
- The use of in-house subject matter experts to evaluate the relative risk.

A functional system is defined as the smallest group of assets that deliver a specific operational function within the facility. As such, a pumping system is a collection of assets that is designed to pump something, be it between two points or to and from a tank[1]. The necessary assets would include the minimal mechanical assets to perform this function, so that valves, sensors, pipes, Main local control switches and possible tankage would form the basic system. Depending on the context, additional assets could be brought into the system or removed (such as a tank if it is part of a larger system. One of the considerations to bear in mind is the collection of failure modes associated with the assets in the system. If the number of asset types is too large then the analysis becomes cumbersome and more difficult because the number of failure modes becomes larger as well.

The use of a subjective approach to risk management was successfully implemented and presented by Marc Yarlott a the 7th Global Congress on Process Safety in a well documented approach based on a substantial body of psychological work[2]. In this approach a team of in-house subject matter experts evaluate the consequences of various functional system failures against the criteria or categories previously identified as important to the organization. "By separating out the consequence and likelihood in the analysis, steps are further taken to improve the subjective risk assessment capacity of the subject matter experts, improving the results. In addition, the consequences can further be categorized by a level of service expectation, for example, ask the question of how the consequence of failure will effect the Environment or the Quality of the product allows the subject matter experts to further evaluate and categorize their responses the evaluations of the failure scenarios."[2]

The combination is a powerful and efficient approach to generating a relative criticality ranking of an entire plant in a fraction of the time, compared to an asset buy asset approach.

A third party software, Criticality Analyzer™ developed by Uberlytics, LLC was used to create a hierarchy, facilitate and manage the process, document the findings, calculate the results of the analysis, and present the data in such a way as to accurately represent the overall risk rankings in one graphic. The software was developed to facilitate this approach and process more efficiently and consistently across hundreds of facilities with all the variations described above. Uberlytics, LLC is located in Phoenix Arizona, and can be reached via Uberlytics.com. The software version used was 1.0.72.

System Level Failure Scenario and Failure Mode Effects and Criticality Analysis (FMECA)

The system level failure scenario was chosen as the most efficient means of accomplishing this criticality analysis for several reasons. First off is a tremendous efficiency. The System Level Failure Scenario approach deals with 100 to 120 systems in a typical municipal facility rather than the 8-900 assets. As such an analysis can be accomplished in far shorter time.

Secondly, eliminating the 80% percent of the systems from the most critical ranking eliminates approximately 80% of the assets as well. The reason is as follows: when systems are deemed to be not important to the overall facility then any asset within that system is no more important to the system itself. This approach permits a rapid and efficient focus to the most critical systems, and hence the assets within those systems.

Thirdly, the failure scenario approach is geared towards an outward focus from each system as it interrelates to the other systems and the plant operation and its stated objectives, and naturally drives towards maintenance activities. This last part is of course of primary importance to an existing operation.

In contrast, FMECA, in its pure form, focuses in on specific asset failure modes at the component level and the effect of that failure mode on the performance of that asset, as well as the consequence of that failure mode on the asset performance. It is a more inward analysis with a view to re-engineer an asset and monitoring asset health. While it can be used to evaluate external effects and consequences beyond the asset itself, the level the sheer volume of evaluation and the discipline needed to go several layers beyond the asset performance makes it far more prone to missing an important discovery, as well as the length of time involved covering 8-900 assets in such detail.

However, these two approaches complement each other extremely well when used together. Once a System Level Failure Scenario Approach is complete there is great value in using something like a FMECA at the asset level for the systems that have the higher risk rankings. In this way the greatest efficiency is leveraged to zero in on vulnerabilities and failure modes at the asset level are identified which fine-tune the specific asset maintenance program.

Register

While the asset register had recently been developed for the new Computerized Maintenance Management System (CMMS), it was not 100% complete. Any meaningful criticality analysis requires a complete and a deep hierarchal structure. This may seem unnecessary at first but the unique 'failure scenario' approach at the functional system level makes up for the extra time in a more efficient approach and identifying risks a traditional asset level FME and FMECA would miss.

An initial evaluation of the asset register was conducted on the then recently developed and completed CMMS. It was reviewed for completeness and suitability for an efficient approach to conducting a criticality analysis. There was some work required to better fit a criticality analysis, not just a list of items existing at the plant. A large part of the rework focused on completing the register to include 100% of the assets. This has often been the case as facilities are overwhelmed with the sheer volume of assets when including all the sensors, pipes, valves, as well as all the cables in any of the electrical or communications systems.

The plant was divided into various process areas, which were then divided into plant sections, and those further split into plant systems. Each system was comprised of a number of assets that collectively comprised the system. The systems were based on the smallest group of assets that delivered a specific operational function within the facility.

All the pipes and sensors in each system were then captured in each system, and given a respective group name that captures their asset type, such as field instrument group asset, or pipe group asset. In this way 100 % of the assets were captured and in a manageable form. The collections of sensors, or pipe sections are then sub-assets below the asset level.

Additional work was focused on ensuring the assets were in fact present and in their correct association with the correct part of the plant. Often lists of assets are not updated sufficiently and may contain obsolete equipment, or miss equipment entirely. Several areas had assets allocated that were in fact not part of that area or process, (allocated to the wrong building) and thus not in the right system.

Developing Failure Scenarios

Once the all the functional systems are identified, as best represented by the minimum number of assets to accomplish their stated function, the entire plant was accounted for. The reason for minimizing of assets for each functional system is to minimize the asset types, which minimizes the failure modes of the list of assets in a system. This aids in keeping the various failure scenarios to a minimum for each system and permits discrete analysis to generate the granularity needed while maintaining the efficiency of the approach at the optimal number of systems to analyze.

The next step was to develop the most generic list of system failures types. For a pumping system, for instance, it can be blockage, or a breach of containment, or incorrect pumping. The various and specific scenarios that could result in these failure types were then captured by the team in a facilitated session and evaluated against the various categories that were important to the facility and reflected the values of the District.

In Figure 1 below is a sample of the top three of the five scenarios evaluated for this particular system:

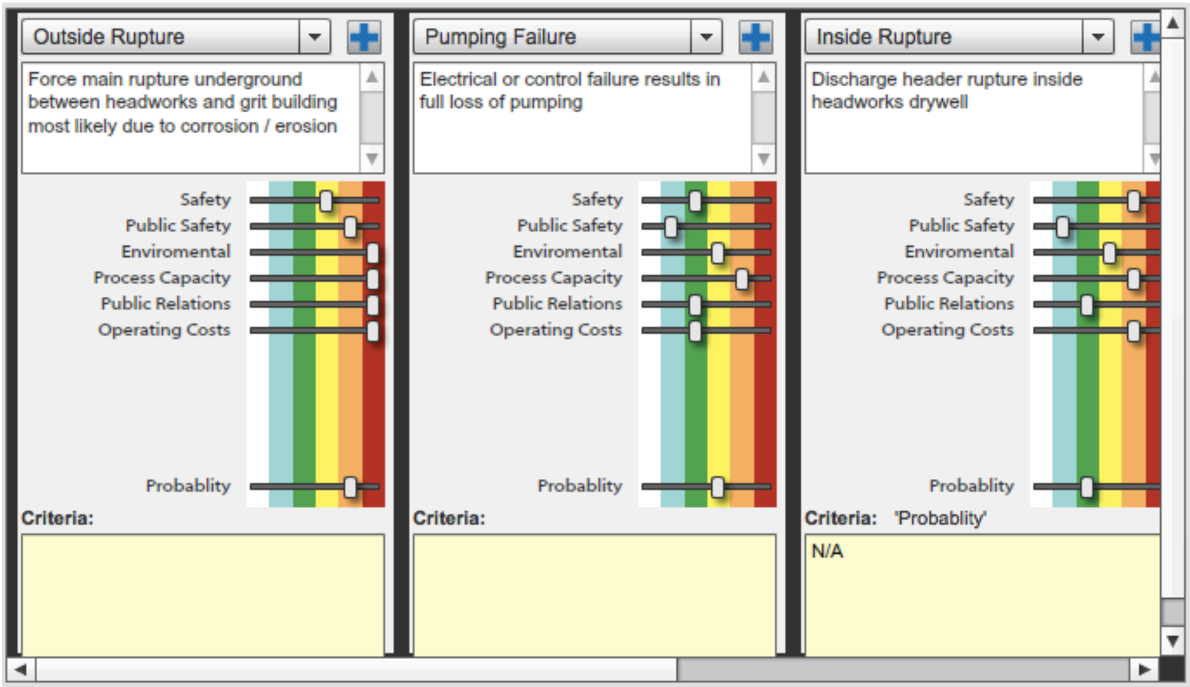

Figure 1: Top 3 scenarios for the Influent Pump Station

The failure scenarios were evaluated against the categories that the District identified as core to their mission statement, the objectives of the facility to maintain the directives of the District. Safety was split in two, staff safety as well as public safety. Not only did public safety related to any sewer overflows or any unwanted discharge into the environment, but also contractors that would occasionally be called in to be on site for any number of reasons.
Public relations were also considered important to the senior management because the manner with which the objectives are met are part of the overall goal. Public perception on housekeeping, speedy response, the ability to see the positive effects of a well-trained and responsive staff while not being inconvenienced or having minimum disruptions to the public were deemed important.

In addition to identifying the above categories the District set the weighting each has relative to the others. This weighting reflects the relative importance the District places on each. In this case the District had any safety concerns weighted as a 4, more than any other category listed. The district also set the scaling factor of the levels of severity from lowest to highest to reflect the relative scale for the levels of severity. This set the ratio of how many failures at one level, say yellow, are equal to a failure at the next level, in this case orange. In addition, the relative importance of the probability can be adjusted to reflect the level of importance the District placed on the highly probable scenarios versus the less probable events. Both of these scaling factors are important in performing sensitivity analysis on the results to note the effects of change in relative severity sensitivity as well as sensitivity to highly probable events. The settings selected are illustrated in Figure 2.

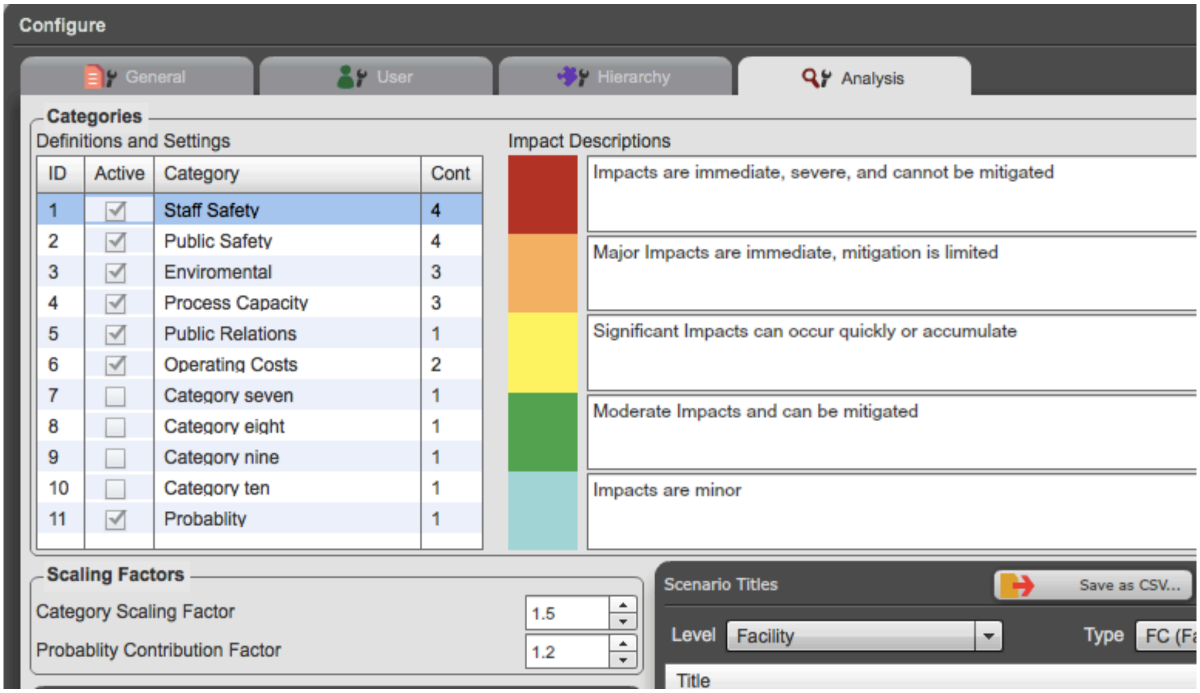

Figure 2: Category Relative Weight, Level of Severity Scale, and Probability Weight

It can be seen from Figure 1,for example, that the first scenario of an Outside Rupture of the pumping station was rated severe in almost all categories, with a high probability of occurrence. In comparison to the other scenarios considered for the pump station this was the one with the most sever consequences.
What was important in this phase of the analysis was to identify the worst case or cases. Each would have a variety of consequences at a higher level than lesser cases. Inititally as many as 6 scenarios were identified and discussed, evaluated, and compared to get really understand the approach. As the staff became more adept fewer scenarios were needed to zero in on the worst case scenario that would have the highest level of severity in the various categories as well as greatest likelyhood of occurance, or probability. This was often marked with a high degree of consensus amongst the participants.

However, there were some systems that presented a mixed bag of severity and likelihood. In this case the discussion continued until every new scenrio was clearly less severe.
The principle here is to not stop until the worst case is identified, which usually happens when discussion ceases, by consensus.

To illustrate this concept, Table 1 below is a listing of all five of the failures types considered for the Influent Pump Station, as well as the specific scenarios from the analysis. It can be seen that blockage posed no credible scenario and thus did not contribute to the ranking. In this case after these 5 scenarios were discussed no further scenario was greater than the outside rupture and the next system was examined.

Table 1. Five Failure Scenarios examined for the Influent Pump Station

System	Failure	Specific Scenario
Influent Pumping System	Blockage	No practical scenario that presents a significant blockage
	Inside Rupture	Discharge header rupture inside headworks drywell
	Outside Rupture	Force main rupture underground between headworks and grit building most likely due to corrosion / erosion
	Pumping Failure	Electrical or control failure results in full loss of pumping
	Pump Control Malfunction	Worst-case scenario in this case is a bubbler fail and a low-low float that does not shut off the pumps. Subsequent air bind of the pumps and possible resulting overflow of the wet well.

Results

Risk Ranking

Typical for most criticality analyses, suspected critical items were confirmed to be critical, but not in the exact ranking. This was a typical example as in almost every other analysis performed, the facility staff usually has a fairly good idea of 80% of the critical assets, though perhaps not exactly in the actual risk rank order given individual biases and their field of expertise. Further, some new or previously unrecognized as ‘critical systems ' were identified which is also almost always the case, and usually fall somewhere in the highest ranked 15% to 20% of the assets. Also, the relative ranking of 100 % of the plant yielded some surprising results. Figure 2 below is a representation of the risk ranking of all the systems in the plant.

hy Level: System

Type-Seq	Name	Local Code	Impact	Probablity	Risk	Manual
PMP-00	Influent Pumping System	FC01AR01SC01	3.71	4	3.79	
BLW-00	Blower and Air System	FC01AR02SC01	3.28	4	3.65	
ELE-02	SBR Blower Room Electri	FC01AR06SC01	2.6	4	3.45	
ELE-04	AWT Ops Electrical Syste	FC01AR06SC01	2.48	4	3.42	
PMP-00	Grit Pumping and Dewate	FC01AR01SC02	2.39	4	3.4	
STC-00	Effluent Splitter and Basin	FC01AR05SC01	1.67	4	3.25	
SCB-00	Chemical Scrubbing Syste	FC01AR04SCB(	4.89	2	3.17	
PMP-02	Backwash Basin Sludge P	FC01AR03SC04	0.86	4	3.14	
MBL-05	Personal Protective Equip	FC01AR07SC02	4.26	2	2.84	
CHM-07	Chlorine Storage and Fee	FC01AR04CHM(	4.4	1	2.65	
ELE-03	Solids Dewatering Electric	FC01AR06SC01	2.3	3	2.58	
PMP-01	AWT Influent Pumping Sy	FC01AR03SC01	2.27	3	2.57	
SBR-02	SBR #2 System	FC01AR02SC02	2.14	3	2.53	
SBR-03	SBR #3 System	FC01AR02SC02	2.14	3	2.53	
SBR-01	SBR #1 System	FC01AR02SC02	2.14	3	2.53	
SBR-05	SBR #5 System	FC01AR02SC02	2.14	3	2.53	

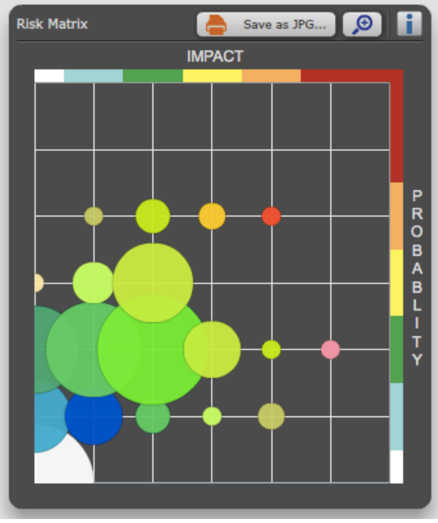

Figure 2. Overall Rancho Risk Ranking Results

The bubble chart on the left represents the relative ranking of all the systems in the District's wastewater facility. Every system represented occupies a risk ranking based on the severity of consequences and probability, or likelihood, of occurrence. The size of the bubbles represents the number of systems with that ranking. So the larger the bubble size, the more systems have that risk ranking, or close to it. The color also gives guidance to the relative criticality, with redder shades signifying higher rankings.

This very effectively visually represents the overall facility risk profile, with the bulk of the plant system rankings centered around the large green and light green bubbles in the lower left quadrant, the good zone, and a few outliers in the upper half, the right half and the upper right quadrant, the bad zone. The 8 or 9 systems that obviously have high consequences or probability ranking formed the basis for immediate attention and further investigation such as condition assessments, failure mode analysis or even a FMECA on the assets, and PM optimization.

In addition to the graphical representation in Figure 2 the specific ranking details are illustrated on the left of the image with the codes, the names of the systems, and the summarized impact, probability, and calculated risk ranking results from the analysis listed in order of highest to lowest risk ranking. The specific weighting of each of the categories, the composite of each of the scenarios, and the relative scaling factor of severity (the weight of red versus orange) are used in the calculations to arrive at the overall risk ranking.

These results have begun the formation of a revised maintenance plan as well as the basis for the follow-up condition assessment and resulting capital planning.

Table 2 below lists the relative risk ranking of the top 20% of the systems evaluated overall and the worst-case scenario discovered. The score is not as important as the order of ranking, since this is a relative criticality analysis. Most interesting are the worst-case scenarios that drove the rankings.

Table 2 Top 20% Risk Ranked Systems with Worst Case Scenarios

Name	**Rank**	**Worst Case Scenario**
Influent Pumping System	3.79	Full loss diverts to drywell with about 1 hour to environmental overflow. Limiting scenario is rupture outside the building.
Blower and Air System	3.65	Rupture of discharge manifold below concrete of SBR building results in no aeration
SBR Blower Room Electrical System	3.45	Limiting case is an electrical fire caused brown out.
AWT Ops Electrical System	3.42	Worst case is Switch gear fire taking out MCC 9
Grit Pumping and Dewatering System	3.4	Suction spool erosion.
Effluent Splitter and Basin System	3.25	Breach of the west basin berm adjacent to the right of way.
Chemical Scrubbing System	3.17	Worst scenario is the failure of the system to start in an emergency - via any of the interconnected functional units via the control system
Backwash Basin Sludge Pumping System	3.14	Major concern is wet well bypass pumping / piping on failure
Personal Protective Equipment	2.84	Given the severity of impact on safety both SCABA and Fall arrest are approximately equal
Chlorine Storage and Feed System	2.65	This is a balance between small leaks in an un-scrubbed room versus a rapid tank leak in a scrubbed room.
Solids Dewatering Electrical System	2.58	Worst Case scenario is staff safety in a fire situation
AWT Influent Pumping System	2.57	Rupture underground near the chlorine building resulting in excavation and interrupting chlorine handling
SBR #1 System	2.53	Worst scenario is loss of internal mixing header pipe
SBR #2 System	2.53	Scenarios for SBR 1
SBR #3 System	2.53	Scenarios for SBR 1
SBR #5 System	2.53	Worst scenario is loss of internal mixing header pipe

SBR #4 System	2.52	Worst Case is in the tank containment: the overflow of the tank spilling onto the chateau and other electrical equipment in front of the tanks
Digester System	2.52	Worst Case is the overflow of the tank spilling onto the chateau and other electrical equipment in front of the tanks
Grounds System	2.46	Worst case scenario is chronic degradation due to cost to repair and higher probability to negatively affect overall consequences
Chlorine Contact Sampling / Analysis System	2.45	Sample line is ruptured after pump toward the analyzer and sample is spilled into the environment
SBR Influent and Effluent Piping / Valves System	2.43	Worst Case is the influent pipe rupture below grade
Plant Vehicles System	2.36	Worst case is the need in the field and the vacuum unit does not function

The results illustrated above were somewhat anticipated, though not in the final ranked order. Depending on the individual staff member, some systems were initially considered more important prior to the analysis, such as the chlorination system. During the analysis all relevant factors were taken into account including plant hydraulics, failure histories, near misses, interrelationships of the systems, building entry and egress, ventilation systems, lighting for night time events, locations of the pipes, the types of control systems, the settings of the same, proximity in and to the plant, etc. Anything that could affect the staff's ability to mitigate the scenario and factors that could present themselves were evaluated.

The Influent Pumping system was considered important, but not initially deemed near the top. While the expected severity of the station failure was initially correctly understood, it was the likely event of a pipe breach outside the containment area that drove this system failure to the top.

Risk Management/Mitigation

During the discovery phase of the analysis many risk-mitigating opportunities were identified. Many of these required little more than a modification of certain staff duties and administrative functions. Some required a slight modification of operational management, and very modest capital commitment, often out of the maintenance budget or within the managers signing authority. Some however, did indicate possibly significant capital commitment to mitigate significant operational risk. At the core, an agreed follow-up priority list was created that influenced the both the maintenance and engineering activities after the analysis.
The identified risk-mitigating opportunities were identified which are listed in Table 3.

Table 3 Risk Mitigation/Follow-up

System or Asset Name	Code	Description
Solids Dewatering Electrical System	HIGH	Consider alternate means of egress from gravity table room
Gas Safety System	HIGH	Ensure all monitors are new models that fail to safe mode
SBR #1 System	HIGH	Influenced by ongoing refurbishment initiatives
SBR Blower Building System	HIGH	Inspect and assess roof and drain condition
Screening System	HIGH	Put in road diversion
SBR Building System	HIGH	Rework in the hierarchy to pull out non-SBR building systems that were included in this system. Analysis done on actual SBR assets
Mobile Towed Equipment System	HIGH	Stage the street legal pump at he main yard where vehicles are available
Headworks and Grit Electrical System	MEDIUM	Add emergency lighting on headworks lower level
Influent Pumping System	MEDIUM	Confirm PM for Influent wet well float functionality
Influent Pumping System	MEDIUM	Confirm high level float overrides low low level float
Headworks Emergency Generator System	MEDIUM	Develop SOP for transfer switch manual operation
Headworks Emergency Generator System	MEDIUM	Have 2 portable generators staged and committed to SRWRF
Chemical Scrubbing System	MEDIUM	Investigate backup power in event of AWT GEN loss
Mobile Towed Equipment System	MEDIUM	Replace existing non-street legal mobile pump with a street legal version
Headworks and Grit Electrical System	LOW	Check at what level in the headworks will the sewer overflow in the street.
AWT Drain Pumping System	REPAIR	Mud valve leakage (scheduled)
Belt Press Feed Pumping System	INVS	Can GTT pumps be used to feed BFP?
AWT Plant Emergency Generator System	INVS	Check SBR high level floats functionality
Gravity Table Sludge Return Pumping System	REDES	Consider replacing with PC pumps (vertical wall mount)
AWT Drain Pumping System	REDES	High-level alarm and backup pump should be considered.
Percolation Basin Transfer Pumping System	REDES	Pumps, Piping, and controls inadequate to transfer to other perc basin
AWT Backwash Water Return Pumping System	REDES	Redesign discharge to route to headworks vs. eq basin

Discussion

Risk Ranking

The results of the analysis, particularly the risk-ranked order of systems was influenced by a number of factors:

- the way the analysis was set up with categories reflecting the values of the District
- the inclusion of the specific group assets, particularly the pipes, as well as the instruments, etc.,
- the methodical approach to failure type and scenario development enforced by the software

This identified the major risk area in a way that focused the attention on the right asset within the system. Similarly so for the second highest ranked system, the inclusion of the pipes in the blower system, correlated with past events highlights the risk this system poses.
This would be in contrast to looking at all the pipe separately over the whole plant that might miss a particular failure scenario since they are tied to real historical events with those systems, and possible trigger events within a system.

The second ranked system is understandably the air delivery system to the SBR basins. Again, loss of this system is obviously catastrophic. But the local context of running the header under a high traffic drive way entrance to a building, coupled with the agreed probability of failure again drove this system to be highly risk-ranked near the top of the list. The local context of a buried design and routing, history, relation to other systems, the impact of other systems on it affected the overall risk rank. Had the header been fully exposed above ground, unaffected by other systems such as traffic loading, its finals risk ranking would likely have been far lower due to the far lower probability of a failure.

Another surprise was the Digester System (SBR #4) ranking. It proved to be higher than expected and was driven by proximity, and age of an affected system. The digester overflow would not necessarily be that sever a consequence given that it would be contained. However, given its proximity next to a small internal climate control room that housed key components of the existing and aged SCADA system, the lack of spare parts in the marketplace, and the obvious evidence of overflow from the tank onto the SCADA room the severity of an overflow would sideline the SCADA temporarily and use up the last spare parts available to the facility. Any further SCADA card failures would possibly require an entirely new SCADA system.

Risk Mitigation

The follow-up items at this stage do not necessarily follow the order of the high risk ranked systems. In other words, the systems with the highest risk rankings do not necessarily have high priority follow-up items. Conversely, some highly risk ranked systems have medium level follow-up items and some lower ranked systems have higher priority or urgent follow up items associated with them.

The reason for this different order of priorities has to do with the interconnection of systems to one another (as in the case of a level sensor functionality on emergency backup power), as well as the revelation or ideas that were generated during the follow-up. It was also apparent that during the analysis the focus was predominantly on the criticality raking, and not the solution mode. This is a discipline needed to get through the analysis in a timely manner.

Further, the staff involved might not be the staff most qualified or experienced to make a complicated recommendation with potential mitigating opportunity or solution might, and quite possibly would be, best addressed with subject matter experts in a follow-on discussion such as in an economic evaluation context.

Interestingly, an area that often gets overlook is vehicles and mobile assets. In this case, vehicular and mobile assets ranked fairly high in the emergency events. It was better to stage certain equipment off site where a vehicle capable of handling the load was also staged. In this way a significant time saving was gained that would mitigate a related emergency and hence the severity of such an event.

Principles

Several Principles emerged as the analysis progressed that were reinforced to the staff for future in-house analysis. These are presented here in summary form and relate to the above sections.

Consensus was one of the biggest advantages to this exercise. Pet-Projects were not permitted and are discouraged in the process. The process is self-regulating by both tempering strong opinions, and elevating consensus driven risk evaluations amongst the team. Through the investigation and analysis several opportunities presented themselves for some participants to want to drive up the consequence numbers in an effort to skew the results towards a particular pet project. This bias was naturally discouraged with a cadre of subject matter experts with years of experience at the facility coupled with a sincere desire by all participants to have meaningful and accurate results. The result is an agreed and validated ranking of priorities that can be presented to senior management for future expenditures and resource allocation.

Interrelationship of systems and proximity to one another is as important as asset failure in determining relative risk. In many cases it was the interrelationship of the systems that drove the risk ranking, as in the case of the Aeration Blower Header. This is to be expected with the outward focus of this approach. It highlighted the risks due to the reality of interconnections. One system failure can result in a far more critical downstream system failure. Proximity was also a factor in that one system geographically sits near another, though they might not be directly connected at all nor rely on one another, and yet the failure of one could seriously impact the operation of another, as in the case of an overflow of a tank onto a SCADA system.
Group Assets enable 100% of the assets to be included and result in otherwise undiscovered risks coming to the forefront. The inclusion of the group assets, like the pipes, in the Functional System Failure Scenario approach identified risks to the operation of the facility that might have been missed otherwise. Often a breach of containment is a significant failure scenario as a result of an internal system issue, as in the case of the Influent Pump Station with a partial pipe rupture insufficient to trigger a pressure drop alarm. Had the pipes been excluded from the analysis the external loss of containment might not have been captured.

Never adjust the consequences of a failure scenario to reflect the impact of the mitigating steps until the mitigating steps are actually finished and implemented. Often the temptation will be to assume or declare that the mitigation will be accomplished in short order, and thus adjust the severity levels to match the fix. Until such time as they are implemented, the consequence/probability levels must reflect the current state of affairs.

The ability to look at progress year over year is valuable from a planning perspective as well as a measure of mitigating identified risk. The analysis should be repeated annually or every other year as progress is made in addressing highly ranked assets within the systems or the system interrelationship and effect on the overall risk profile. As an example, a plant that has performed semi-annual analysis might be able to show significant progress in their overall risk profile as illustrated in Figure 4 below, showing 2006 versus 2012 results[3].

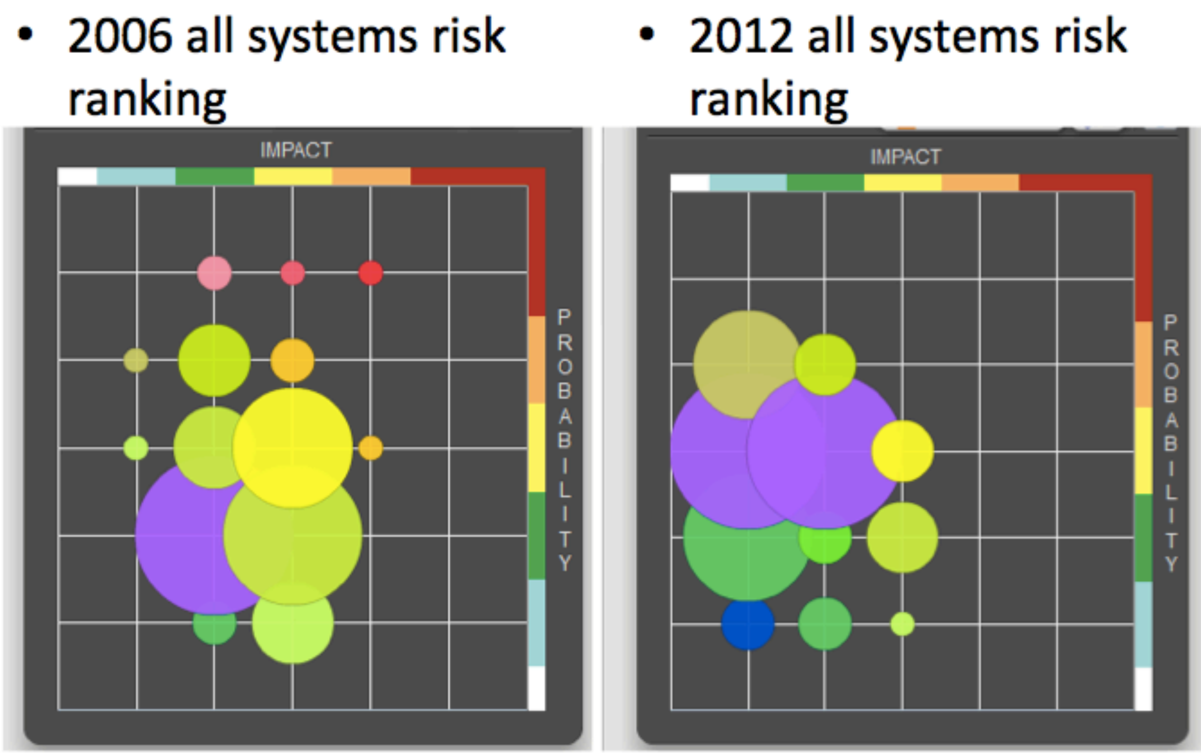

Figure 4. Sample 2006 versus 2012 Criticality Analysis Results

Conclusions

The Criticality Analysis was very timely for the Rancho California Water District Several. Several surprises were evident along the way, from systems posing more risk than previously thought, identifying risks that had not been considered or understood previously, as well as a consensus amongst the staff and divisions as to what was a priority and what was not. Additional valuable lessons and information was garnered from the unique and efficient approach to criticality analysis, including documented risk mitigation, and some key principles along the way to bring in-house and repeatedly conduct a superior criticality analysis.
The success of the approach, as well as the enabling of and training of the staff in the approach has resulted in steady progress at the wastewater plant to address the risk items, engage a

condition assessment, and ley the groundwork for a comprehensive and planned capital plan. Further, the ability to replicate the approach in the water resource management side of the District has enabled them to perform a functional system failure scenario criticality analysis and plan for the condition assessment and capital planning exercise.

References

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