Stormwater Infrastructure in Honolulu; Comparative Analyses from a Year Abroad

This is the verbal portion of a presentation originally given to the Engineers and Architects of Hawaii weekly meeting on June 1, 2018 by Bob Bourke

1. Hi My name is Bob Bourke and I've lived and worked in Hawaii as a fish biologist and environmental scientist since 1975 when I moved here from the west coast. During my time here it has become clear that many of the problems with Hawaii's marine ecosystems are the result of human practices on land – stormwater being a major component. For the past two decades I worked on a wide variety of storm water and watershed projects. After retiring in late 2017 my wife and I took the opportunity to travel a bit – California, Oregon, Nevada, Utah, New Mexico, New York, Washington DC, and most recently 6-weeks in France. It became apparent to me that during my 42 year absence, a great many changes, mostly positive, had taken place with the public parks, public trails, and stormwater infrastructure on the mainland, and that I had not witnessed parallel improvements in Hawaii. This talk is about some of the improvements I've seen to the stormwater systems in other cities and how I think they may be applicable to Hawaii's need to improve its management of this resource.
2. No, this is not the set for the opening scene of "Indiana Jones and the Raiders of the Lost Arc". It's Paris! Paris is the City of Lights – but it is also the Mother of all Sewers. In 1850 work began on a 40-year program to construct large aqueducts from springs and creeks high in the surrounding hills, and to drain away this water in sewers to be located beneath every street in Paris. The project was initially conceived as an engineering water supply and drainage project….Not a sanitary sewer project. Those 17 beautiful large decorative fountains scattered about Paris were initially the public water source for the entire city. Up to 20,000 Parisians were employed to carry buckets of water from the fountains to homes in Paris. The drainage system created connects both sides of Paris beneath the River Seine with large inverted siphons. The tunnel behind me in this photo is a mock-up of one of the inverted siphons connecting the East and West Bank of Paris. To clean this tube a positively buoyant wooden ball is assembled at one end and pushed into the flow. As water pressure builds up behind it a jet of water forms beneath the ball in the designed gap at the bottom of the channel and scours any built up sediments into the flow ahead as the ball works its way through the pipe,. Smaller balls are used to clean smaller pipes throughout the system. However, the vast majority of sewer channels are walkable – and maintainable by maintenance personnel on foot.
3. . Want a sewer map of Paris? Just download a street map. Every small street has a sewer right down the center line. If the street is wider than 25 meters it will have two sewers – one left and one right
4. Each of the sewers is named for the street above it and often street signs are hung at sewer intersections to guide maintenance workers. The sewers were all hand dug, and were initially designed to just take stormwater and street

runoff, with sanitary flows directed to cesspools beneath each building. But, as many in Paris depended upon well water for drinking, concern about well water contamination soon led to connection of the sanitary sewers to the main sewers. Initially flowing directly to the Seine, once human sewage was added, the flow was directed as irrigation to farmlands 80 km downstream where it was reported they grew "fruits and vegetables of amazing size!"

5. The sewers of Paris were all designed to be gravity flow, be man accessible for maintenance, and to act as carriers for other utilities: potable and non-potable water, telephone, compressed air, and electric lines for traffic lights. This is one of the reasons why one rarely sees any of the Paris Streets being dug up for utility repairs. Heavy sediment loads fall out into designed sinks – from which they are dredged for removal. Sewer workers use specially designed equipment to clear any debris or buildup from every sewer (all 500 miles!) at least once per year. Deep sections with hydraulic dredge buckets fixed to the overhead, serve as settling basins for heavier sediments. 50 tons of solids per day are removed from the system. Floatables are captured in large revolving screens and removed to drainage pits. Between1990 – 2008 the entire system of 100-year-old tunnels was re-constructed. The few pumps in the system are used during periods of flood to pump water into the St Martin barge canal, which is then re-cycled to the sewer once flow is lowered. The rare storm overflow events to the Seine are limited to mid-water effluent not carrying either bed load or flotsam.
6. Given the difficulties of removing sediment and debris from the wet sewer flow, it quickly became apparent that it was more cost effective to keep solids OUT of the sewers in the first place. Many of the 20,000 Parisians previously employed in water delivery soon found themselves engaged as street sweepers. Drains are designed to exclude solids that are collected by a wide variety of street sweepers – including many private shop owners who take responsibility for their own frontage.
7. The effluent that initially flowed to farm lands down stream now flows down-slope to a large waste water treatment system plant, the effluent from which feeds this series of constructed wetland ponds that function as bird and wetland habitat prior to flowing back to the Seine.
8. Summary of the development and modernization of Paris sewers.
    a. Constructed 1850-1890 initially ONLY as drainage.
    b. All gravity flow – All <u>walkable</u> for cleaning
    c. Fears of groundwater contamination resulted in inclusion of sanitary sewer flows
    d. Contamination of Seine resulted in off-site treatment
    e. Tunnels typically also hold potable and non-potable fresh water, compressed air, pneumatic, telephone and electric (traffic light) service
    f. 1990-2007 Completely re-constructed
    g. Flow ~ 1,200,000 m^3/day all secondary & wetland treated (~300 mgd)
    h. Solids removal from tunnels ~ 50 m^3/day

i. Focus on keeping solids out of the sewers by intense street cleaning
j. Secondary use of WWTP effluent for wetland bird habitat

9. There appears of be a natural progression in the development of storm drains, with each solution presenting new insidious problems, which lead to new solutions as the system evolves over time.
    a. Increased water supply caused drainage problems
    b. Improved Drainage → Flooding as ditches overflowed
    c. Hardened Culverts → Downstream peak flow flooding
        i. → Stream Incision
        ii. → Loss of Stream Habitat
        iii. → Loss of Riparian Recreational Zone
    d. Improved Pollutant & Waste Control in Effluent
    e. Habitat Restoration as Cost Effective Control Measure
    f. Recreational and Environmental Opportunities
    g. Triple Bottom Line Asset Management - - $$$$$

10. In Honolulu the construction of storm sewers began in earnest after WWII, peaked in the early 1970s, and came to an almost complete halt around 1980 when it became apparent that the hardening of stream culverts was resulting in significant adverse impacts. Honolulu appears to be just entering the phase where pollutant prevention and control in storm drains is beginning to occur. As Honolulu increases the management structure necessary to effectively prevent and control waste streams in storm water flows, we can expect greater realization of the recreational and environmental enhancement opportunities inherent in a well managed system.
11. There appear to be three roadmaps that lead cities to upgrade their stormwater management and infrastructure to the highest levels: 1) the "Grand Gesture, 2) via law suits and Consent Decrees, and 3) following directions outlined in Total Maximum Daily Load (TMDL) studies.
12. Back to Paris. The Saint Martin canal was one of those initially constructed to bring fresh water to Paris and eventually was converted to a barge canal with a series of locks lowering it through, and under, Paris to join with the Seine. In 2008 the mayor of Paris decreed in a Grand Gesture that the filthy waters of the canal would be made fishable and swimmable for the citizens of Paris. Because of the lock system, they were able to drain and clean the entire canal and then induce sufficient flow to keep it clean. The new goal is to have some portion of the 2024 Olympics swimming competition conducted in the waters of St. Martin Canal. That is a Grand Gesture indeed!
13. Today the canal is fishable – and swimmable for several months in the early summer before rising temperatures, lower water flow, and rising bacteria levels make it off limits for swimming.
14. Before restoration, properties bordering the canal were either light industrial or depressed urban housing. Today, the shores of this canal are THE place to be. I picked this shot because it reminded me of the Ala Wai canal. This is the area planned for the 2014 Olympic swimming competitions.

15. Another prevalent way that storm drains and water get cleaned up is through Consent Decree. Initiated by a lawsuit either by a private entity or by the EPA, a City agrees to a very aggressive program to make improvements. Honolulu has had two consent decrees – one involving the sanitary sewer outfall and another with the HDOT_Highways. While consent decrees are often successful, they are also known to be very expensive and often not adaptable to the iterative approach preferred by most stormwater professionals. In Washington DC, consent decrees – a take-over of the district's storm water branch by the Federal EPA – and a focus on cleaning the Potomac River has led the way to a greatly improved storm water system.
16. This is one of the 23,000 catch basins retroactively installed into the existing streets. Stickers on the curb identify dates when the basin was inspected and cleaned. Maintenance crews have found that cleaning the basins with specially designed man-hole sized clam-shell buckets is much more efficient than using suction and tanker trucks. Eight crews remove an average of 23 tons per day from the storm drain system. A crew using clam-shells on hydraulic arms can clean 30-70 basins per day, but a crew using vacuum trucks can only clean 8-12 basins per day. In Honolulu our vacuum trucks manage to clean only about half this number of catch basins per day.
17. Instead of installing catch basins where it was easiest or least expensive, the installations focused around several natural areas where the benefits could be best realized and enjoyed by the people of DC. Rock Creek, once a very polluted and trash filled waterway, now has fish, abundant wildlife, and miles of well-used hiking and jogging trails in a park-like recreational area.
18. The third approach to successful stormwater control is through the TMDL program. Communities that develop simple but straight-forward TMDLs and then follow them appear to outperform Cities that take a more laissez-faire approach to the application of BMPs. In California there is a relatively HUGE bureaucracy built around storm water control – and it works. The City of Pacific Grove is one of seven cities in the County of Monterey. The county is about the same physical size as Honolulu with about half the population and has a board made of private citizens plus one manager from each of the seven cities. The county's regional board is one of many within the Central Coast Regional Water quality Control Board area – which is one of Nine regions in California. All of the regions are coordinated through the California State Water resources control Board. What really makes this system work, however, is the presence of the California Stormwater Quality Association, an independent non-profit organization of storm water professionals that integrate across all levels of the process. Honolulu should consider joining this organization.
19. Pacific Grove, California is adjacent to the world famous Monterey Bay Aquarium and the shoreline waters are part of a National Marine Sanctuary. These storm water outfalls come from two of five CDS units as part of a $10M storm drain upgrade program. The CDS units filter runoff from the down town area equal to about 60% of the runoff from the entire city. The remaining 40% is directed to a golf course. In the future another $2.5M will

be spent to construct underground storage sufficient to hold an additional 25% of the runoff from an annual 24-hour storm and this water will be metered out slowly to infiltrate the golf course.

20. There are as many approaches to cleaning up stormwater as there are Cities. Each city has unique physical, cultural, and economic challenges. Here are some of the more common approaches with examples from cities I've visited.
21. Traffic calming devices are marvelous for two reasons 1) they target the trash, road gravel, and petroleum pollutants generated by highways, and 2) they are usually paid for through highway funds – not stormwater funds. Traffic calming devices are becoming very common in France, somewhat common in New York and DC, and are beginning to appear some places in California.
22. To the east of San Francisco the dry climate and increasing urbanization calls for the inclusion of green infrastructure in every new development. On this cul-de-sac the City and homeowners built rain gardens to accept flow from the street to protect the adjacent stream.
23. Green infrastructure for flood storage in Cities can often be shared through public-private partnerships. In this East Bay city a pond created on private land adjacent to an office and shopping complex receives runoff from city storm drains and acts both as a storm water detention basin and as a visual amenity to the community. The dry rain garden surrounding private businesses receives runoff from public streets and parking areas.
24. Back in Paris, a pedestrian bridge rises over a park that doubles as a stormwater retention basin during winter months.
25. Highways benefit from green medians for beautification, traffic calming, and stormwater retention and infiltration. Example on the left is from Washington DC, and on the right is in Oregon.
26. In the 1980's a buried storm drain through the UC Berkeley campus was dug up and restored to its natural status as Strawberry Creek (upper left), the first intentional "daylighting" of a stream. In Yonkers, New York, the final half mile of a stream once contained in a buried box culvert has been daylighted prior to emptying into the Potomac River. Bottom: One of the most extensive daylighting projects took place in Korea on the Cheonggyecheon-Stream right through the center of town displacing a freeway. The practice of daylighting streams has been gaining favor across the nation for improving water quality, increased storm flow capacity, and enlivening urban areas with natural habitat.
27. EPA Region-9 just (May 17) released a white paper entitled "Evolution of Stormwater Permitting and Program Implementation Approaches" from which I stole, and greatly condensed, ten major directives for a successful stormwater program. I've abbreviated the list here. They are worth repeating, thinking seriously about, and incorporating into long range storm drain planning.
    a. Fresh water is a resource and should be treated as such
    b. Stormwater systems must be integrated within watersheds
    c. Stormwater management should be treated as a business

d. Constructed and natural stormwater assets are business assets
e. Natural assets are integrated into new and re-built into old designs
f. Stormwater assets are managed in life cycles dependent upon use, efficiency, and maintenance requirements.
g. Climate change is real. Design accordingly.
h. Embrace technology as part of the solutions.
i. Water quality monitoring should be used for decision making
j. Focus on "small" watersheds with easily improvable receiving water bodies that have wide public interest

28. Monet made many many paintings of this pond, the lily pads, and this bridge. Was Monet's talent as an artist enable him to capture the natural beauty of his many "Lily Pond" paintings? Or was it his true talent as the pond builder and gardener ?
29. The pond, the bridge, the lily pads are still there today. But it's all really just a "fake". You see, Monet was not only a good painter who actually made money from his paintings while still alive, but he was also an accomplished gardener.
30. Because of Monet's financial success as a painter he was able to build these ponds and create the surrounding gardens where once was only a "pig wallow surrounded by blackberry vines." Similarly, we have the ability to take our box culverts, buried stormwater sewer pipes, flood basins and other pieces of our stormwater infrastructure into duel use assets within the human ecosystem in which we live. But we are not all rich painters with disposable income. Stormwater programs often tend to be the "poor cousin" of water supply boards or regional waste water sanitation bureaus
31. There is no excuse for any new development not to have the most updated and effective permanent BMPs designed and built as part of the development. Stormwater Utilities have been created in about 20% of Cities across the US as an effective way to fund and manage this public resource. Revolving Funds and Bonding both provide temporary sources of funding for building infrastructure.In some communities were post construction BMP requirements (most commonly retention requirements) are strict and enforced, markets are often developed to construct retention features off site.
32. Summary Slide:
    a. MS4s that don't meet permit conditions result in
        i. State (DOH) Non-compliance initiatives
        ii. EPA Consent decrees (Hawaii has 4) or Petition for withdrawal
    b. More successful programs tend to be either
        i. <u>Goal oriented</u> "Grand Gesture" politically fostered projects focusing on recovering specific water body ecosystems,
        ii. <u>Permit induced</u> stemming from <u>TMDL load limit</u> requirements,
        iii. <u>Lawsuit induced</u> through Consent Decrees – EPA or 3rd Parties

c. Programs that focus only on meeting permit conditions tend to have a scattered approach to BMP implementation without definitive positive impact on downstream water bodies.
d. "Whole System" approaches are more successful than segmented ownership driven initiatives
e. Dedicated and adequate long term capitol improvement and maintenance funding is necessary for success
f. Consider a regulatory program focused on BMP results not methods
g. Consider joining the California Stormwater Quality Association for scientific and technical support.

33. The time is quickly approaching when Honolulu must decide upon its course of action to control stormwater pollutants. Will there be a "Grand Gesture", a build-up and realignment of City management to effectively follow watershed TMDL plans, or will we wait for the inevitable consent decree?
Aloha.