Greater Everglades Model and Performance Measure Summary

Summary of NSRSM and Performance Metrics for Hydrologic Panel Discussion

1. NSRSM – NSRSM Is a useful tool to visualize one representation of hydrology in a predrainage everglades. Keeping with the recommendations of the 2007 independent peer review of NSRSM, it should not be used to set hard targets. It should be used as one of several lines of evidence for evaluation restoration plan scenarios.
2. Performance Measures – Performance measures should be based on defining characteristics of the Everglades (http://www.evergladesrestoration.gov/content/ids/meetings/012615/4_IDS%20_Guiding_Principles.pdf). Models can be used to help us understand where those defining characteristics might appear in a restored system of what we can achieve (CERP for example).
3. Climate Change - Climate Change effects need to be factored into our modeling and uncertainties. Modeling scenarios of climate change drivers helps us understand how the system might change, how our expectations might change given different scenarios of driver effects (Scenarios), what plans/options are more robust to climate change. How do we handle Sea-Level Rise? Make assumptions and correct model output to match Multivariate Linear Regression models used in SCS to better link to NSRSM output on the southern end. Develop and use a model that bridges RSM/NSRSM with SCS targets?
4. (Robustness/Resilience), and how we might envision habitats changing and moving across the landscape (adaptation).
5. Communication - Need to work better at communicating models, model output, restoration performance goals, and what we might get from restoration plans.
6. System Approach - Need to better link GE and SCS performance measures to better understand system performance and ensure evaluation of plans are cohesive in describing what might happen with restoration and climate change scenarios.
7. Models and Adaptive Management – Models should be used to develop the right adaptive management tests to perturb the system to more extremes in a controlled setting to see how the system will actually respond. These tests can also help us understand how resilient communities are with respect to climate change. Need to use models to understand areas that are most vulnerable to change that we can focus restoration efforts to improve resiliency.

Northern Estuaries

Introduction by Gretchen Ehlinger

C-43 Update by Janet Starnes

1. Purpose - C-43 West Basin Storage Reservoir Project is to improve the timing, quantity, and quality of freshwater flows to the Caloosahatchee River and Estuary.
2. Storage - Biggest reservoir under construction on the East Coast of US and will store up to 170,000 acre-ft. Two phases.
3. Schedule – It will be designed under two phases due to costs for each part of the reservoir and the budgeting/expenditure process. Design process is currently updating the design for levees from the original PIR developed in 2007 to meet new levee standards developed after Katrina

guidance of 2007 (more robust levee standards). Design is also reconsidering electric vs. diesel pumps for cost savings and ease of operation for remote operations.

a. Design package 1 – Preload and Demolition. Preload large piles of dirt will compress the clay before we start the pump station. Remaining demolition of structures on site to make way for perimeter of reservoir.
b. Surprises - Gopher tortoises were found unexpectedly, and 32 gopher tortoises need to be relocated. In addition, panthers roam the sites and an active education program is in place for all construction works to avoid any interaction with panthers.
c. Pump station S470 and S483 to be completed by 2017. Expanding Townsend canal for capacity. Considering need for manatee barrier to ensure we don't create a warmwater refugia.
d. Reconsidering overwash and elimination of stair steps similar to C-44.
e. Reservoir fully operation by 2020.
f. Need to update project operating manual which is too simple. Operations currently, when S-79 flows drop below 450, we'll release water. If flow is greater than 450, and reservoir water level is between 19.2 and 29.0, S-470 will begin pumping to the reservoir to fill. Need to consider operational flexibility to maximize use of reservoir.

4. RECOVER Support – RECOVER support is needed during the operations plan update to incorporate how this project should operate as part of the C&SF system to meet CERP goals.

C-43 Project Monitoring Plan by Peter Doering

1. C-43 Monitoring Plan and Timing – The monitoring plan was developed and approved as part of the Project Implementation Report (PIR) in 2011. It relied on RECOVER and other partner monitoring networks, which have all faced some adjustments since 2011. A comparison of project PIR monitoring requirements to current available monitoring was completed and discussed in this presentation.
2. Salinity Monitoring Plan – Two existing networks maintained by the SFWMD and Sanibel-Captive Conservation Foundation. Salinity monitoring is going on but not necessarily in sites originally envisioned in PIR.
3. Water quality – Water quality sampling by the SFWMD occurs every two months. Other partners are sampling biweekly or monthly determining the parameter. PIR monitoring plan recommended continuous samplers co-located at salinity monitoring sites using electronic sensors and deployable wet chemical units, as well as light extinction. Nutrients were supposed to be twice a day, and dissolved oxygen every 30 minutes. SCCF network monitors some of the nutrients but not all sites.
4. Oysters - Oyster monitoring added one station to RECOVER monitoring project in 2011, which was 7 stations total. Now we have 4 active stations, all measured monthly, live oyster density and size twice per year.
5. Submerged Aquatic Vegetation (SAV) - SAV using aerial photography, and Quadrat sampling. RECOVER was to map every 5 years. Last aerial mapping was in 2014. Hydroacoustic mapping was conducted by SFWMD 3 times a year, but has been discontinued. Path scale quadrat monitoring, added two stations to RECOVER program.
6. Fisheries - SFWMD funded FWC to do their fisheries independent monitoring to Caloosahatchee. Relationships were found but not to useful for management. Sampling is ongoing for sawfish.

Dave Ceilley Johnson Engineering work on *Vallisneria Americana*

1. Introduction - *Vallisneria* provides habitats for fish and invertebrates (many are sportfish/commercial fisheries), forage for endangered species, stabilization of sediments and improves water clarity.
    a. Found throughout North America and has been successfully planted *Vallisneria*.
    b. Tolerant of oligohaline conditions <10 psu.
    c. Once covered 1200 acres until recently.
    d. Able to respond and recover quickly under right conditions (salinity, water clarity, nutrient types, and genetic strains.
    e. In Caloosahatchee, currently only grows to 3-4 ft deep due to water clarity.
2. Restoration –
    a. Herbivory issue – many things like to eat *Vallisneria*, and it has not returned, but will grow under cages. Need to consider restoring enough beds so there is some resiliency in the system.
    b. Ecosystem Services for SAV were evaluated by one estimate as 26,000$ per acre.
    c. Question - What works best, tubers, seeds, plantings? Developed experimental design to look at *Vallisneria* recovery with and without cages. Small cages were more successful because large cages can be moved/damaged by boat wakes, manatees, humans, and cows.
    d. *Vallisneria* restoration goals should include establishing large enough plots to achieve sexually mature populations to reseed the Caloosahatchee to allow for regrowth prior to restoration project improving wet season and dry season flows.

James Douglass FGCU and SAV Sampling

1. Introduction - Presented Conceptual Ecological Model of effects on SAV related to hydrology affecting salinity, water quality, nutrient loading, epiphytic algae covering SAV, and Algal Grazers. Using patch scale monitoring from 1986-2014, not every year. And have a continuous set of flow and salinity data.
2. Flows and SAV - Flow is measured from the tidal basin below S-79, C-43 basin above S-79, and LO releases from S-77. S-79 has had a lot of ups and downs. 450-2800 cfs is the current ideal flow regime described in the RECOVER PM to benefit. Look at flow in days per year outside of the target of 30 day mean (79.29 m2s-1). SAV data is assessed using the flow data to connect back to effects of the water management system, droughts, basin flows. Used Yongshan Wan's salinity model to calculate salinity from flow for each SAV monitoring sties from 1985-2015. Now developing Salinity Stress Indices (fresh and salt water) for different SAV species.
3. Results - *Vallisneria* trends in relation to SSI in upper estuary. Used only summertime averages for SAV to remove seasonal variations.
    a. *Halodulee wrightii* (shoal grass) does poorly in freshwater conditions, highly correlated with flows and salinity.
    b. *Thalassia testudinum* (turtle grass) is a saltwater species that has back after big freshwater flows 2004-2005. Response regulated by competition with shoal grass.

c. Light maybe stressing seagrasses in system, which barely meeting DEP targets.
d. Ephytic algae could also reduce light. What is role in invertebrate grazing on algae, which may be sensitive to restoration flows? Epiphytic algae density levels are qualitative 0-3. Looking for quantitative way to measure abundance using chlorophyll extraction and spectrometry or epiphyte biomass. Used Frankovitch equation for % light blocked by Epiphytes, which indicated up to 50-60% of light can be blocked. Use test of scrubbed clean SAV vs. not clean SAV to measure growth. Also control grazers to see how epiphyte growth affect health and causes of epiphytic growth. Using a factorial experiment demand.

Aswani Volety – UNC Wilmington – Oyster Monitoring

1. Introduction – Provided story of effects of freshwater inflows on the oyster population in Caloosahatchee. Oysters provide 3-D habitat food shelter. Expectation is that oysters should move upstream if flow flashiness is reduced and may need an upstream monitoring station to detect. Downstream sites where salinity can go above 35 psu are not as important.
2. Restoration Results –
   a. Results vary by rainfall year (Wet, Normal and Dry)
   b. For oysters, the ideal salinity range using Cape Coral Bridge would be maintained by 1000-3500 CFS at S-79.
   c. Temperature drives a lot of the processes, including reproduction. Current high flow releases have a silver lining, as it's the best time to release water during dry season and not during the wet season due to temperature. Oyster mortality has not been high yet at Cape Coral Bridge. 3 degree temperature lowers growth. 25 degrees as a control was higher. The interaction of temperature with higher salinity decreased growth and survival faster.
   d. Disease is high in dry years, medium in moderate, low in wet years. Freshwater flows are a necessary evil to kill disease, and could be helpful in the right amount to not also kill oysters.
   e. Caloosahatchee is not a larval limited system, it's a substrate limited system, which should be considered as part of restoration implementation, as spat recruitment should move upstream.
   f. Recruitment is high in wet years downstream in tarpon and kitchel bay. Spat recruitment is April through November. High rate is June through October.
   g. Oyster reproduction is good during freshwater events.
   h. Wet season good for oysters, not as good for live density during dry season of dry years because salinity increases predation and decreases survival
   i. Predation pressure is huge in regulating oyster recovery. Closed bags better growth compared to open.
   j. Freshwater flow events over 10 days lead to mortality of juveniles. Pulsing of freshwater flow events is key to avoiding shocking of estuaries. Two weeks is the maximum for adult oysters at zero salinity

Panel discussion:

Can RECOVER do anything else to help the project?

1. Monitoring Priorities - Baseline monitoring is necessary in addition to operations within system and how much more do we need. Need input as to when to release considering other factors.
    a. Fish Monitoring – why were fish not considered to be useful to management? Fish density related to lag flow at S-79, averaging flow over a particular period of time could be 1 to over 365 days. Generating a curve where there is fish density related to lag flow. Lag flows were long to improve fish density. Fish were primarily being investigated related to flow and not salinity.
    b. Water Quality - USGS actively monitors water quality from Punta Rassa up Caloosahatchee (Salinity, temp, DO, turbidity). Station at S-79, temp, nitrate, turbidity, FDOM as surrogate for DOC. Water quality in McIntyre creek related to S-79. FDOM can only be used as a surrogate for light for certain flow regimes if the contribution of other water quality constituents is understood as well.
    c. Sea-Level Rise (SLR) Effects – Are the Northern Estuaries positioned to assess response to SLR due to climate change? How is landscape (seascape) changing? - Process for Climate Change requirements were minimal for C-43 when the PIR was developed. An assessment at this point wouldn't effect design because C-43 was limited by how much of a reservoir could be built safely near towns. An assessment would help understand effects and how operations need to be changed (when, how, how much water we pump vs. how much more storage we need)
2. C-43 Baseline – Are we monitoring what is needed to assess C-43 benefits?
    a. Oysters - Caloosahatchee has a good baseline. What should we be doing? Frequency for certain parameters should go increase in upstream and decrease downstream. Look at recruitment growth to fine tune relationships between flow duration and growth.
    b. Oysters - Need to improve predictive monitoring to improve feedback to management. For example, if recruitment moves upstream may want to consider substrate augmentation upstream.
    c. SAV - Existing data relating flow salinity and SAV. Need to understand unexplained variation related to algae and grazers and relationship to flow. Need good techniques and data at right scale to better understand changes and lack of recovery/recovery.
    d. C-43 and Upstream - Need to consider as living ecosystem with a dynamic metabolism. C-43 could polish water quality, especially if *Vallisneria* was grown in the reservoir. Replenishing *Vallisneria* in the upstream could improve water quality. Also, need to look at all trophic levels.
3. What should be the performance measure target for the whole ecosystem? Or are we looking at individual species or attributes?
    a. Oysters - Oysters are system-wide indicator so are part of whole system PM. Look at biomass of oysters and community of species present there. Oysters are a proxy for fish and invertebrate community.

    b. SAV - Goal is to have a different mix of SAV species in every region of the estuary. Flow envelop will benefit multiple species. However, SLR may change our expectations for what we can achieve where and within the flow envelop.
    c. Vallisneria - Need to improve resiliency in system. Opportunities in tributaries where there will be freshwater. *Vallisneria* can comeback quickly vs. *Halodule*. Orange river has *Vallisneria* in it.
4. How much variability in flow do we remove and how much do we control at the right times to determine what we will expect and achieve with restoration?
    a. C-43 start reactivating the PDT to support monitoring and operation.
    b. Should we focus on vulnerable ecosystem attributes? *Halodule* is pretty resilient. Turtle grass and *Vallisneria* in upper system, those species take some time. Need to consider vulnerable species that we aren't addressing.

IRL-S and C-44 – Beth Kacvinsky

1. Introduction – The Project Implementation Report was complete in 2004 and authorized by Congress in 2007. North Fork water reservation rule developed in 2011. Project Partnership Agreement with USACE 2010 to construct each component (SFWMD – STA/pump station; USACE – reservoirs). Project will benefit estuary and Indian River lagoon. Goals are to maintain flood control, maintain or improve water supply, maintain healthy ecosystem. Large foot print for South Fork and Northfork components, followed by muck remediation and artificial habitat.
    a. C-44 reservoir up to 50,600 acre-feet of stage averaged depth of 15 ft, and 6300 acres of STA. Reduce C-44 basin runoff and loading to estuary. Pump station 1,100 cfs reservoir with 12,000 acre citrus trees removed. Removed TIWCD district flood control.
    b. Constructed intake canal and access road, access, communication tower, removal of agricultural contaminated soils, and system discharge spillway complete. A fixed crest weir structure will be used for discharge.
    c. STA contract is 100 million and should be finished in 2018.
    d. Pump station will be complete in 2018. Contract 2 of reservoir to be completed in 2020 with a 51 month construction time frame and 600 cfs to sta. STA normal operating depth is 1.5 feet. Each STA cell is independent. System discharge is up to 1,800 cfs for large storms. Permit required intake and discharge from reservoirs and STAs.
    e. Expect reduction of high flow events to maintain S-80 flows at 735 or less, which was about 24.5 % of flows to estuary. However, there is a potential to capture up to 66% of flows from an average annual basis. Design incorporates a southern diversion of up to 250 cfs out of C-23 basin to C-44 project.

Jessica Lunt – Benthic Monitoring

2. Benthic Infauna Monitoring - Useful for detecting changes in the estuary, links to primary producers and higher level consumer, diverse life styles and habitats.
    a. Amiphipods and cumaceans are only in sandy areas not mucky.
    b. Polychaete and clam are more abundant in impacted sites that are mucky.
    c. Monitoring sites across St. Lucie and IRL Benthic grabs, measure size, transfer to jars for sorting and ID. Sort into groups, and lowest possible taxon.

d. Also take sediment samples (two samples each quarter for % organic and water, and once a year for sediment classification)
e. Effort has involved 1700 grabs, 800 taxa, 500,000 individuals 41% were polychaete species, Fabricinuda was 20%. Full data set – there are 11 groups total that comprise 56.2 % of abundance (groups – amphipod, gastropod, oligochaete, Ostracod). 9 priority sites with 16 groups represent 297,000 individuals.
f. Important species indicate population patchiness and boom and bust cycles. M7 good site where muck doesn't confound effects in data. S-80 flows have not been completely linked to species richness. However, flow (salinity) and sediments (muck and fine suspension) are correlated with certain species.

Oyster monitoring – Melanie Parker

1. Introduction - Sites at North, South, and Middle estuary in 12th year of sampling. Same parameters as Caloosahatchee.
    a. Low salinity results in acute stress and death. Temperature is also important, because oysters are currently living at the upper limits of temperature in their range. Need to fix salinity issue first before worrying about substrate. Oyster dieoffs have occurred many times.
    b. Analyzed data by major events: 2005 hurricanes, Tropical Storm Faye in 2008, 2010 (freshwater release by management that started in March through September), 2013 - 50 days where salinities were less than 8, and 2016 first time to monitor oysters during El Nino year.
    c. After 2005 hurricanes it took 1 year to start recovering up to 500/m2. Dropped to 10/m2 after Faye. No oyster die-off in 2010 but still important. 2013 releases ended before spawning season.
2. Spat and Recruitment - Spat settles March through December. Bi modal peak in spring and fall related to temperature. Spat has been detected again shortly after oyster dieoff. There was no recruitment in 2005, 2008 ended quickly, and only small amounts of recruitment in 2009. Need to think of timing and duration of flows affecting spat recruitment vs. adult oyster mortality. In 2010 there was no dieoff of oysters, but no recruitment occurred and larvae was likely physically flushed out of estuary or died. 2013 event ended early enough in Fall to result in spawning recruitment event. 2014-2015 conditions were ideal for recruitment and oyster densities increased from 144/m2 to 1100/m2.
3. High Salinity Impacts - High salinity can create negative effects related to DERMO (disease), oyster drills, stone crabs, and oysters weakened by disease. Short-term salinity decreases can benefit oysters by decreasing parasite and predator densities. DERMO prevalence increased due to high salinities 2011 to 2013. Looking at pulse releases to handle how we release water.
4. Panel Discussions –
    a. Benthic Infauna - Invertebrates are being used as an indicator differently than as ecosystem indicators. Previous reports didn't monitor oxygen. Sediment is important stressor and DO (only have 1 continuous DO sampler at HR 1). Why are benthic invertebrates important, and are DO sensors needed? There are continuous DO monitoring probes in estuary Harbor Branch and RECON. Sites near C-44 reservoir need to be used to determine effects from CERP. 10 year data set describes cyclical variability

(annual pattern vs. freshwater effects). M5 will also be important to see how it recovers as it is in the worst site.

b. Oyster Disease - Dermo is an indicator of initial oyster stress before salinity stress occurs. Oysters weren't in best shape to handle an additional stressor in 2013.