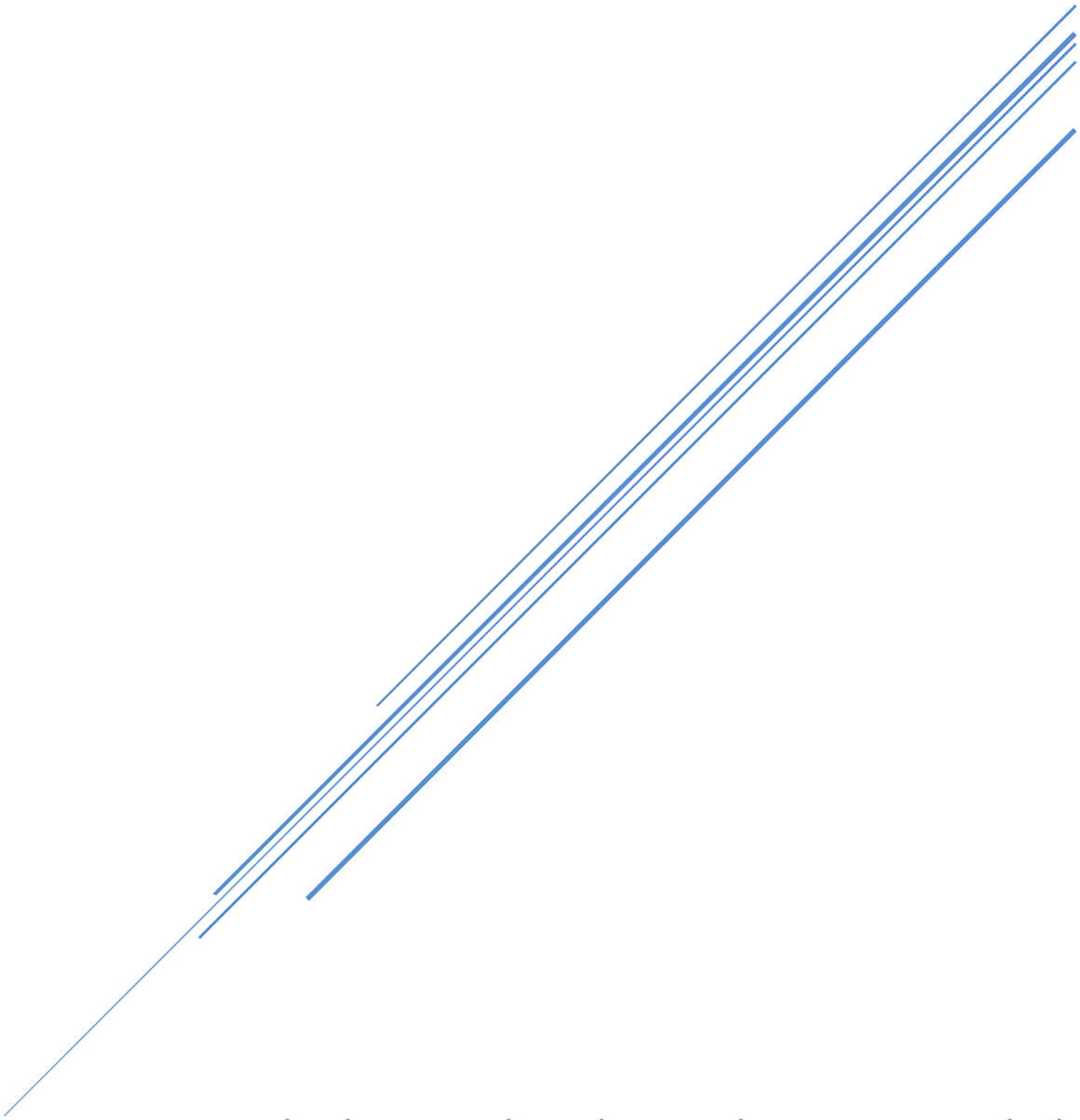
APPENDIX 6A

Natural Systems Analysis



Lower Charlotte Harbor Flatwoods Strategic Hydrologic Restoration Plan

Lower Charlotte Harbor Flatwoods Strategic Hydrologic Restoration Plan

6A – Natural Systems Analysis

PREPARED FOR:

1050 Loveland Boulevard
Port Charlotte, Florida 33980

PREPARED BY:

IN CONJUNCTION WITH:

LOWER CHARLOTTE HARBOR FLATWOODS HYDROLOGIC MODELING/PLANNING PROJECT

TECHNICAL MEMORANDUM – TASK 6A – NATURAL SYSTEMS ANALYSIS

To: Ms. Jennifer Hecker, Ms. Nicole Iadevaia, Ms. Sarina Weiss
From: Roger Copp and Kirk Martin, P.G. Water Science Associates
Date January 9, 2023
Re: Task 6A – Natural Systems Model Analysis

INTRODUCTION

Water Science Associates (Water Science) was contracted by the Coastal & Heartland National Estuary Partnership (CHNEP) to develop a hydrologic restoration plan for the Lower Charlotte Harbor Flatwoods that will promote sheet flow enhancement, restore wetland hydroperiods in the Babcock Webb and the Yucca Pens Wildlife Management Areas (WMA), and improve the timing and magnitude of flows to tidal creeks west of Yucca Pens WMA.

Project tasks include:

1. Compilation of existing hydrologic data,
2. Installation of new surface and groundwater monitoring stations and rain gages,
3. Evaluation of vegetative indicators of wetland health,
4. Maintenance of the monitoring stations and management of manual and electronic data,
5. Development of an existing conditions hydrologic model of the study area,
6. Evaluation of alternative management scenarios, and
7. Development of a Lower Charlotte Harbor Flatwoods Strategic Hydrological Restoration Planning Tool and Report.

Tasks 1 through 5 have been completed. Task 6 includes modeling natural pre-development and future conditions scenarios. This memorandum describes the work associated with Task 6a, the Natural Systems Model analysis. The Scope of Work stipulates that this memorandum describe natural system or pre-development water levels and hydroperiods using information obtained from geo-referenced 1953-vintage aerial photos and a hydrologic ranking developed by Kemmerer and Liebermann (2018). The natural systems analysis was conducted to estimate what wet season water depths and hydroperiods were likely in Babcock Webb and Yucca Pens prior to anthropomorphic changes to the landscape. These estimated natural system water depths and hydroperiods can then be used as a comparison against restoration scenarios. The restoration scenarios can be ranked based on how well each scenario meets the restoration objectives.

The work conducted for this deliverable was a GIS analysis comparing results for the existing conditions model to a natural systems GIS shape file of optimum hydroperiods and average wet season water depths. A MIKE SHE/MIKE 11 natural systems model was not developed because flow patterns have been altered by man-made canals that have significantly re-aligned drainage basin divides and hydrologic conveyance. Modification of the existing conditions MIKE SHE/MIKE 11 model would have required many assumptions including extensive changes to the ground topography and an entirely new network of surface water conveyances. The changes were so significant that the modeling team felt that the resulting hydrologic simulation results would have a high level of uncertainty. This deliberation was discussed during a CHFI meeting, and the

decision to use a GIS analysis rather than development of a MIKE SHE/MIKE 11 model was the consensus decision of the CHFI stakeholders attending that meeting.

NATURAL SYSTEMS MODEL HYDROPERIODS, WATER DEPTHS AND FLOW PATTERNS

Kemmerer and Liebermann (2018) collated a group of 1953-vintage aerial photographs for the Babcock Webb and Yucca Pens area and referenced the photographs to a horizontal datum using ArcGIS. A GIS soils database was then overlain on top of the aerial photos and was modified to create a map of hydrologic conditions, ranked from dry to wet (Kemmerer and Liebermann, 2018). The four hydrologic rank categories along with typical vegetation, hydroperiods, and average wet season depths from Duever and Roberts (2013) are listed below in

Table 1. Pre-development wetland hydroperiods from Duever and Roberts (2013) are presented in **Appendix A**.

Table 1. Pre-Development Hydrologic Regimes (Duever and Roberts, 2013)

Rank	Hydrologic Condition	Typical Vegetation	Typical Hydroperiod, months	Typical Wet Season Depth, ft
1	Dry	Mesic flatwoods	0-1	0
2	Slightly wet	Hydric Flatwoods	1-2	0.2 – 0.5
3	Moderately wet	Wet Prairie	2 – 6	0.5 – 0.8
4	Wet	Cypress, marsh	6 - 10	1 - 2

Slight refinements were made to the hydrologic rank polygons to better capture the rank classes (e.g. add a polygon of wet [#4] where a dark area is evident from the historic aerial photographs. The mapped 1953 aerial photographs are presented in ***Figure 1*** and the mapped hydrologic (hydro) classes are presented in ***Figure 2***. The wet areas (hydrologic rank 4) show up as very dark in the aerial photographs while the dry areas have a light grey color. Hydrologic rank 3 (somewhat wet) areas are not as dark as the hydrologic rank 4 areas. The slightly wet (hydrologic rank 2) are even lighter than hydrologic rank 3 areas but have a darker shade than the dry areas.

Babcock Webb wetlands appear as a series of isolated wetlands connected by narrow flow-ways. The northern portion of Babcock Webb flows northwest towards what is now known as Myrtle Creek. A number of wide moderately wet flow-ways flow southwest from Babcock Webb toward Yucca Pens and the historic headwaters of Yellow Fever Creek. In addition, there is a wide flow-way to the south towards Del Prado/Mellow Lane (historic headwaters of Powell Creek) and Nalle Road (North Fort Myers). Yucca Pens wetlands appear as relatively narrow strands that flow west towards Burnt Store Road (see Durden and Yucca Pens Creek on ***Figure 2***). The southeastern portion of Yucca Pens flows south towards Yellow Fever Creek, west towards Burnt Store Road, and west via a flow-way artificially channelized by the Gator Slough canal.

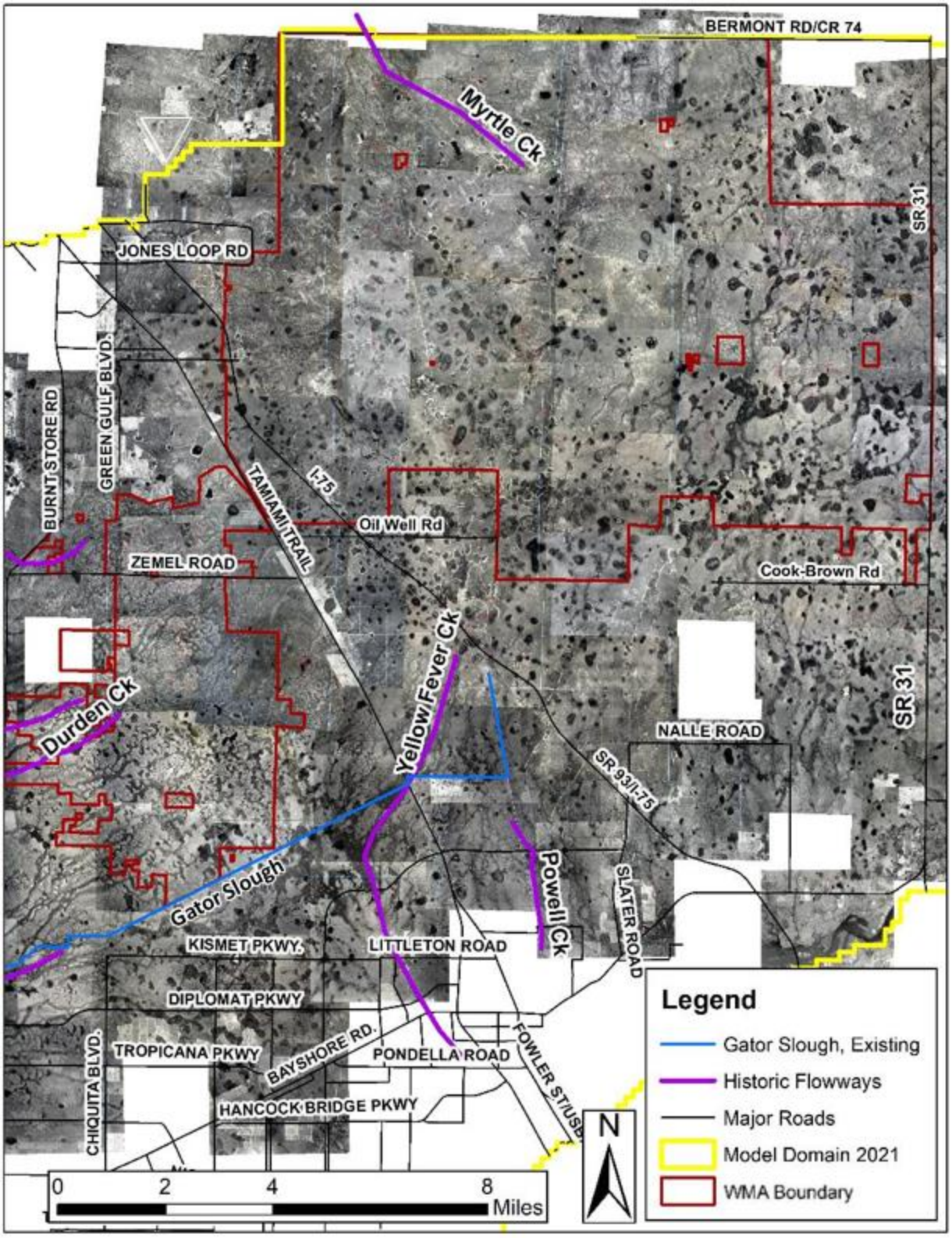


Figure 1. 1953 Aerial Photos for Babcock Webb and Yucca Pens WMA

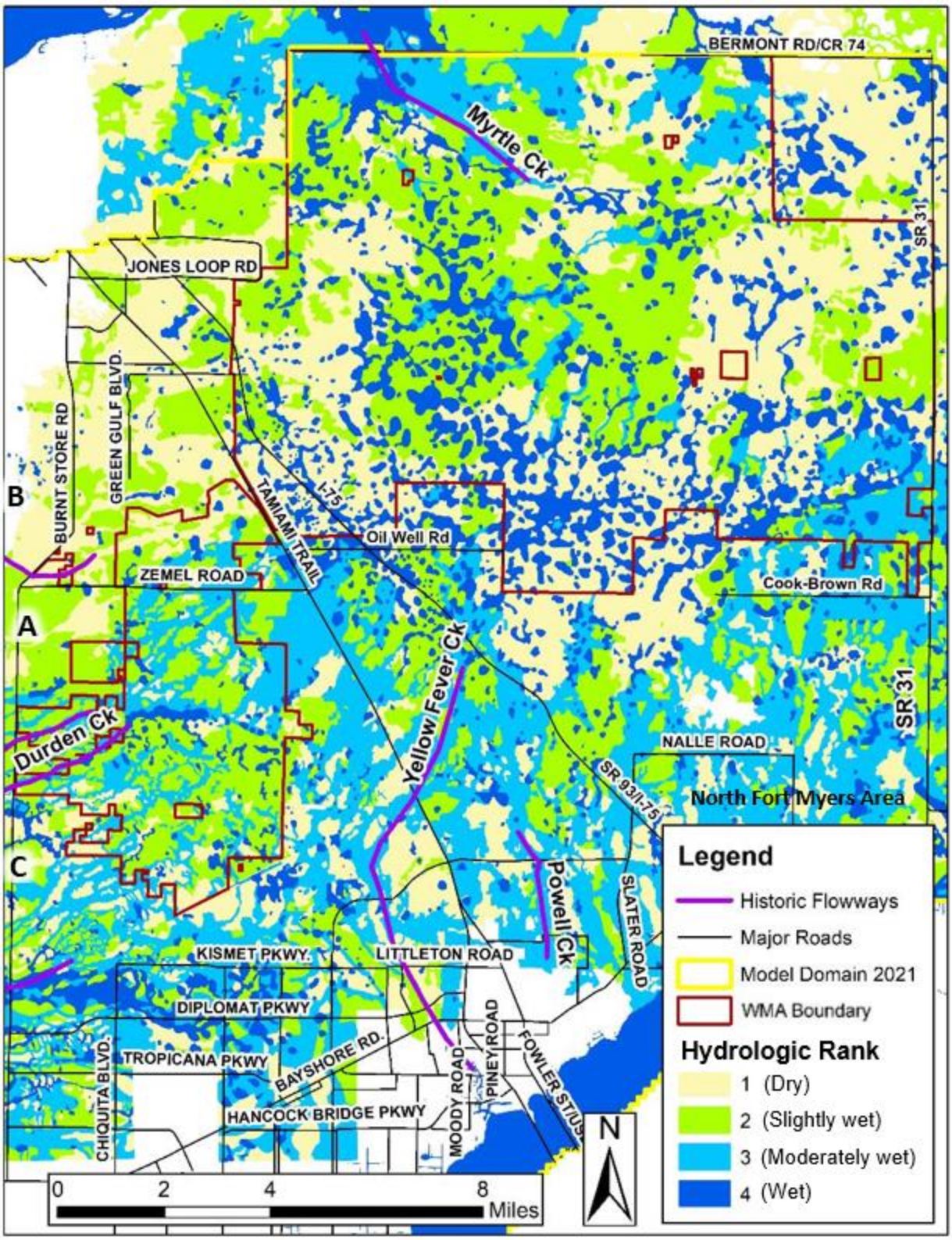


Figure 2. Pre-Development Hydrologic Rank (A – Yucca Pens Creek, B – Zemel Canal, C – Gator Slough)

HYDROPERIODS AND WET SEASON WATER DEPTHS

Areas of Interest (AOI) were defined to assist in the comparison of simulated hydroperiods and water depths to historic hydrologic rank areas. The Babcock North AOI represents an area within Babcock Webb that has a range of habitat conditions and does not have areas of extensive inundation that are experienced in the South Walk-In Area (SWIA). The Babcock Webb South AOI is an area that may or may not be impacted by hydroperiod restoration of the SWIA. ***Figure 3*** illustrates the AOI for Babcock Webb and Yucca Pens. The South Walk In Area (Reduced) polygon is an area within the SWIA where wetland ground elevations were reduced based on transect surveying. The South Walk-In Area Reduced polygon (beige color) is a subset of the Babcock Webb South polygon. The modeling team used this portion of the SWIA for the comparisons since there were concerns regarding the accuracy of ground elevation data outside of this area. The Yucca Pens AOI is different from the Yucca Pens WMA boundary because the modeling team wanted to evaluate changes to natural lands both within and adjacent to the WMA boundary. Yucca Pens north of Zemel Canal was not included in the Yucca Pens AOI because hydrologic improvements were not expected in this area of the WMA.

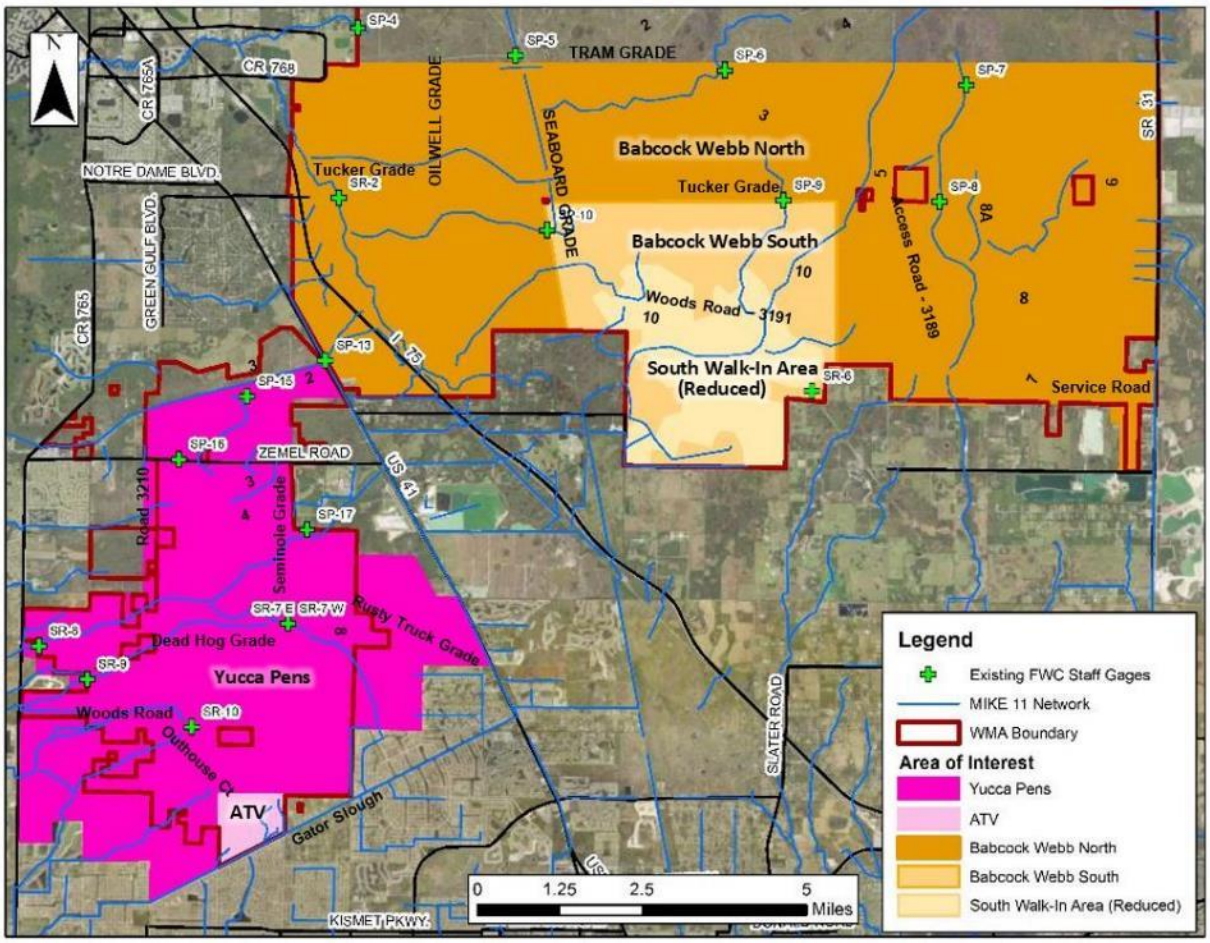


Figure 3. Areas of Interest in Babcock Webb and Yucca Pens

Figures 4 and ***5*** present the spatial distribution of simulated annual hydroperiods in Babcock Webb and Yucca Pens, respectively. These maps were produced at a finer spatial resolution by comparing the simulated water levels at each day in the 750-ft model grid with the 50-ft resolution topography. As noted in prior memoranda (Section D of Memorandum 5c), Yucca Pens hydroperiods are rarely greater than five months which is less than optimum, especially for the

cypress strands of Yucca Pens. The hydroperiod for the southern portion of Yucca Pens is less than one month, and the western cypress strands of Yucca Pens have hydroperiods ranging from two to five months. The simulated hydroperiods are consistent with the findings of the Task 3 ecologic investigations which indicated extended inundation of the SWIA and dry conditions in Yucca Pens. Conversely, hydroperiods in Babcock Webb are above nine months in much of the South Walk-In Area.

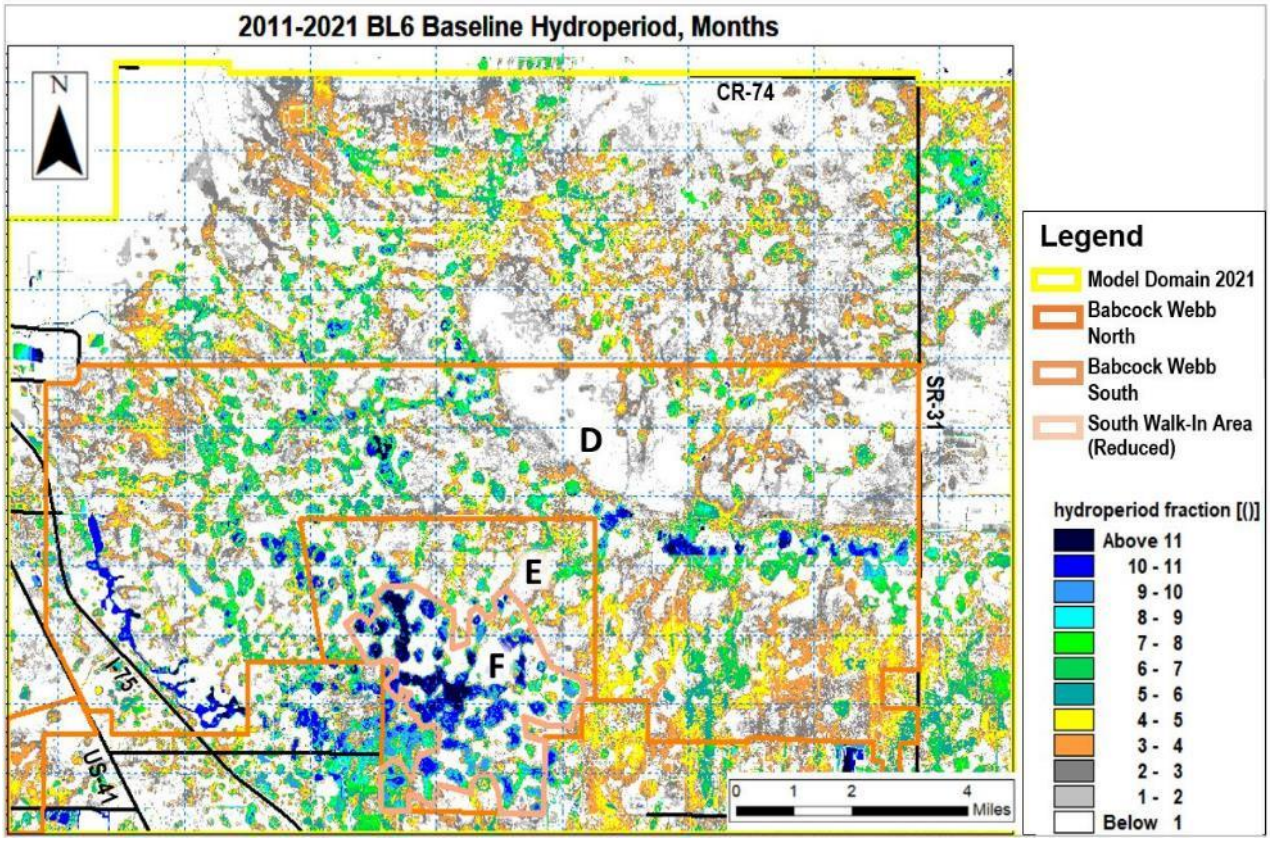


Figure 4. Average annual hydroperiod duration in Babcock Webb at a 50-ft resolution as predicted by the Existing Conditions Baseline Model during the period 2011-2020 (D – Babcock Webb North, E – Babcock Webb South, F – South Walk-In Area (Reduced))

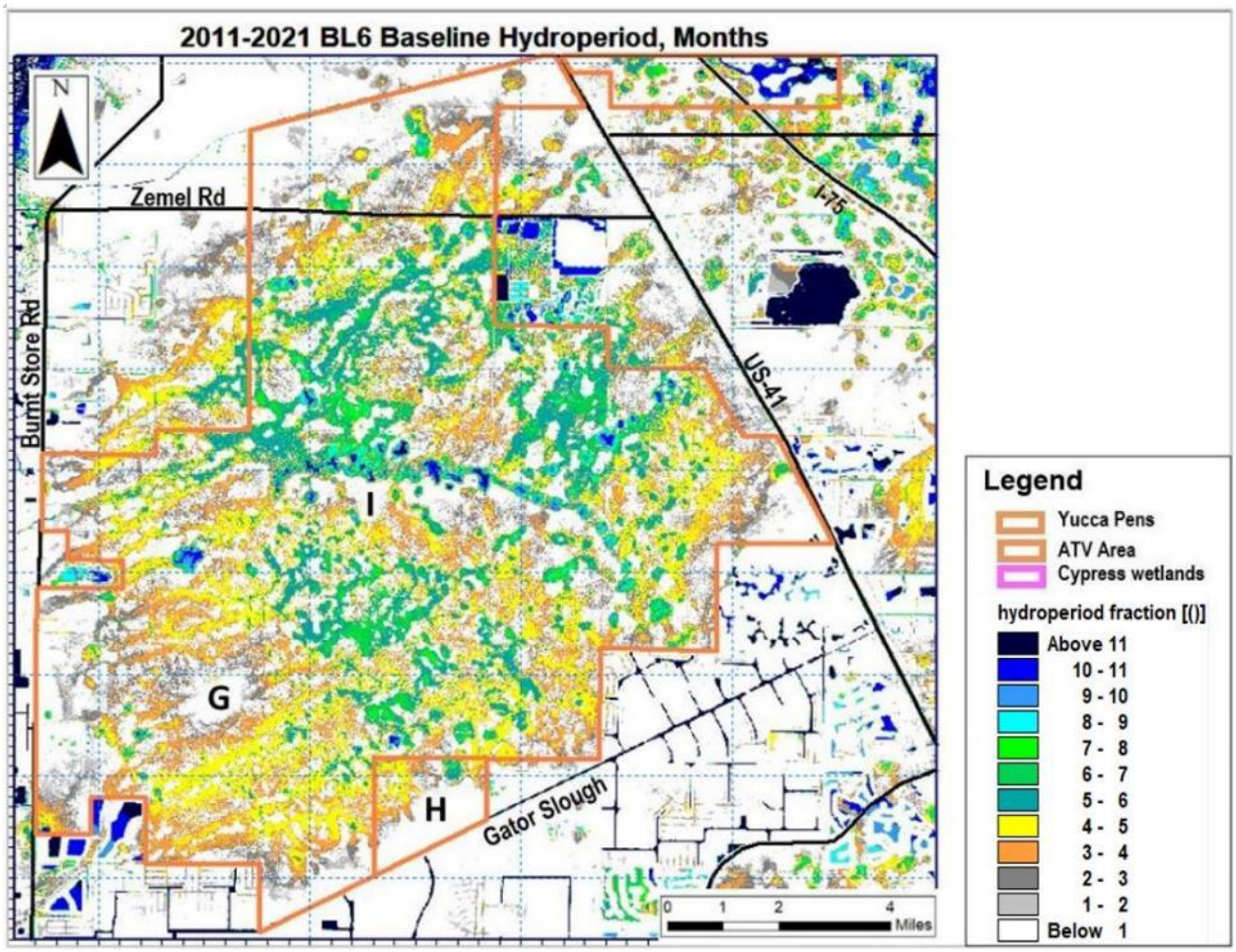


Figure 5. Average annual hydroperiod duration in Yucca Pens at a 50-ft resolution as predicted by the Existing Conditions Baseline Model during the period 2011-2020 (G – Yucca Pens, H – ATV area, I – Cypress wetlands)

Average wet season depths (defined here as July 1st through October 15th) for the 2011 – 2020 baseline simulation are presented in ***Figure 6, 7***, and ***8***. Note that the definition of the wet season differs from the definition used in memoranda 5B and 5C (July 1st through November 30th) associated with this project. The hydroperiod used in memoranda 5B and 5C were based on observed rainfall patterns for 2020 and 2021 which experienced a late initiation of the wet season with rainfall continuing into December for 2020 and November for 2021. The analysis for the baseline simulation of 2011 through 2020 uses a more common definition of the wet season since rainfall patterns varied across the simulation period and typically did not have the patterns observed in 2020 and 2021.

Depths in excess of one foot are common in the South Walk-In Area of Babcock Webb while they are rare in Yucca Pens. Of particular concern, ***Figure* 8** illustrates that average wet season water depths in excess of one foot are relatively rare in the cypress wetlands of Yucca Pens. Note that elevations within the South Walk-In Area with water depths less than 0.1 feet may be inaccurate due to current LiDAR data limitations. Although the modeling is using the best available data at present and producing useful information, further ground-level surveying in addition to more accurate LiDAR data in the Babcock Webb area would increase the accuracy of simulation results. More accurate elevations in low-lying areas and in some “upland” areas that are frequently

flooded provided by ground-level surveying would result in more accurate estimates of wet season depths and wetland hydroperiods. Therefore, this is a recommendation in updating the model in the future.

These simulation results suggest that increased conveyance from the South Walk-In Area is needed, and that water levels in Yucca Pens wetlands need to be increased. Simulated wet season water depths are not observed in the southern portion of the ATV Area (see call-out in ***Figure 7***) of Yucca Pens immediately north of Gator Slough. The only portion of the ATV Area with depths exceeding 0.5 feet are in the northeast portion of the ATV area, and that marsh was restored as part of the 2013 hydrologic restoration project that installed ditch blocks south of that marsh (FWC, 2011).

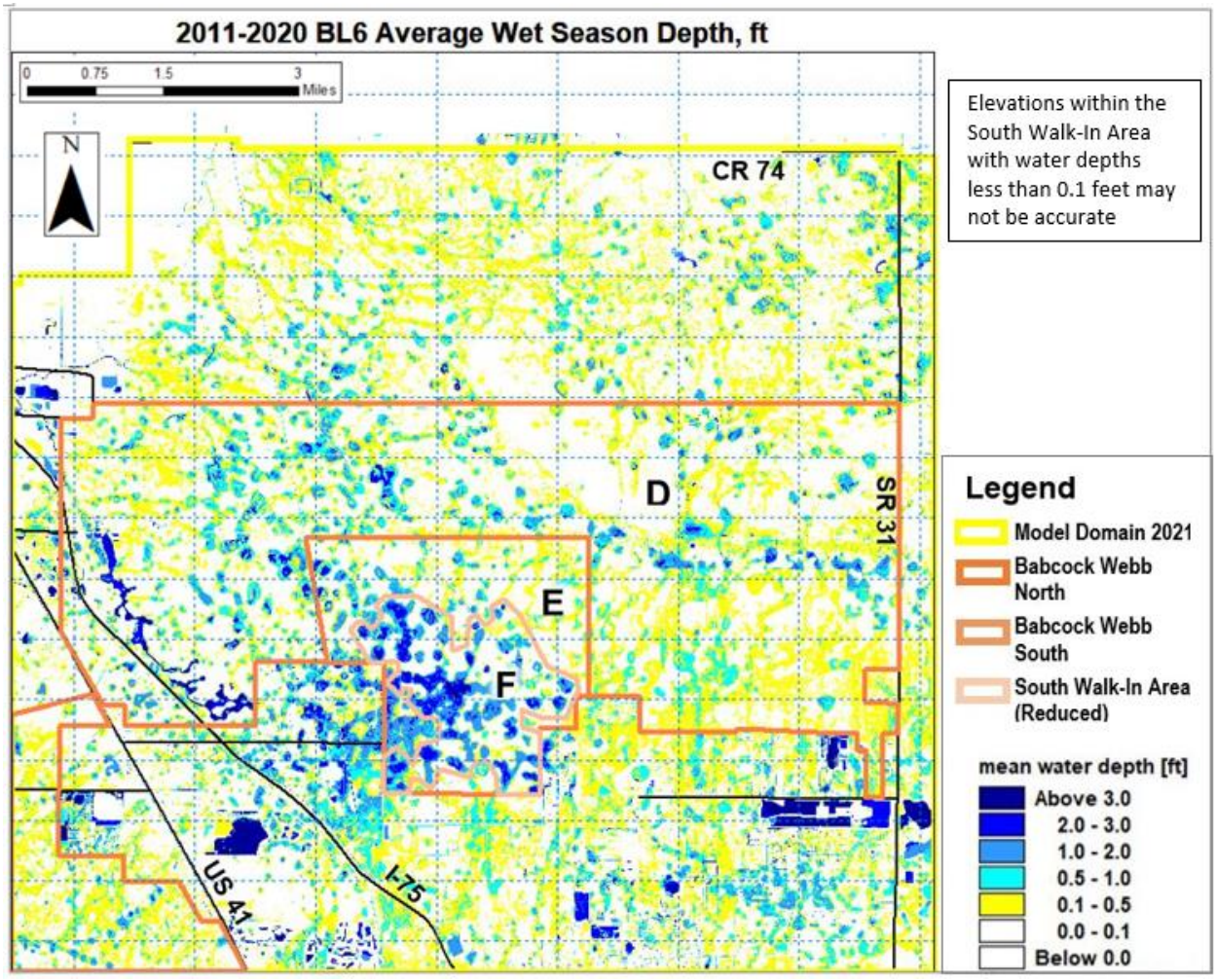


Figure 6. Mean water depth in Babcock Webb during the wet season (July 1 – Oct. 15) at a 50-ft resolution as predicted by the Existing Conditions Baseline Model during the period 2011-2020 (D – Babcock Webb North, E – Babcock Webb South, F – South Walk-In Area (Reduced))

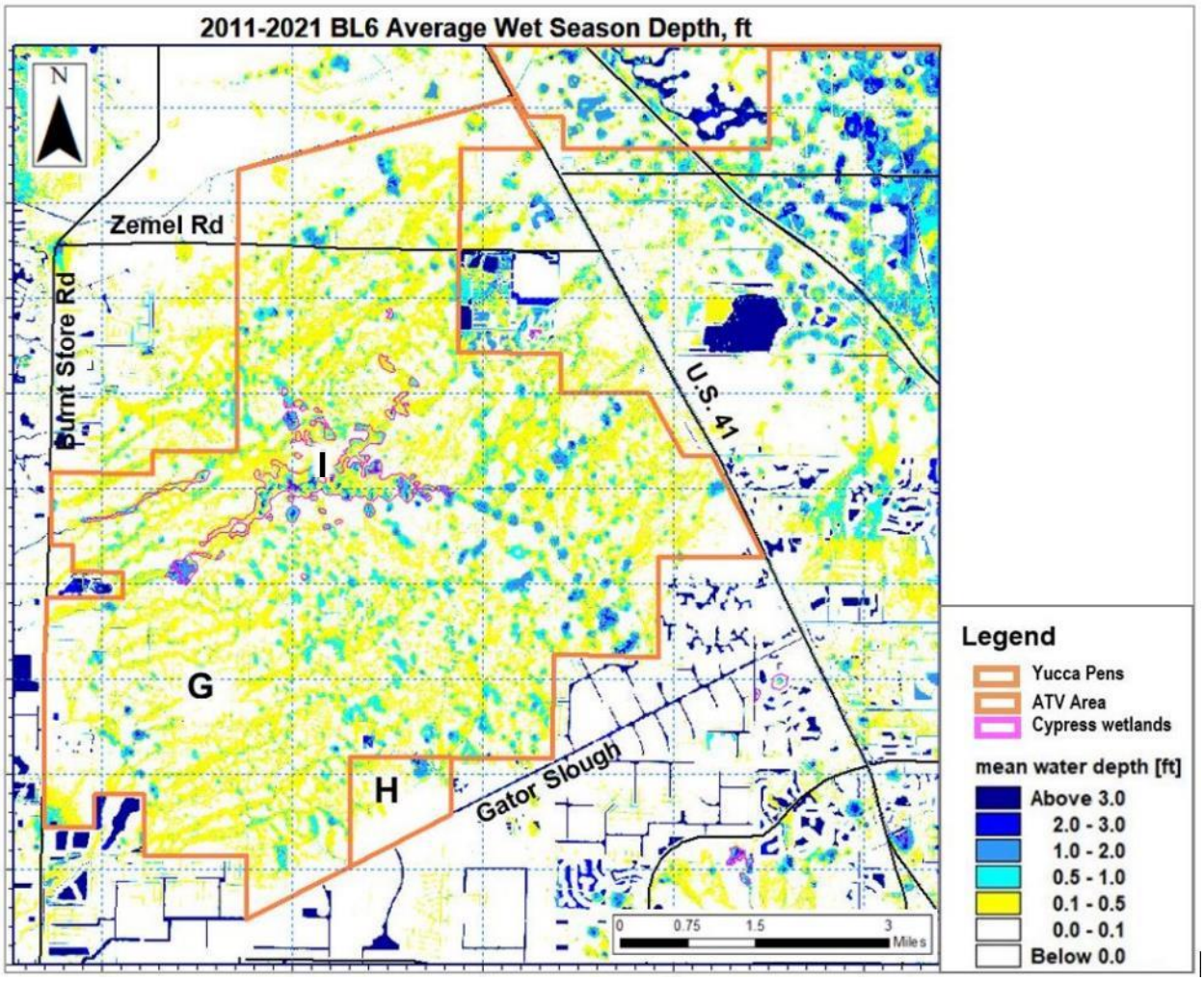


Figure 7. Mean water depth in Yucca Pens during the wet season (July 1 – Oct. 15) at a 50-ft resolution as predicted by the Existing Conditions Baseline Model during the period 2011-2020 (G – Yucca Pens, H – ATV area, I – Cypress wetlands)

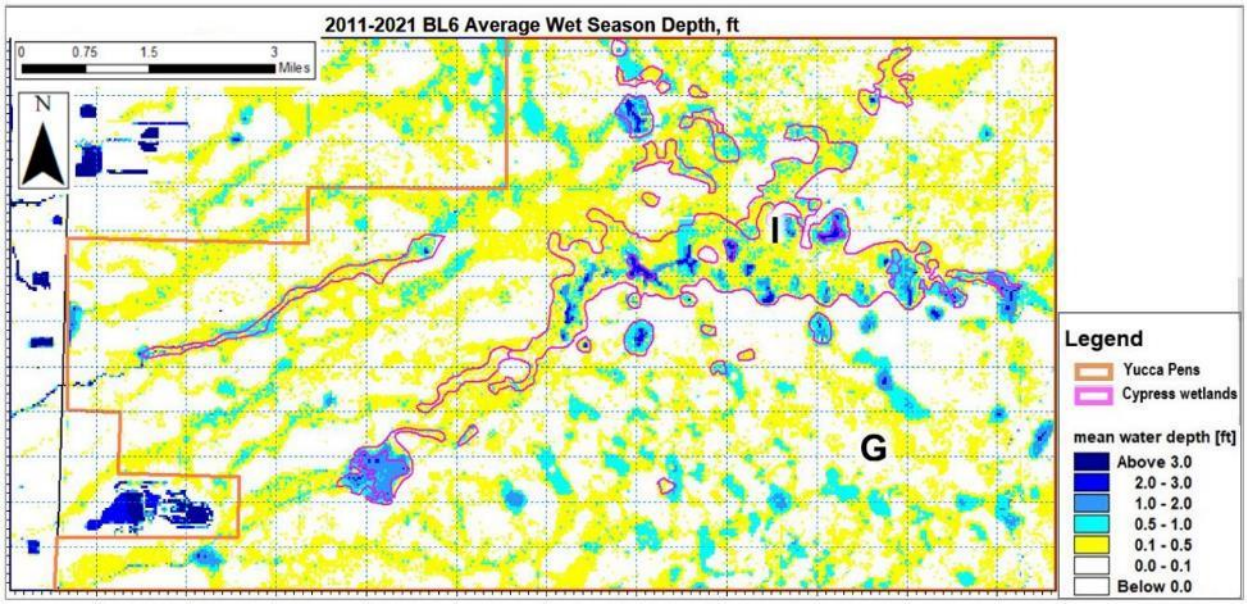


Figure 8. Mean water depth in Yucca Pens Cypress during the wet season (July 1 – Oct. 15) at a 50-ft resolution as predicted by the Existing Conditions Baseline Model during the period 2011-2020 (G – Yucca Pens, I – Cypress wetlands)

COMPARISON OF SIMULATED RESULTS TO HISTORIC CONDITIONS

Simulated hydroperiods were compared to historic (pre-development) hydroperiods using the methodology summarized below:

- Convert the hydrologic rank shape file to a 50-ft resolution grid file that is aligned with the simulated hydroperiods
- Simulated baseline hydroperiod cell values were extracted for the different Hydrologic Rank classes at selected Areas of Interest (AOIs), labeled as Babcock Webb North, Babcock Webb SouthWalkIn, YuccaPens, YuccaPens ATV, and YuccaPens Cypress.
- Histograms are made to compare the distribution of hydroperiod values among Hydrologic Ranks inside each AOI.
- This same procedure was also used for average wet season water depths.

The Yucca Pens AOI does not correspond directly to the FWC boundary of Yucca Pens because there are privately owned lands within and adjacent to the Yucca Pens WMA that are undeveloped and were therefore included in this evaluation. The Yucca Pens ATV area is located at the south end of the Yucca Pens WMA just north of Gator Slough.

The results of the hydroperiod analysis are presented below in ***Figure 9*****,** and wet season water depth histogram graphs are presented in ***Figure 10***. The hydroperiod graphs in Figure 9 and the water depth graphs in Figure 10 are all presented on the same page to facilitate comparison between AOIs. Note that shaded bars represent optimum hydroperiod ranges for hydro rank 3 and 4. Larger-scale figures are presented in **Appendix B**. Each graph in ***Figure 9*** shows the cell count of modelled hydroperiods within a given hydrologic rank.

The simulated median ATV wet season water depths for hydrologic rank areas 3 and 4 are 0.2 and 0.6 feet, respectively, and the simulated median hydroperiods for areas 3 and 4 are 3 and 4.3 months, respectively (see ***Table 2*** and ***Table* 3**). On average, depths should range from 0.75

to 1.5 feet and hydroperiods should range from four – eight months (see

Table 1). These results clearly indicate that the south area of Yucca Pens (referred to herein as the ATV area) should have higher water depths and longer hydroperiods. The results for the Babcock Webb North AOI are unexpected and need further study. This area was not a focus during the ecologic investigations as hydrologic impacts to this area were not expected.

Explanations for Figure 9 below:

- Babcock Webb North hydrologic rank #4 have simulated hydroperiod that most commonly range from 4.5 to 11 months, both below and above optimum hydroperiods.
- Babcock Webb South hydrologic rank #4 (wet, blue line) has simulated hydroperiods that are most commonly in the range of ten months, approximately two months greater than optimum conditions.
- Babcock Webb South Walk-In Reduced AOI hydrologic rank #4 wetlands have hydroperiods longer than for Babcock Webb South, indicating conditions wetter than optimum
- The ATV area of Yucca Pens has simulated hydroperiods that are commonly in the range of four to five months. Hydrologic rank #3 (somewhat wet) has simulated hydroperiods most commonly four months.
- The Cypress area of Yucca Pens has simulated hydroperiods for hydrologic rank 3 and 4 are most commonly 5.5 and 6 months. Cypress hydroperiods should be 6 – 8 months.

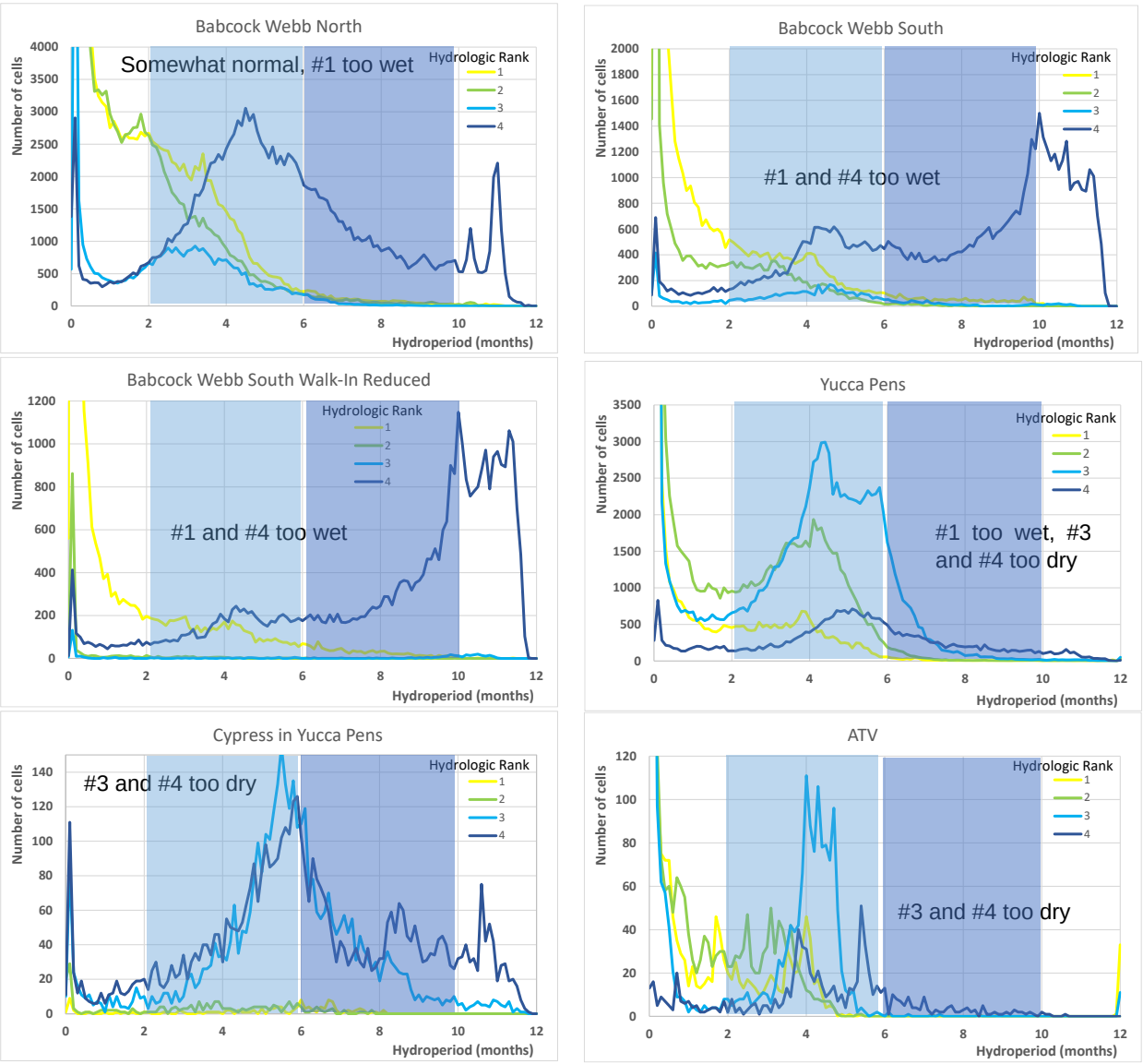


Figure 9. Hydroperiod Histograms for Areas of Babcock Webb and Yucca Pens

Explanations for **Figure 10** below:

- For Babcock Webb North, the most common simulated water depth for hydrologic rank 4 is 0.5 feet, which is too dry (optimum depth is 1 – 2 feet, as shown in Table 1)
- For Babcock Webb South, the most common simulated depths for hydrologic rank #4 range from less than 0.5 to 2.5 feet. Portions of this hydro rank are drier than optimum and some are wetter than optimum.
- For Babcock Webb South Walk-In Reduced, the most common simulated depths for hydrologic rank #4 range from less than 1.5 ft to 2.5 feet, which is too wet (optimum depth range is 1 to 2 feet).
- The most common simulated depths for hydrologic rank 4 for Yucca Pens, Cypress in Yucca Pens, and the ATV area are less than 1 foot, which is too dry (optimum depth is 1 – 2 feet).
- The most common simulated depths for hydrologic rank 3 for Yucca Pens, Cypress in Yucca Pens, and the ATV area are less than 0.5 feet, which is too dry (optimum depth from Table 1 is 0.5 – 0.8 feet)

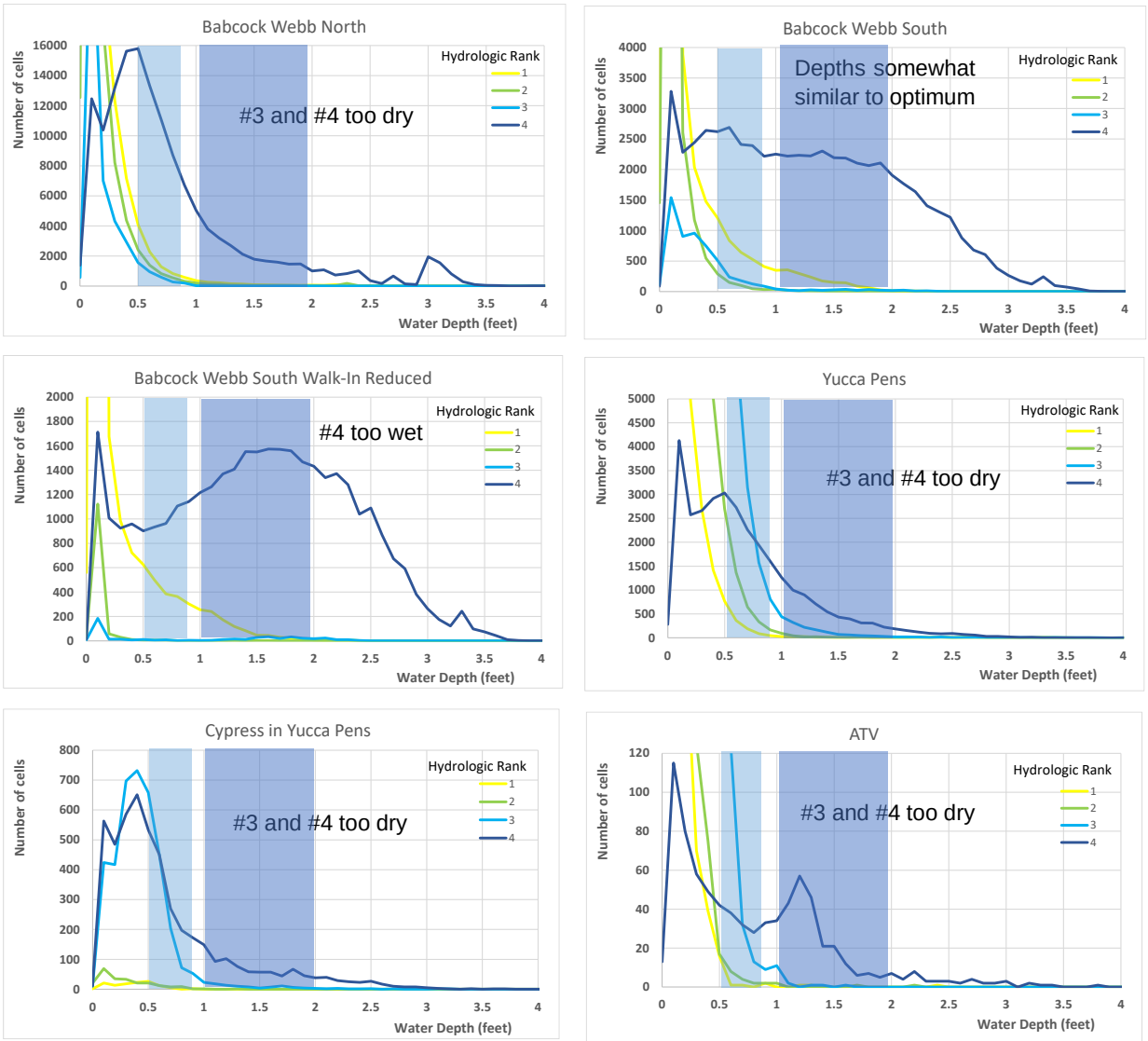


Figure 10. Wet Season Water Depth Histograms for Areas of Babcock Webb and Yucca Pens (see Appendix B for full scale graphs for Yucca Pens and ATV AOIs)

Babcock Webb South and the reduced area of the South Walk-In Area have extended hydroperiods (commonly greater than 10 months for hydrologic rank 4). Median wet season simulated water depths for hydrologic rank 4 in the South Walk-In Area range from 1.5 to 2.5 feet and should be 1 – 2 feet. As shown in **Tables 2** and **3,** simulated median hydroperiods in hydrologic rank areas 3 and 4 (moderately wet to wet) are longer than desired for the focus area of the South Walk-In Area, and median depths are at the upper range of acceptable for the focus area of the South Walk-In Area.

The discussion below compares the most common hydroperiod or wet season depth to the mid-range of optimum hydroperiods and depths. This approach is taken so the discussion is as clear as possible. It is recognized that there is a range of optimum hydroperiods and depths for each vegetation class.

The median simulated water depths in the cypress wetlands with a hydrologic rank 3 and 4 are 0.2 and 0.4 ft respectively, and the median hydroperiod is approximately 5.8 months for hydrologic rank areas 3 and 4. The optimum wet season depth range for cypress is one to two feet and the optimum wetland hydroperiod range is six to ten months (see ***Table 1***). This analysis of wet season water depths indicates that the cypress wetlands of Yucca Pens have water levels and hydroperiods significantly less than are typically observed in that habitat type. Combined with the hydroperiod results presented above in ***Figure 8***, it is clear that management efforts for Yucca Pens should include measures to either increase flows to or reduce discharges from these wetlands.

Data from ***Table 2*** demonstrate that the simulated median hydroperiod of 5.8 months for hydrologic rank area 3 is greater than the 4-month **optimum** hydroperiod for the Babcock Webb South Walk-In Area (reduced). Simulated median hydroperiods from ***Table 3*** for hydrologic rank area 4 for the South Walk-In Area (BW S Red) also indicate conditions wetter than optimum.

Data from ***Table 2*** demonstrate that the ATV AOI in southern Yucca Pens is also too dry with a median simulated hydroperiod of 3 months for hydrologic rank 3, which is less than the lower range of optimum 4-month hydroperiod. ***Table 3*** indicates that the ATV AOI simulated median hydroperiod is 4.3 months for hydro rank 4, significantly less than the optimum of 8 months.

Table 2. Median Simulated Hydroperiods (HP) for Hydrologic Rank Area 3

Metric	BW North	BW South	BW S Red	Yucca Pens	YP Cypress	ATV
Optimum HP, mo	4	4	4	4	4	4
Median HP, mo	2.3	4.0	5.8	4.0	5.6	3.0
Difference	-43%	0%	45%	0%	40%	-25%
Optimum Depth, ft	0.5 – 0.8	0.5 – 0.8	0.5 – 0.8	0.5 – 0.8	0.5 – 0.8	0.5 – 0.8
Median Depth, ft	0.1	0.2	0.7	0.2	0.2	0.2
Difference	-91%	-65%	+6%	-68%	-46%	-72%

Note: BW = Babcock Webb, S Red = South Walk-In Area Reduced, YP = Yucca Pens, WS = wet season

Table 3. Median Simulated Hydroperiods for Hydrologic Rank Area 4

Metric	BW North	BW South	BW S Red	Yucca Pens	YP Cypress	ATV
Optimum HP, mo	8	8	8	8	8	8
Median HP, mo	5.1	8.4	9.6	5.1	5.9	4.3
Difference	-36%	5%	20%	-36%	-26%	-46%
Optimum Depth, ft	1 - 2	1 - 2	1 - 2	1 - 2	1 - 2	1 - 2
Median Depth, ft	0.5	1.2	1.5	0.5	0.4	0.6

Difference	-65%	-23%	-2%	-67%	-72%	-60%

Note: BW = Babcock Webb, S Red = South Walk-In Area Reduced, YP = Yucca Pens, WS = wet season

MANAGEMENT IMPLICATIONS OF NATURAL SYSTEMS ANALYSIS

The natural systems analysis presented above confirms the findings of the ecological analysis conducted as part of Task 3 of this project. In Task 3, wetlands biologists visited approximately 60 wetland locations in both Babcock Webb and Yucca Pens during both the dry and wet seasons of 2020 and established average wet season depths using vegetative indicators of inundation. That analysis determined that the South Walk-In Area of Babcock Webb had inundation levels higher than optimum conditions and that the southern and western portions of Yucca Pens had inundation levels below optimum conditions.

The Natural Systems analysis confirmed the Task 3 ecologic analysis. In order to restore optimum ecologic conditions in Babcock Webb and Yucca Pens, hydroperiods need to be reduced in Babcock Webb and increased in Yucca Pens. The target restoration goals are presented below in ***Table 4*** for Hydrologic Rank 3 areas and ***Table 5*** for Hydrologic Rank 4 areas.

Table 4. Target Restoration Goals for Hydrologic Rank Area 3 in Babcock Webb and Yucca Pens

Area	EX Hydroperiod, mo.	Opt. Hydroperiod, mo.	Change, mo.
BW South Walk-In Area	5.8	4	-1.8
Yucca Pens ATV	3	4	+1.0
Area	**EX WS Depth, ft**	**Opt. Depth, ft**	**Change, ft**
BW South Walk-In Area	0.7	0.65	-0.15
Yucca Pens ATV	0.2	0.65	+0.45

Table 5. Target Restoration Goals for Hydrologic Rank Area 4 in Babcock Webb and Yucca Pens

Area	EX Hydroperiod, mo.	Opt. Hydroperiod, mo.	Change, mo.
BW South Walk-In Area	9.6	8	-1.6
Yucca Pens Cypress	5.9	8	+2.1
Yucca Pens ATV	4.3	8	+3.7
Area	**EX WS Depth, ft**	**Opt. Depth, ft**	**Change, ft**
BW South Walk-In Area	1.5	1.5	No change[1]
Yucca Pens Cypress	0.4	1.5	+1.1
Yucca Pens ATV	0.6	1.5	+0.9

1. Not believed to be correct due to topographic issues in the South Walk-In Area

COMPARISON OF SIMULATED FLOW TIME SERIES TO FLOW RESTORATION OBJECTIVES

A key objective of the project is to reduce peak flows and increase the duration of positive flows to tide from the creeks that flow from Yucca Pens to Matlacha Pass. ***Table 6*** provides a listing of low flow periods for the Yucca Pens Creeks. Bear Branch, Hog Branch, Durden Creek, and Greenwell Branch (locations shown in ***Figure 11***) all experienced low flow periods during the summer of 2020. Low flow periods were not experienced during the summer of 2021, however runoff did not begin until mid to late June at most creeks except for Bear Branch where the wet

season began in mid-May. Simulated flows were evaluated to determine the time periods when flows were less than 1 cfs. This flow value was selected as most of the Yucca Pens tidal creeks are ephemeral and have positive flows above 10 cfs only during the wet season. Therefore, 1 cfs was deemed an appropriate measure to elucidate the frequency of low flow conditions.

Increasing the duration of flows above 1 cfs is a key objective of this project. Scenarios will be evaluated on the effectiveness of increasing flows to greater than 1 cfs during the summer period as well as to achieve flows greater than 1 cfs until December 31 for seven of ten years of the simulation period (2011 – 2020). It is unlikely that it will be possible to achieve this goal for the Yucca Pens creeks with the smaller drainage areas, such as Bear Branch and Hog Branch, since it is likely that these creeks were ephemeral during pre-development conditions.

Table 6. Low Flow Periods (less than 1 cfs) During 2020 and 2021 in Yucca Pens Creeks

Creek	2020 Low Flow Periods	2021 Low Flow Periods
Zemel Canal	Station not installed until August	Feb 4-5, Mar 17 – mid June
Bear Branch	Short portions of May, 1st half of July	March 4-16, March 24 to mid-May
Hog Branch	May, June 21 – Aug 25, Sept 2 – 9,	Jan 6 – June 16, Oct 5 – Nov 5
Yucca Pens Creek	First half of May[1], Nov 6 – 9, Nov 26 - 30	Jan 6 – June 26
Durden Creek	Most of May, late June to July 20	Jan 9 – June 28, Oct 14 – Nov 5
Greenwell Branch	Mid-May to June 2, June 12-14, 23-25, June 27 – July 24, July 30 – Aug 7, Aug 16-22, Sept 6-9	Jan 9 – June 28, Nov 1-5

1. Information for May 2020 at Yucca Pens Creek is from an upstream monitoring station (SR-8) located on the western edge of Yucca Pens WMA. The Burnt Store Road station was not installed until September, 2020.

DESCRIPTION OF SCENARIOS

The scenarios that will be analyzed are summarized below. Key components of the potential Babcock Webb restoration measures are presented in ***Figure 12***.

Scenario 1

- Pump water from Babcock Webb to Bond Farm storage area
- Block ATV trails in Yucca Pens (see ***Figure 13***). Note that the exact locations and number of ATV channel blocks will need to be determined though a localized model to further evaluate how they can best be implemented.
- Add cutoff wall if blocking ATV trails in south Yucca Pens results in higher water levels on adjacent private lands or if ATV blocks provide a limited response

Scenario 2

- Include flow-way from Bond Farm to Yucca Pens if blocking ATV trails in Yucca Pens does not achieve restoration goals
- If restoration is not achieved in the South Walk-In Area with Bond Farm, then convey water to potential new storage area on Southwest Aggregates
- If storage on Bond Farm and Southwest Aggregates does not achieve restoration goals in the South Walk-In Area, then add a third storage cell on Bond Farm using northern portion of the Stolle Property

Scenario 3

- Scenario 2 with climate change added (7.5% drier scenario from Habitat Restoration Needs Plan Phase 2 report [ESA, 2019])

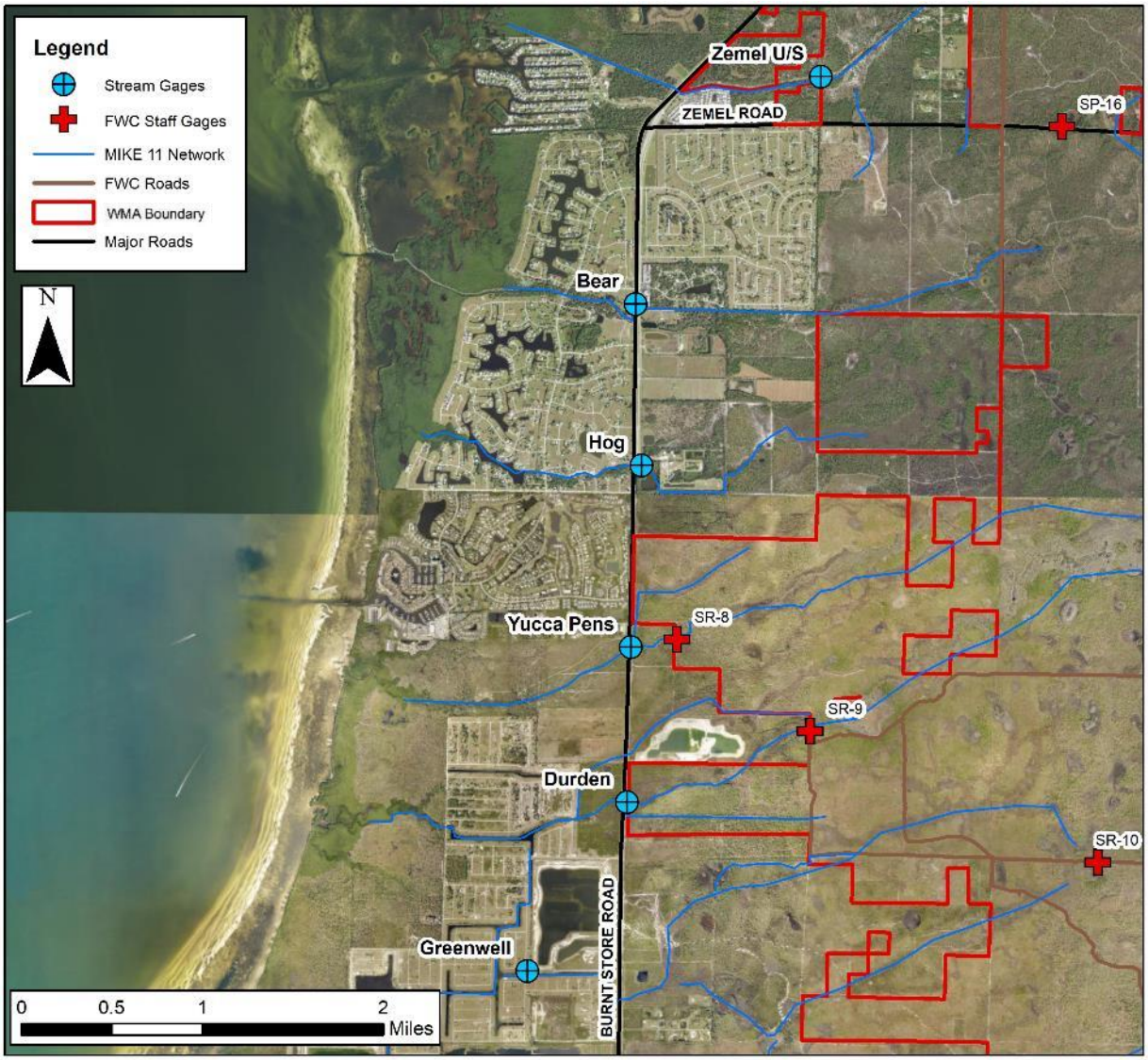


Figure 11. Yucca Pens Flow Monitoring Stations

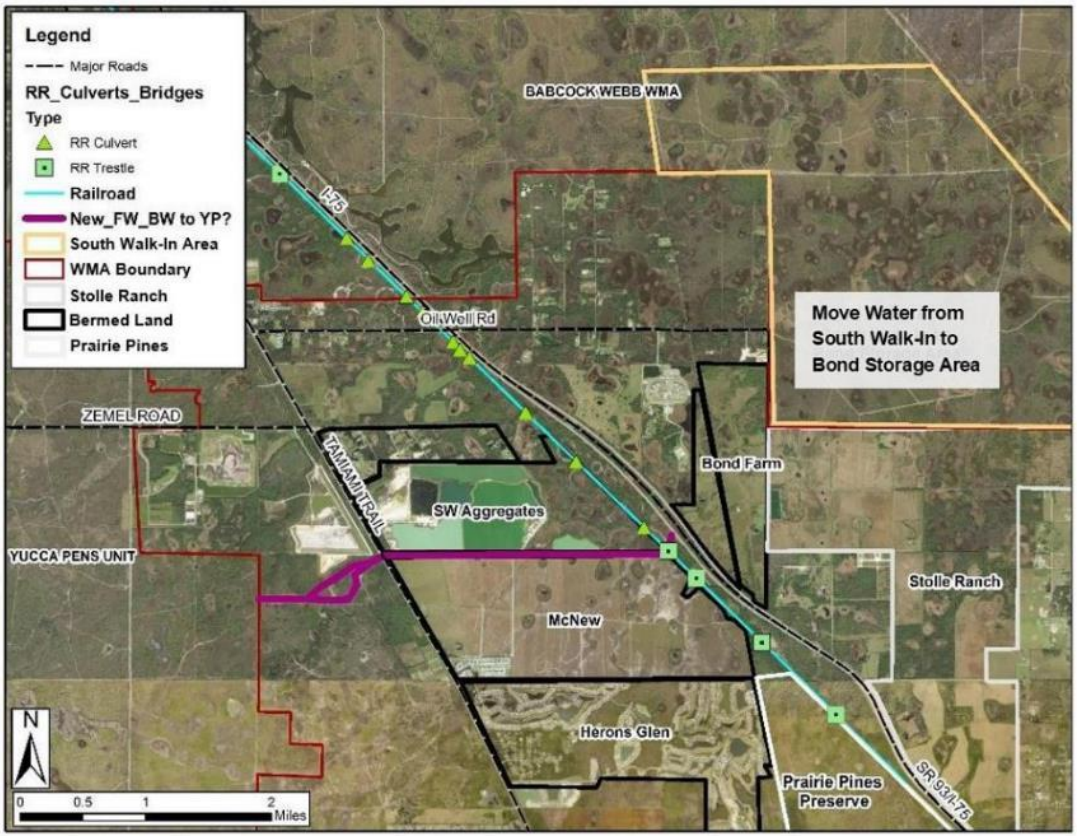


Figure 12. Diagram of Restoration Features

Note that not all ATV blocks may be needed

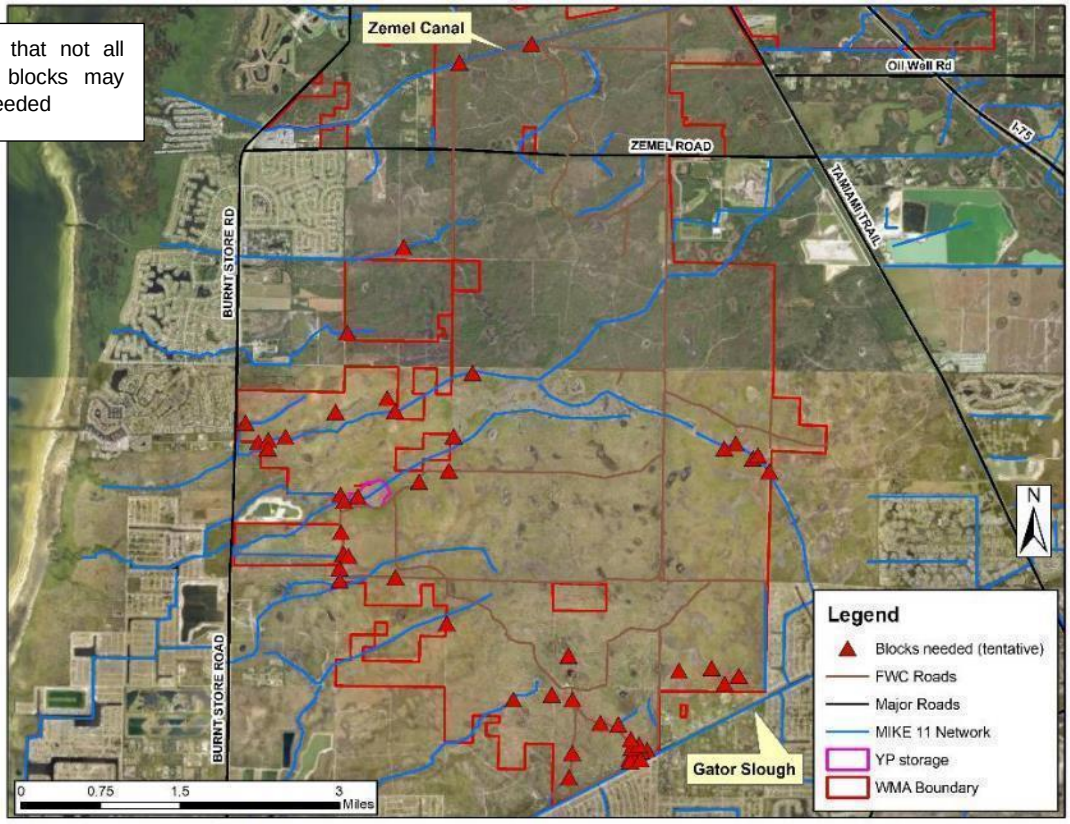


Figure 13. Locations of Potential Restoration Measures for Yucca Pens

REFERENCES

ESA & CHNEP (2019). Habitat Restoration Needs Plan for the Coastal & Heartland National Estuary Partnership Area, prepared for CHNEP by ESA, May, 2019.

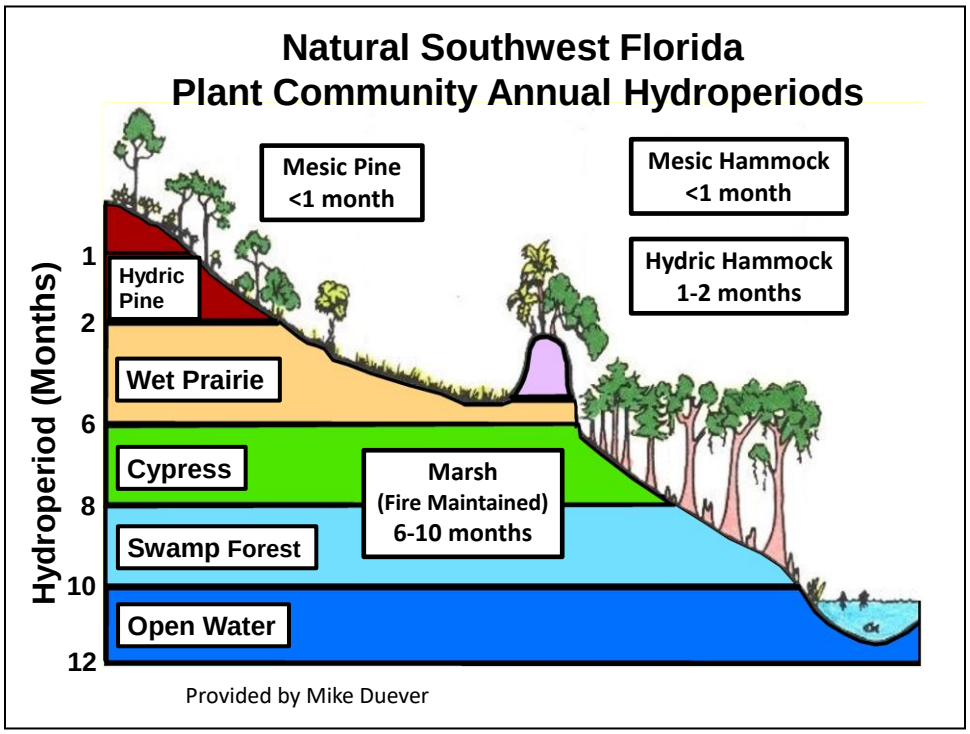
Duever, Michael J. and Richard E. Roberts (2013). Successional and Transitional Models of Natural South Florida, USA, Plant Communities. Fire Ecology Volume 9, Issue 1, pages 110 – 123.

Florida Fish and Wildlife Conservation Commission (2011). U.S. Army Corps of Engineers Permit SAJ-2011-00969. Issued August 18, 2011.

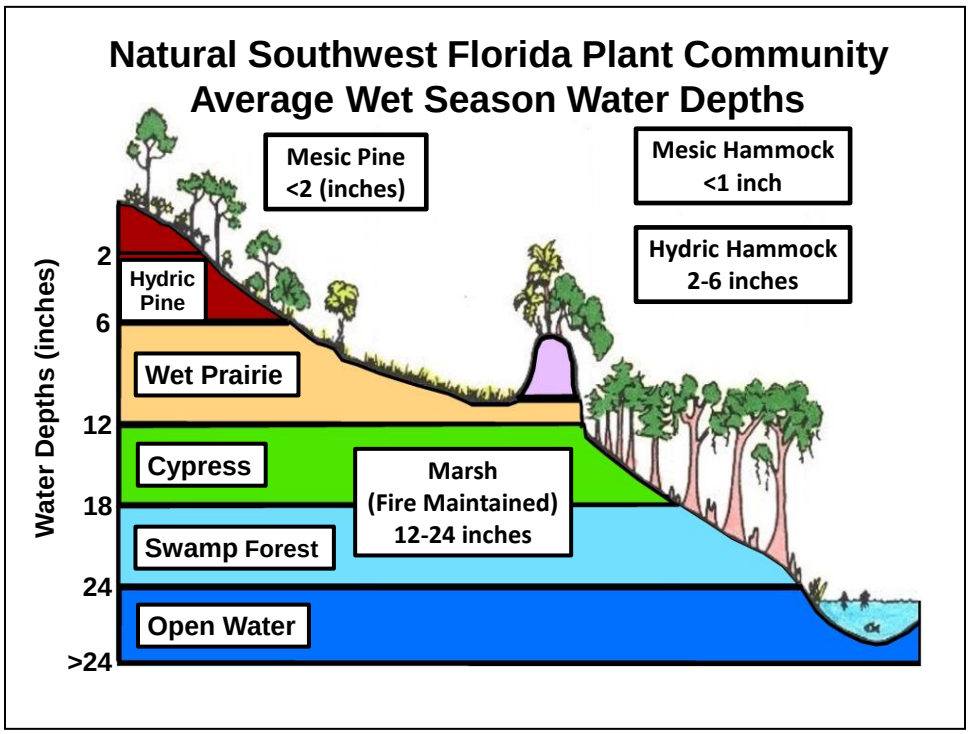
Kemmerer, Michael, and Tim Liebermann (2018). 1953 Babcock Webb Wildlife Management Area Aerial Photographs and Hydrologic Mapping, Maps presented to the Charlotte Harbor Flatwoods Initiative by Mike Kemmerer, Florida Fish and Wildlife Conservation Commission Babcock Webb Wildlife Management Area and Tim Liebermann, South Florida Water Management District (retired), December 13, 2018.

Appendix A

Pre-Development Hydroperiods and Depths (Duever and Roberts, 2013)



Provided by Mike Duever



Hydrologic Regimes of Natural Southwest Florida Plant Communities

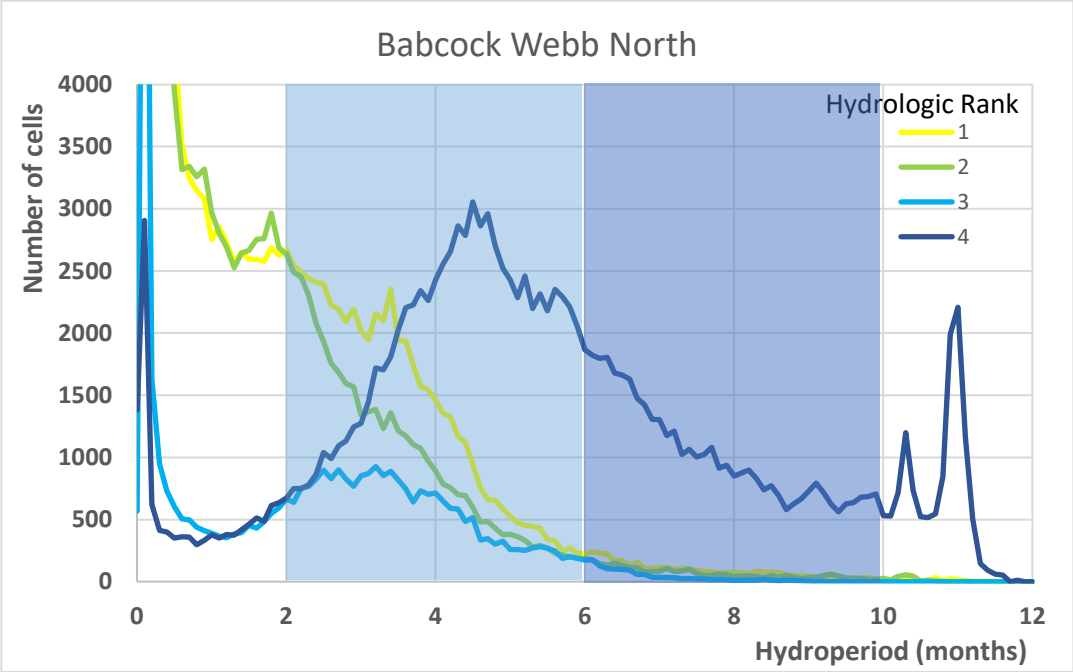
1: avg yr,
10: 10-yr drought

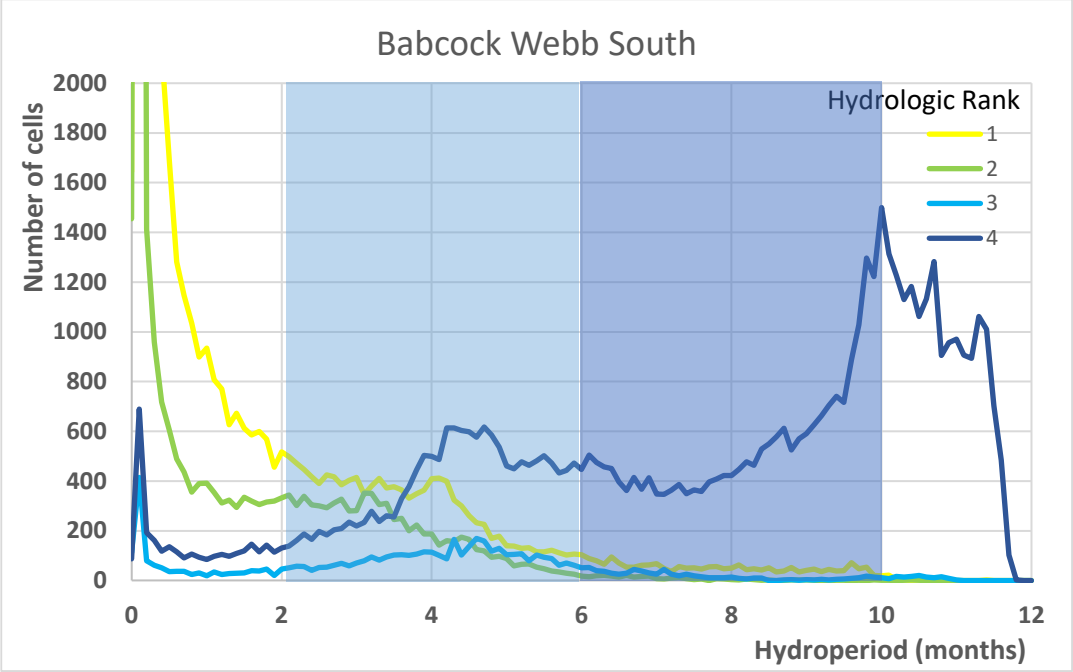
SW Fla Plant Communities	Hydroperiod (months)	Water Level (in) Wet	Dry (1,10)
Xeric Flatwood, Xeric Hammock	0	≤-24	-60, -90
Mesic Flatwood, Mesic Hammock	≤1	≤2	-46, -76
Hydric Flatwood, Hydric Hammock	1 - 2	2 - 6	-30, -60
Wet Prairie, Dwarf Cypress	2 - 6	6 - 12	-24, -54
Marsh	6 - 10	12 - 24	-6, -46
Cypress	6 - 8	12 - 18	-16, -46
Swamp Forest	8 - 10	18 - 24	-6, -36
Open Water	>10	≥24	< 24, -6
Tidal Marsh, Mangrove, Beach	Tidal	Tidal	Tidal

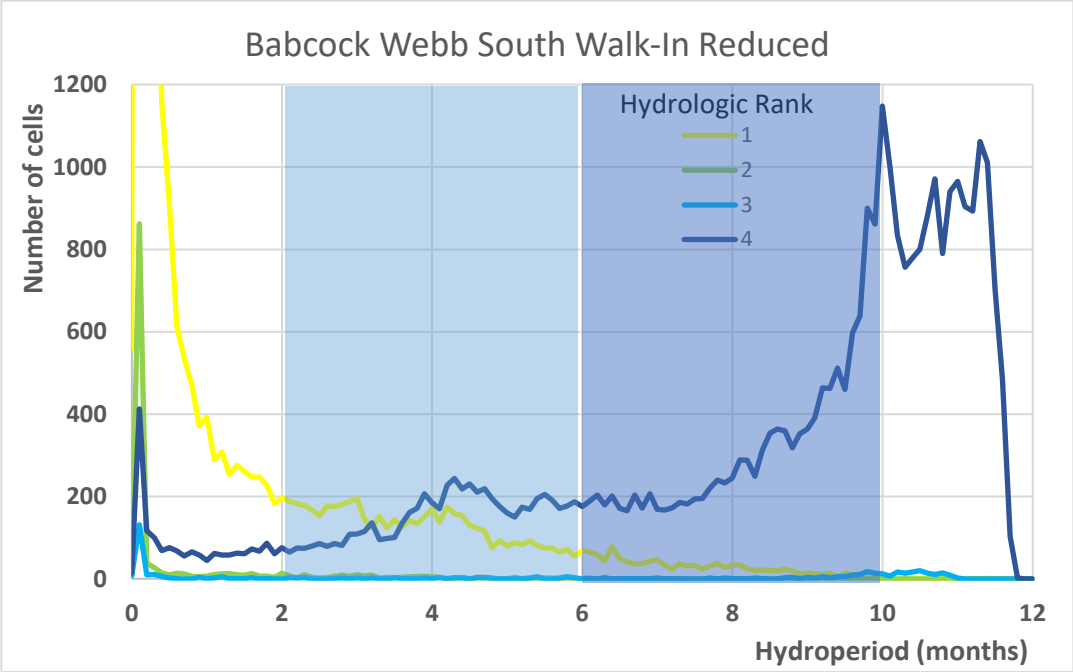
Provided by Mike Duever

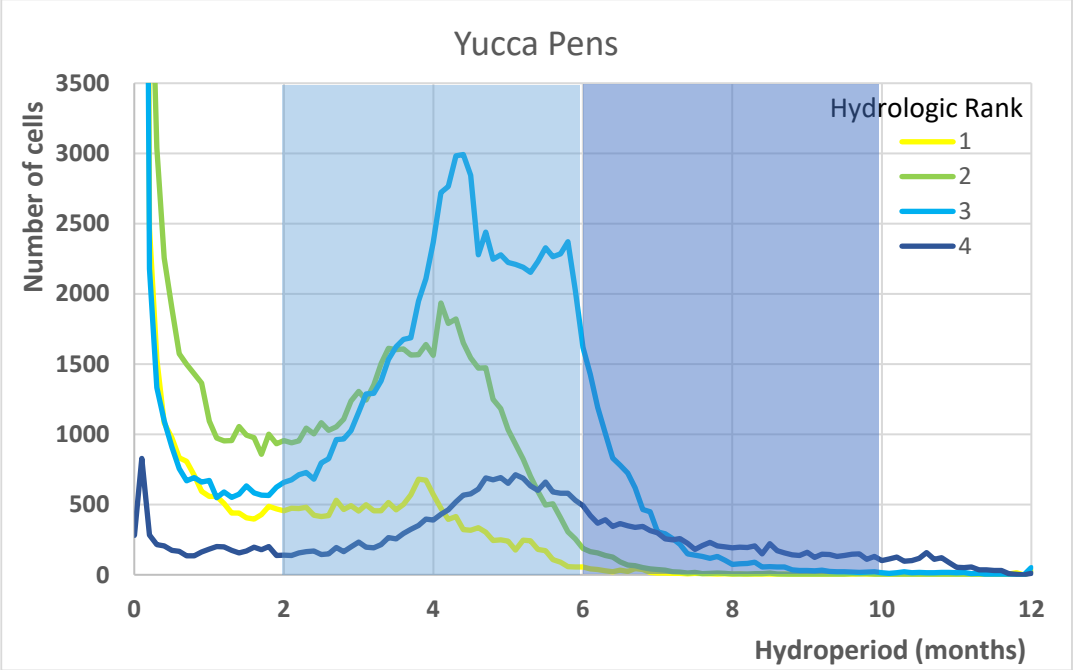
Appendix B

Full-scale Images for Figure 9 and 10


Babcock Webb North
Number of cells
4000
3500
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
Hydroperiod (months)
Hydrologic Rank
1
2
3
4


Babcock Webb South
Number of cells
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
Hydroperiod (months)
Hydrologic Rank
1
2
3
4


Babcock Webb South Walk-In Reduced
Number of cells
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
Hydroperiod (months)
Hydrologic Rank
1
2
3
4


Yucca Pens
Number of cells
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3000
2500
2000
1500
1000
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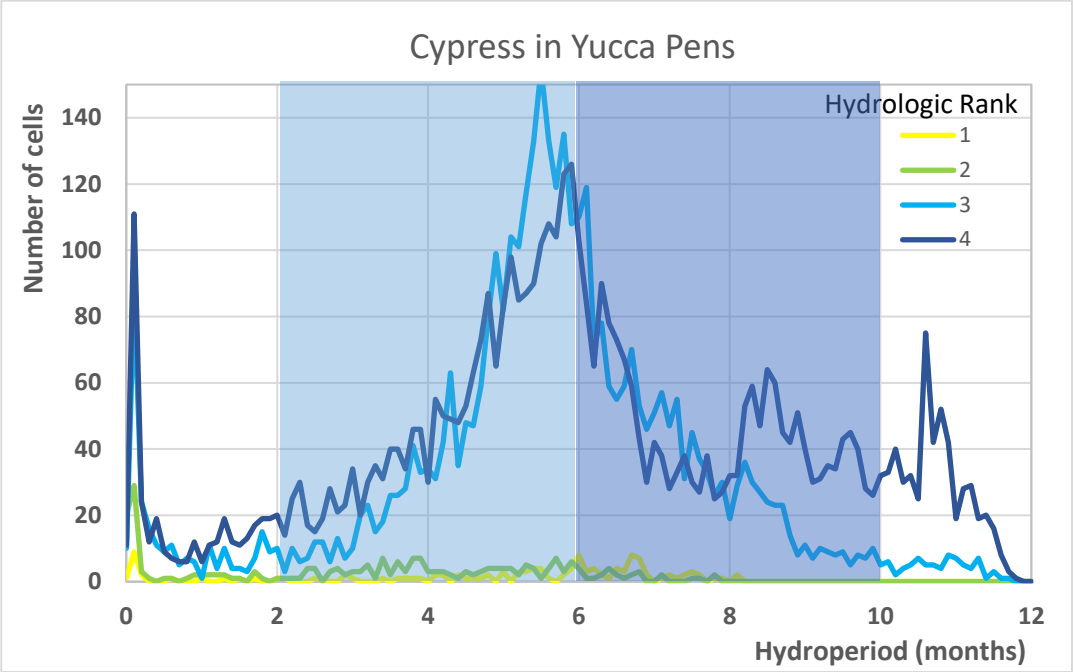
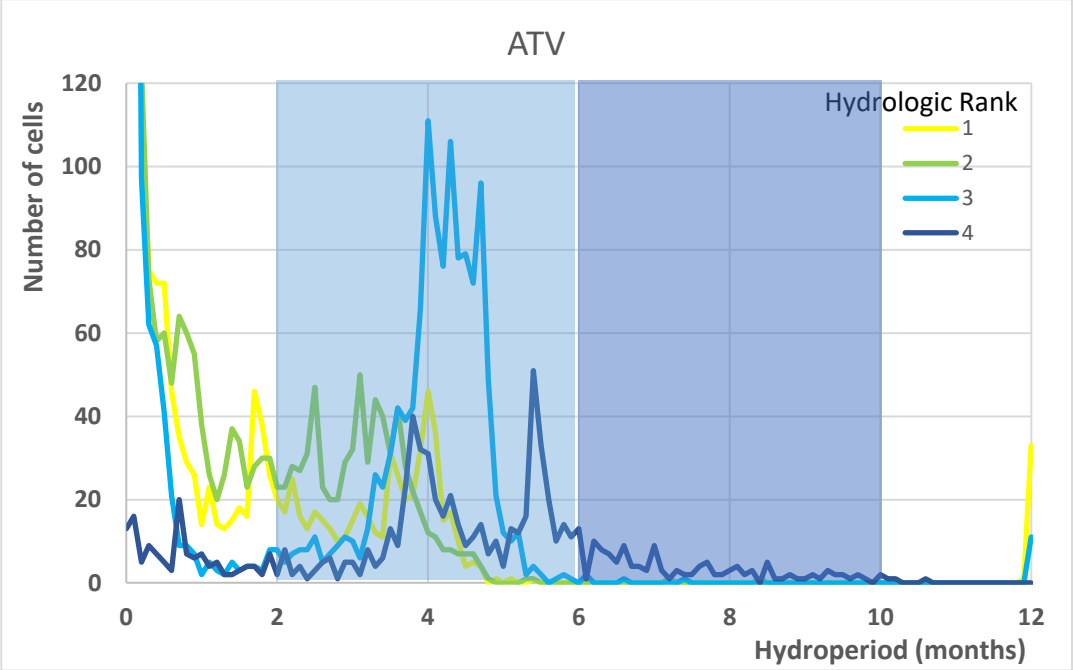
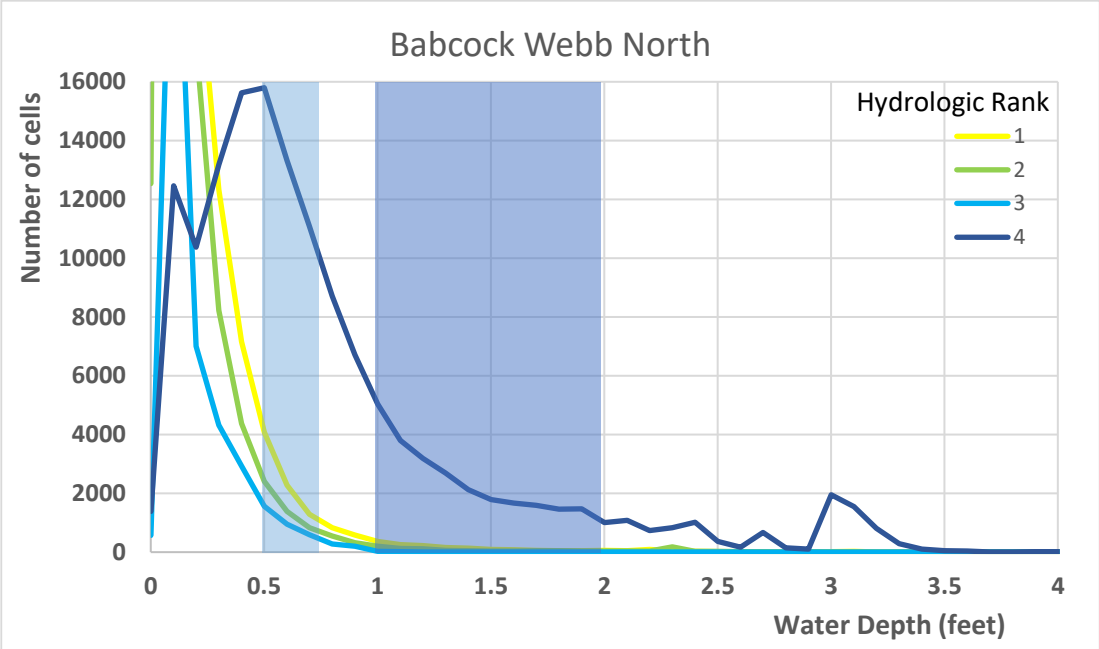
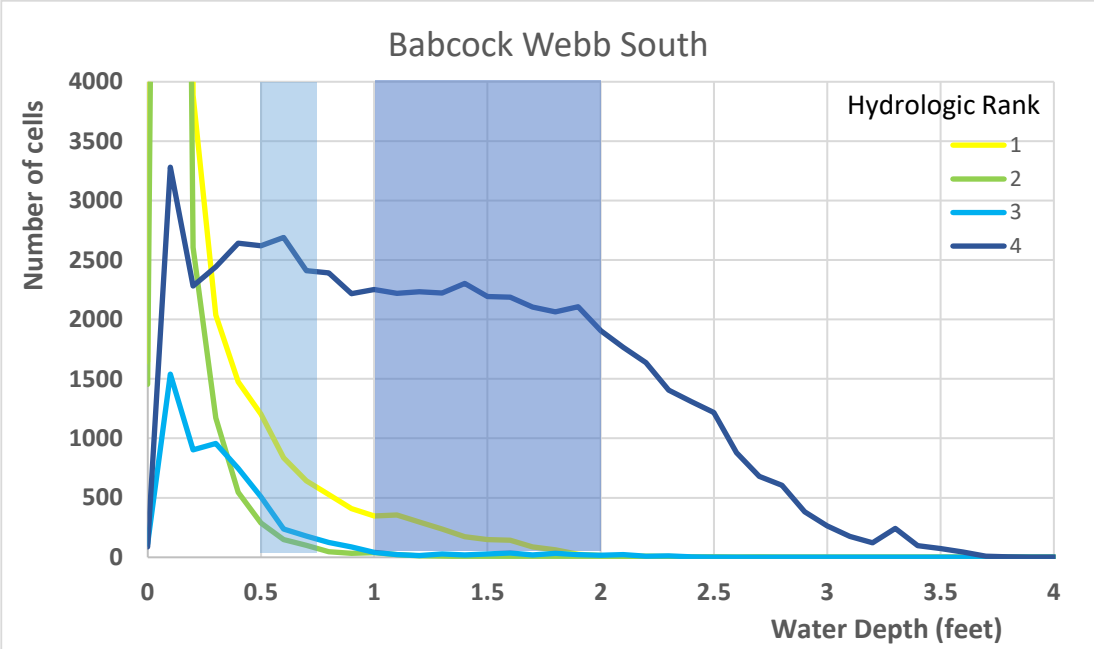
0
0
2
4
6
8
10
12
Hydroperiod (months)
Hydrologic Rank
1
2
3
4


Cypress in Yucca Pens
Number of cells
0
20
40
60
80
100
120
140
0
2
4
6
8
10
12
Hydroperiod (months)
Hydrologic Rank
1
2
3
4


ATV
Number of cells
0
20
40
60
80
100
120
0
2
4
6
8
10
12
Hydroperiod (months)
Hydrologic Rank
1
2
3
4


Babcock Webb North
Number of cells
16000
14000
12000
10000
8000
6000
4000
2000
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Water Depth (feet)
Hydrologic Rank
1
2
3
4


Babcock Webb South
Number of cells
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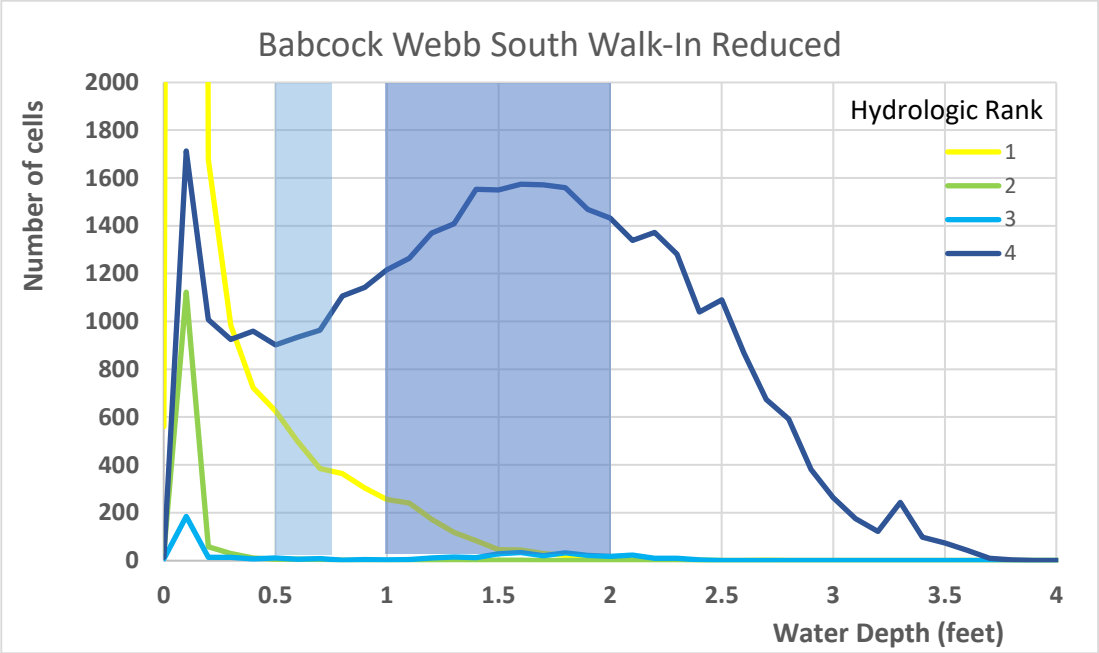
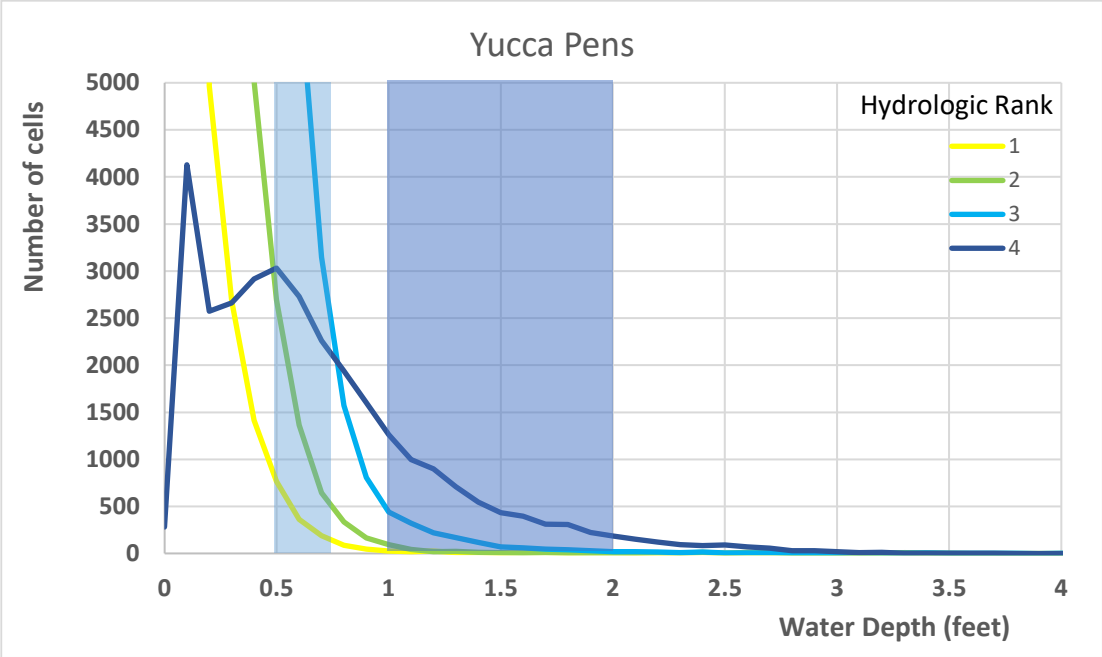
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Water Depth (feet)
Hydrologic Rank
1
2
3
4


Babcock Webb South Walk-In Reduced
Number of cells
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Water Depth (feet)
Hydrologic Rank
1
2
3
4


Yucca Pens
Number of cells
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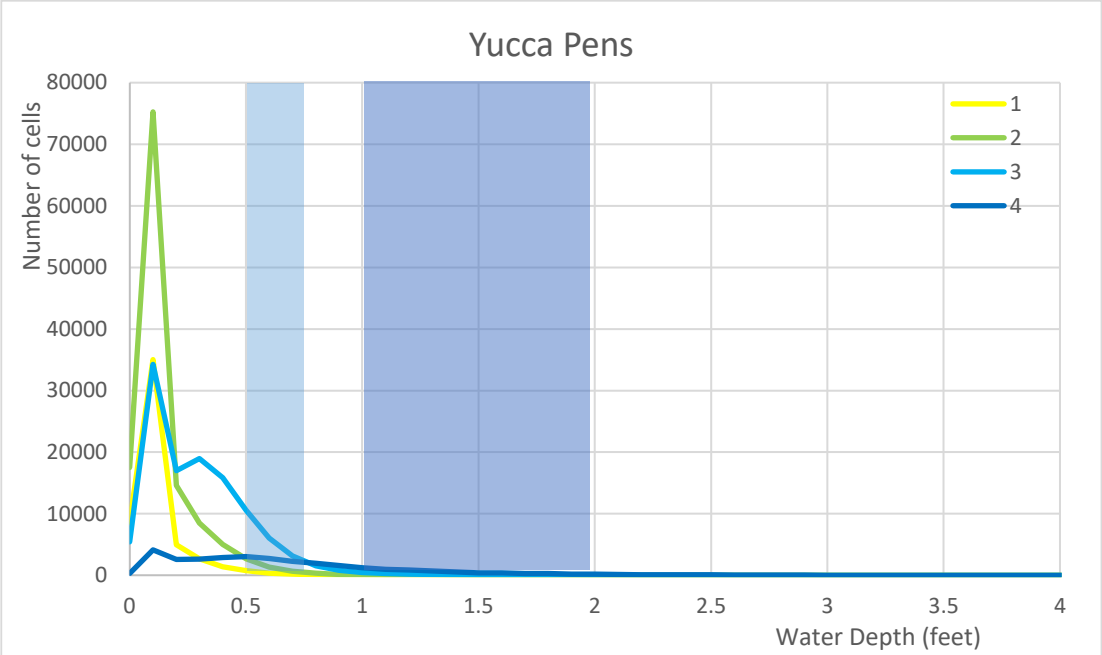
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Water Depth (feet)
Hydrologic Rank
1
2
3
4


Yucca Pens
Number of cells
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70000
60000
50000
40000
30000
20000
10000
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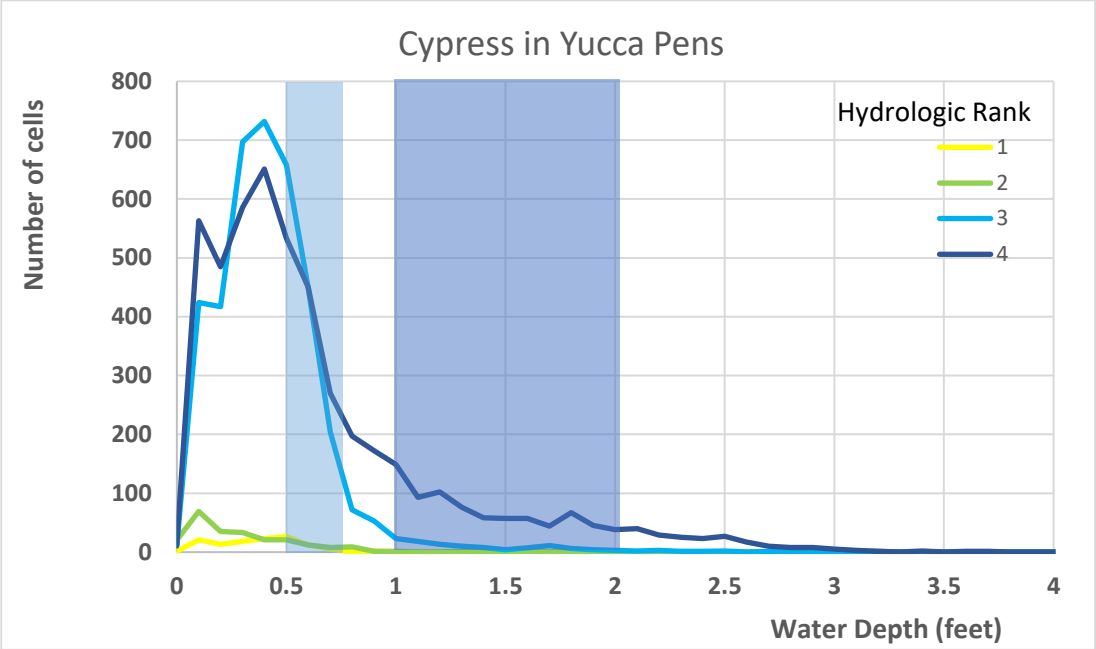
1
1.5
2
2.5
3
3.5
4
Water Depth (feet)
1
2
3
4


Cypress in Yucca Pens
Number of cells
800
700
600
500
400
300
200
100
0
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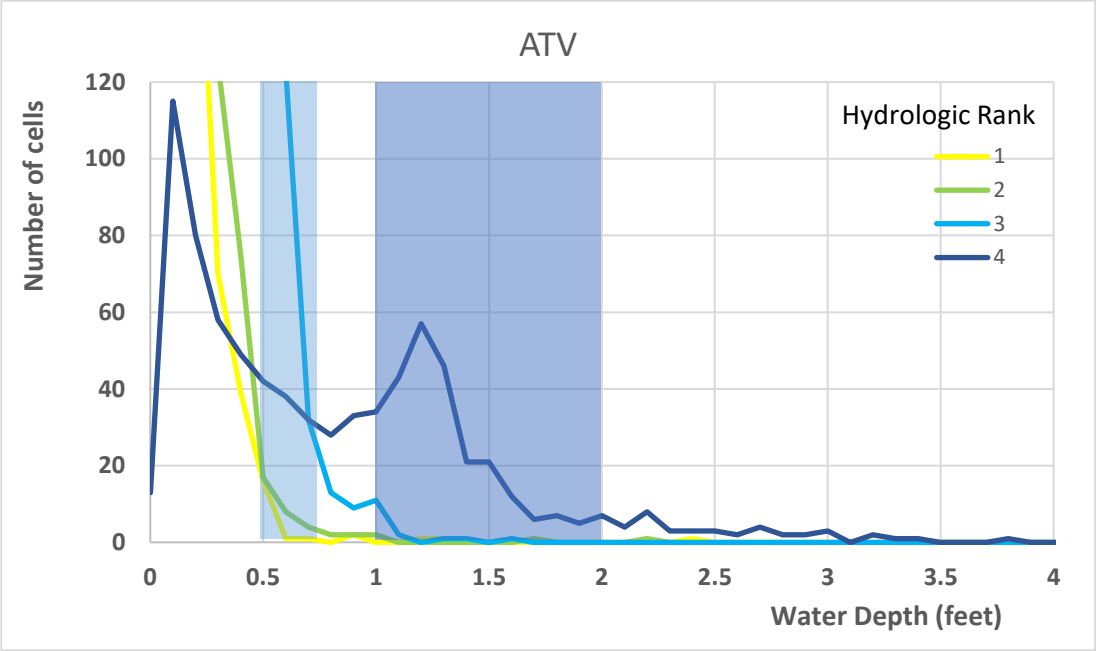
0.5
1
1.5
2
2.5
3
3.5
4
Water Depth (feet)
Hydrologic Rank
1
2
3
4


ATV
Number of cells
120
100
80
60
40
20
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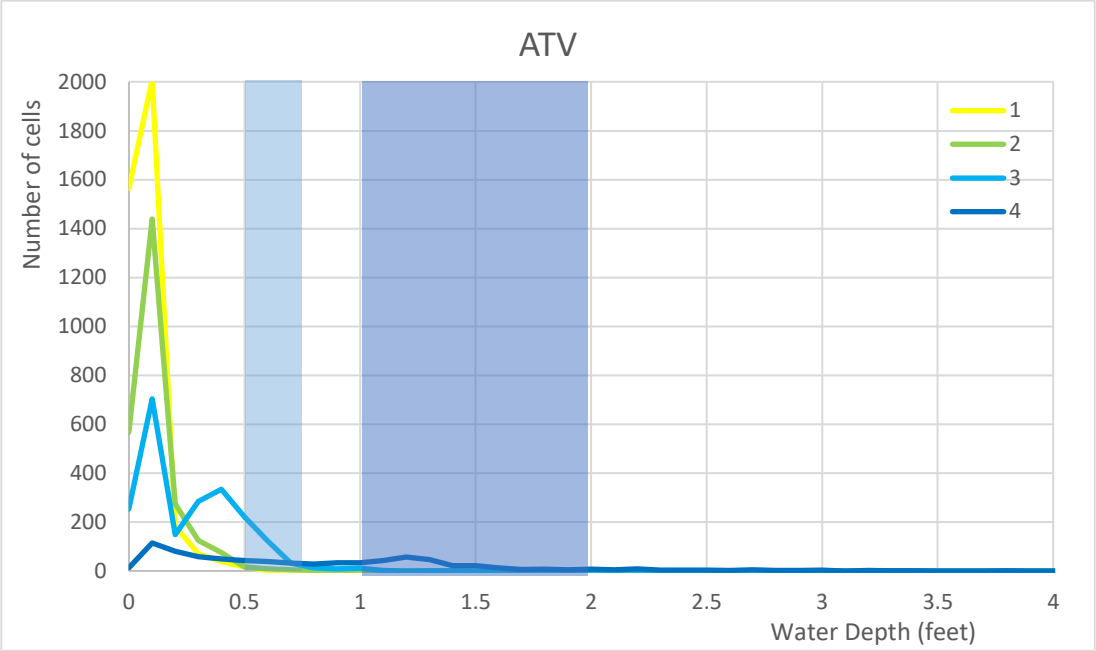
1
1.5
2
2.5
3
3.5
4
Water Depth (feet)
Hydrologic Rank
1
2
3
4


ATV
Number of cells
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Water Depth (feet)
1
2
3
4