APPENDIX I

COMBINED OPERATIONAL PLAN

SOCIOECONOMICS

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I.1 INTRODUCTION

The following sections will detail the analysis of the socioeconomic impacts of the various alternatives, including the preliminary preferred alternative (PPA), as those impacts pertain to the objectives, constraints, and planning considerations of the Combined Operational Plan (COP). Section 2 will describe the study areas specific to the economic impact analysis and the existing conditions therein (e.g. socioeconomic characteristics, land use), the method and sources for data collection, and an inventory of what is at-risk. Section 3 will outline the tools (i.e. models), methodology, and assumptions underpinning the evaluation. Section 4 will fully detail the no action plan as well as the various base conditions in order to characterize the starting point of the analysis as well as present a summation of economic findings for each of the alternatives investigated during the various distinct modeling rounds and provide an economic reference point for how the planning process evolved through each round of modeling.

I.1.1 Basis for Economic Evaluation

There are various planning objectives, constraints, and considerations under COP based on previous authorized studies which provide the framework and scope for this economic evaluation. The COP is an integrated operational plan for two modifications of the Central & Southern Florida (C&SF) project – known as the Modified Water Deliveries (MWD) project and the C-111 South Dade (C-111) project. The purpose of COP is to define the combined water management operations for the C-111 and MWD projects that would be consistent with their respective project purposes as defined by the authorizing legislation and further refined by subsequent general design memoranda (GDM) and general reevaluation reports (GRR). From these reports levels of flood damage prevention for the C-111 Project and flood mitigation for the MWD (8.5 Square Mile Area) are obtained and define the constraints under which COP must operate. The COP constraints are further described in Section 2.1.2 of the COP EIS, with full documentation of the infrastructure components and operational criteria provided in the Hydraulics and Hydrology Appendix (Appendix H), Annex 3 (Section H-3.3 and Section H-3.5). More specifically, the 1994 C-111 South Dade GRR, hereafter referred to as the Base94, defines the level of flood damage prevention required for the South Dade area and the 2000 8.5 Square Mile Area (SMA) GRR Record of Decision (ROD) establishes the flood mitigation constraints for the 8.5 SMA, hereafter referred to as the Base83 (both of these geographic areas are defined more clearly below in **Section I.2.1)**. The primary purpose of this economic analysis is to verify that these constraints are not violated with respect to the current land use in the study areas as was done under the previous authorizing document.

I.2 EXISTING CONDITIONS OF THE STUDY AREA

I.2.1 Study Area Defined

Since the COP must be concerned with several base conditions, there are two unique study areas which have been delineated with respect to each of these base conditions. The study areas discussed in this appendix are specific to the socioeconomic analysis and represent a subset of the broader study area detailed in the main report (i.e. these are the study areas specific to the socioeconomic impact analysis). The first study area contains assets of interest relating to the 94Base and is broken down into 11 watersheds, some of which were only partially analyzed due to their large eastern extent, which are captured in **Figure 2-1**. The second area, 8.5 SMA, is captured in **Figure 2-2** and is the portion of the study area containing assets relating to the Base83 condition, all of which are residential.

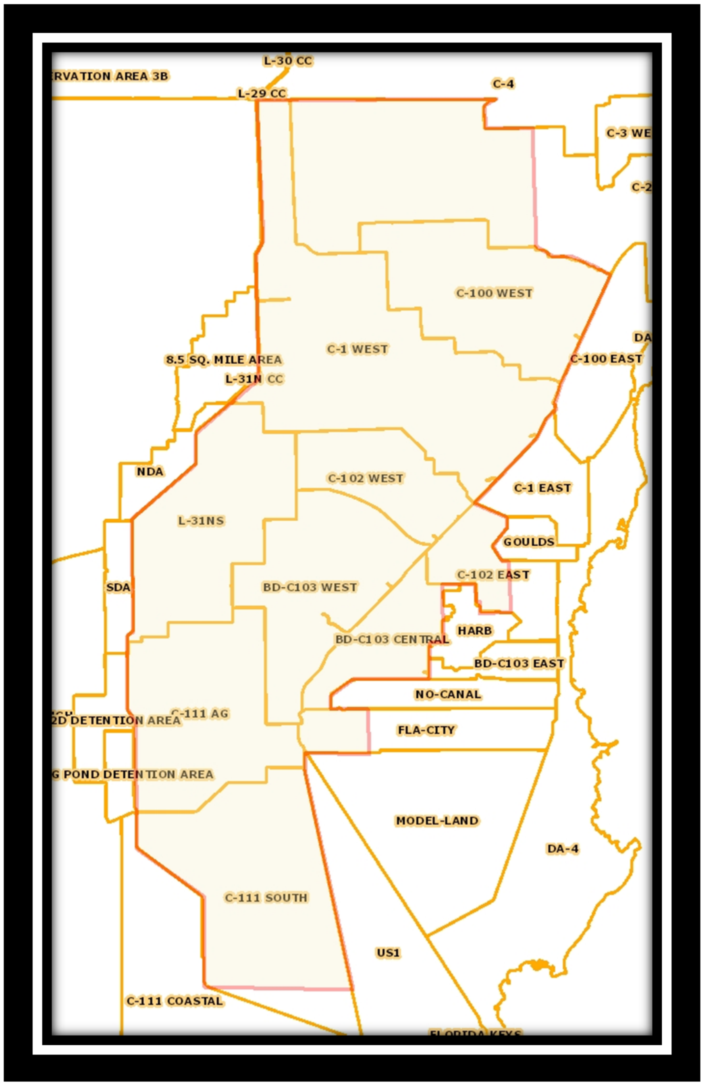

Figure 2-1: COP Study Area Governed by 1994 GRR Constraint

Figure 2-2: Study Area Governed by 1983 Base Condition – 8.5 Square Mile Area

I.2.2 Study Area Demographics – County Level[1]

All of the study area falls within the boundaries of Miami-Dade County, which has a population of 2.7M with a median age of 39.5. The majority of the population are Hispanic or Latino, making up over two-thirds of the total population followed by the second largest group, African American, which is approximately 16% (**Table 2-1**). The median household income is $46,338 with the largest percent of households (16.4%) earning between $50,000 and $74,999 (**Table 2-2**). The dominant employment sector of the county with one in every five worker employed is in educational, healthcare, and social assistance services followed closely by professional services (**Table 2-3**). At the county level agriculture only makes up 0.7% of total employment but plays a larger role in the COP analysis due to the proximity of agriculture parcels to water management features affected by COP (discussed in larger detail below).

[1] All tables and facts are from the 2017 American Community Survey, Census Bureau unless otherwise noted.

Total population	2,702,602	2,702,602
Hispanic or Latino (of any race)	1,823,038	67.5%
Mexican	61,903	2.3%
Puerto Rican	101,449	3.8%
Cuban	976,332	36.1%
Other Hispanic or Latino	683,354	25.3%
Not Hispanic or Latino	879,564	32.5%
White alone	371,233	13.7%
Black or African American alone	441,604	16.3%
American Indian and Alaska Native alone	2,344	0.1%
Asian alone	40,868	1.5%
Native Hawaiian and Other Pacific Islander alone	541	0.0%
Some other race alone	6,840	0.3%
Two or more races	16,134	0.6%
***American Community Survey 2017**		

Table 2-1: Demographic Summary of Miami-Dade County

INCOME AND BENEFITS (IN 2017 INFLATION-ADJUSTED DOLLARS)	Number	Percent
Total households	858,289	100%
Less than $10,000	85,270	9.9%
$10,000 to $14,999	54,740	6.4%
$15,000 to $24,999	105,104	12.2%
$25,000 to $34,999	91,222	10.6%
$35,000 to $49,999	118,778	13.8%
$50,000 to $74,999	140,674	16.4%
$75,000 to $99,999	87,953	10.2%
$100,000 to $149,999	92,102	10.7%
$150,000 to $199,999	36,256	4.2%
$200,000 or more	46,190	5.4%
Median household income (dollars)	46,338	(X)
Mean household income (dollars)	72,162	(X)
***American Community Survey 2017**		

Table 2-2: Income Summary of Miami-Dade County

Civilian employed population 16 years and over	1,272,735	1,272,735
Agriculture, forestry, fishing and hunting, and mining	8,760	0.7%
Construction	95,264	7.5%
Manufacturing	57,907	4.5%
Wholesale trade	49,068	3.9%
Retail trade	156,449	12.3%
Transportation and warehousing, and utilities	96,852	7.6%
Information	26,374	2.1%
Finance and insurance, and real estate and rental and leasing	97,119	7.6%
Professional, scientific, and management, and administrative and waste management services	164,530	12.9%
Educational services, and health care and social assistance	252,739	19.9%
Arts, entertainment, and recreation, and accommodation and food services	145,040	11.4%
Other services, except public administration	79,606	6.3%
Public administration	43,027	3.4%
***American Community Survey 2017**		

Table 2-3: Employment Summary of Miami-Dade County

I.2.3 Land Use and Inventory of the Study Areas

The two different study areas have specific land use types that were considered for the economic impact analysis. The South Dade area immediately adjacent to the L-31 Canal contains much of Miami-Dade's agriculture as well as considerable amounts of residential and commercial assets. The 8.5 SMA, west of the L-31 Canal, contained only residential assets. These land use types are more fully described and inventoried in the following subsections.

I.2.3.1 South Dade Land Use and Inventory - Agriculture

According to the 2017 Census of Agriculture, produced by the United States Department of Agriculture's (USDA) National Agricultural Statistics Service (NASS), Miami-Dade County is home to 2,752 individual farms operating on 78,543 acres of land. Of those acres 55,206 are cropland and, more specifically, 50,488 acres are harvested cropland. The market value of all agricultural products sold are $837.7 million, about 95% of which are from crops[2]. Farmers in the County also received $1.7 million in government payments[3].

During the formulation of the socioeconomic analysis for COP the detailed 2017 USDA census data was not available since the data tables were released in April of 2019 (i.e. after all three rounds of modeling, which are discussed below, had already been complete). However, 2017 parcel data was developed and available. As such, the 2017 parcel data specific to the broad category of land use (i.e. row crop, fruit crop,

[2] Including nursery and greenhouse crops

[3] Approximately 50 farms were recipients of government payments. Government payments consists of "payments from Conservation Reserve Program (CRP), Wetlands Reserve Program (WRP), Farmable Wetlands Program (FWP), and Conservation Reserve Enhancement Program (CREP); loan deficiency payments; disaster payments; other conservation programs; and all other Federal farm programs under which payments were made directly to farm producers, including those specified in the 2014 Agricultural Act (Farm Bill), including Agriculture Risk Coverage (ARC) and Price Loss Coverage (PLC)" (2017 American Community Survey, Census Bureau).

container crop, and in-ground nursery crop) was used for the spatial inventory for the socioeconomic analysis (i.e. used for measuring what and where items are at risk). Since the specific data on the type of crop grown from the USDA census (e.g. avocado, tomatoes, foliage plants) was not available the data that informed the assumptions of the analysis was from the 2012 USDA Census (i.e. valuation of at-risk assets). All tables within this report that show summaries of acreage and farms for specific crops are derived from the 2012 census unless otherwise noted. Crop types specific to the COP analysis were divided into three different categories: row crops (i.e. vegetable crops), fruit crops, and container crops. A fourth crop type, in-ground nurseries, was not included in the analysis due to its limited representation in the watersheds most impacted by COP (this decision is discussed in more detail in **Section I.3.1.1** below). **Figure 2-3** shows the overall composition of agricultural land use types in the South Dade study area based on the 2017 parcel data. Future changes in cropping patterns were not analyzed in this study as it is estimated that other market forces (e.g. future or present trade agreements, tariffs) will play a much larger role in land use decisions and therefore remain similar in the existing or alternative operating conditions. This is consistent with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (Watt, 1983).

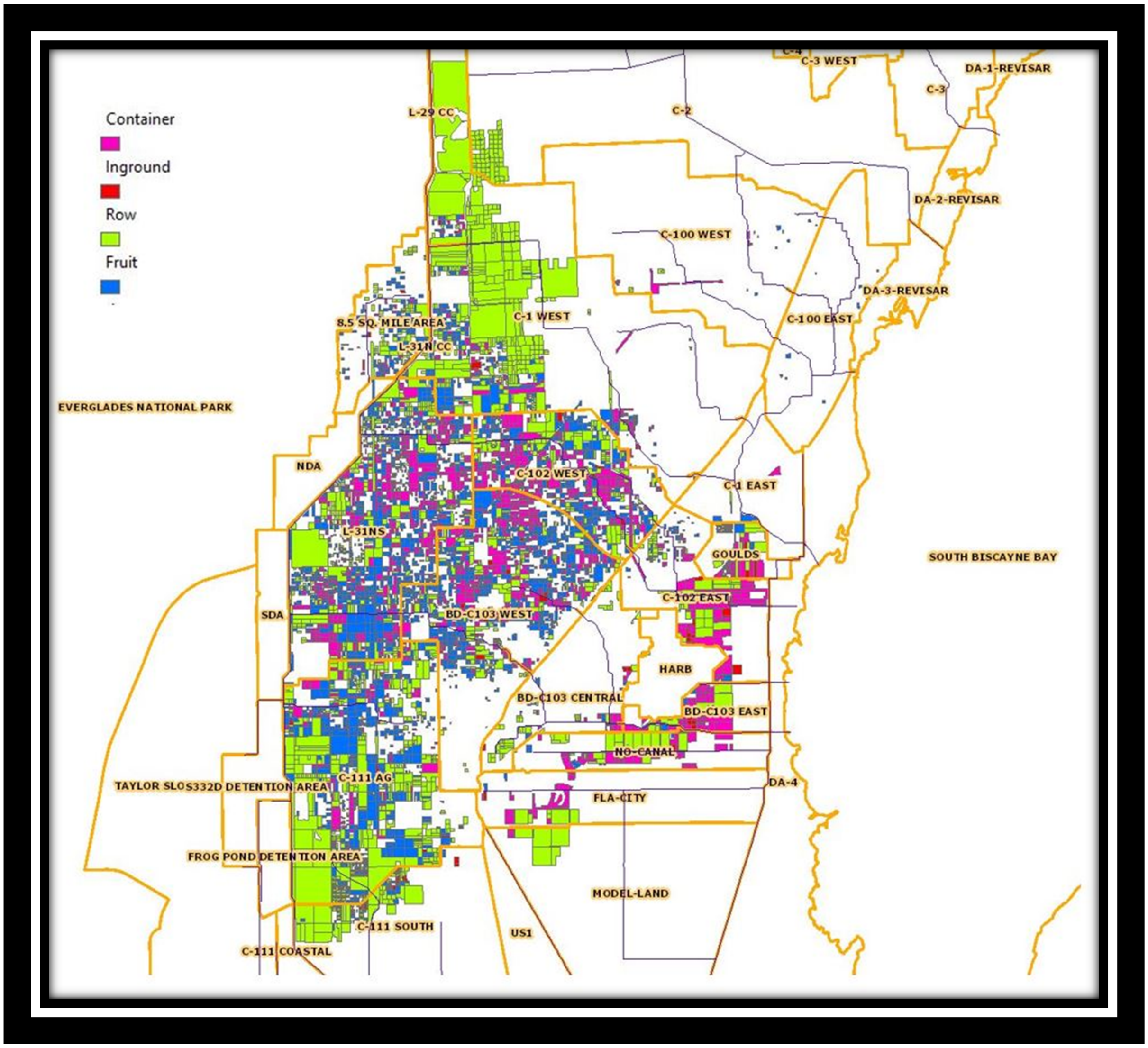

Figure 2-3: Crop Composition in the Miami-Dade County[4]

Table 2-4 below shows the breakdown of the specific vegetable crops grown in Miami-Dade County. These vegetable crops are the types of crops that show up in the parcel data sets as "Row Crops" (the lime green color in **Figure 2-3** above) and are aggregated as such. The primary vegetable crops grown include snap beans, sweet corn, squash, sweet potatoes, and tomatoes in the open which account for nearly 85% of all vegetable acres harvested.

[4] It is important to note that this image displays all crops in the county. This parcel file was later trimmed to match the boundaries of the study area as shown in **Figure 2-1** above in order to measure potential COP impacts more precisely. The parcel data was based on the 2017 census data.

Vegetable Crop Type	Acres[5]	Farms	% Total Acres
BEANS, SNAP (BUSH & POLE)	11,126	34	37%
SWEET CORN	5,252	11	17.68%
TOMATOES IN THE OPEN	3,809	31	12.82%
SWEET POTATOES[6]	2,825	7	10%
SQUASH, ALL	2,159	10	7.27%
OKRA	129	5	0.43%
EGGPLANT	41	7	0.14%
PEPPERS OTHER THAN BELL (INCLUDING CHILE)	41	3	0.14%
OTHER VEGETABLES	20	9	0.07%
COLLARDS	11	10	0.04%
CABBAGE, CHINESE[6]	9	6	0%
POTATOES	5	9	0.02%
HERBS, FRESH CUT	4	8	0.01%
LETTUCE, LEAF[6]	3	7	0%
TURNIP GREENS	3	4	0.01%
CARROTS[6]	1	4	0.00%
RADISHES[6]	1	4	0%
WATERMELONS	1	4	0.00%
CABBAGE, HEAD	D	11	D
CANTALOUPES & MUSKMELONS	D	2	D
CUCUMBERS AND PICKLES	D	5	D
MUSTARD GREENS	D	2	D

Vegetable Crop Type	**Acres**[5]	**Farms**	**% Total Acres**
ONIONS, GREEN	D	2	D
PEAS, GREEN SOUTHERN (COWPEAS) BLACKEYED, CROWDER	D	2	D
PEPPERS, BELL (EXCLUDING PIMIENTOS)	D	1	D
PUMPKINS	D	1	D
TOTAL VEGETABLES HARVESTED FOR SALE	**29,703**	**108**	**100%**

Table 2-4: Vegetable Crops Grown in Miami-Dade County[5,6]

Table 2-5 below shows the breakdown of fruit crops grown in Miami-Dade County. Though Florida is known for its citrus production, much of Miami-Dade's citrus crops were damaged by Citrus Canker between the years 2000 and 2005. Citrus Canker eradication was abandoned in 2006 when the USDA determined that 75% of commercially grown citrus was within five miles of a known canker infection, prompting the agency to place the entire State of Florida under quarantine (Lowe, 2009). By then, much of the citrus capacity was reduced and this impact can be seen today as only 2% of fruit crops are attributable to citrus fruits. The majority of specific fruit production in Miami-Dade County is comprised of avocado, bananas, guavas, and mangoes which account for over 75% of fruit acreage. Avocados alone represent nearly 60% of fruit crop acreage making it a dominant crop in the area. Combining row crop and fruit crop acreage, nearly 25% of all acres are avocado.

[5] Any crop marked with a "D" for acres indicates a crop where acreage is not specified due to proprietary exclusions.

[6] Data not available in 2012 census, 2007 USDA census used to approximate 2012 value.

Fruit Crop Type	Acres[5]	Farms	% Total Acres[5]
AVOCADOS	12,755	998	59.4%
OTHER NONCITRUS FRUIT	4,205	780	19.6%
MANGOES	1,803	399	8.4%
GUAVAS	1,270	112	5.9%
BANANAS	884	117	4.1%
PASSION FRUIT	62	12	0.3%
GRAPES	16	10	0.1%
PLUMS AND PRUNES	12	5	0.1%
PEACHES, ALL	4	8	0.0%
APPLES	3	10	0.0%
PERSIMMONS	2	3	0.0%
POMEGRANATES	2	8	0.0%
PAPAYAS	D	44	D
NONCITRUS, ALL (Subtotal)	**21,018**	**1,780**	**97.9%**
LIMES	234	19	1.1%
OTHER CITRUS FRUIT	149	64	0.7%
ORANGES, ALL	28	33	0.1%
OTHER ORANGES	26	30	0.1%
GRAPEFRUIT	12	14	0.1%
LEMONS	5	17	0.0%
VALENCIA ORANGES	2	7	0.0%
CITRUS FRUIT, ALL (Subtotal)	**456**	**127**	**2.1%**
All Fruit Crops	**21,474**	**1,907**	**100.0%**

Table 2-5: Fruit Crops Grown in Miami-Dade County

The parcel data available for download from the 2017 census made a distinction between in-ground nursery parcels and container crop parcels. Despite that distinction, the 2012 USDA Census data available combines all nursery crops. The majority of container nurseries consist of those producing woody and herbaceous ornamentals in containers in the open. A second type of container nursery included greenhouse and shade house nurseries producing foliage plants, orchids, bromeliads, and woody ornamentals for interiors. **Table 2-6** shows all of the nursery crops grown in Miami-Dade without a distinction between in-ground and container.

Nursery Crop Type	Acres in the Open	Farms	% Total Acres
AQUATIC PLANTS	11	7	0.08%
CUTTINGS, SEEDLINGS, LINERS, AND PLUGS	42	20	0.29%
FOLIAGE PLANTS, INDOOR (INCLUDING HANGING BASKET)	1,247	191	8.63%
POTTED FLOWERING PLANTS	385	109	2.67%
OTHER FLORICULTURE AND BEDDING CROPS	174	42	1.20%
NURSERY STOCK CROPS	12,584	643	87.12%
SOD HARVESTED	1	3	0.01%
Total	**14,444**	**1,015**	100.00%

Table 2-6: Nursery Crops Grown in Miami-Dade County

I.2.3.2 South Dade Land Use and Inventory – Residential

In addition to agricultural parcels, Miami-Dade County has a large contingent of land under use for residential and commercial purposes. Within the study area denoted in figure **Figure 2-1** there are 43,242 single-family parcels, 602 multi-family parcels, and 255[7] commercial parcels. An additional 214 single-family parcels are located in the 8.5 SMA (study area in **Figure 2-2**). Each of the parcels and the accompanying data were a part of the modeling effort which is described more fully in **Sections I.3.1** and **I.3.2** below. **Figure 2-4** displays the property points within the study areas for each parcel and are delineated by watershed. Parcel data in the form of geographic information system (GIS) shapefiles were obtained from the Miami-Dade County Office of the Property Appraiser. Data items included but were not limited to occupancy type, number of bedrooms and bathrooms, year structure was built, structure assessment year, depreciated replacement value, lot size, folio numbers, and X-Y coordinates. A key piece of inventory information for use in economic damage modeling, the first-floor elevation (FFE) of the structures, was absent from the shapefile. As a result a separate sampling effort was conducted to obtain FFE's from the various properties in the county using data from the Miami-Dade County Department of Regulatory and Economic Resources. Data collection required the use of elevation certificate searches based on folio numbers (i.e. unique identifiers for each parcel). In all, 3,704 FFE data were extracted since the collection process required manually extracting FFE for each structure one at a time. Most folios did not return search results for FFE's. However, given the large sample size available relative to the total population of structures in the inventory the FFE estimate is calculated to have a margin of error of 2% at the 99% confidence level. Additionally, a site visit was conducted on 14-15 March 2018 by two USACE economists to ground truth the elevation estimates. Specific attention was paid to the 8.5 SMA during the site visit. The breakdown of property type and stock of depreciated replacement value is presented in **Table 2-4** below. Note that this total valuation includes the 214 structures located within the 8.5 SMA.

[7] Though there are 255 commercial parcels, there is a higher number of commercial properties since there are instances in which many independently-owned or -operated buildings are located on a single parcel (e.g. a strip mall or retail outlet center). This phenomenon does not impact the analysis.

Property Type	Property Count	Depreciated Replacement Value (FY19)	Percent of Total Value
Multi-Family	602	$ 340,959,658	5%
Single-Family	43,456	$ 6,487,171,113	92%
Commercial	255	$ 205,990,959	3%
Total	***44,313***	***$ 7,034,121,730***	***100%***

Table 2-7: Residential Inventory of South-Dade Study Area[8]

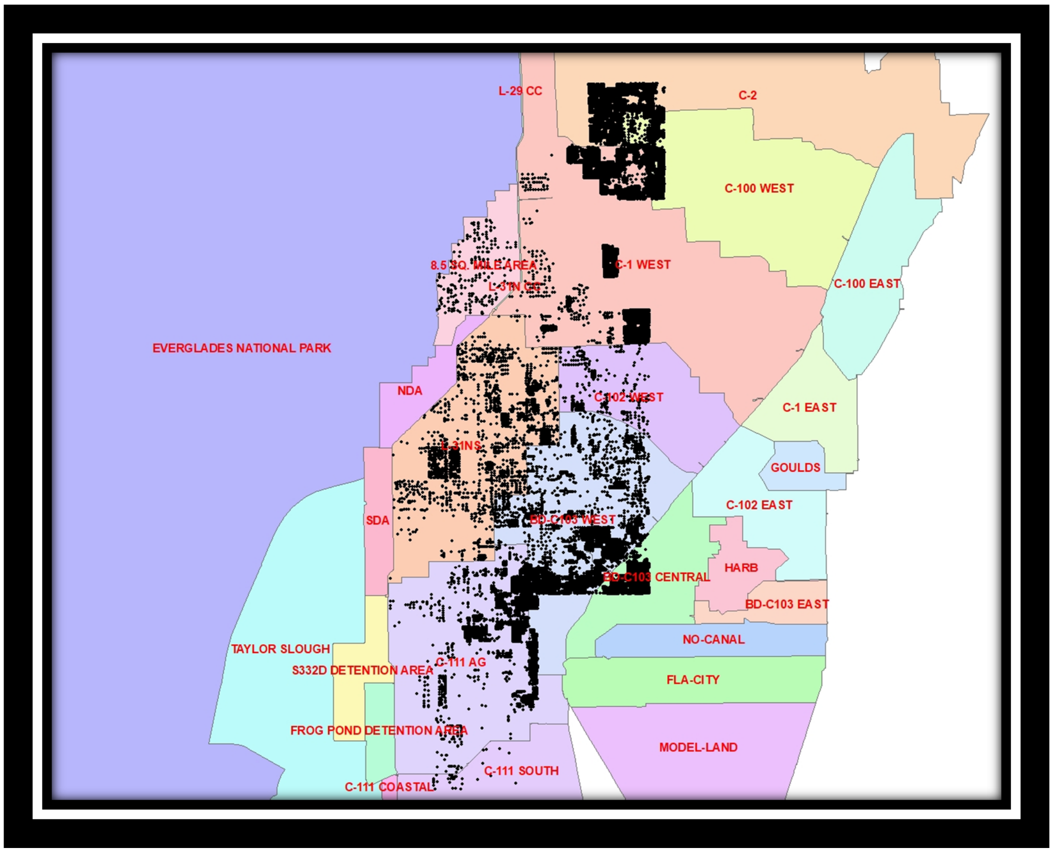

Figure 2-4: Residential and Commercial Properties in the South Dade and 8.5 SMA Study Areas

I.3 EVALUATION METHODOLOGY AND ASSUMPTIONS

As mentioned in **Section I.1.1** (**Basis for Economic Evaluation)**, the primary objective of the economic analysis for COP is to verify that constraints are not being violated while allowing for maximum environmental restoration of the PPA. The primary constraint for this analysis is the flood damage prevention constraint represented by the Base94 operating condition in the South Dade area and the flood mitigation constraint the 83Base operating condition in the 8.5 SMA. The 2019 existing condition

[8] Includes 214 residential structures within the 8.5 SMA

baseline (ECB19 or ECB19RR[9]) was used as a baseline for the planning consideration to explore opportunities to enhance flood control and mitigation (EIS Section 1.7), and to generally minimize flood risk in the South Dade area given consideration of historically-observed water management conditions. However, minimizing flood risk compared to the ECB19RR at the expense of environmental restoration was not considered. The existing condition is intended to represent conditions assumed in place at the time of implementation of the COP Water Control Plan in 2020. The existing condition assumptions are further described in Section 2.2.1 of the COP EIS, with full documentation of the infrastructure components and operational criteria provided in the Hydraulics and Hydrology Appendix (Appendix H), Annex 3 (Section H-3.2 and Section H-3.5). For the existing condition assumptions, which are in part derived from the Increment 1.2 and Increment 2 field test operational criteria, the typical operating ranges within the South Dade Conveyance System (SDCS) are moderately lower than the long-term levels experienced prior to the start of the MWD incremental field test (2012 Water Control Plan levels) for the L-31N Canal reach between G-211 and S-331 (lower by 0.2-0.3 feet), the L-31N Canal reach between S-331 and S-176 (lower by 0.2-0.3 feet), and the C-111 Canal reach between S-176 and S-18C (lower by 0.3-0.5 feet, due to 2016 changes to the SFWMD C-111 Spreader Canal permitted operational criteria). The SDCS primary canal operational stage ranges are provided in Table 4-33 of the COP EIS.

Economic performance measures (PMs) were established to specifically measure the potential impacts of the various alternative plans on flood risk management. The PMs assessed the severity and the spatial extent affected by the COP alternative scenarios based on (1) below-ground thresholds established by root zone impacts of the surrounding crop types (reference **Section I.3.1.1** for assumptions on root zone impacts); and (2) above-ground stage thresholds established by FFE's of the surrounding residential zones. There were three distinct rounds of modeling and the evaluation methodology evolved based on the round of modeling. The rationale for adjusting the evaluation is based on the fact that two different hydrologic models were utilized in the COP analysis and better model resolution allowed for a greater level of detail in later rounds (i.e. dollar damages to residential areas and crop types were estimated). Evaluation procedures and the assumptions underpinning them for each of the model rounds are discussed in the following sections. For overall context of the COP hydrologic modeling process and an overview of the RSM-GL and MD-RSM hydrologic models, the reader is additionally referred to the COP Hydrologic Modeling Strategy included in the Hydraulics and Hydrology Appendix (Appendix H), Annex 1.

The antecedent condition is imperative for understanding the concept of flood risk. The goal of the COP Socioeconomic Analysis and EIS with respect to flood risk is narrowly targeted to verify that constraints are not being violated. The framework for doing so has been pre-established by authorizing documents as abovementioned. As a result, a full range of antecedent conditions has been utilized in determining the flood risk impact under COP operations. 41-years of antecedent conditions were reviewed using the RSM-GL model and leveraged to identify flood risk under various alternative operations and is discussed in the following section (also refer to Section 4.14 of the COP EIS). The MD-RSM model was then utilized to determine flood risks at peak stages under specific annual conditions. These peak stages were heavily influenced and inseparable from the antecedent groundwater conditions leading up to said peak stage. Peak stages across the MD-RSM model domain were a composite of instantaneous maximum stages

[9] ECB19 and ECB19RR are used interchangeable throughout this appendix. The ECB19RR denotes the existing condition after a modeling adjustment was implemented between modeling Rounds 1 and 2 (discussed below). The differences between the two are not substantial and for narrative and explanatory purposes can be used interchangeably.

simulated within each wet, dry, or average year that was simulated. Further, using the MD-RSM model specific rainfall events (i.e. 10-year, 25-year, 100-year) were modeled to analyze flood risk under COP; these rainfall events were likewise influenced and inseparable from antecedent conditions. These concepts are more fully discussed in the following sections

I.3.1 Round 1 Modeling Methodology

The hydrologic model used was the RSM-GL model, which provided daily average water levels across a 41-year period of simulation. In using RSM-GL, neither the Base94 nor the Base83 (i.e. the constraints) hydrologic modeling results were available to be used as part of the screening-level socio-economics evaluations. As a result the alternatives were compared to the 2012 Water Control Plan (2012WCP; RSM-GL simulation name “ECB16R”) to somewhat approximate the long-term levels experienced prior to the start of the MWD incremental field test. The conditions under the ECB19 were also compared to the alternatives to explore opportunities for enhancing flood damage reduction and mitigation. Since the constraint operating conditions could not be verified during this round of alternatives it was considered a screening round to assist in the development of the alternatives to be carried into subsequent rounds where the constraint would be tested. For Round 1 modeling agriculture and residential impacts were examined in similar but different ways and will be discussed separately in the next two sub-sections. The analysis was done using a spreadsheet.

I.3.1.1 Round 1 Agriculture Methodology

The first step in determining how to proceed with the agricultural evaluation was to decide which watersheds to focus on spatially and then which crop types would be analyzed within those watersheds. To determine which watersheds would be used the L-31 canal was used as a reference point and the six watersheds nearest the canal, which contain roughly 80% of total crop acreage, were chosen based on best professional judgment as to those most at risk of being affected by the COP. In order to determine which crop types should be analyzed parcel data per watershed was reviewed and any crop type that represented less than 25% of the overall acreage was omitted. As a result, there was no in-ground nursery evaluation as each of the watersheds contained less than 25% of total acreage pertaining to in-ground nursery. The crop composition of the six selected watersheds are presented in **Table 3-1** to **Table 3-6** and the crop types selected per watershed are underlined.

L-31 NS Watershed		
Crop Type	Acres	% Total Within Watershed
CONTAINER NURSERY	*3,339.4*	*29.5%*
FRUITS/GROVES	*4,626.2*	*40.9%*
IN GROUND NURSERY	18.7	0.2%
ROW CROPS	*3,328.8*	*29.4%*
Total in Watershed	**11,313.1**	**100%**
Percent of Overall Study Area Acreage	**18.78%**	

Table 3-1: L-31 NS Watershed Crop Composition

C-111 AG Watershed		
Crop Type	Acres	% Total Within Watershed
CONTAINER NURSERY	910.3	7.6%
FRUITS/GROVES	4,120.4	34.2%
IN GROUND NURSERY	49.7	0.4%
ROW CROPS	6,953.8	57.8%
Total in Watershed	**12,034.2**	**100%**
Percent of Overall Study Area Acreage	**19.97%**	

Table 3-2: C-111 AG Watershed Crop Composition

C-102 WEST Watershed		
Crop Type	Acres	% Total Within Watershed
CONTAINER NURSERY	2,130.9	38.1%
FRUITS/GROVES	1,858.5	33.3%
IN GROUND NURSERY	64.1	1.1%
ROW CROPS	1,532.3	27.4%
Total in Watershed	**5,585.8**	**100%**
Percent of Overall Study Area Acreage	**9.27%**	

Table 3-3: C-102 West Watershed Crop Composition

BD-C103 WEST Watershed		
Crop Type	Acres	% Total Within Watershed
CONTAINER NURSERY	2,600.1	32.9%
FRUITS/GROVES	3,734.0	47.3%
IN GROUND NURSERY	126.9	1.6%
ROW CROPS	1,433.5	18.2%
Total in Watershed	**7,894.5**	**100%**
Percent of Overall Study Area Acreage	**13.10%**	

Table 3-4: BD-C103 West Watershed Crop Composition

C-2 Watershed		
Crop Type	Acres	% Total Within Watershed
CONTAINER NURSERY	-	0.0%
FRUITS/GROVES	-	0.0%
IN GROUND NURSERY	-	0.0%
ROW CROPS	705.4	100.0%
Total in Watershed	**705.4**	**100%**
Percent of Overall Study Area Acreage	**1.17%**	

Table 3-5: C-2 Watershed Crop Composition

C-102 West Watershed		
Crop Type	Acres	% Total Within Watershed
CONTAINER NURSERY	2,130.9	38.1%
FRUITS/GROVES	1,858.5	33.3%
IN GROUND NURSERY	64.1	1.1%
ROW CROPS	1,532.3	27.4%
Total in Watershed	**5,585.8**	**100%**
Percent of Overall Study Area Acreage	**9.27%**	

Table 3-6: C-102 West Watershed Crop Composition

The next important step in determining how to analyze the risk was determining a spatial subset of model cells for evaluation that best represented each watershed. The RSM-GL simulation period-of-record covers 41 years (1965-2005) using a daily time step. Water stage levels are estimated for each day across the entire spatial extent of the study area and are broken down by model cell. With roughly 6,700 model cells and 14,975 days in the period of record there were over 100 million potential data points to assess. As a result of this immense dataset, specific "indicator cells" were required to best approximate the impacts of the alternatives during Round 1 of modeling in order to reduce the spatial extent for the screening-level analyses. Specific indicator cells were selected in each of the abovementioned representative watersheds in the study area for both residential and agriculture. For the agricultural indicator cells four criteria were used:

1. **Density -** An indicator cell was selected with the highest density of the specific crop types needing to be analyzed (determined during step one above via the watershed crop compositions). In other words, if a particular watershed had row crop and fruit crops selected to be evaluated then a cell within that watershed with the highest density of acreage of row and fruit crops was selected. This allowed for each watershed to be evaluated based on highest density of risk. The indicator cell could potentially contain the highest density of row and fruit within a watershed but this was not always the case.

2. **Topography -** A second indicator cell was selected to evaluate the impact of topography. Each indicator cell that was selected based on the first criterion above was reviewed to determine its ground surface elevation. Then, the average ground surface elevation across the entire watershed was calculated to determine if the selected indicator cell was relatively high or relatively low. If the cell was relatively high, a contrasting cell with a lower elevation was selected while still ensuring that there was a high enough density of representative crop types within. In some cases the indicator cell selected based on the first criterion was near the average topography or there lacked an appropriately significant topographical variant to select and, therefore, not every watershed has an indicator cell based on this topographical criterion (review **Table 3-7** below to view which watersheds have topographical indicator cells).
3. **Existing Gauge -** Any cells within a watershed that had an existing real-time groundwater gauge associated with it was selected.
4. **RECOVER -** Cells that were used by the RECOVER (Restoration Coordination and Verification) team in previous studies to assess flood risk within South Dade were also selected. RECOVER is a multi-agency team of scientists, modelers, planners and resource specialists who organize and apply scientific and technical information in ways that are essential in supporting the objectives of the Comprehensive Everglades Restoration Plan (CERP). Since these cells had previously been used in other studies they provided a good reference point and they had already been extensively calibrated and the model bias already known. In some cases the RECOVER cells overlapped with a cell selected using one of the other three criteria.

From this process 22 indicator cells were selected in the six different watersheds. These indicator cells are displayed spatially in **Figure 3-1** with the corresponding RSM-GL cell ID in bold within the cell. The associated data for each indicator cell is presented in **Table 3-7**.

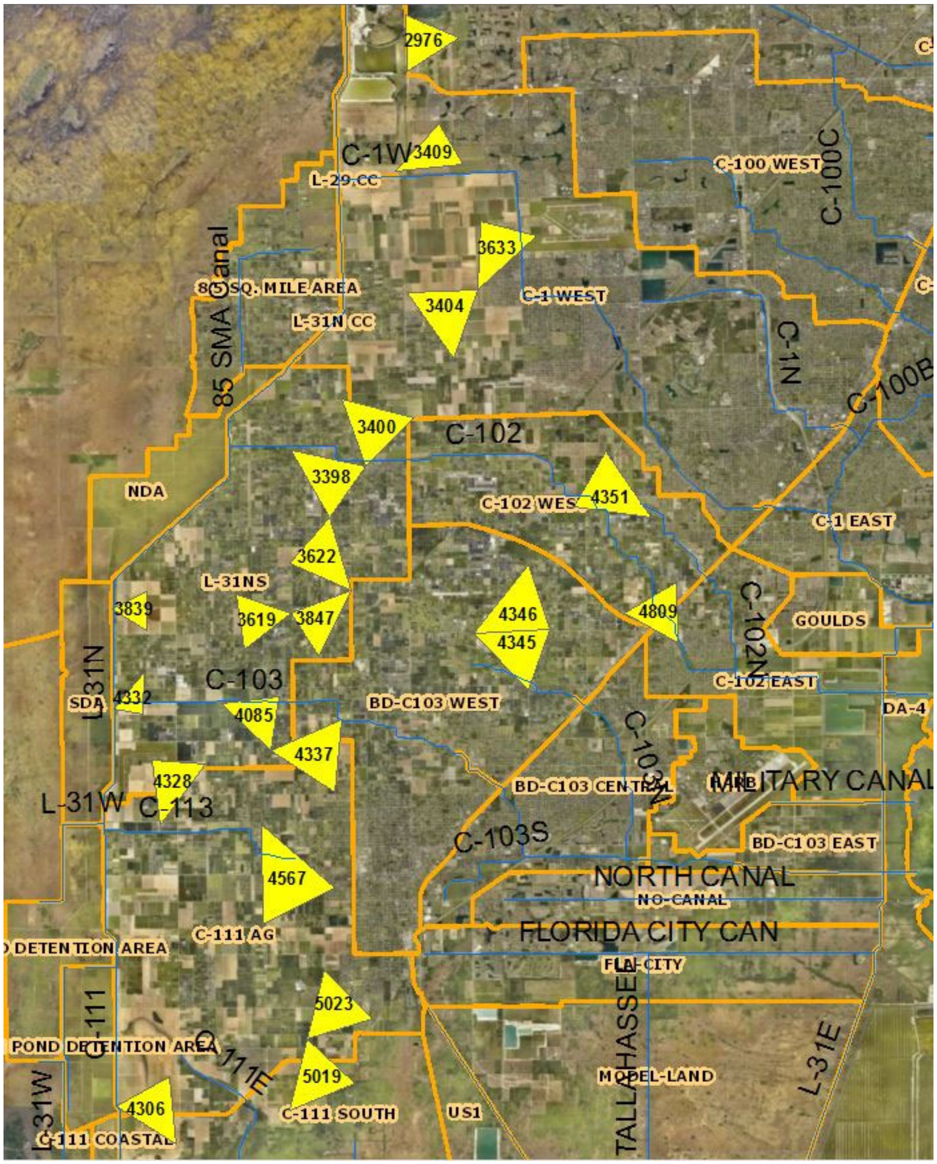

Figure 3-1: Spatial Representation of Indicator Cells

Selected RSM-GL Indicator Cell	Criteria Used for Selection	Watershed	Average Ground Surface Elevation of Watershed (Ft NGVD)	Ground Surface Elevation of Indicator Cell (Ft NGVD)	Crop Type(s) Represented in Cell
4345	Density	BD-C103 WEST	7.13	11.27	Fruit/Container
4346	Gauge	BD-C103 West	7.13	11.48	Fruit/Container
3404	RECOVER	C-1 WEST	9.18	9.33	Row/Fruit/Container
3409	RECOVER	C-1 WEST	9.18	7.75	Row
3633	Density	C-1 WEST	9.18	8.82	Row
4809	Density	C-102 WEST	10.62	9.94	Row/Container
4351	Density	C-102 WEST	10.62	9.70	Fruit
4306	Density & RECOVER	C-111 AG	5.72	5.76	Row
4337	Topography	C-111 AG	5.72	8.72	Row
4328	RECOVER	C-111 AG	5.72	6.51	Fruit/Container
4567	Topography	C-111 AG	5.72	7.38	Fruit
5019	Density	C-111 AG	5.72	5.55	Fruit
5023	Gauge	C-111 AG	5.72	6.86	Fruit
2976	Density & RECOVER	C2	8.62	6.52	Row
3400	Gauge	L-31 NS	8.87	8.57	Fruit/Container
3622	RECOVER	L-31 NS	8.87	9.32	Fruit/Container
3847	Gauge	L-31 NS	8.87	9.55	Fruit/Container
4085	Density	L-31 NS	8.87	8.66	Fruit
3398	Topography	L-31 NS	8.87	8.42	Container
4332	Density	L-31 NS	8.87	6.58	Container
3619	Topography	L-31 NS	8.87	9.35	Row
3839	Density	L-31 NS	8.87	7.41	Row

Table 3-7: Indicator Cell Data

In order to approximate the increased or decreased risk of damages to crops each of these indicator cells for every day in the period of record was examined for all of the alternatives as well as the ECB19RR and 2012WCP. Using a threshold stage level at which damage was assumed to occur (see **Footnote 12** for more information on determination of residential threshold level) each day was counted in which the estimated groundwater stage was above said threshold. Any instance in which an alternative had a day counted when the base condition did not was considered an increase in risk of crop damage. The results of these comparisons are summarized and described in the model result sections below. These results were used in conjunction with the results from the ecological sub-team's analysis of the proposed benefits from the alternatives to inform operational changes leading into modeling Round 2, which will be discussed in the following section. The goal of Round 1 was to eliminate any alternative which significantly increased flood risks over an alternative with similar environmental benefits.

I.3.1.2 Round 1 Residential[10] Methodology

For the residential approach a similar methodology was used. The first step was to determine the watersheds that would be the most impacted by the COP and to choose indicator cells that best represented the risk in the area. Again, watersheds nearest the L-31 Canal were chosen for analysis and 7 watersheds were selected (**Table 3-8**). Indicator cells were also selected but were only selected based on density and therefore there are only 7 residential indicator cells. The rationale for only selecting density-based indicator cells for Round 1 is that, given the fact that the COP is only using the existing water budget (i.e. not bringing more water into the system) it was estimated that aboveground (i.e. impacts to first-floors) risk would not be greatly increased. Additionally, a more robust risk analysis to residential was conducted during Rounds 2 and 3 as well as optimization Round 4 using synthetic storm events. The 7 indicator cells are shown graphically in **Figure 3-2**.

Basin	Residential Structure Count
C-2	30,438
C-1 West	29,850
BD-C103 Central	16,672
BDC-103 West	7,741
C-111 AG	4,136
L-31 NS	2,203
8.5 SMA	214

Table 3-8: Selected Residential Watersheds

[10] Residential zones include commercial properties but will be labeled simply as residential.

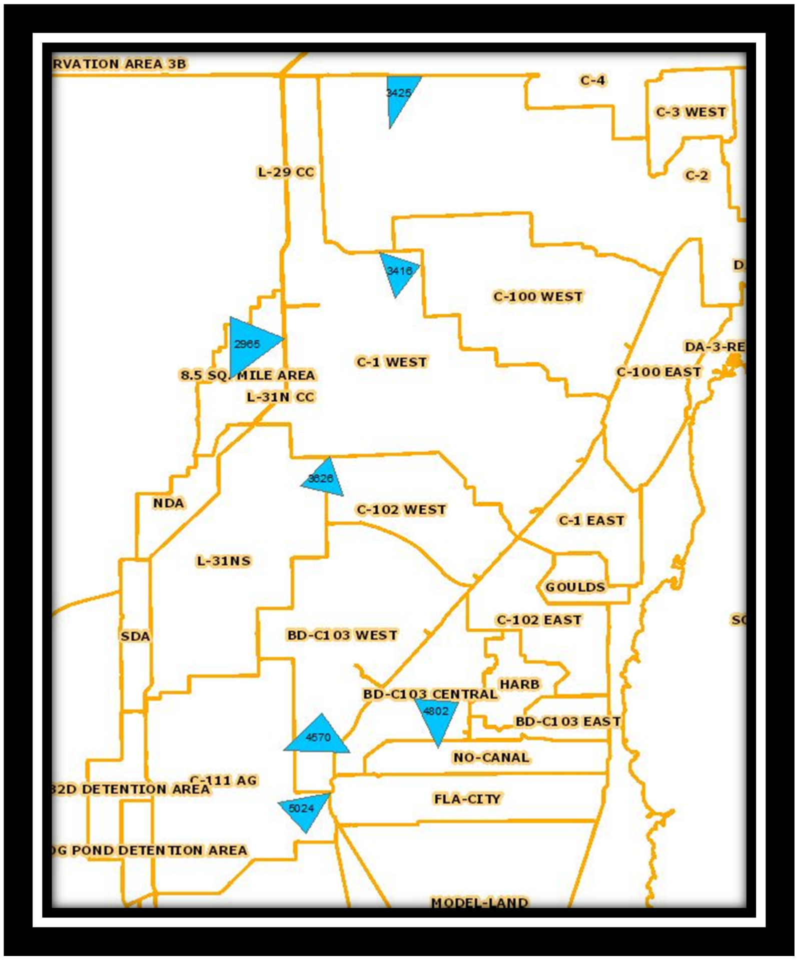

Figure 3-2: Residential Indicator Cells

Similar to the way in which agricultural impacts were analyzed each of these indicator cells for every day in the period of record was examined for all of the alternatives as well as the ECB19RR and 2012WCP. Using a threshold stage level at which damage was assumed to occur (see **Section I.3.1.1** for more information on determination of threshold levels) each day was counted in which the estimated groundwater stage was above said threshold. Any instance in which an alternative had a day counted when the base condition did not was considered an increase in risk of crop damage. The results of these comparisons are summarized in tables and can be found in **Section I.4.1.3** below. These results were used in conjunction with the results from the ecological sub-team's analysis of the proposed benefits from the alternatives to inform operational changes leading into modeling Round 2, which will be discussed in the following section. The goal of Round 1 was to eliminate any alternative which significantly increased flood risks over an alternative with similar environmental benefits.

I.3.2 Rounds 2, 3, and 4 Modeling Methodology

The hydrologic models used were both the RSM-GL and the MD-RSM. For the RSM-GL model, the exact same methodology outlined for Round 1 above was re-created in order to maintain consistency and provide a reference point for potential increases or decreases in risk compared to the alternatives modeled in Round 1 (Round 2 and Round 3 alternatives were each also simulated with the RSM-GL model).

The MD-RSM complementary simulation of the alternatives, which were available for the Round 2 and Round 3 alternatives, introduced the modeled constraint conditions and therefore allowed comparison of alternatives to the Base94 condition, the Base83, and the ECB2019. The MD-RSM simulation period covered a single wet, dry, and average year using a sub-hourly time step. This additional detail and the specific output provided by the model (i.e. a raster file with stage data at each cell across the entire spatial domain) allowed for an estimation of dollar damages using depth-damage functions (discussed more fully in **Section I.3.3.2.2**) for both agriculture and residential parcels. Based on dollar damages the project delivery team (PDT) was able to verify that constraints are not being violated by the alternatives (i.e. conditions for flood risk management are not worse than the Base94 or Base83 conditions). Since the MD-RSM model provided event-based (i.e. wet, dry, and average year) output instead of distinct storm events it was determined that the best economic model to use in order to estimate dollar damages was the Hydrologic Engineering Center's Flood Impact Analysis[11] (HEC-FIA) model. In Round 2, the ranking of alternatives was achieved by dollar-damage estimates. Again, the alternatives were specifically compared to the base conditions modeled in order to measure the alternatives against the planning constraints and considerations. By Round 3 it was assumed that the alternative modeled would be the Preliminary Preferred Alternative (PPA) and this alternative would be modeled against a set of design storm events in Round 4 to ultimately verify that the Base83 and Base94 constraints are met (note: Round 4 modeling of design storms was only conducted using MD-RSM, and no RSM-GL simulations were completed). The methodology used to develop the event-specific rainfall pattern for the design storms, which were updated for the MD-RSM wet year 2005-2006, is detailed in the Hydraulics and Hydrology Appendix (Appendix H), Annex 7.

I.3.3 Modeling Assumptions

The assumptions underpinning the modeling rounds were pivotal in addressing the risks to both agriculture and residential zones. The assumptions used during Round 1 (i.e. screening level) were used to inform the more detailed assumptions in Round 2.

I.3.3.1 Round 1 Modeling Assumptions

For Round 1 a groundwater stage threshold for agriculture and an aboveground stage threshold for residential was used and it was assumed that total damage to crop or residential was immediately incurred when the threshold was breeched (i.e. the damaging event is discrete). Once that threshold was breached, no further damage for consecutive days above the threshold were tabulated (i.e. damage cannot occur beyond the initial damaging event since it assumed to be complete). For an example on how these consecutive days were controlled and calculated within the data set see **Figure 3-3** where the 2012WCP had eight consecutive days above the 24" threshold but only counted as a single damaging event**.**

[11] HEC-FIA evaluates consequences from events defined by hydraulic model output such as gridded data (e.g., depth and arrival time Grids) or HEC's Data Storage System (HEC-DSS) Stage Hydrographs. The consequences HEC-FIA computes include economic losses (losses to structures and their contents), agricultural losses, and expected life loss from these hydraulic events. For COP purposes, only economic damage to structure/content and agriculture will be evaluated using the model. More information can be found at https://www.hec.usace.army.mil/

Example from raw data: 2012WCP, Sub-Basin C-1West, Cell 3409, Row Crop Evaluation

Date	Groundwater Stage	Cumulative Days Above 24"	Damage Count 24"
31Oct1965	-29.19	0	0
01Nov1965	-7.53	1	0
02Nov1965	-10.53	1	**1**
03Nov1965	-13.62	1	0
04Nov1965	-16.83	1	0
05Nov1965	-19.27	1	0
06Nov1965	-21.13	1	0
07Nov1965	-22.67	1	0
08Nov1965	-23.97	1	0

Figure 3-3: Round 1 Agriculture Damaging Event Defined

A single threshold for residential parcels, 18" aboveground, was used based on the preliminary[12] average FFE (as described in **Section I.3** for the properties in the study area. For agricultural parcels more detailed thresholds were required since the range of uncertainty as to when damages accrue was greater. Damage was estimated to occur when belowground stages entered root zones of the specific crop types described above (i.e. row, container, fruit). It was determined that the most appropriate approach was to set the threshold for the root zone of the most susceptible crop in each crop type since the exact location of a crop within a crop type was not known (i.e. the parcel data did not specify if a row crop was tomato or bean, nor did a fruit crop identify if it were mango or avocado). Data on the susceptibility and root zone depths of crops was collected to determine the appropriate thresholds. For container and fruit crops the threshold was a more straightforward determination whereas the threshold for row crops was more difficult to obtain.

Container crops were assumed to be kept in containers at ground level and thus the threshold was determined to be a stage of 0" belowground (i.e. at surface elevation). For fruit crops, avocados were the most susceptible crop since damage occurs within 24 hours of groundwater entering the root zone (Balerdi, Crane, & Schaffer). Avocado root zones extend 24" and are not commonly raised with a bedding height[13]. Therefore the threshold for fruit crops was assumed to be 24".

Row crops had a larger extent of uncertainty surrounding the damaging threshold. The soil on which row crops are generally grown tends to be of a slightly finer texture than fruit crops and is therefore subject

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[12] During Round 1 modeling the 3,704 FFE certificates had not been completely compiled and calculated, but those that had indicated 18" was a reasonable assumption height for all of the watersheds.

[13] Personal communication with Miami-Dade Agricultural Manager C. LaPradd (April 09, 2018).

to capillary rise. Capillary rise occurs when water travels upward through the soil due to the cohesive and adhesive properties of water molecules. Depending on many factors, such as soil texture and the duration of the elevated water table, subsoil water can rise as much as eight feet in finer texture soils (Franzen, 2016). It is unlikely that the capillary action in the study area will be as severe as eight feet since the soil is not extremely fine, but the level of rise is uncertain. Therefore, based on best professional judgment, several threshold values were selected for row crops which were 24”, 18”, 12”, and 2”. The 2” threshold was the most extreme threshold and was based on the average bedding height for crops minus the root zone depth of the crops (i.e. no capillary rise was considered) which, for the vast majority of the row crops in the study area, is 6” and 8” respectively (see **Table 3-9**). The other three threshold values were added to account for the potential of capillary rise and were therefore sensitivity measures of increased risk. Additionally, since most of the crops receive damage within 24 hours, the single day duration of the RSM-GL model was deemed appropriate. An important assumption for the agricultural analysis was determining how to analyze the seasonal nature of growing crops in Miami-Dade. Fruit and container crops are grown, sold, and harvested year round. The vast majority of row crops have a seasonal component and are not typically grown during the hydrologic wet season. However, there are some crops, such as the Boniato, which is grown countercyclical to the majority of row crops. As a result, during Round 1 there was no adjustment for seasonality.

Row Crop Type	Root Zone Depth (In)	Bedding Height (In)	Inundation Depth & Damage Duration Thresholds (Hrs.)
Beans	8	6	18
Boniato	8	6	24
Cabbage	8	6	18
Calalu	8	6	18
Chives	8	6	18
Corn	8	6	18
Eggplant	8	6	18
Herbs	8	6	18
Malabar Spinach	8	6	18
Malanga	8	6	18
Mixed Field Crops	8	6	18
Okra	8	6	18
Peppers	8	6	18
Pole Beans	8	6	18
Potatoes	8	6	24
Soybean	8	6	18
Squash	8	6	18
Strawberries	8	6	18
Sugar Cane	8	6	18
Sunflowers	8	6	18
Sweet Potato	8	6	24
Tomatillo	8	6	18
Tomatoes	8	6	18
Leaf Crops	8	6	18
Calabaza	8	6	18
Cucumbers	8	6	18

Sources: Institute of Food and Agriculture Sciences (IFAS) (Degner, Stevens, & Morgan, 2002) & C. LaPradd, (Personal Communication, April 09, 2018)

Table 3-9: Row Crop Susceptibility and Root Zone Data

I.3.3.2 Rounds 2 and 3 Modeling Assumptions

With the introduction of a new hydrologic model (MD-RSM) and a new economic model (HEC-FIA) as discussed above, it was important to further refine the economic assumptions to be more in line with the higher resolution modeling tools. Though Round 1 modeling was a screening level effort, the process and all assumptions stated above for Round 1 were repeated during Rounds 2 and 3 for a directly relevant comparison of the alternatives that were each simulated again with the RSM-GL model (i.e. to show the direct changes resulting in the operational changes from Round 1 alternatives to Round 2 and 3 alternatives). How assets were damaged (e.g. damage functions, dollar damage calculation), where assets were damaged (i.e. spatial resolution), when assets were damaged (i.e. period of record) all differ using the MD-RSM and HEC-FIA modeling during Rounds 2 and 3 and will be specifically detailed in the following subsections. It is important to note that the assumption creation and modeling was an iterative process so a small change occurred from Round 1 to Round 2, but the assumptions documented in the below sections outline those used for the final modeling of the PPA. The damage functions for the agriculture analysis changed slightly from Round 2 to Round 3. Since the comparisons are on a round-by-round basis and not across rounds, the small change does not impact PPA selection.

I.3.3.2.1 Spatial Assumptions

In using HEC-FIA indicator cells were no longer necessary since a raster file containing each cell in the domain was made available. The model cells were snipped from the entire domain to allow for smoother running capacity as well as to eliminate noise from the results. Best professional judgment was used in order to select the modeling cells that would remain for the economic analysis and a wide net was cast in order to capture all potential effects of the COP alternatives. In total, 14,574 cells were modeled spanning a distance of approximately 36 miles from north to south and approximately 18 miles east to west (see **Figure 3-4** for the light blue polygons detailing the modeled cells). The residential structures and agricultural parcels that fall within the modeling domain are the same as expressed in **Figure 2-4** and **Figure 2-3** above. Economic modeling reaches were then created for use in HEC-FIA in order to aggregate flood risk impacts. The economic modeling reaches were based on the MD-RSM modeling reaches but were further dissected in order to avoid over aggregation of potential flood risk impacts. The result was 11 economic modeling reaches as shown in **Figure 3-5**. Important to note, the 8.5 SMA area was specifically segmented as its own modeling reach since it is governed by a different base condition, the Base83, than the other modeling reaches within South Dade which are governed by the Base94 condition. The Base83 was only run for comparison purposes for properties within the 8.5 SMA modeling reach.

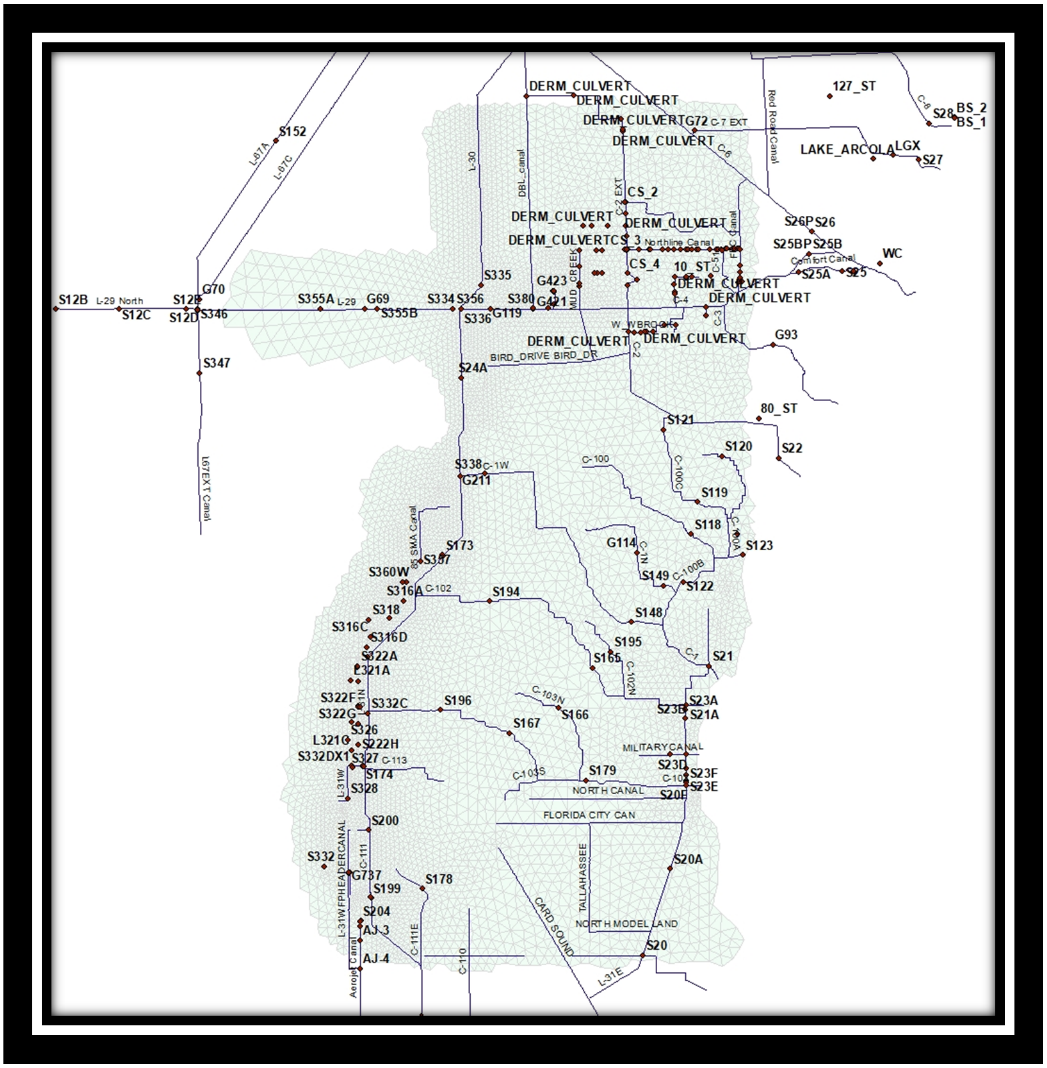

Figure 3-4: Selected MD-RSM Modeling Cells for Economic Analysis[14]

[14] The points with labels in the graphic refer to water management structures within the study area.

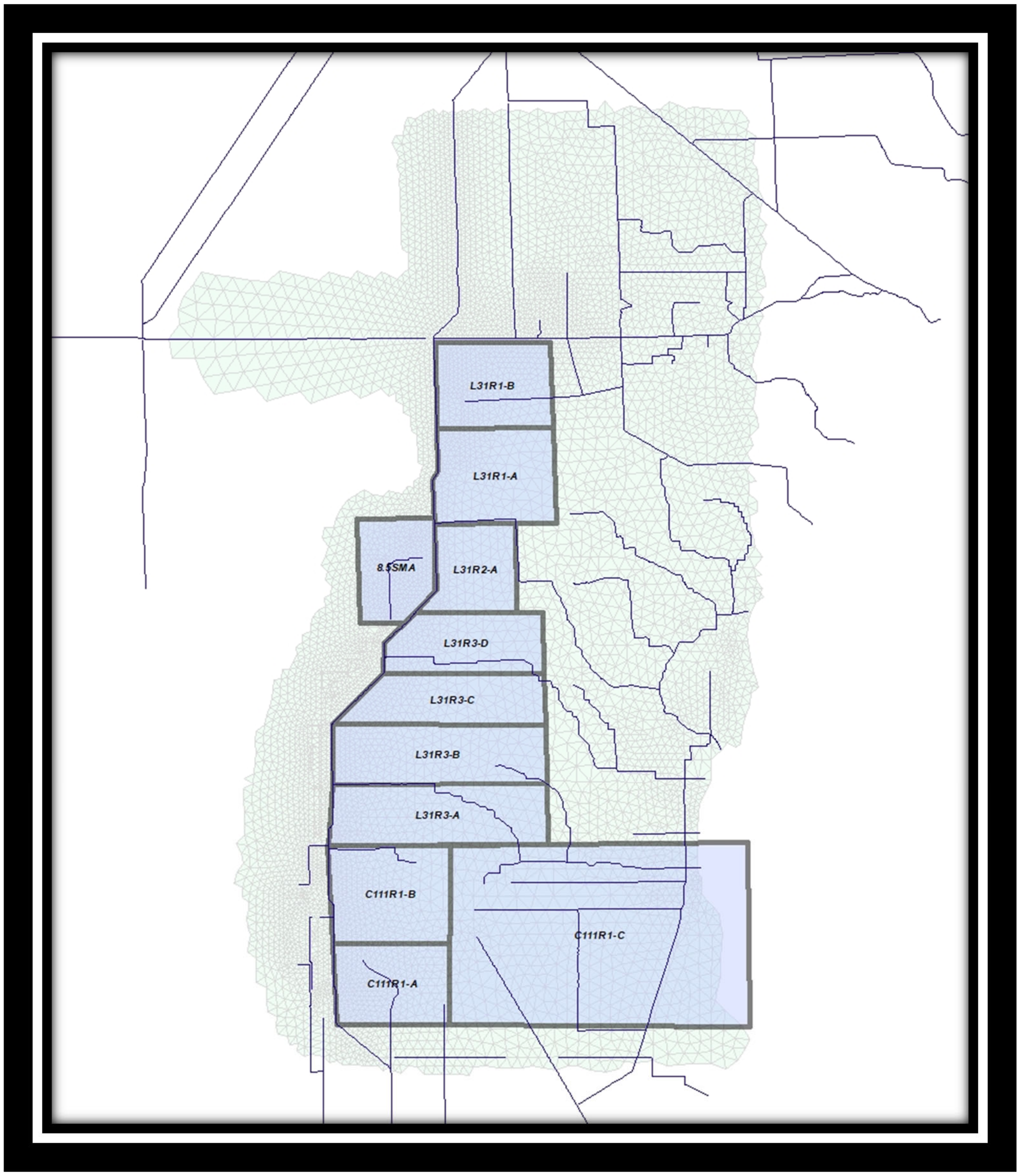

Figure 3-5: HEC-FIA Economic Modeling Reaches[15]

I.3.3.2.2 Dollar-Damage Parameter Assumptions

The first step in estimating the dollar damages in the study area was to assign a value to each asset that would be modeled. For residential assets the valuation was a more straightforward process. Each asset that was pulled from the Miami-Dade County Office of the Property Appraiser included a depreciated replacement value which was used directly in the modeling efforts. However, agricultural parcels did not

[15] It is important to note that this is the finalized set of reaches modeled in the HEC-FIA model. During Round 2 (see I.4.2.3 below) there was a larger spatial extent modeled with more reaches than are pictured in this Figure. Much of the additional spatial extent modeled under Round 2 was considered noise and was condensed to form these finalized reaches used during Rounds 3 and 4.

have a valuation but did include an acreage estimate. In order to derive the valuation the PDT economists pulled data from University of Florida IFAS Cost and Return Analysis Tool as well as the IFAS Electronic Data Information Source (EDIS)[16] on the yields per acre and average wholesale prices of the various crops grown within the study area. Since data on the exact crop grown within a given crop type did not exist, it was necessary to formulate a weighted average for each crop type (row, fruit, container) given the information gathered from the Cost and Return Analysis tool. The specific weight given to a crop was based on the crop composition from the 2012 USDA Census as shown in **Table 2-4**, **Table 2-5**, and **Table 2-6**. The weighted value per acre was then multiplied by the number of acres within that parcel in order to obtain the overall value of crops grown on that specific parcel. An additional adjustment factor was required for the acreage calculation. The parcel file contained the overall acreage of the entire parcel polygon which included things such as roads, houses, farms, fencing, and drainage ditches. These additional acres within a parcel where crops were not actually grown had the potential to overstate the value of a given parcel and therefore an adjustment factor was applied. The adjustment factor was measured using GIS imagery on a sample of parcels from each of the crop types whereby the acres consumed by roads, farms, houses, etc. were subtracted from the overall acreage and an average ratio determined from these measurements. The factor was then applied to all parcels in the dataset to arrive at an "acres utilized" calculation. Thus, the final valuation of a crop within any given parcel was calculated by $Weighted\ Value\ per\ Acre \times Acres\ utilized = Total\ Crop\ Value$. The acre adjustment factors and weighted value per acre for each of the crop types that gave rise to the valuation are displayed in **Table 3-10** along with some of the statistics from the COP dataset.

Crop Type	Weighted Value Per Acre[17]	Acre Adjustment Factor	Parcel Count	Total Value of All Parcels
Row Crop	$ 6,484	0.87	1,752	$ 138,320,000
Fruit Crop	$ 10,267	0.77	2,407	$ 116,969,000
Container Crop	$ 10,000	0.73	1,311	$ 57,705,000

Table 3-10: Crop Type Value Determinants

The next step in determining dollar damages was assigning specific damage functions to each of the distinct residential occupancy types and crop types within the HEC-FIA model. Again, residential application proved straightforward since there were standard, approved, off-the-shelf functions available

[16] The Cost and Returns Analysis Tool is an interactive tool created by the University of Florida's Agricultural Economics Extension Program. Information on this tool and the program can be found at http://agecon.centers.ufl.edu/index.html.

[17] Container crop production numbers and wholesale prices were not readily available due to the large variance in the crops stocked amongst producers and the lack of overall data on container crops. The weighted value per acre was derived from personal communications with three large container operators in the study area who were asked to provide a valuation on the total inventory of their nursery. This data was provided on condition that the values were not published due to proprietary concerns. The total inventory valuation was divided by the acreage of the three operators to determine the average value. This should be considered a rough order of magnitude valuation but is still useful in comparison of risk estimation across alternatives.

for use. For the residential COP modeling the 1992 IWR Damage Functions (Davis & Skaggs, Catalog of Residential Depth-Damage Functions, 1992) were used and for non-residential structures the 2013 IWR Damage Functions (Davis, Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation, 2013) were used.

For agricultural damages, no such standard curves exist. As a result, the expert elicitation from the interagency COP Flood Risk Sub-Team[18] that was instrumental in determining the damaging thresholds during Round 1 was used to estimate damage functions for the various crop types. Factors such as, but not limited to, capillary rise, weighted distribution of specific crops, and the potential for crop rotation were considered in the creation of the crop damage functions. Since there are no standard curves, nor is there a substantial body of scientific evidence that gives rise to a quantifiable depth-damage curve, for the crop types in the study area these new depth-damage curves involve a lot of risk and uncertainty in the damages that they will estimate. However, the risk and uncertainty is constant in each of the base conditions as well as in each of the alternatives which allows for a direct and reasonable comparison. The damage estimates in COP resulting from the HEC-FIA modeling are not being used to economically justify any infrastructure or alternative that involves an increase in costs (i.e. no benefit-to-cost ratio is being calculated) but instead are being used to verify the constraints and risk potential for each alternative. The final dollar-damage estimation to crops that arrives from the COP modeling should not be used as an actual determination of dollar damages given a particular operational scheme but should instead be viewed as a proxy for increased and decreased risk among crop acreage that arises from changes (i.e. between base conditions and alternatives) in the operational scheme. The selected damage functions for Fruit, Row, and Container Crops are presented **in Figure 3-6, Figure 3-7**, and **Figure 3-8**.

[18] Agencies involved in the Flood Risk Sub-Team include Florida Department of Agriculture and Consumer Services (FDACS), South Florida Water Management District (SFWMD), Miami-Dade County, United States Department of the Interior (DOI), National Park Services, and USACE.

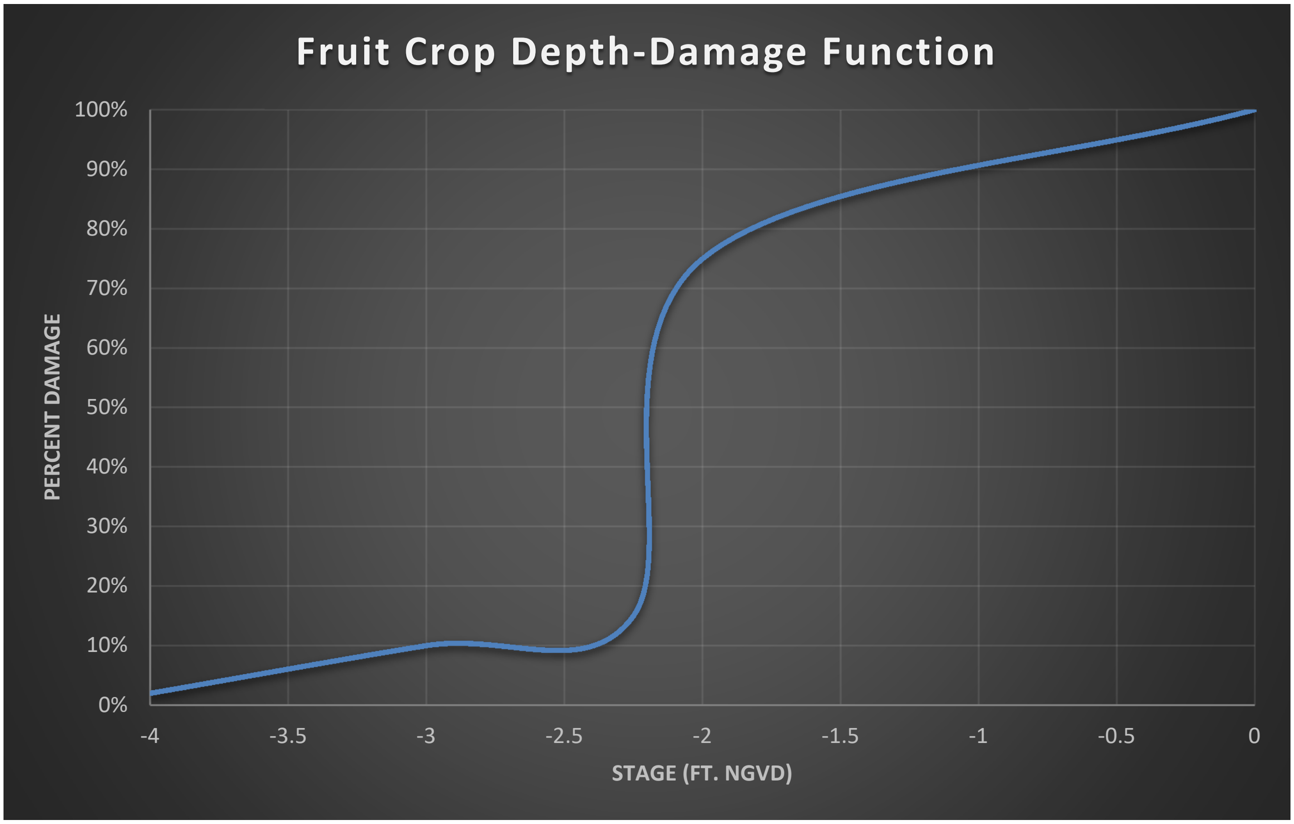

Figure 3-6: Fruit Crop Depth-Damage Function

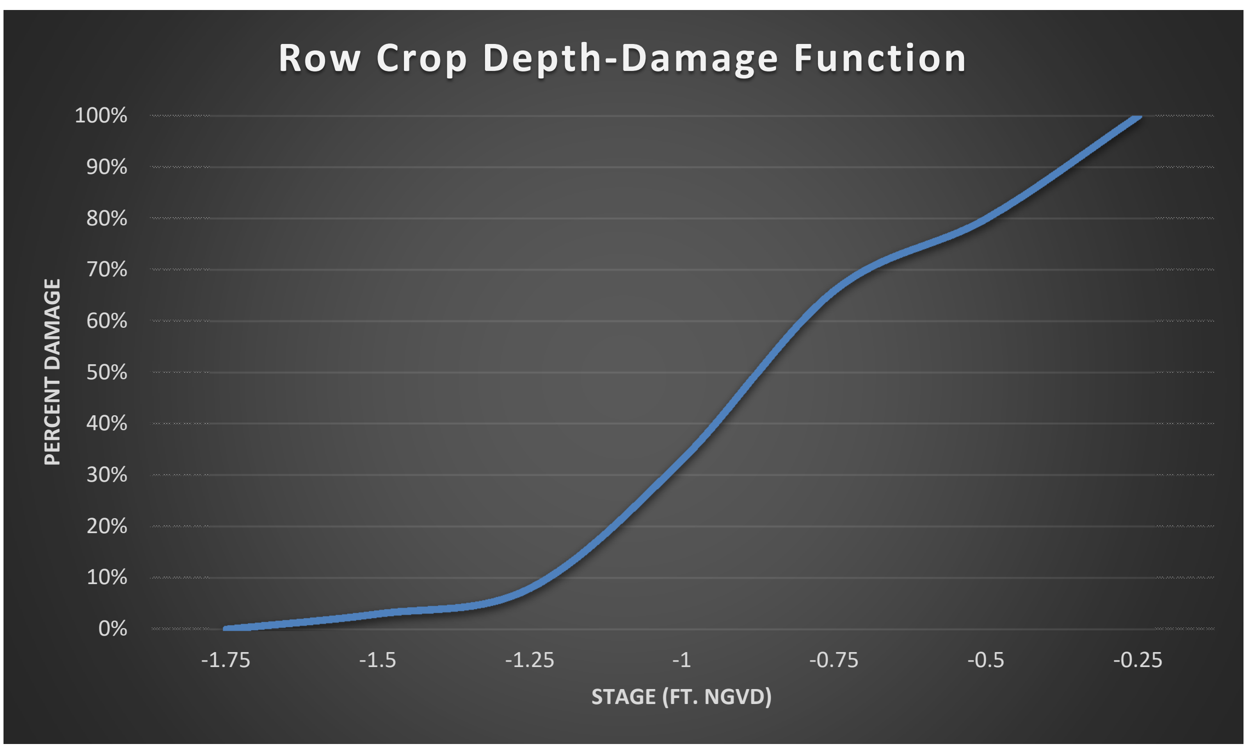

Figure 3-7: Row Crop Depth-Damage Function

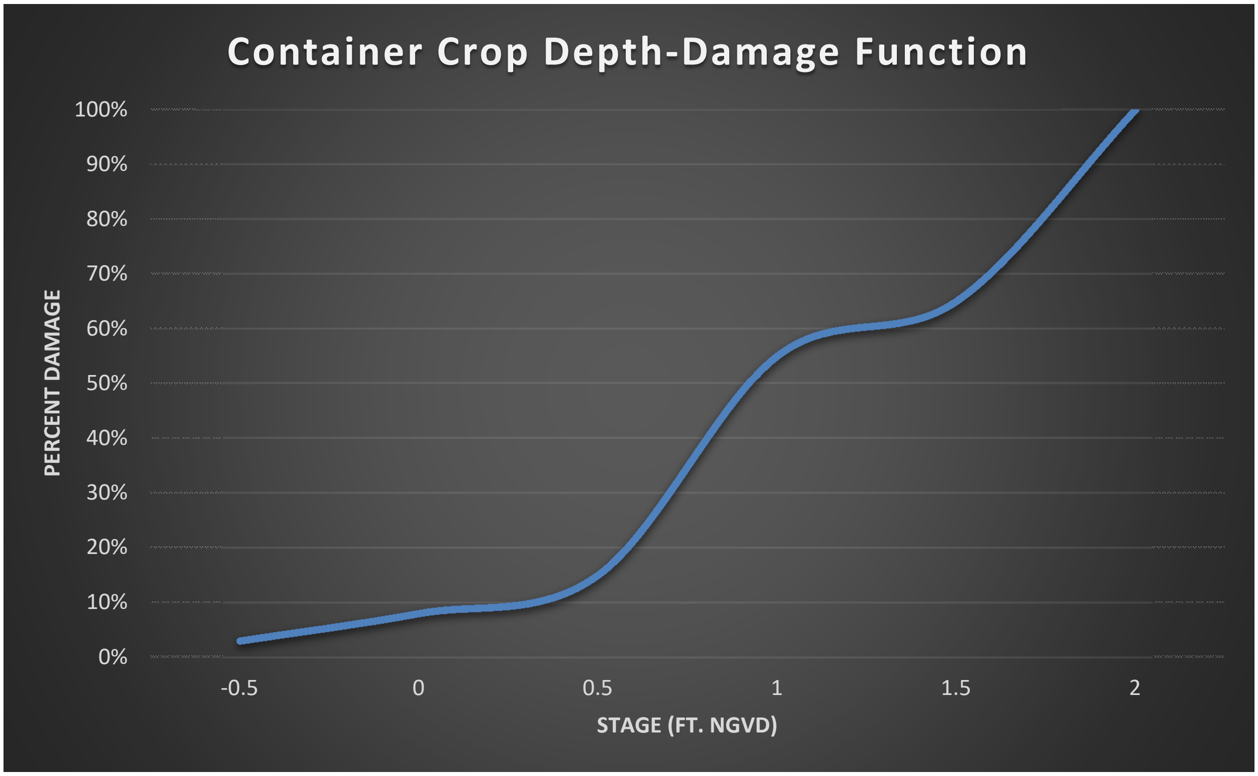

Figure 3-8: Container Crop Depth-Damage Function

I.3.3.2.3 Temporal Assumptions

During Round 1, the RSM-GL hydrologic model produced an averaged stage output on a daily basis. With the MD-RSM model during Round 2, a larger array of outputs within a year was made possible by the sub-daily (15 minute) time step. Though the period of record was less lengthy by using a single wet year, dry year, and average year versus a 41-year period of record, there were still more data points to review (105,120 versus 14,975 individual stages computed per base condition and alternative) due to the shorter MD-RSM model time step. As mentioned previously, the HEC-FIA model is an event-based model so a decision needed to be made on which out of the 105,120 total possible discreet stage computations would be used to estimate damages for comparison across all operating conditions.

For residential computations, much like all other assumptions in the COP process, the decision was more straightforward. The peak stage in each of the three years (wet, dry, average) would be modeled at each property point to estimate economic damages. The rationale for choosing the peak stage is simple: if a home is damaged by a lessor (i.e. lower stage) event at a different time in the year, whether before or after, it would be inconsequential compared to the peak stage damages that would accrue. A key assumption underpinning the use of the peak stage is that a residential property would not be fully rebuilt or repaired following the peak stage event within the same calendar year. This assumption is confirmed by historical observations related to the lengthy time in which peak flood waters recede and the accompanied lengthy process of insurance claim and collection in order to rebuild or repair a damaged property.

For agricultural damage computation, the timing consideration was more nuanced. The level of damage that accrues at a peak stage is less certain since there is a damaging duration threshold per specific crop (as detailed in **Section I.3.3.1**). However, most crops, especially those most susceptible to flood risk, had a damaging duration threshold of around 24 hours. As such, damages for two different stages for each of the three MD-RSM simulated years was calculated: 1) Peak stage damages and 2) 24 hours post peak stage damages[19]. Estimating damages 24 hours after peak stage also allows for a comparison of the immediate post-event recession rates of the stages amongst the alternatives. It is likely that measuring instantaneous peak stage damages will overstate the damages, due to the duration threshold for each crop, but by estimating damages 24 hours later this effect is somewhat mitigated.

I.3.3.2.4 First-Floor Elevations

Section I.2.3.2 detailed how the 3,700+ FFE certificates were pulled and recorded. Those FFE's were entered into the parcel details within the COP GIS database and compared to the MD-RSM model cell elevation containing the individual parcel in order to calculate a foundation height (i.e. the first-floor elevation relative to the ground-surface elevation). Each watershed was assigned its own average foundation height if a significant enough sample size came from that watershed. If a watershed did not have enough certificates to have a significantly significant sample size, such as the 8.5 SMA which had very limited certificates on file, then the average from all structure types across the entire project area domain was used. It is important to note that some of these regions are in FEMA flood zones and are required by code to be built 2 feet above the base flood elevation (BFE). One such reach with many parcels falling within the FEMA flood zone was the 8.5 SMA which had a BFE of 8 feet NGVD, which meant any homes built after 1994 needed to have a minimum 10 feet NGVD FFE. However, homes built prior to that date may be grandfathered in and considered non-conforming structures. As a result, the 10 feet NGVD FFE was not used, but instead the average from the entire project area domain was used in order to conservatively estimate the risk to the area. If a nonconforming home in that FEMA zone were to incur damages of greater than 50% of assessed value, it would be required to be rebuilt to code (i.e. raised elevation to 2 feet above BFE). The average foundation heights used in the HEC-FIA model are found in **Table 3-11**.

[19] 24 hours post peak stage was only modeled for the PPA in Round 3 and the optimization round when design storms were added.

Watershed	Average Foundation Height (Feet Above Ground-Surface)
8.5 SMA	2.6
BD-C103 Central	1.41
BDC-103 West	2.36
C-1 West	1.86
C-100 West	3.15
C-102 West	2.42
C-111 AG	3.2
C-2	3.8
L-31 NS	2.54

Table 3-11: Average Foundation Heights by Watershed

I.3.3.3 Optimization Modeling Round (Round 4)

After a PPA has been selected during Round 3 modeling, the PPA will be evaluated using all of the same assumptions during Rounds 2 and Rounds 3 with the introduction of design storm events that will be modeled in the HEC-FIA economic model. Due to scope and schedule constraints, only three design storms were selected to model: 10-year, 25-year, and 100-year events. By adding those three design events to the already modeled wet year, dry year, average year estimations with the PPA, a full suite of stages will have been measured throughout the COP process. The Round 3 and design storm modeling will also fulfill the Corps' requirement from the C-111 Limited Reevaluation Report (LRR, November 2016) to update the economic analysis performed during the 1994 GRR during development of the C-111 South Dade operational plan (now integrated into the COP).

I.4 MODELING RESULTS

The following sections will detail the results that came out of each round of modeling as they pertain to the economic analysis. The no action alternative (ECB19RR) and the 2012WCP will be compared to the alternatives formulated in each round as will be the base conditions when available (Rounds 2 and beyond). At the conclusion of each modeling round the various members of the COP interagency PDT met and discussed all of the results and collectively made decisions on how to adjust the alternatives for modeling in each subsequent rounds. The COP Flood Risk sub-team also evaluated each of the alternative simulations consistent with the methodology detailed in this Appendix, and the sub-team recommendations were integrated within the broader COP interagency PDT formulation process. This socioeconomic appendix will not go into detail on the decisions made and the specific operational changes from one alternative to the next since they are detailed in other sections of the COP EIS report. The purpose of the following sections of the appendix is to demonstrate the analysis done on the alternatives which informed each subsequent round of alternative creation with specific respect to flood risk. Additionally, the sections will detail the alternative's impact on the various stakeholders (i.e. residential and agricultural) as well as the primary goal of ensuring constraint compliance.

I.4.1 Round 1 Modeling Results[20]

I.4.1.1 Round 1 Row Crop Results

The first step for the alternative comparison was to characterize the damaging event calculations within the ECB19 and the 2012WCP. Below, **Table 4-1** summarizes the ECB19 results while **Table 4-2** summarizes the 2012WCP results using a "stop light" formatting in the table where the green color indicates decreased risk and red indicates increasing risk. From these two tables it is clear that the 2012WCP shows a slightly higher level of risk than does operations under the ECB19. This result is intuitive since the ECB19 operations are specifically programmed to reduce water volumes while C-111 South Dade construction efforts were performed within the study area and given consideration of potential increased flood risk associated with increased groundwater seepage resultant from increased stages within eastern ENP during the Increment 1.2 field test. Thus, compared to the long-term levels experienced prior to the start of the MWD incremental field test, the ECB19 represents a temporary and incidental beneficial condition in terms of risk to agriculture, especially within the northern part of the South Dade study area (watersheds C2 and L-31NS). The risk to these existing conditions is also somewhat associated with both the absolute and relative elevation of the indicator cell. In cases where the entire watershed is relatively low (e.g. C2, C-111 AG), there is increased risk. Additionally, in cases where the indicator cell has a lower elevation relative to the average watershed elevation (e.g. cell 3409, cell 2976), increased risk is also indicated. Another intuitive result is that with an increase in the threshold, the estimated risk to the row crops are increased. One contradiction to this result is found in Watershed C2 cell 2976 where the risk appears to be greater at the 12" and 18" threshold than the 24" threshold. A deeper dive into the data shows this is a result on the way the damaging events are calculated. Since consecutive days are not calculated, there are some instances in continuously wet conditions where there will be imperfect subsets of damaging events calculated. Cell 2976 is certainly a continuously wet cell as is evidenced by the hydrograph from that cell shown in **Figure 4-1** where the 24" threshold is met or exceeded for around 80% of the period of record (or approximately 11,980 days). Since there are so many days in the period of record where the 24" threshold is exceeded the damaging events calculated are reduced as compared to the other thresholds since the gaps between events estimated during the 12" and 18" thresholds are not filled (i.e. consecutive) at the 24" threshold. A representation of this phenomenon from the dataset is graphically demonstrated and explained in **Figure 4-2.** This phenomenon has implications for alternative comparison. Due to the way these damaging events are calculated there could be a case in which an alternative actually slightly lowers the ground stage in an indicator cell, thus causing minor gaps between consecutive days and adding more damaging events to the calculations, but yet is summarized as increasing the risk within that cell. In order to control for this all of the datasets were reviewed and the stage duration curves for each indicator cell studied in order to adequately capture the risk in the cells. After review of the data it appeared that only cell 2976 in watershed C2 had this potential issue. In order to control for this and accurately capture some estimation of risk increase or decrease only the consecutive days (i.e. not the damaging events as defined in the evaluation methodology) within that cell from alternative to alternative were used to compare against the base condition.

[20] Any references to topographical data are listed in NGVD 29.

WATERSHED	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
2" Threshold	0	2	0	0	0	0	0	0	29
12" Threshold	0	5	0	0	0	0	0	2	149
18" Threshold	1	17	0	0	3	1	1	14	176
24" Threshold	2	59	0	0	14	2	2	51	77

Table 4-1: Round 1 ECB19 Damaging Event Summary by Watershed and Indicator Cell

WATERSHED	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
2" Threshold	0	4	0	0	0	0	0	0	34
12" Threshold	0	12	0	0	0	0	0	2	153
18" Threshold	2	30	0	0	4	0	1	6	206
24" Threshold	7	74	0	0	17	2	2	56	74

Table 4-2: Round 1 2012WCP Damaging Event Summary by Watershed and Indicator Cell

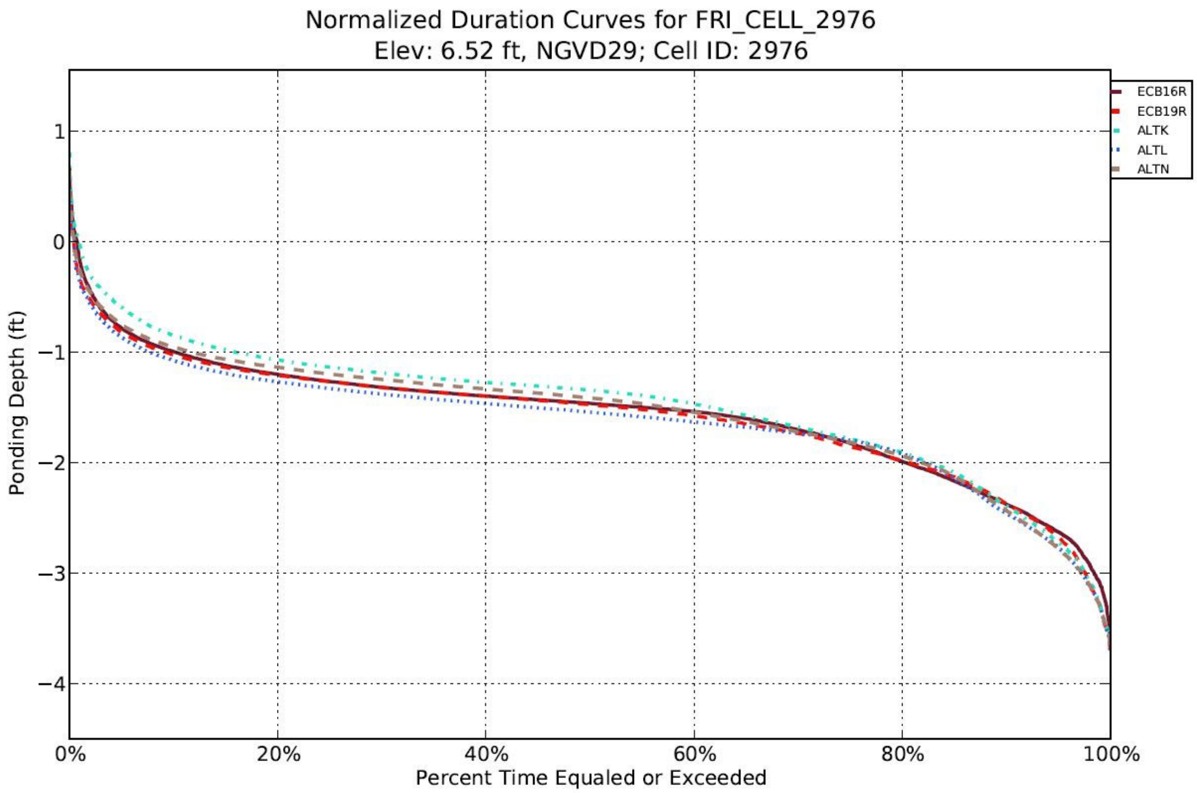

Figure 4-1: Indicator Cell 2976 Stage Duration Curve

Example from raw data: 2012WCP, Cell 2976, Row Crop Evaluation

Date	Groundwater Stage	At Least 48 Hours Above 18"	At least 48 Hours Above 24"	Damage Count 18"	Damage Count 24"
01Jan1965	-20.12723923	0	0	0	0
02Jan1965	-20.05523872	0	1	0	1
03Jan1965	-19.77803993	0	1	0	0
04Jan1965	-19.50683784	0	1	0	0
05Jan1965	-19.25604057	0	1	0	0
06Jan1965	-19.19843674	0	1	0	0
07Jan1965	-18.84443665	0	1	0	0
08Jan1965	-18.63923836	0	1	0	0
09Jan1965	-18.48443985	0	1	0	0
10Jan1965	-18.31043816	0	1	0	0
11Jan1965	-18.20603943	0	1	0	0
12Jan1965	-18.11844063	0	1	0	0
13Jan1965	-18.04883766	0	1	0	0
14Jan1965	-18.19883537	0	1	0	0
15Jan1965	-18.05243683	0	1	0	0
16Jan1965	-17.88803673	0	1	0	0
17Jan1965	-17.86763763	1	1	1	0
18Jan1965	-18.01403618	0	1	0	0
19Jan1965	-17.89283752	0	1	0	0
20Jan1965	-17.84123611	1	1	1	0
21Jan1965	-17.83164024	1	1	0	0
22Jan1965	-18.06803513	0	1	0	0
23Jan1965	-17.99123955	0	1	0	0
24Jan1965	-17.97443962	1	1	1	0
25Jan1965	-17.97443962	1	1	0	0
26Jan1965	-17.8760376	1	1	0	0
27Jan1965	-17.90603828	1	1	0	0
28Jan1965	-18.22163773	0	1	0	0
29Jan1965	-18.16763878	0	1	0	0
30Jan1965	-15.35483551	0	1	0	0
31Jan1965	-15.61403847	1	1	1	0

Gaps between events

Consistently wet conditions (no gaps)

Additional damaging events calculated because of gaps

Only damaging event calculated because of consistently wet period

Figure 4-2: Example of Imperfect Subsets of Estimated Risk

After characterizing the existing conditions, it was time to compare the Alternatives K, L, and N to the ECB19 and 2012WCP (ECB16R) to examine which of them potentially increased or decreased risk of row crop damages. Each of the distinct thresholds have their own table since, as abovementioned, each of the thresholds was considered a distinct measurement of risk. The alternatives compared to the 2012WCP at the 2”, 12”, 18”, and 24” thresholds are shown in **Table 4-3**, **Table 4-4**, **Table 4-5**, and **Table 4-6** respectively. Comparisons to the ECB19 are shown in **Table 4-7, Table 4-8, Table 4-9,** and **Table 4-10** at the same thresholds. Based on these results the following bullets are some key takeaways for each of the alternatives:

- Alternative K – Best performing alternative in cells 3839, 3619 and 4306 but is the worst performing alternative in cells 2976[21], 3409, and 3404. Cells 2976 and 3409 represent the most at risk cells in the system based on the existing condition analysis. Therefore, this alternative shows best performance in the L31 Watershed (northern portion of the study area) but is the worst performer for cells that already have high risk of damages.
- Alternative L – Has some of the best performance in cells where the risk is highest (3409, 2976) as well as in cell 3404. It is the worst performer in cells 3619 and 4306 and thus represents somewhat of a mirror image of alternative K in terms of performance.
- Alternative N – Has consistent beneficial performance throughout the system but does have slight increased risk in 3839 and 2976.

Row crops are just one piece of the risk puzzle so in the next subsections the fruit and container crop analysis will be highlighted along with residential risks.

WATERSHED (2" Threshold, Row Crops)	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
Alt_K	0	0	0	0	0	0	0	0	17
Alt_L	0	-1	0	0	0	0	0	0	-9
Alt_N	0	0	0	0	0	0	0	0	5

Table 4-3: Round 1 Alternative Comparison to 2012WCP - Row Crops at 2" Threshold

[21] The tables for cell 2976 show the damaging event calculations that contain the limitations discussed above and visually demonstrated in **Figure 4-2**. As a result the conclusions on alternative performance are based on the cumulative days which are shown in the stage duration curve presented in **Figure 4-1**.

WATERSHED (12" Threshold, Row Crops)	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
Alt_K	0	2	0	0	0	0	0	0	38
Alt_L	0	-6	0	0	0	0	0	0	-19
Alt_N	0	-5	0	0	0	0	0	1	18

Table 4-4: Round 1 Alternatives Comparison to 2012WCP – Row Crops at 12" Threshold

WATERSHED (18", Row Crop Analysis)	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
Alt_K	0	25	0	0	-2	0	0	0	-94
Alt_L	-1	-12	0	0	0	0	0	2	7
Alt_N	0	0	0	0	-1	0	0	5	-75

Table 4-5: Round 1 Alternatives Comparison to 2012WCP – Row Crops at 18" Threshold

WATERSHED (24" Thresh-old, Row Crops)	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
Alt_K	-1	53	0	0	-10	0	-1	-29	-14
Alt_L	-3	-16	0	0	3	0	1	-3	-17
Alt_N	-2	7	0	0	-3	0	0	0	-8

Table 4-6: Round 1 Alternatives Comparison to 2012WCP – Row Crops at 24" Threshold

WATERSHED (2" Thresh-old, Row Crops)	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
Alt_K	0	2	0	0	0	0	0	0	22
Alt_L	0	1	0	0	0	0	0	0	-4
Alt_N	0	2	0	0	0	0	0	0	10

Table 4-7: Round 1 Alternatives Comparison to ECB19 – Row Crops at 2" Threshold

WATERSHED (12" Thresh-old, Row Crops)	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
Alt_K	0	9	0	0	0	0	0	0	42
Alt_L	0	1	0	0	0	0	0	0	-15
Alt_N	0	2	0	0	0	0	0	1	22

Table 4-8: Round 1 Alternatives Comparison to ECB19 – Row Crops at 12" Threshold

WATERSHED (18" Threshold, Row Crops)	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
Alt_K	1	38	0	0	-1	-1	0	-8	-64
Alt_L	0	1	0	0	1	-1	0	-6	37
Alt_N	1	13	0	0	0	-1	0	-3	-45

Table 4-9: Round 1 Alternatives Comparison to ECB19 – Row Crops at 18" Threshold

WATERSHED (24" Threshold, Row Crops)	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	IC_3404	IC_3409	IC_3633	IC_4809	IC_4306	IC_4337	IC_3619	IC_3839	IC_2976
Alt_K	4	68	0	0	-7	0	-1	-24	-17
Alt_L	2	-1	0	0	6	0	1	2	-20
Alt_N	3	22	0	0	0	0	0	5	-11

Table 4-10: Round 1 Alternatives Comparison to ECB19 – Row Crops at 24" Threshold

I.4.1.2 Round 1 Fruit and Container Crop Results

An identical comparison as row crops was conducted for fruit and container crops based on all the assumptions highlighted above in **Section I.3.1.1** for these specific crop types. The following tables summarize the results visually (using the same color scheme as row crops above).

WATER-SHED (Fruit Crops)	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	C-111 AG	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	7.13	7.13	9.18	10.62	5.72	5.72	5.72	5.72	8.87	8.87	8.87	8.87
Indicator Cell Topo	11.27	11.48	9.33	9.70	6.51	7.38	5.55	6.86	8.57	9.32	9.55	8.66
Cell ID	IC_4345	IC_4346	IC_3404	IC_4351	IC_4328	IC_4567	IC_5019	IC_5023	IC_3400	IC_3622	IC_3847	IC_4085
ECB2019	0	0	4	0	187	18	66	17	12	14	2	1
2012WCP	0	0	8	0	249	20	69	17	6	7	2	0
Alt_K	0	0	10	0	146	16	56	13	5	8	1	0
Alt_L	0	0	5	0	258	26	68	18	9	7	3	0
Alt_N	0	0	8	0	226	19	59	14	12	11	4	1

Table 4-11: Total Damaging Events for Fruit Crops by Watershed and Cell ID

WATERSHED (Container Crops)	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	7.13	7.13	9.18	10.62	5.72	8.87	8.87	8.87	8.87	8.87
Indicator Cell Topo	11.27	11.48	9.33	9.94	6.51	8.42	9.33	9.32	9.55	6.58
Cell ID	IC_4345	IC_4346	IC_3404	IC_4809	IC_4328	IC_3398	IC_3400	IC_3622	IC_3847	IC_4332
ECB2019	0	0	0	0	3	0	0	0	0	0
2012WCP	0	0	0	0	4	0	0	0	0	0
Alt_K	0	0	0	0	2	0	0	0	0	0
Alt_L	0	0	0	0	5	0	0	0	0	0
Alt_N	0	0	0	0	5	0	0	0	0	0

Table 4-12: Total Damaging Events for Container Crops by Watershed and Cell ID

Watershed (Fruit Crops)	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	C-111 AG	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	7.13	7.13	9.18	10.62	5.72	5.72	5.72	5.72	8.87	8.87	8.87	8.87
Indicator Cell Topo	11.27	11.48	9.33	9.70	6.51	7.38	5.55	6.86	8.57	9.32	9.55	8.66
	IC_4345	IC_4346	IC_3404	IC_4351	IC_4328	IC_4567	IC_5019	IC_5023	IC_3400	IC_3622	IC_3847	IC_4085
Alt_K	0	0	6	0	-41	-2	-10	-4	-7	-6	-1	-1
Alt_L	0	0	1	0	71	8	2	1	-3	-7	1	-1
Alt_N	0	0	4	0	39	1	-7	-3	0	-3	2	0

Table 4-13: Round 1 Alternatives Compared to ECB19 – Fruit Crop Damaging Events by Watershed and Cell ID

Watershed (Container Crops)	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	**7.13**	**7.13**	**9.18**	**10.62**	**5.72**	**8.87**	**8.87**	**8.87**	**8.87**	**8.87**
Indicator Cell Topo	**11.27**	**11.48**	**9.33**	**9.94**	**6.51**	**8.42**	**9.33**	**9.32**	**9.55**	**6.58**
	IC_4345	**IC_4346**	**IC_3404**	**IC_4809**	**IC_4328**	**IC_3398**	**IC_3400**	**IC_3622**	**IC_3847**	**IC_4332**
Alt_K	0	0	0	0	-1	0	0	0	0	0
Alt_L	0	0	0	0	2	0	0	0	0	0
Alt_N	0	0	0	0	2	0	0	0	0	0

Table 4-14: Round 1 Alternatives Compared to ECB19 – Container Crop Damaging Events by Watershed and Cell ID

Watershed (Fruit Crops)	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	C-111 AG	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	**7.13**	**7.13**	**9.18**	**10.62**	**5.72**	**5.72**	**5.72**	**5.72**	**8.87**	**8.87**	**8.87**	**8.87**
Indicator Cell Topo	**11.27**	**11.48**	**9.33**	**9.70**	**6.51**	**7.38**	**5.55**	**6.86**	**8.57**	**9.32**	**9.55**	**8.66**
	IC_4345	**IC_4346**	**IC_3404**	**IC_4351**	**IC_4328**	**IC_4567**	**IC_5019**	**IC_5023**	**IC_3400**	**IC_3622**	**IC_3847**	**IC_4085**
Alt_K	0	0	2	0	-103	-4	-13	-4	-1	1	-1	0
Alt_L	0	0	-3	0	9	6	-1	1	3	0	1	0
Alt_N	0	0	0	0	-23	-1	-10	-3	6	4	2	1

Table 4-15: Round 1 Alternatives Compared to 2012WCP – Fruit Crop Damaging Events by Watershed and Cell ID

Watershed (Container Crops)	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	**7.13**	**7.13**	**9.18**	**10.62**	**5.72**	**8.87**	**8.87**	**8.87**	**8.87**	**8.87**
Indicator Cell Topo	**11.27**	**11.48**	**9.33**	**9.94**	**6.51**	**8.42**	**9.33**	**9.32**	**9.55**	**6.58**
Cell ID	**IC_4345**	**IC_4346**	**IC_3404**	**IC_4809**	**IC_4328**	**IC_3398**	**IC_3400**	**IC_3622**	**IC_3847**	**IC_4332**
Alt_K	0	0	0	0	-2	0	0	0	0	0
Alt_L	0	0	0	0	1	0	0	0	0	0
Alt_N	0	0	0	0	1	0	0	0	0	0

Table 4-16: Round 1 Alternatives Compared to 2012WCP – Container Crop Damaging Events by Watershed and Cell ID

Since container crops had very little risk based on this analysis the summarization of the Round 1 results in this subsection will focus primarily on those related to fruit crops. The below bullet points represent a narrative summary of the alternatives while **Figure 4-3** shows the spatial location of the cells as identifies which alternative reduces the risk the most in each of those cells[22].

- Alternative K – This alternative performed dramatically different for fruit crops than it did for row crops (see summary above). Alternative K was the best performing alternative in cells with the highest risk (5019, 4328) as well as in four additional cells (3847, 3400, 5023, 4567) and was not a "worst performer" in any of the cells.
- Alternative L – This alternative performed the worst in the cells highest at risk and the best in only a single cell (3622). Again, this was a deviation from how alternative L performed in terms of risk to row crops.
- Alternative N – One of the poorer performers for fruit crops, but only narrowly when compared to Alternative L.

As can be seen from the tables above and the figures below, Alternative K was a clear best performing alternative for fruit crops, most notably in cell 4328 where it reduced the risk over the RSM-GL simulation period-of-record, 1965-2005 (POR) by an estimated 103 potentially damaging events. However, Alternative K did not perform as admirably for row crops as evidenced by the summary in **Section I.4.1.1** above.

[22] Cells where two or more alternatives reduced or increased risk to the same degree were marked as "Undefined"

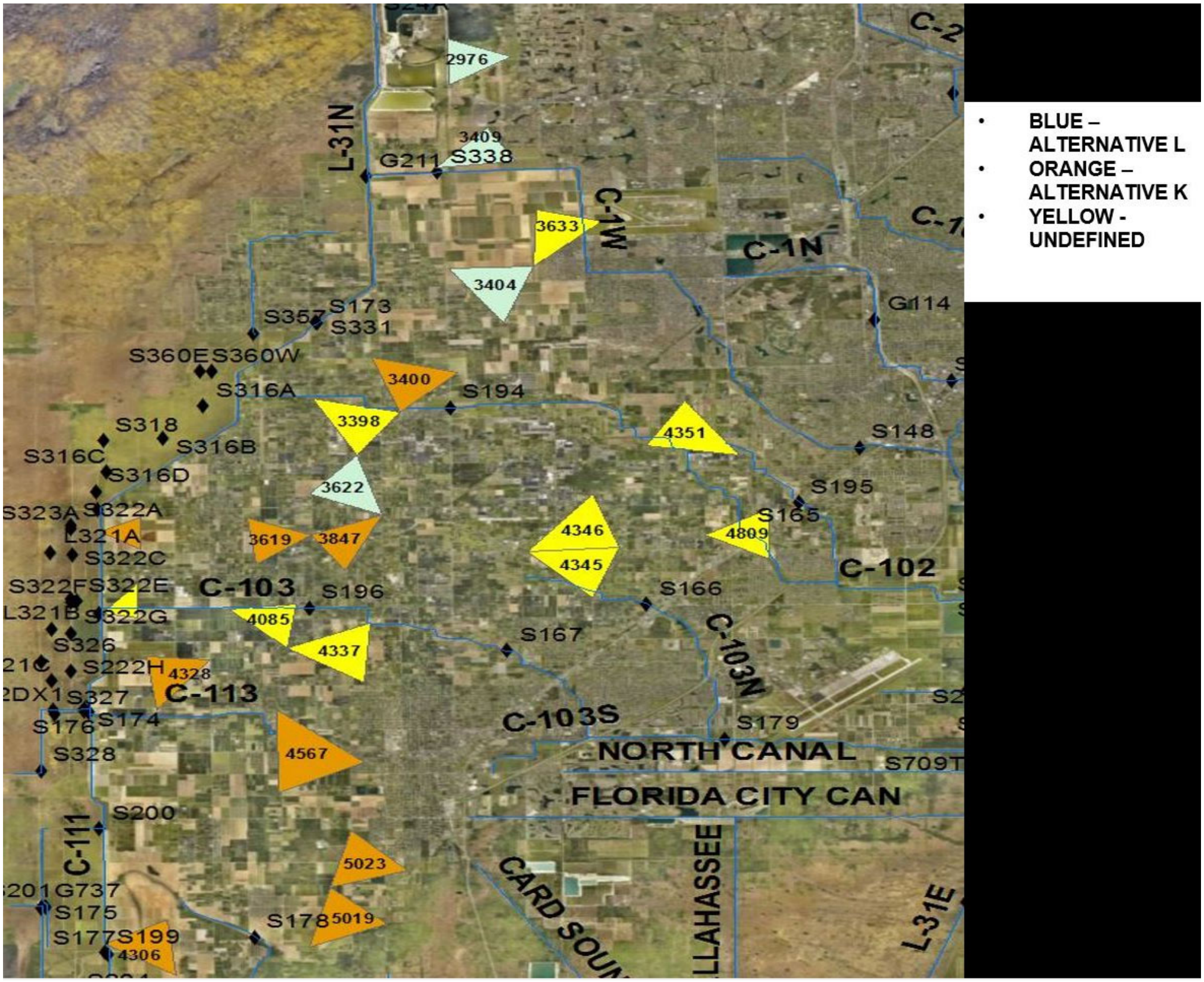

Figure 4-3: Spatial Representation of Best Performing Alternatives for Fruit Crops (Round 1)

I.4.1.3 Round 1 Residential Results

Based on the 18” threshold assumption, there were no recorded damaging events throughout the entire RSM-GL POR under any of the modeled conditions as seen in **Table 4-17**. As a result, a sensitivity was conducted in order to see if an alternative outperformed another at a different threshold. The sensitivity threshold selected was 0” (i.e. ground-surface). This elevation was selected as it could potentially capture some nuisance flood risk that wasn’t otherwise measured using the 18” threshold. **Table 4-18** presents those results and concludes that flood risk to residences is estimated to be very minimal based on this analysis. The highest count of damaging events is 9, which is 0.06% of the POR and is not statistically significant from 0. There was also very little difference between and amongst alternatives and base conditions. As a result, residential results did not weigh heavily on formulation of alternatives for subsequent rounds of modeling.

Watershed	8.5 SMA	BDC103-C	BDC103-W	C1 WEST	C2	C111	L31
Watershed Topo (Avg)	7.45	6.61	9.49	8.93	8.62	6.23	8.05
Indicator Cell Topo	7.71	4.07	7.13	9.18	6.38	5.72	8.87
Cell ID	*2965*	*4802*	*4570*	*3416*	*3425*	*5024*	*3626*
2019 ECB	0	0	0	0	0	0	0
2012 WCP	0	0	0	0	0	0	0
Alt K	0	0	0	0	0	0	0
Alt L	0	0	0	0	0	0	0
Alt N	0	0	0	0	0	0	0

Table 4-17: Round 1 Damaging Events to Residential – 18" Threshold

Watershed	8.5 SMA	BDC103-C	BDC103-W	C1 WEST	C2	C111	L31
Watershed Topo (Avg)	7.45	6.61	9.49	8.93	8.62	6.23	8.05
Indicator Cell Topo	7.71	4.07	7.13	9.18	6.38	5.72	8.87
Cell ID	*FRI-CELL-2965*	*FRI-CELL-4802*	*FRI-CELL-4570*	*FRI-CELL-3416*	*FRI-CELL-3425*	*FRI-CELL-5024*	*FRI-CELL-3626*
2019 ECB	0	9	0	0	7	4	0
2012 WCP	2	9	0	0	9	5	0
Alt K	0	7	0	1	7	4	0
Alt L	0	8	0	0	7	6	0
Alt N	0	7	0	0	7	4	0

Table 4-18: Round 1 Damaging Events to Residential – 0" Threshold

I.4.1.4 Round 1 Modeling Results Summary

Since residential results were not significantly informative the following section will summarize results strictly in terms of the agricultural analysis. Also, since the 2012WCP is the best approximation available for the constraint condition in South Dade the summary will also discuss alternatives in terms of their performance compared to this base. **Figure 4-4, Figure 4-5,** and **Figure 4-6** are spatial summaries of the alternatives as they compare to the 2012WCP. Alternatives K and L perform very well in the southern and eastern cells with alternative K as the clear best performer for fruit crops nearest the water control structures[23]. Alternative N also has minimal increases in risk throughout the system. The Round 1 results were somewhat inconclusive since there was no single alternative which performed best throughout the entire system. It was clear that topography plays a role in flood risk in absolute terms, as evidenced by the raw numbers of damaging events in the existing condition and alternatives. However, when comparing the risk reduction impacts of the alternatives against each other and the baseline conditions it was obvious that the proximity of cells to existing water control structures was a large factor (i.e. the cells along the western flank and northern border nearest the L31 Canal). There are only a couple of cells driving the majority of the risk in the entire system for each land use type and as such there was little difference between alternatives in the remaining cells. Based on this analysis there was little concern of constraint violation, with the exception of possibly cell 2976[24] in the north, so each alternative was considered acceptable for moving into the next round and the deciding factor should be the alternative's environmental restoration potential. An important observation was made during this modeling round in terms of strategies for reducing flood risk to the South Dade agricultural community. Historically, flows into Northeast Shark River Slough[25] (NESRS) were limited in order to protect the parcels of land to the east of the L31 Canal. Alternative K specifically included a trigger mechanism designed to similarly limit the flows to NESRS but, as seen in the results, this trigger did not provide holistic enhancement of flood risk throughout all of South Dade. This observation was seen as an important indicator of the COP's limited ability to truly enhance flood risk across the entire system compared to the ECB19 while maintaining environmental restoration benefits.

[23] Water control structures are marked in the figures as black diamonds with a structure label attached (e.g. S357).

[24] This cell, however, is a cell that is chronically inundated with a high water table and it is not completely clear what the constraint condition damages will be until more resolution is added to the modeling in subsequent rounds.

[25] Please refer to the planning objectives of COP in the main portion of this EIS for the importance of NESRS.

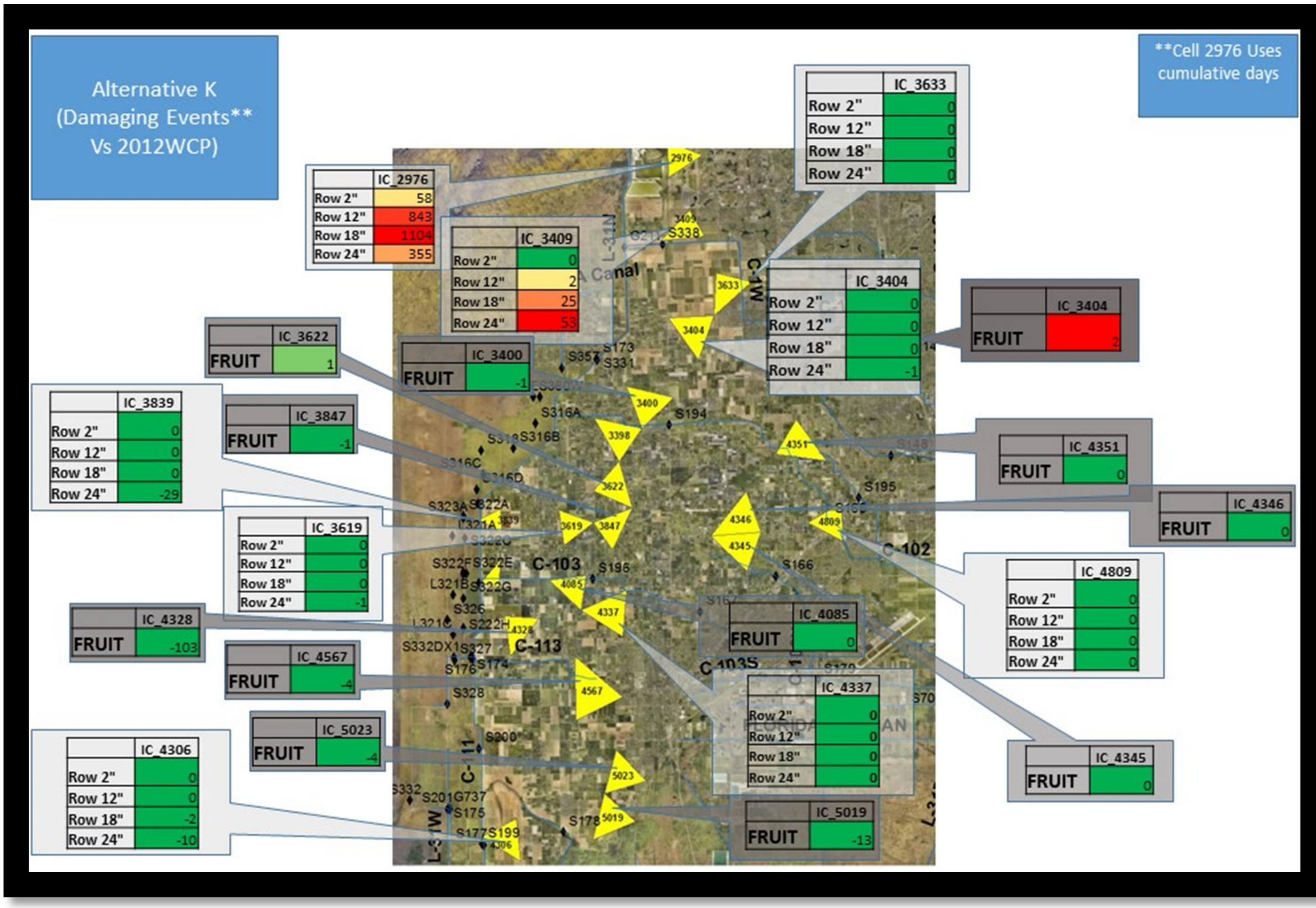

Figure 4-4: Round 1 Spatial Summary – Alternative K vs. 2012WCP

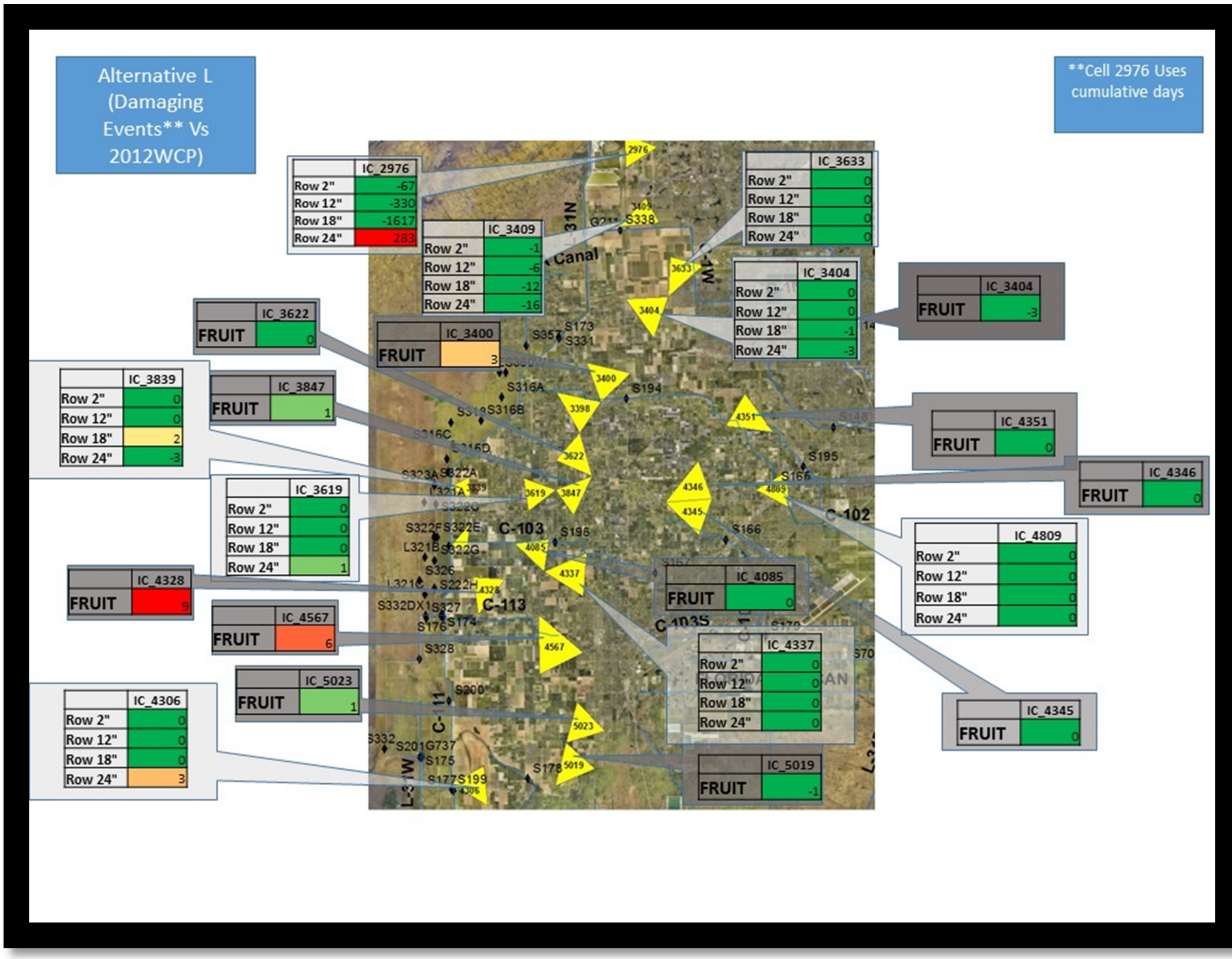

Figure 4-5: Round 1 Spatial Summary – Alternative L vs. 2012WCP

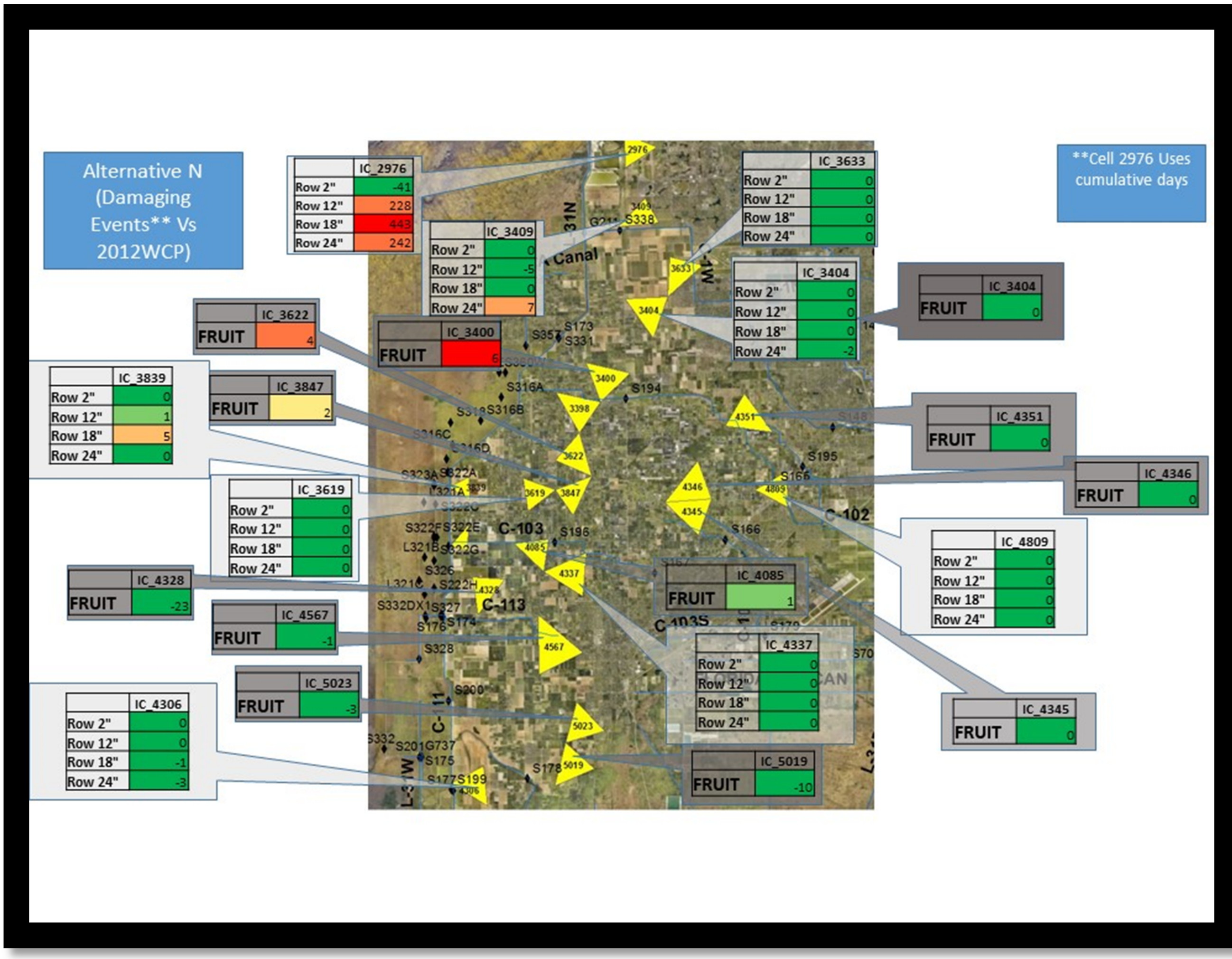

Figure 4-6: Round 1 Spatial Summary – Alternative N vs. 2012WCP

I.4.2 Round 2 Modeling Results

Round 2 modeling introduces the socioeconomic analysis using the MD-RSM hydrologic model output via the HEC-FIA economic modeling tool and repeats the analysis done during Round 1 under the RSM-GL hydrologic model with the newly formulated alternatives N2 and O[26] as well as the sensitivity run SR3. SR3 was conducted starting from ALT N2 and included lower canal levels in South Dade. Operational criteria for the following structures were revised to match lower canal levels included in Alternative O for the South Dade Canal reaches between S-331 and S-177 (for further details regarding the COP Round 2 sensitivity run assumptions, refer to the Hydraulics and Hydrology Appendix (Appendix H), Annex 4,

[26] After Round 2 had completed, it was discovered that there was an error in the hydrologic assumptions for Alternative O. Please refer to Section 2 of the Main Report or to the Engineering Appendix for more details. The error was taken into consideration during formulation for Round 3, but no remodeling was conducted under Round 2.

Section H-4.1.1. SR3 was identified by the COP interagency PDT as responsive to stakeholder input received during Round 2 alternative development and responsive to the COP "Planning Consideration" to "explore opportunities to enhance flood control and mitigation." It is important to note that the ECB2019 results that will be detailed under the RSM-GL results are slightly different than those shown above during Round 1. This is due to a revised assumption for the S-333N operations, consistent with a newly-issued FDEP operating permit coincident with the COP Round 1 modeling. With respect to the project area for this socio-economics analysis, the model stage changes were minimal and would not have had an impact on the conclusions of Round 1 so there was no remodeling conducted. In some of the tables and charts the ECB2019 will be referred to as ECB19RR which represents the newly corrected version of the ECB2019 and is used interchangeably for the purposes of this analysis. The following sections will detail the results separately by model.

I.4.2.1 Round 2 RSM-GL Results – Agriculture

The first several tables measure the overall damaging events for all base conditions, alternatives, and sensitivity runs after which the alternatives will be compared to the ECB19 and the 2012WCP. The same issue with imperfect subsets for cell 2976 as detailed above for Round 1 is true for Round 2 as well. Thus, the comparison table at the 24" threshold is not indicative of the best performing alternative but a similar spatial summary slide will be presented with the cumulative results in 2976 that were used by the Flood Risk Sub-Team to make informed decisions on the best performing alternative.

ROW 2" Threshold									
Watershed	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
ECB19RR	0	2	0	0	0	0	0	0	28
2012WCP	0	4	0	0	0	0	0	0	34
Alt_O	0	2	0	0	0	0	0	0	28
ALT_SR3	0	4	0	0	0	0	0	0	38
Alt_N2	0	4	0	0	0	0	0	0	38

Table 4-19: Round 2 Damaging Events – Row Crops 2" Threshold

ROW 12"									
Watershed	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
ECB19RR	0	5	0	0	0	0	0	2	145
2012WCP	0	12	0	0	0	0	0	2	153
Alt_O	0	6	0	0	0	0	0	2	155
ALT_SR3	0	8	0	0	0	0	0	2	171
Alt_N2	0	8	0	0	0	0	0	2	171

Table 4-20: Round 2 Damaging Events – Row Crops 12” Threshold

ROW 18"									
Watershed	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
ECB19RR	1	17	0	0	3	1	1	14	173
2012WCP	2	30	0	0	4	0	1	6	206
Alt_O	2	22	0	0	3	1	1	10	180
ALT_SR3	2	28	0	0	3	1	1	11	143
Alt_N2	2	29	0	0	3	1	4	11	143

Table 4-21: Round 2 Damaging Events – Row Crops 18” Threshold

ROW 24"									
Watershed	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
ECB19RR	2	58	0	0	13	2	2	50	78
2012WCP	7	74	0	0	17	2	2	56	74
Alt_O	6	58	0	0	14	2	2	50	55
ALT_SR3	5	79	0	0	12	2	2	39	71
Alt_N2	5	80	0	0	10	2	2	49	71

Table 4-22: Round 2 Damaging Events – Row Crops 24" Threshold

FRUIT Crops												
Watershed	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	C-111 AG	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	7.13	7.13	9.18	10.62	5.72	5.72	5.72	5.72	8.87	8.87	8.87	8.87
Indicator Cell Topo	11.27	11.48	9.33	9.70	6.51	7.38	5.55	6.86	8.57	9.32	9.55	8.66
Cell ID	4345	4346	3404	4351	4328	4567	5019	5023	3400	3622	3847	4085
ECB19RR	0	0	4	0	182	18	66	17	12	13	2	1
2012WCP	0	0	8	0	249	20	69	17	6	7	2	0
Alt_O	0	0	6	0	200	17	65	16	10	10	3	1
ALT_SR3	0	0	8	0	190	18	59	14	11	11	2	1
Alt_N2	0	0	8	0	207	19	59	14	12	12	3	1

Table 4-23: Round 2 Damaging Events – Fruit Crops

Container										
Watershed	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	7.13	7.13	9.18	10.62	5.72	8.87	8.87	8.87	8.87	8.87
Indicator Cell Topo	11.27	11.48	9.33	9.94	6.51	8.42	9.33	9.32	9.55	6.58
Cell ID	4345	4346	3404	4809	4328	3398	3400	3622	3847	4332
ECB19RR	0	0	0	0	3	0	0	0	0	0
2012WCP	0	0	0	0	4	0	0	0	0	0
Alt_O	0	0	0	0	4	0	0	0	0	0
ALT_SR3	0	0	0	0	3	0	0	0	0	0
Alt_N2	0	0	0	0	3	0	0	0	0	0

Table 4-24: Round 2 Damaging Events – Container Crops

When looking at estimated overall damaging events a similar trend as Round 1 emerges in the sense that a few cells are driving the overall risk for both the existing condition baselines as well as the alternatives. Additionally, the differences between the existing condition and alternatives are not large, though, they have increased from the alternatives in Round 1. The following tables will demonstrate the estimated risk reduction or increase from the alternatives as compared to the 2012WCP. The ECB2019 result tables are not displayed as they are very similar to the 2012WCP and therefore somewhat redundant to display. Comparisons to the 2019ECB will be displayed more prominently in the discussion on the Round 2 MD-RSM/HEC-FIA results.

ROW 2"									
Watershed	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
Alt_O	0	-2	0	0	0	0	0	0	-6
ALT_SR3	0	0	0	0	0	0	0	0	4
Alt_N2	0	0	0	0	0	0	0	0	4

Table 4-25: Round 2 Row Crop Comparison to 2012WCP – 2” Threshold

ROW 12"									
Watershed	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
Alt_O	0	-6	0	0	0	0	0	0	2
ALT_SR3	0	-4	0	0	0	0	0	0	18
Alt_N2	0	-4	0	0	0	0	0	0	18

Table 4-26: Round 2 Row Crop Comparison to 2012WCP – 12” Threshold

ROW 18"									
Watershed	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
Alt_O	0	-8	0	0	-1	1	0	4	-26
ALT_SR3	0	-2	0	0	-1	1	0	5	-63
Alt_N2	0	-1	0	0	-1	1	3	5	-63

Table 4-27: Round 2 Row Crop Comparison to 2012WCP – 18” Threshold

ROW 24"									
Watershed	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Watershed Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
Alt_O	-1	-16	0	0	-3	0	0	-6	-19
ALT_SR3	-2	5	0	0	-5	0	0	-17	-3
Alt_N2	-2	6	0	0	-7	0	0	-7	-3

Table 4-28: Round 2 Row Crop Comparison to 2012WCP – 24" Threshold

FRUIT												
Watershed	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	C-111 AG	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Watershed Topo (Avg)	7.13	7.13	9.18	10.62	5.72	5.72	5.72	5.72	8.87	8.87	8.87	8.87
Indicator Cell Topo	11.27	11.48	9.33	9.70	6.51	7.38	5.55	6.86	8.57	9.32	9.55	8.66
Cell ID	4345	4346	3404	4351	4328	4567	5019	5023	3400	3622	3847	4085
Alt_O	0	0	-2	0	-49	-3	-4	-1	4	3	1	1
ALT_SR3	0	0	0	0	-59	-2	-10	-3	5	4	0	1
Alt_N2	0	0	0	0	-42	-1	-10	-3	6	5	1	1

Table 4-29: Round 2 Fruit Crop Comparison to 2012WCP

Container										
Watershed	**BD-C103 WEST**	**BD-C103 West**	**C-1 WEST**	**C-102 WEST**	**C-111 AG**	**L-31 NS**	**L-31 NS**	**L-31 NS**	**L-31 NS**	**L-31 NS**
Watershed Topo (Avg)	**7.13**	**7.13**	**9.18**	**10.62**	**5.72**	**8.87**	**8.87**	**8.87**	**8.87**	**8.87**
Indicator Cell Topo	**11.27**	**11.48**	**9.33**	**9.94**	**6.51**	**8.42**	**9.33**	**9.32**	**9.55**	**6.58**
Cell ID	**4345**	**4346**	**3404**	**4809**	**4328**	**3398**	**3400**	**3622**	**3847**	**4332**
Alt_O	0	0	0	0	0	0	0	0	0	0
ALT_SR3	0	0	0	0	-1	0	0	0	0	0
Alt_N2	0	0	0	0	-1	0	0	0	0	0

Table 4-30: Round 2 Container Crop Comparison to 2012WCP

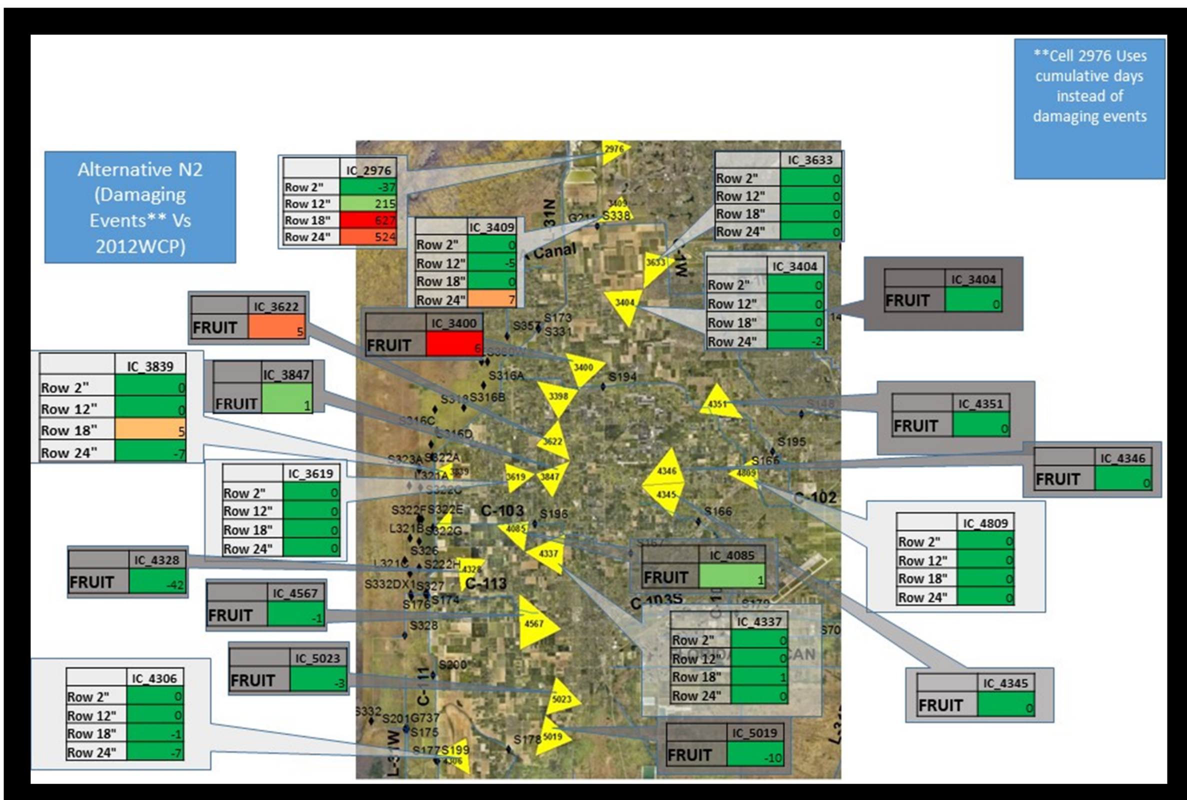

Figure 4-7: Round 2 Agriculture Spatial Summary – Alternative N2 vs 2012WCP

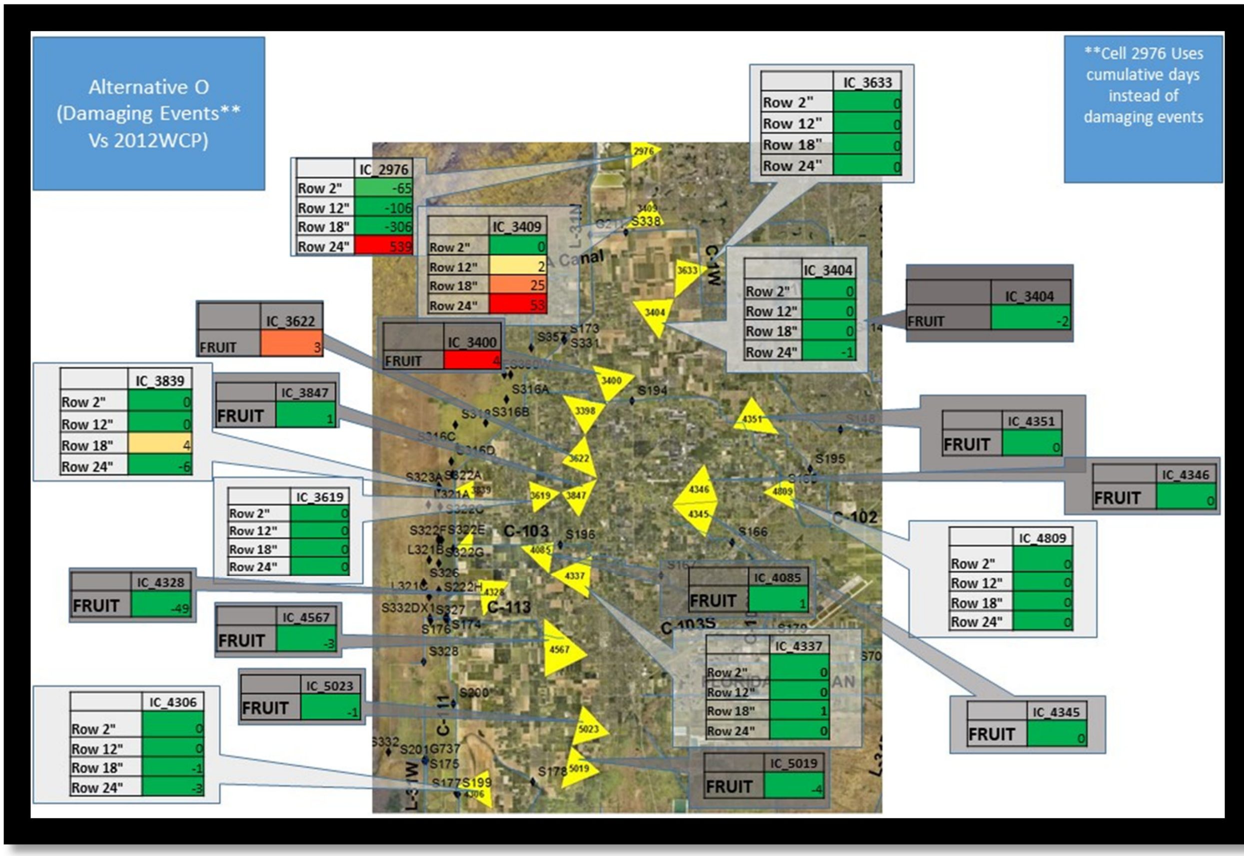

Figure 4-8: Round 2 Agriculture Spatial Summary – Alternative O vs 2012WCP

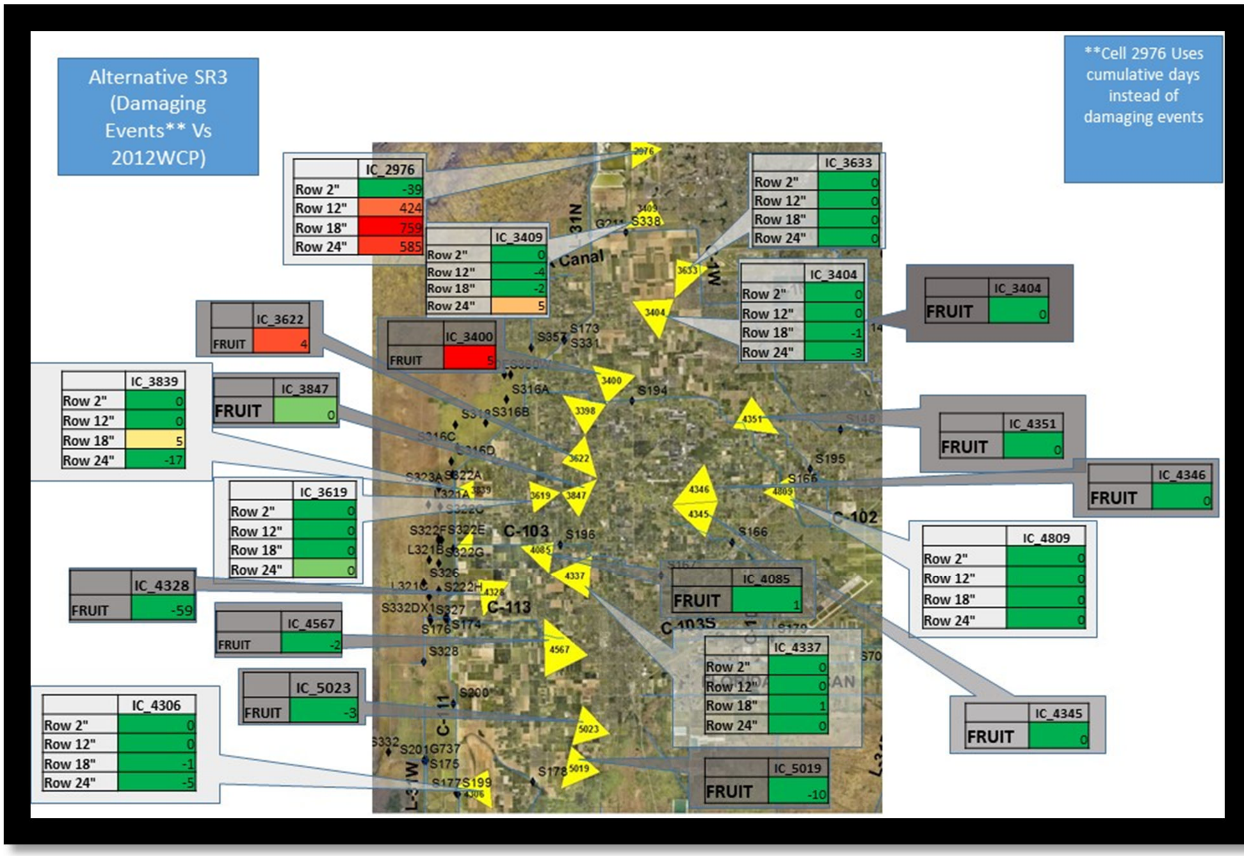

Figure 4-9: Round 2 Agriculture Spatial Summary – Alternative SR3 vs 2012WCP

From these tables and figures it can be seen that each of the alternatives has improved on their predecessors from Round 1. However, residual risk remains in the northern portion of the system (north of and immediately south of S-331) much as it did during Round 1. No single alternative clearly outperforms but N2, O, and SR3 all appear acceptable in terms of constraint violation (which will be discussed in the following section with the introduction of the modeled 1994GRR base condition).

I.4.2.2 Round 2 RSM-GL Results – Residential

Round 2 had similar results as Round 1 in terms of residential performance. Remembering back to **Table 4-18**, there was very little risk to residential parcels even at the 0" threshold sensitivity run in the base conditions and alternatives. The same is true here and each alternative had very little difference compared to either base condition. All alternatives performed similarly in reducing risk as demonstrated in **Table 4-31.**

Watershed	8.5 SMA	BDC103-C	BDC103-W	C1 WEST	C2	C111	L31
Watershed Topo (Avg)	**7.45**	**6.61**	**9.49**	**8.93**	**8.62**	**6.23**	**8.05**
Indicator Cell Topo	**7.71**	**4.07**	**7.13**	**9.18**	**6.38**	**5.72**	**8.87**
Cell ID	***2965***	***4802***	***4570***	***3416***	***3425***	***5024***	***3626***
Alt O	-2	-1	0	0	-3	-1	0
Alt SR3	-2	0	0	0	-3	-1	0
Alt N2	-2	-3	0	0	-3	-1	0

Table 4-31: Round 2 RSM-GL Residential Results: Alternatives Compared to 2012WCP

I.4.2.3 Round 2 MD-RSM and HEC-FIA Results – Agriculture

The sensitivity run SR3 which was modeled under the RSM-GL outputs above was not replicated for the MD-RSM/HEC-FIA model runs so the following sections will only display results for the ECB19, the constraint condition (94Base), and the two Alternatives N2 and O. However, two HEC-FIA sensitivity runs specific to agriculture, in which it is assumed crops are raised in beds 6” and 12” high, were run and are detailed in **Section I.4.2.3.1**. The summation of results are estimates of dollar damages based on the methodology and assumptions outlined above in **Sections I.3.2** and **I.3.3.2.** Dollar damages are estimated for each of the dry, average, and wet years for all conditions. It is important to note that the peak stage for each cell in the dry year was actually higher than that of the average year and, as a result, damages will be higher in the dry than the average. This may seem counterintuitive but since damages were modeled on the peak stage and not an average stage across the year or season (dry years were selected based on annual sub-basin rainfall totals), it was not impossible for this to occur. Each year is still an appropriate measure of potential damages in the system. The damages are summarized in the following six tables and figures.

Reaches	MD-RSM Average Year Damages (FY19 $1,000)			
	94Base_Avg	ECB19_Avg	N2_Avg	O_Avg
C111R1-A	$ 9,144	$ 7,197	$ 7,375	$ 7,771
C111R1-B	$ 8,813	$ 5,398	$ 5,856	$ 6,324
C111R1-C	$ 10,006	$ 9,762	$ 9,813	$ 9,799
L31R1-A	$ 6,403	$ 5,536	$ 6,284	$ 5,969
L31R1-D	$ 1	$ 1	$ 1	$ 1
L31R2-A	$ 2,965	$ 1,119	$ 2,258	$ 2,167
L31R2-B	$ -	$ -	$ -	$ -
L31R3-A	$ 1,683	$ 901	$ 960	$ 931
L31R3-B	$ 6,890	$ 3,719	$ 4,252	$ 4,146
L31R3-C	$ 6,956	$ 4,044	$ 4,592	$ 4,608
L31R3-D	$ 7,636	$ 4,654	$ 5,609	$ 5,652
L31R3-E	$ 4,810	$ 4,756	$ 4,778	$ 4,783
Total	***$ 65,308***	***$ 47,086***	***$ 51,777***	***$ 52,150***

Table 4-32: MD-RSM/HEC-FIA Round 2 Dollar Damages (FY19, $1,000) for Average Year

Reaches	MD-RSM Dry Year Damages (FY19 $1,000)			
	94Base_Dry	**ECB19_Dry**	**N2_Dry**	**O_Dry**
C111R1-A	$ 14,737	$ 13,348	$ 13,512	$ 13,690
C111R1-B	$ 11,016	$ 9,170	$ 9,567	$ 9,515
C111R1-C	$ 11,728	$ 11,673	$ 11,657	$ 11,666
L31R1-A	$ 8,149	$ 7,226	$ 7,987	$ 7,890
L31R1-D	$ 5	$ 5	$ 5	$ 6
L31R2-A	$ 2,980	$ 1,216	$ 2,192	$ 1,922
L31R2-B	$ -	$ 0	$ -	$ 0
L31R3-A	$ 3,631	$ 2,417	$ 2,791	$ 2,248
L31R3-B	$ 9,596	$ 7,090	$ 7,530	$ 6,666
L31R3-C	$ 6,106	$ 4,091	$ 4,643	$ 3,779
L31R3-D	$ 5,749	$ 3,726	$ 4,567	$ 3,275
L31R3-E	$ 6,440	$ 6,323	$ 6,453	$ 6,397
Total	***$ 80,138***	***$ 66,287***	***$ 70,904***	***$ 67,053***

Table 4-33: MD-RSM/HEC-FIA Round 2 Dollar Damages (FY19, $1,000) for Dry Year

Reaches	MD-RSM Wet Year Damages (FY19 $1,000)			
	94Base_Wet	ECB19_Wet	N2_Wet	O_Wet
C111R1-A	$ 19,605	$ 19,088	$ 18,958	$ 19,171
C111R1-B	$ 31,506	$ 30,644	$ 30,320	$ 30,639
C111R1-C	$ 12,666	$ 12,638	$ 12,629	$ 12,636
L31R1-A	$ 11,491	$ 11,171	$ 11,436	$ 11,253
L31R1-D	$ 6	$ 6	$ 6	$ 6
L31R2-A	$ 24,109	$ 19,168	$ 23,331	$ 20,319
L31R2-B	$ 44	$ 32	$ 49	$ 36
L31R3-A	$ 12,636	$ 11,655	$ 11,354	$ 11,461
L31R3-B	$ 25,504	$ 23,927	$ 23,845	$ 23,742
L31R3-C	$ 15,794	$ 14,893	$ 14,995	$ 14,863
L31R3-D	$ 17,567	$ 15,728	$ 16,361	$ 15,664
L31R3-E	$ 8,221	$ 8,103	$ 8,310	$ 8,133
Total	***$ 179,148***	***$ 167,054***	***$ 171,594***	***$ 167,922***

Table 4-34: MD-RSM/HEC-FIA Round 2 Dollar Damages (FY19, $1,000) for Wet Year

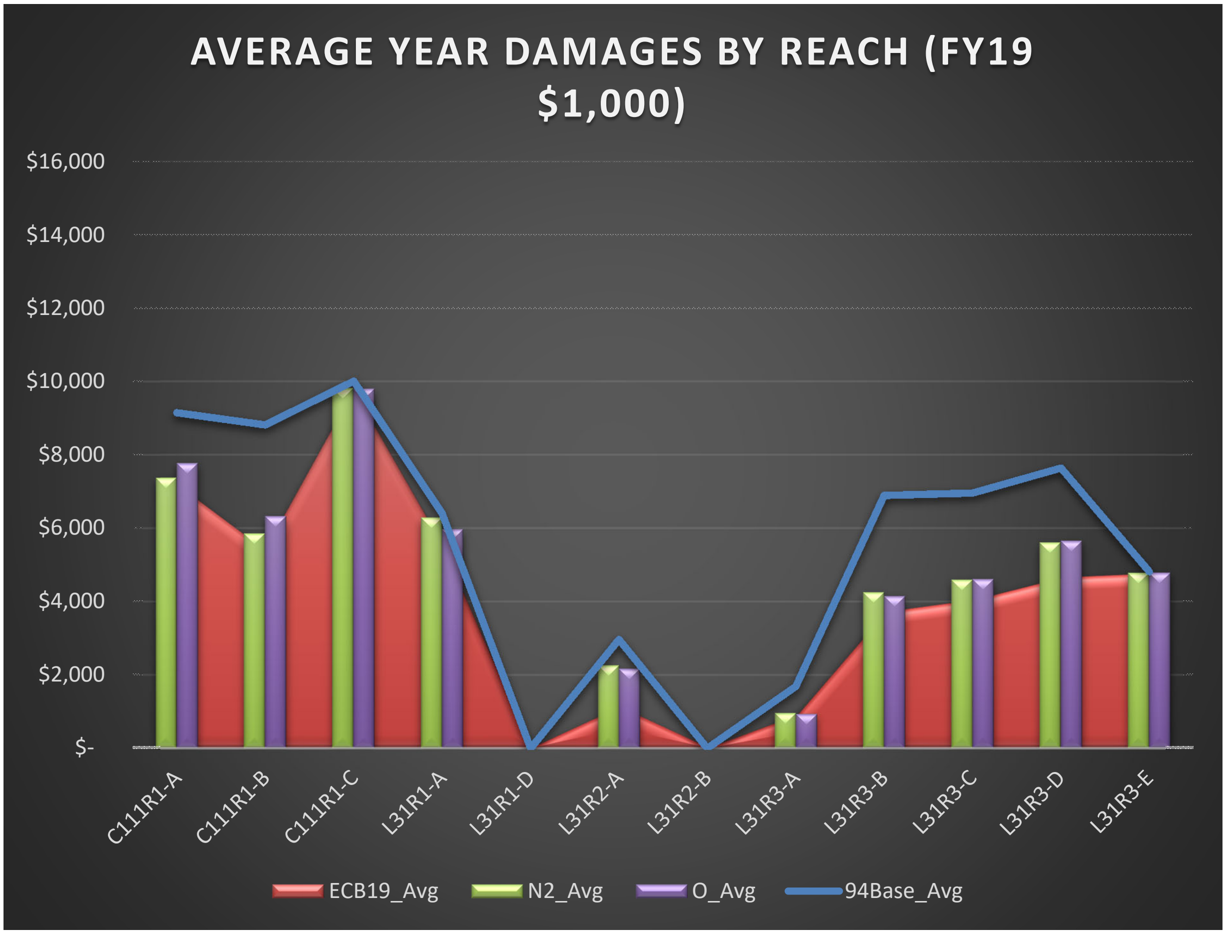

Figure 4-10: Round 2 Average Year Damages (FY19, $1000) by Reach and Operating Condition

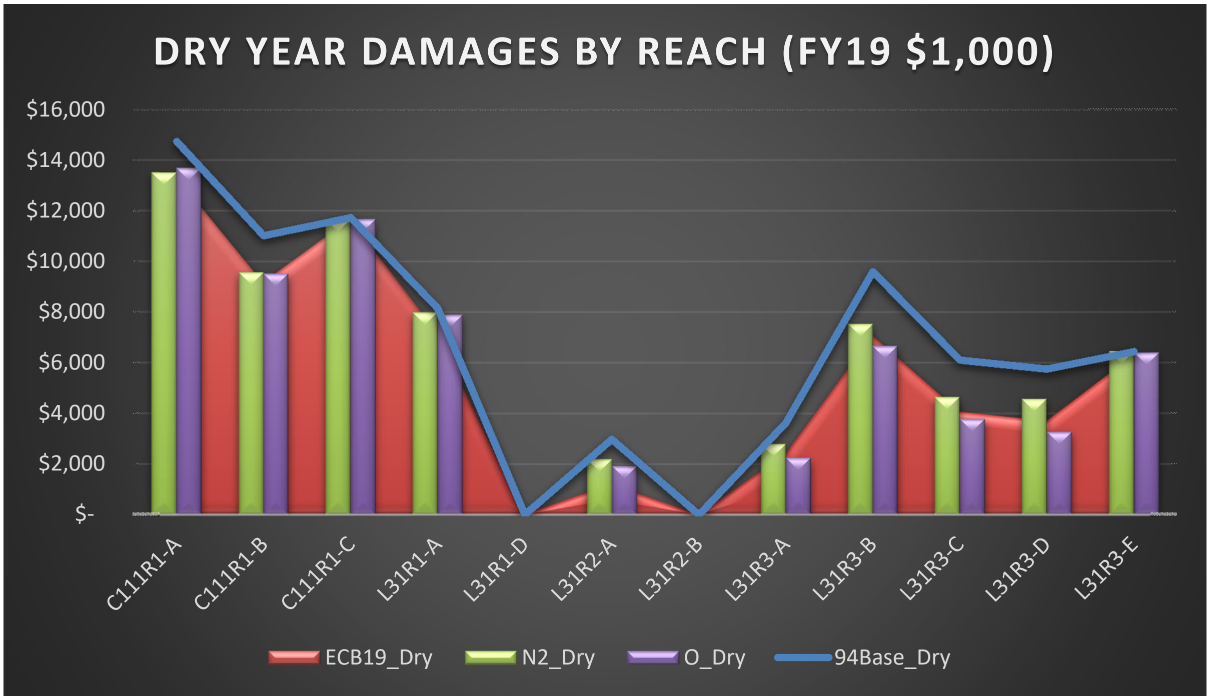

Figure 4-11: Round 2 Dry Year Damages (FY19, $1000) by Reach and Operating Condition

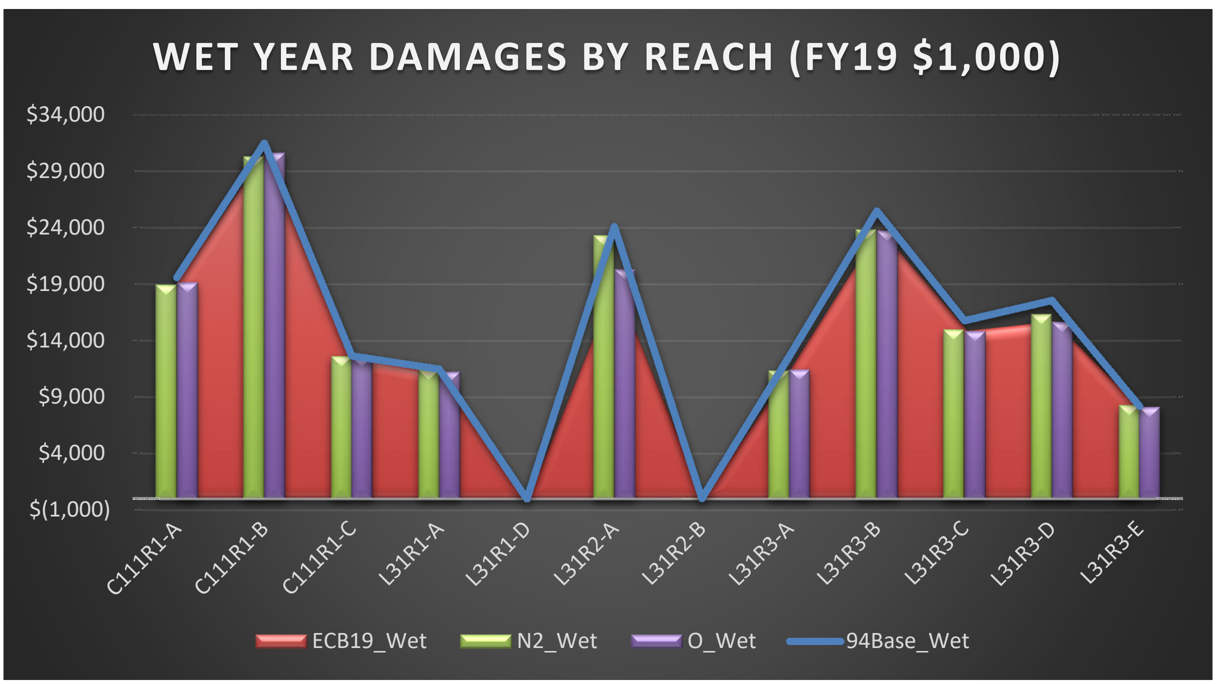

Figure 4-12: Round 2 Wet Year Damages (FY19, $1000) by Reach and Operating Condition

The largest damages in each of the event years is estimated to come from the constraint operating condition, the 94Base. Unsurprisingly, a large amount of damage is attributable to the wet year as a large swath of crops are estimated to be damaged based on the depth-damage functions for Fruit Crops and Row Crops. As one can see from **Figure 4-12**, the differences between each of the conditions in the wet year is very minimal, indicating very little room for separation amongst the alternatives. However, in the other average and dry years, there are several reaches in which the alternatives operate vastly better than the 94Base condition. Important to note that in nearly all reaches the alternatives satisfy the constraint and improve upon the estimated damages. The exception is one reach (L31R2-B) in the wet year for Alternative N2 where there is an increase of $5,000 in estimated damages. However, this reach was one of the reaches where the cells with agricultural parcels were very far removed from COP operations and were condensed and/or removed in future modeling rounds as described in **Footnote 15.** The following three tables demonstrate to what extent the alternatives reduced risk compared to the constraint[27].

Alternatives Compared to 1994 Base Condition - Average Year ($1,000 FY19)				
Reaches	Alt N2 Damage Increase / Decrease	Alt N2 Percent Change	Alt O Damage Increase / Decrease	Alt O Percent Change
C111R1-A	$ (1,769)	-19%	$ (1,374)	-15%
C111R1-B	$ (2,957)	-34%	$ (2,489)	-28%
C111R1-C	$ (193)	-2%	$ (208)	-2%
L31R1-A	$ (119)	-2%	$ (435)	-7%
L31R1-D	$ (0)	-3%	$ 0	-
L31R2-A	$ (708)	-24%	$ (798)	-27%
L31R2-B	$ -	-	$ -	-
L31R3-A	$ (723)	-43%	$ (751)	-45%
L31R3-B	$ (2,638)	-38%	$ (2,744)	-40%
L31R3-C	$ (2,364)	-34%	$ (2,348)	-34%
L31R3-D	$ (2,027)	-27%	$ (1,984)	-26%
L31R3-E	$ (33)	-1%	$ (27)	-1%
Total	**$ (13,531)**	**-21%**	**$ (13,158)**	**-20%**

Table 4-35: Round 2 Agriculture Constraint Confirmation – Average Year ($1,000 FY19)

[27] A negative number indicates reduced risk (i.e. damage reduction)

Alternatives Compared to 1994 Base Condition - Dry Year ($1,000 FY19)				
Reaches	Alt N2 Damage Increase / Decrease	Alt N2 Percent Change	Alt O Damage Increase / Decrease	Alt O Percent Change
C111R1-A	$ (1,225)	-8%	$ (1,047)	-7%
C111R1-B	$ (1,449)	-13%	$ (1,501)	-14%
C111R1-C	$ (71)	-1%	$ (62)	-1%
L31R1-A	$ (162)	-2%	$ (259)	-3%
L31R1-D	$ 0	0%	$ 0	-
L31R2-A	$ (788)	-26%	$ (1,058)	-36%
L31R2-B	$ -	-	$ 0	-
L31R3-A	$ (840)	-23%	$ (1,382)	-38%
L31R3-B	$ (2,066)	-22%	$ (2,930)	-31%
L31R3-C	$ (1,463)	-24%	$ (2,327)	-38%
L31R3-D	$ (1,183)	-21%	$ (2,474)	-43%
L31R3-E	$ 13	0%	$ (44)	-1%
Total	**$ (9,235)**	**-12%**	**$ (13,085)**	**-16%**

Table 4-36: Round 2 Agriculture Constraint Confirmation – Dry Year ($1,000 FY19)

Alternatives Compared to 1994 Base Condition - Wet Year ($1,000 FY19)				
Reaches	Alt N2 Damage Increase / Decrease	Alt N2 Percent Change	Alt O Damage Increase / Decrease	Alt O Percent Change
C111R1-A	$ (647)	-3%	$ (435)	-2%
C111R1-B	$ (1,186)	-4%	$ (867)	-3%
C111R1-C	$ (38)	0%	$ (31)	0%
L31R1-A	$ (55)	0%	$ (238)	-2%
L31R1-D	$ (0)	0%	$ (0)	-
L31R2-A	$ (778)	-3%	$ (3,790)	-16%
L31R2-B	$ 5	-	$ (8)	-
L31R3-A	$ (1,281)	-10%	$ (1,175)	-9%
L31R3-B	$ (1,659)	-7%	$ (1,761)	-7%
L31R3-C	$ (799)	-5%	$ (930)	-6%
L31R3-D	$ (1,206)	-7%	$ (1,903)	-11%
L31R3-E	$ 89	1%	$ (88)	-1%
Total	**$ (7,554)**	**-4%**	**$ (11,226)**	**-6%**

Since Alternative O clearly outperformed N2 in the wet and dry years and was virtually the same in the average year, a deeper dive was taken into O's results. A spatial comparison was made to the ECB19 in order to identify potential areas of enhanced flood risk reduction where possible. The following three figures show Alternative O increases/decreases in damages by MD-RSM cell in each of the event years.

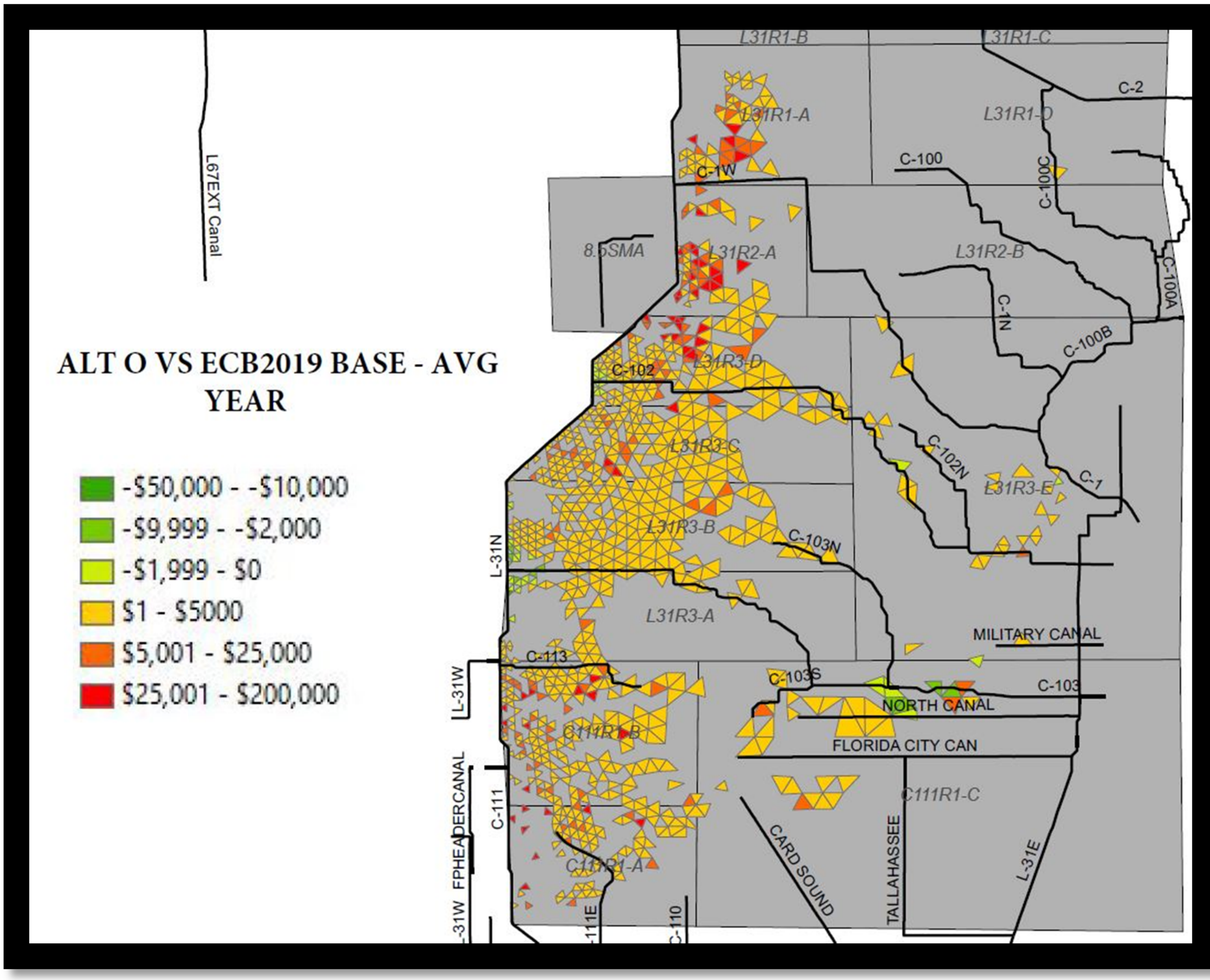

Figure 4-13: Round 2 Agriculture Spatial Summary – Alternative O Vs ECB19 Average Year ($ FY19)

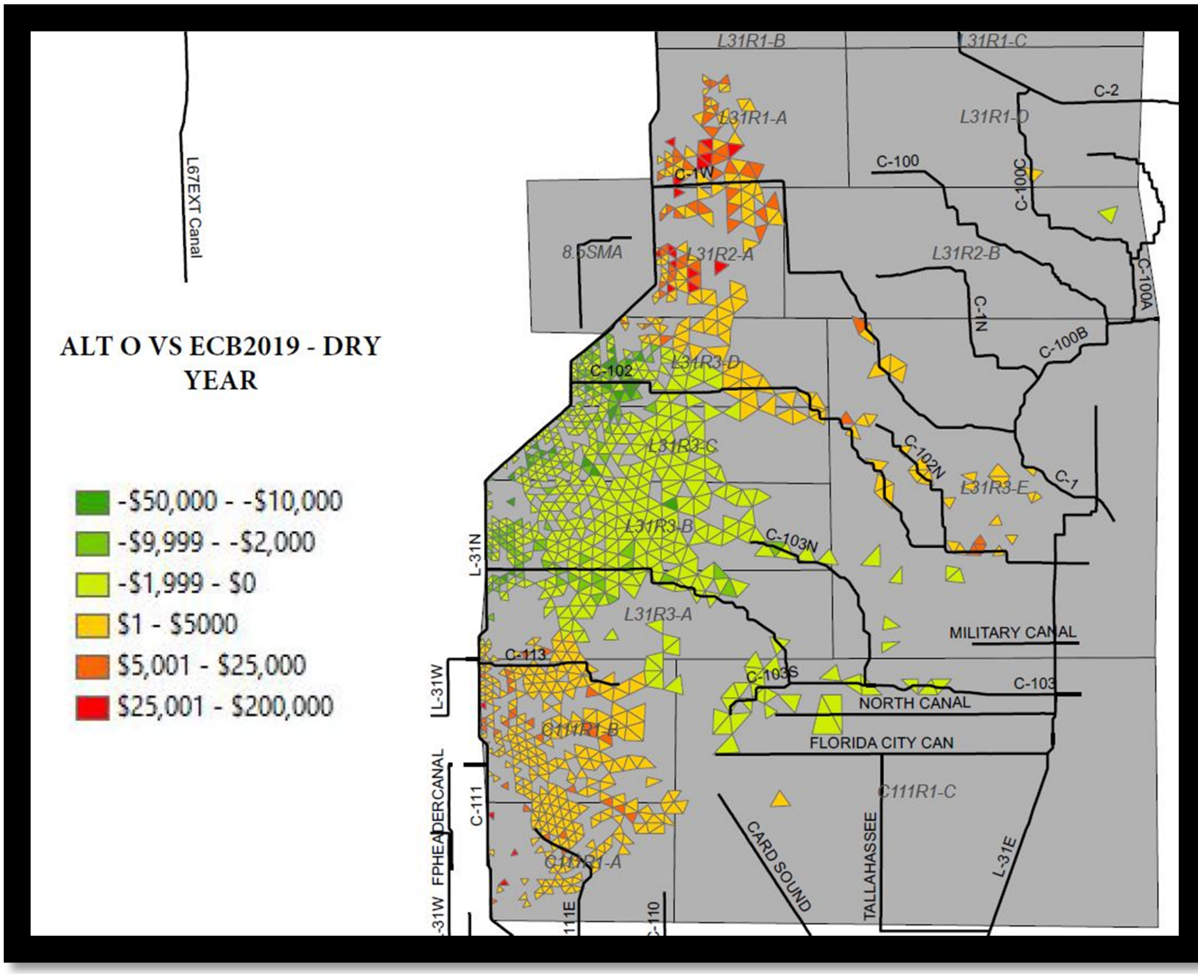

Figure 4-14: Round 2 Agriculture Spatial Summary – Alternative O Vs ECB19 Dry Year ($ FY19)

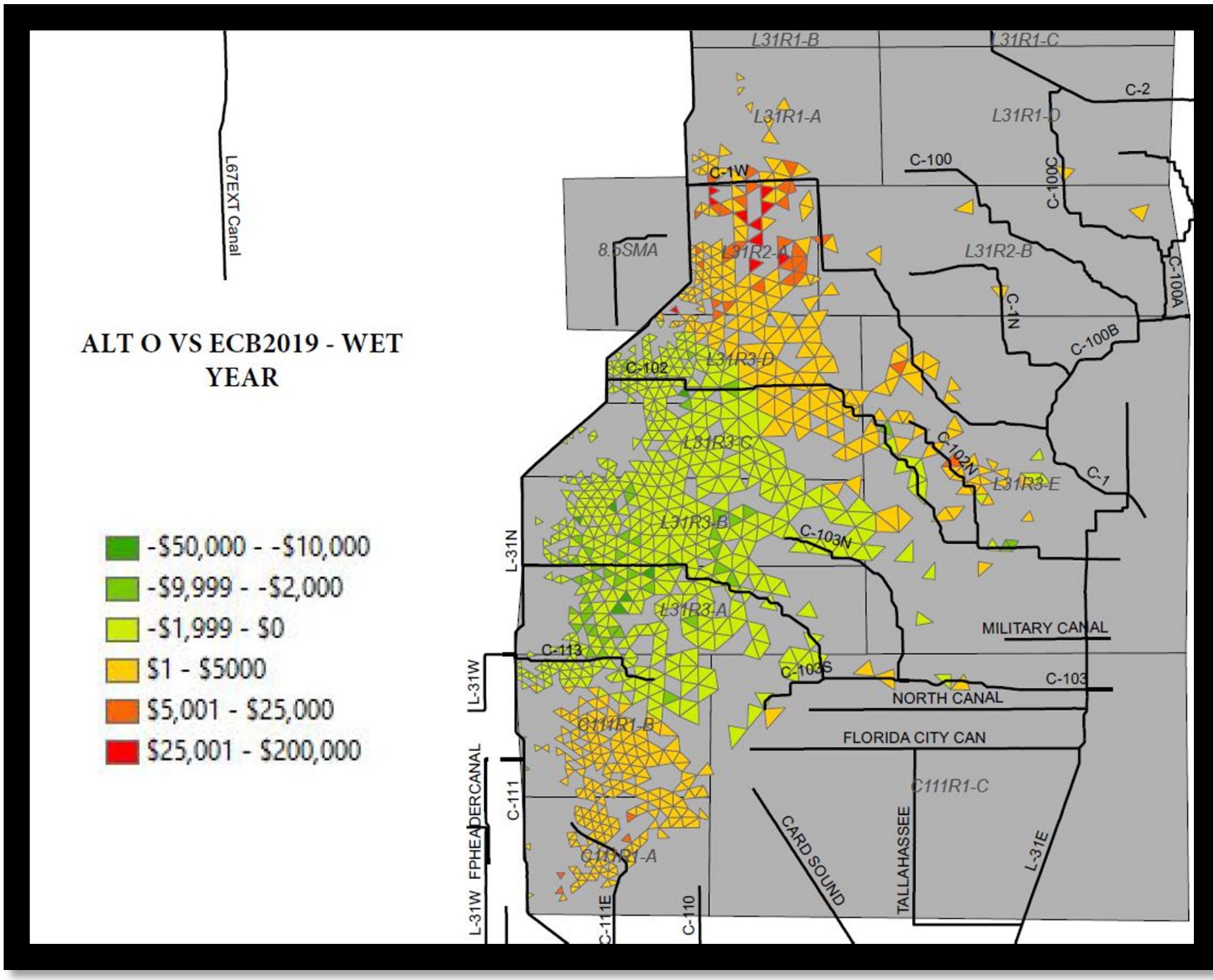

Figure 4-15: Round 2 Agriculture Spatial Summary – Alternative O Vs ECB19 Wet Year ($ FY19)

A clear pattern emerges from the spatial analysis in which the northern and southern portions of the system are showing increased flood risk compared to the ECB19, whereas the central portion of the domain shows a decreased risk. Again, the increase in risk in the northern area as compared to the ECB19 harks back to the above explanation, in **Section I.4.1,** of the incidental benefits received in this area by the intentional drawdown of stages during construction periods and to mitigate potential risk associated with increased water levels within eastern ENP during the MWD incremental field test. So, though it is clear that Alternative O outperforms Alternative N2 and provides a significant enhancement of flood risk reduction, there is still residual risk with this alternative as compared to the ECB19. This information was used during PDT discussions to formulate Round 3 alternatives and ultimately the preferred alternative, Q+.

I.4.2.3.1 Round 2 MD-RSM/HEC-FIA Agriculture Sensitivity – Raised Bedding Heights

Currently, bedding heights in the Miami-Dade area are very minimal. This is often due to a limited quantity of fill available on any given parcel that is needed in order to substantially raise a crop bed. However, it was important to determine the level of significance raising would have on damage estimation in the study area. The Institute of Food and Agriculture Sciences (IFAS) does recommend “planting fruit trees on a 2 to 3 ft. high…mound of native soil”, which includes the highly susceptible avocado crop (Crane, Balerdi, & Maguire, 2016). For this analysis, the ground surface elevation of the crops was artificially raised both 6” and 12” prior to running the HEC-FIA model for conditions under Alternative O only (i.e. holding the ECB19 elevation constant) in order to simulate the effect of raising bedding heights. This is a similar methodology used in modeling first-floor elevation raising for residential parcels under non-structural alternative evaluation. The beneficial results to flood risk reduction from raised bedding heights under Alternative O were estimated to be substantial. Bedding heights raised 12” reduced damages by as much as 48%, 73%, and 66% for the wet, average, and dry years respectively while a 6” raised bed height still provided a 21%, 40%, and 34% reduction for the wet, average, and dry years respectively. The summation of dollar-damage reduction ranged, depending on the event year, from $18.7M to $34.8M for 6” bed heights and $34.2M to $80.8M for 12” bed heights. These results are displayed graphically in **Figure 4-16** below. It is important to note that there are two sides of this equation to consider, the benefits and the costs. The benefits are laid out clearly under this analysis but under COP the scope did not allow for an analysis of the potential costs that would arrive from raising bed heights to the degree modeled. There would be fill costs, mobilization costs, transplant costs, risk of death during transplant, and possible costs in production forgone while the raising process is completed. According to the agricultural manager of Miami-Dade County, Mr. Charles LaPradd, these costs could prove to be substantial. With that said, it is still an important concept to note with regards to minimizing flood risk to agriculture. As was mentioned during Round 1 modeling, there is a limit in the extent to which operational changes, such as those proposed under the COP process, can systematically enhance flood risk reduction. However, the sensitivity analysis performed here indicates that there are potentially other preventative measures that can be undertaken to dramatically reduce risk from flooding. These concepts should be utilized in any future studies of the area that sets out with the specific objective of flood risk reduction to Miami-Dade agriculture. Costs should be fully developed in order to understand if there are potential net-benefits from raising bedding heights.

Impact Areas	ECB19_Wet	ECB19_Avg	ECB19_Dry	AltO12-Wet	AltO12-Avg	AltO12-Dry	AltO6-Wet	AltO6-Avg	AltO6-Dry
C111R1-A	$ 19,088	$ 7,197	$ 13,348	$ 9,910	$ 2,127	**$ 4,177**	$ 15,429	$ 4,276	**$ 8,599**
C111R1-B	$ 30,644	$ 5,398	$ 9,170	$ 17,982	$ 1,050	**$ 1,974**	$ 25,585	$ 2,572	**$ 5,331**
C111R1-C	$ 12,638	$ 9,762	$ 11,673	$ 8,877	$ 2,816	**$ 6,637**	$ 11,566	$ 6,395	**$ 10,019**
L31R1-A	$ 11,171	$ 5,536	$ 7,226	$ 5,098	$ 1,156	**$ 2,442**	$ 9,130	$ 3,143	**$ 5,503**
L31R1-D	$ 6	$ 1	$ 5	$ 6	$ -	**$ 1**	$ 6	$ 0	**$ 2**
L31R2-A	$ 19,168	$ 1,119	$ 1,216	$ 3,705	$ 334	**$ 303**	$ 10,966	$ 813	**$ 589**
L31R2-B	$ 32	$ -	$ 0	$ 1	$ -	**$ -**	$ 9	$ -	**$ -**
L31R3-A	$ 11,655	$ 901	$ 2,417	$ 4,320	$ 175	**$ 599**	$ 8,086	$ 451	**$ 1,112**
L31R3-B	$ 23,927	$ 3,719	$ 7,090	$ 12,986	$ 641	**$ 1,489**	$ 19,780	$ 1,715	**$ 3,323**
L31R3-C	$ 14,893	$ 4,044	$ 4,091	$ 10,347	$ 1,257	**$ 824**	$ 13,175	$ 2,800	**$ 2,177**
L31R3-D	$ 15,728	$ 4,654	$ 3,726	$ 8,094	$ 1,113	**$ 755**	$ 11,668	$ 2,551	**$ 1,445**
L31R3-E	$ 8,103	$ 4,756	$ 6,323	$ 4,924	$ 2,203	**$ 3,567**	$ 6,869	$ 3,646	**$ 5,322**
Total	***$ 167,054***	***$ 47,086***	***$ 66,287***	***$ 86,250***	***$ 12,873***	***$ 22,769***	***$ 132,269***	***$ 28,361***	***$ 43,423***
% Change From ECB19				**-48%**	**-73%**	**-66%**	**-21%**	**-40%**	**-34%**

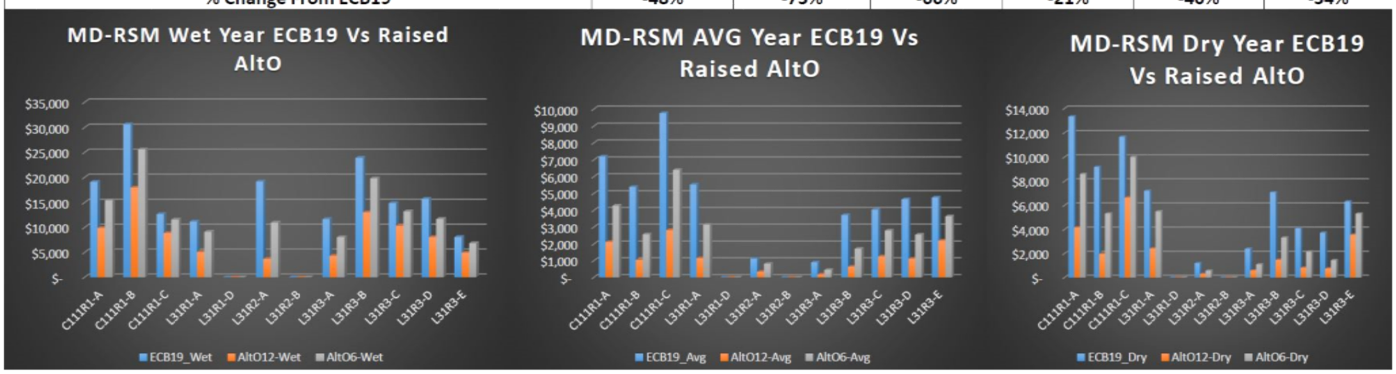

Figure 4-16: Risk Reduction Benefits from Raised Bedding Heights (6" & 12") – Alternative O vs. ECB19

I.4.2.1 Round 2 MD-RSM and HEC-FIA Results – Residential

Much like the modeling conducted using the RSM-GL model, there were no relevant damages to be measured for residential parcels. However, a similar sensitivity run was conducted in the 8.5 SMA in order to get an idea of the relative performance of each alternative as it compares to the 83Base constraint condition. The 8.5 SMA was focused on specifically due to its location as this area was estimated to be potentially at risk when delivering more water to NESRS. The PDT wanted to be fully informed on stage differences in the area in order to fully develop a Round 3 alternative with maximum restoration benefits that adhered to the 8.5 SMA flood mitigation constraint. The sensitivity conducted was to assume all FFE's were equal to ground surface (i.e. artificially lower the true estimated FFE). Again, this would give the team an idea of potential nuisance flooding and to also gauge the potential for further restoration efforts into the next round. The results of this sensitivity showed that both Alternative N2 and Alternative O performed better than the 83Base condition, especially in the wet year with a reduction of over 50% of damages for each alternative. The differences between Alternative O and N2 were minimal so each would be considered acceptable in terms of residential flood risk

MD-RSM Simulation Year	Alternative	Total Damage ($1,000)	Difference From 83 Base ($1,000)
Wet	Base83	$ 4,090	$
	AltN2	$ 1,827	$ (2,263)
	AltO	$ 1,687	$ (2,403)
	ECB19	$ 1,640	$ (2,450)
Average	Base83	$ 1,486	$ -
	AltN2	$ 1,122	$ (364)
	AltO	$ 1,117	$ (369)
	ECB19	$ 1,020	$ (466)
Dry	Base83	$ 1,494	$
	AltN2	$ 1,295	$ (199)
	AltO	$ 1,290	$ (204)
	ECB19	$ 1,119	$ (375)

Table 4-37: Round 2 8.5 SMA Sensitivity Damage Estimate (First-Floor Artificially Lowered)

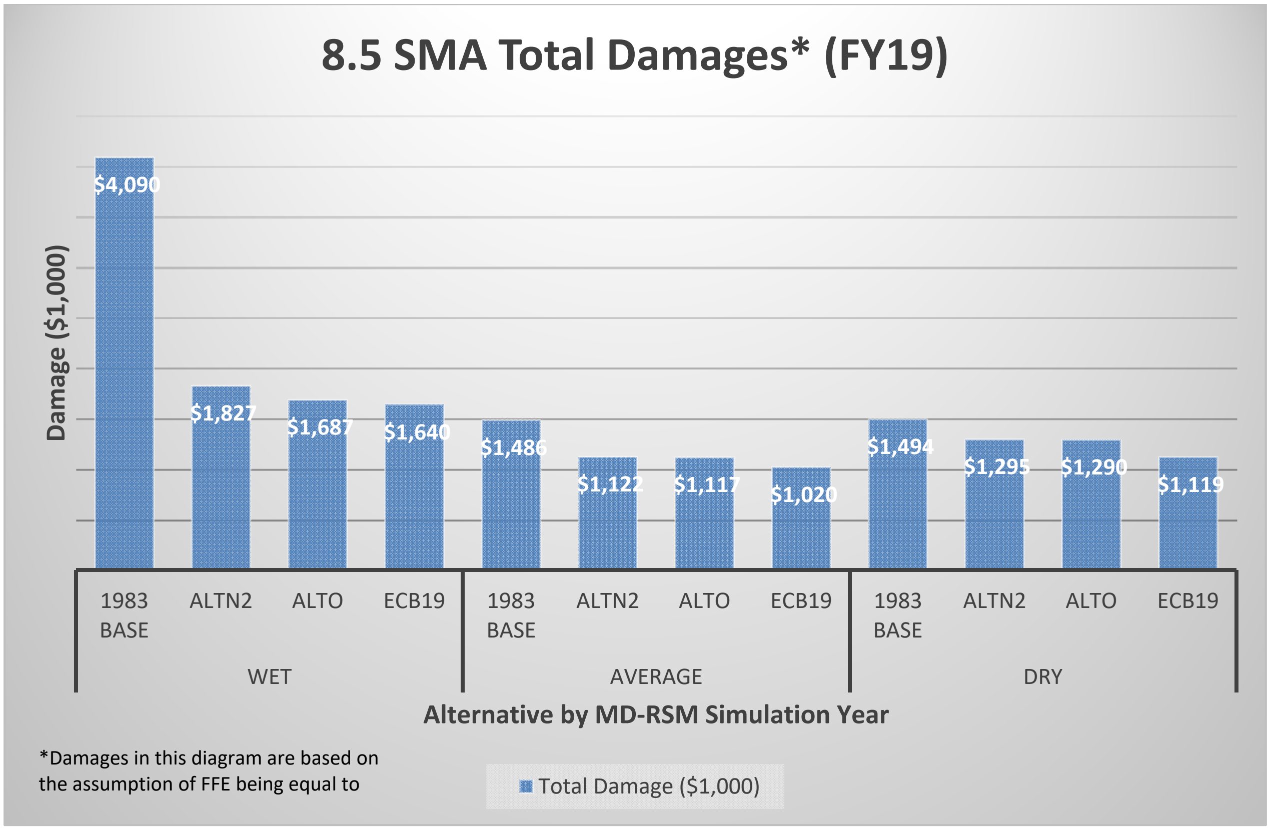

Figure 4-17: Round 2 8.5 SMA Sensitivity Damage Estimate – Alternatives Compared

I.4.3 Round 3 Modeling Results

The alternatives from Round 2 were reviewed from a flood risk and ecological enhancement point of view and the PDT decided on operations that formed Alternative Q, which largely tracks Alternative O. In the following sections Alternative Q will be reviewed to verify that the alternative does not violate any constraint conditions. Additionally, variants of Q (i.e. QM, QM1) will be modeled under the MD-RSM and HEC-FIA models in order to inform the ultimate operational criteria for the PPA (Alt Q+)[28]. These variants are not modeled for the socioeconomics using RSM-GL. Additionally, since very little risk to residential parcels in the RSM-GL model were recorded during Round 2 evaluations, the residential analysis was skipped for Round 3. Residential properties were still modeled using the more robust MD-RSM and HEC-FIA in order to gauge risk and verify the constraint conditions are met.

I.4.3.1 Round 3 RSM-GL Results – Agriculture

Since the only alternative to compare in this section is Q, the following tables have condensed the comparison of the alternative and the two base conditions (ECB19, 2012WCP) into one whereas the previous sections have displayed these comparisons separately. Based on these tables, it is clear that the

[28] Because the operational criteria are so similar, the variants of Q were only modeled for agriculture and 8.5 SMA during Round 3. In Round 4 using the design storms Alternatives Q and Qm will be modeled for the entire residential spatial domain as a check on the 1994Base constraint.

alternative performs similar to Alternative O and shows a benefit throughout the majority of the system. There are some areas where residual risk remains, however it is minimal based on this analysis especially when compared to the 2012WCP (indicative of the long-term levels experienced prior to the start of the MWD incremental field test).

ROW 2"									
	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Sub-Basin Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
Q vs 2012WCP	0	0	0	0	0	0	0	0	-7
Q vs ECB19	0	2	0	0	0	0	0	0	-1

Table 4-38: Alternative Q vs 2012WCP and ECB19 – Row Crop 2” Threshold

ROW 12"									
	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Sub-Basin Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
Q vs 2012WCP	0	-5	0	0	0	0	0	0	-1
Q vs ECB19	0	2	0	0	0	0	0	0	7

Table 4-39: Alternative Q vs 2012WCP and ECB19 – Row Crop 12” Threshold

ROW 18"									
	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Sub-Basin Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
Q vs 2012WCP	0	-7	0	0	-1	1	0	3	-39
Q vs ECB19	1	6	0	0	0	0	0	-5	-6

Table 4-40: Alternative Q vs 2012WCP and ECB19 – Row Crop 18" Threshold

ROW 24"									
	C-1 WEST	C-1 WEST	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	L-31 NS	L-31 NS	C2
Sub-Basin Topo (Avg)	9.18	9.18	9.18	10.62	5.72	5.72	8.87	8.87	8.62
Indicator Cell Topo	9.33	7.75	8.82	9.94	5.76	8.72	9.35	7.41	6.52
Cell ID	3404	3409	3633	4809	4306	4337	3619	3839	2976
Q vs 2012WCP	-3	-7	0	0	-3	0	0	-14	-21
Q vs ECB19	2	8	0	0	1	0	0	-8	-25

Table 4-41: Alternative Q vs 2012WCP and ECB19 – Row Crop 24" Threshold

FRUIT Crops												
Watershed	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	C-111 AG	C-111 AG	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Sub-Basin Topo (Avg)	7.13	7.13	9.18	10.62	5.72	5.72	5.72	5.72	8.87	8.87	8.87	8.87
Indicator Cell Topo	11.27	11.48	9.33	9.70	6.51	7.38	5.55	6.86	8.57	9.32	9.55	8.66
Cell ID	4345	4346	3404	4351	4328	4567	5019	5023	3400	3622	3847	4085
Q vs 2012WCP	0	0	-1	0	-59	-3	-2	0	4	0	1	1
Q vs ECB19	0	0	3	0	8	-1	1	0	-2	-6	1	0

Table 4-42: Alternative Q vs 2012WCP and ECB19 – Fruit Crops

Container Crops										
Watershed	BD-C103 WEST	BD-C103 West	C-1 WEST	C-102 WEST	C-111 AG	L-31 NS	L-31 NS	L-31 NS	L-31 NS	L-31 NS
Sub-Basin Topo (Avg)	7.13	7.13	9.18	10.62	5.72	8.87	8.87	8.87	8.87	8.87
Indicator Cell Topo	11.27	11.48	9.33	9.94	6.51	8.42	9.33	9.32	9.55	6.58
Cell ID	4345	4346	3404	4809	4328	3398	3400	3622	3847	4332
Q vs 2012WCP	0	0	0	0	0	0	0	0	0	0
Q vs ECB19	0	0	0	0	1	0	0	0	0	0

Table 4-43: Alternative Q vs 2012WCP and ECB19 – Container Crops

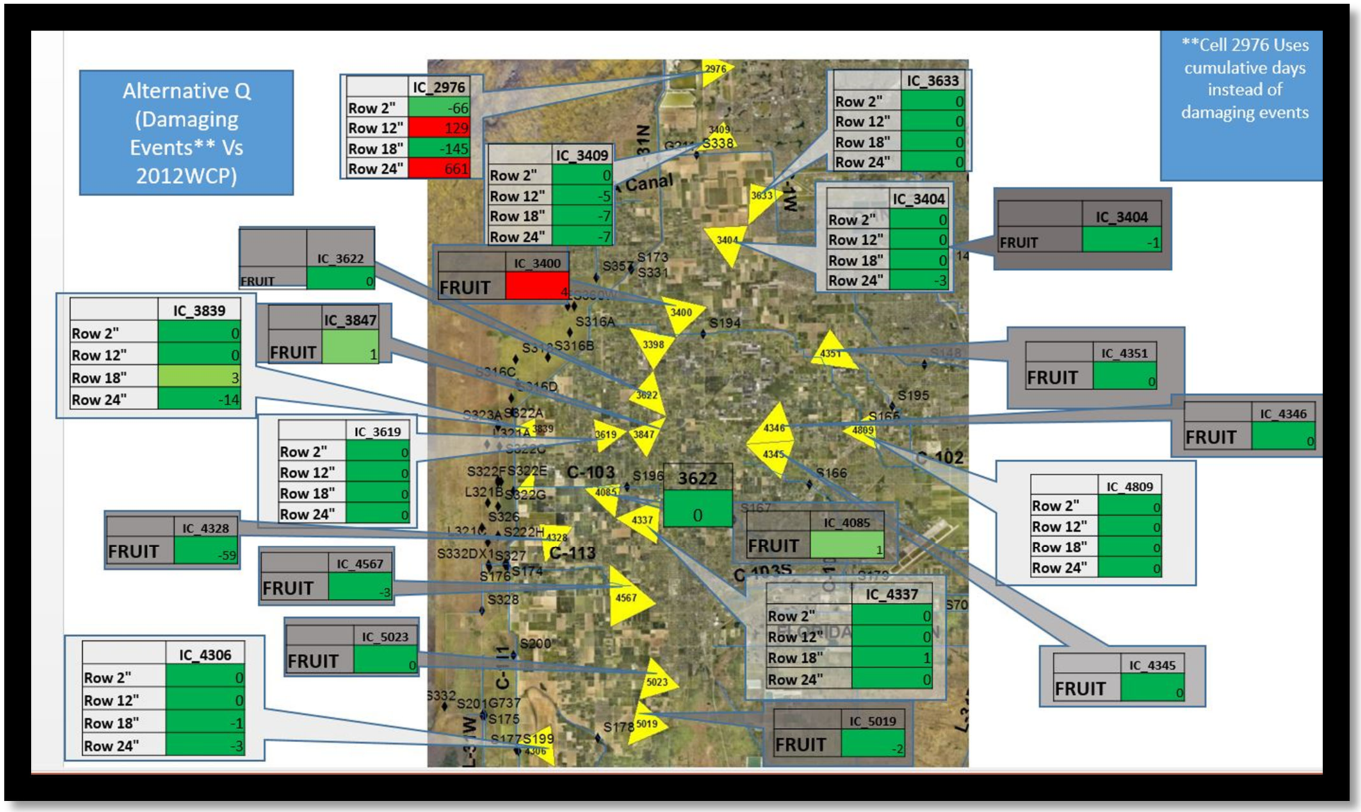

Figure 4-18: RSM-GL Alternative Q vs 2012WCP Spatial Summary

I.4.3.2 Round 3 MD-RSM Results – Agriculture

As introduced in Section 4.14.5 of the COP EIS, a modified version of the initial MD-RSM ALT Q simulation, labeled as ALT Qm (Q modified), was completed in MD-RSM with explicit representation of the event-based operations assumed for the 8.5 SMA at S-357 and S-331 that were specified in the PPA identified by the PDT. The expected COP performance for the 8.5 SMA and the South Dade basin (which receives additional volume discharged using S-331with the inclusion of 8.5 SMA event-based operations in the MD-RSM simulation) is effectively bracketed between ALT Q (with inclusion of minimum C-357 Canal operations at S-357 during high-water events) and ALT Qm. ALT Qm is the most appropriate MD-RSM modeling representation of the COP Recommended Plan (Alternative Q Plus) following the COP PDT Round 3 technical evaluations. The performance of ALT Q+ if the FDOT constraint for the L-29 Canal is able to be removed through continued monitoring and coordination with FDOT is evaluated with the MD-RSM simulation SR Qm1, which includes the event-based operations at S-357 and S-331.

Alternatives Q, Qm, and Qm1 each performed well overall in terms of agricultural risk reduction. In the wet year each alternative reduced the estimated damages by approximately 10% when compared to the Base94. For the average and dry years the reduction was even greater with a nearly 30% reduction and approximately 20% reduction respectively. The overall results can be seen in **Table 4-44.** The damage reduction capacity of Q, Qm, and Qm1 compared to the Base94 condition is true across all reaches as well (i.e. no single reach is pulling the average reduction up) as can be seen in **Table 4-45, Table 4-46** and **Table 4-47 .** When compared to the ECB19 baseline there are also many reaches in which the alternatives show substantial risk reduction, though, there are some reaches where residual risk remains a concern. This pattern is best viewed in the spatial summary of the alternatives as compared to the baseline conditions which are shown in **Figure 4-19** through **Figure** 4-24**.** As one can see, the residual risk is concentrated mostly in the northern and southern tails of the study area when compared to the ECB19. In wet conditions there is also some residual risk in the central portion of the study area immediately adjacent to the L-31 canal and extending partially eastward. From this analysis it is clear that the constraint is met under each of the Q variants but attention must be paid to the central portion of the system under wet conditions when developing the adaptive management plan. Another takeaway from the tables and figures below is that there is very little difference, in terms of flood risk, between Q, Qm, and Qm1, and as such any operational criteria within the alternatives would be acceptable with respect to the Base94 constraint.

Reaches	MD-RSM TOTAL AGRICULTURE DAMAGES (ALL SIMULATION YEARS)														
	Total Damage Wet ($1,000 FY19)					Total Damage Average ($1,000 FY19)					Total Damage Dry ($1,000 FY19)				
	Base94	ECB19	AltQ	AltQm	AltQm1	Base94	ECB19	AltQ	AltQm	AltQm1	Base94	ECB19	AltQ	AltQm	AltQm1
C111R1-A	$ 22,016	$ 21,353	$ 21,407	$ 21,429	$ 21,470	$ 10,151	$ 8,635	$ 8,392	$ 8,395	$ 8,415	$ 16,535	$ 15,041	$ 15,212	$ 15,259	$ 15,327
C111R1-B	$ 34,171	$ 33,027	$ 32,861	$ 33,535	$ 33,677	$ 9,480	$ 6,696	$ 6,007	$ 6,146	$ 6,241	$ 11,984	$ 9,976	$ 9,881	$ 10,235	$ 10,414
C111R1-C	$ 14,566	$ 14,539	$ 14,490	$ 14,526	$ 14,527	$ 11,510	$ 11,277	$ 11,201	$ 11,215	$ 11,225	$ 13,499	$ 13,423	$ 13,405	$ 13,413	$ 13,422
L31R1-A	$ 13,298	$ 12,872	$ 13,068	$ 12,923	$ 12,852	$ 7,399	$ 6,369	$ 6,742	$ 6,742	$ 6,756	$ 9,760	$ 8,699	$ 9,119	$ 8,969	$ 8,962
L31R2-A	$ 27,722	$ 21,604	$ 22,289	$ 20,745	$ 19,490	$ 3,127	$ 1,159	$ 1,356	$ 1,350	$ 1,361	$ 3,513	$ 1,570	$ 1,894	$ 1,472	$ 1,294
L31R3-A	$ 13,631	$ 12,258	$ 11,766	$ 11,780	$ 11,935	$ 1,794	$ 1,013	$ 874	$ 886	$ 892	$ 3,964	$ 2,864	$ 2,122	$ 2,235	$ 2,391
L31R3-B	$ 27,304	$ 25,418	$ 24,598	$ 24,984	$ 25,098	$ 7,423	$ 4,123	$ 3,702	$ 3,706	$ 3,717	$ 10,569	$ 7,906	$ 6,510	$ 6,692	$ 6,951
L31R3-C	$ 16,792	$ 15,758	$ 15,422	$ 15,829	$ 15,851	$ 7,339	$ 4,284	$ 4,091	$ 4,090	$ 4,102	$ 6,747	$ 4,523	$ 3,536	$ 3,600	$ 3,723
L31R3-D	$ 18,985	$ 16,776	$ 16,072	$ 15,386	$ 15,202	$ 7,937	$ 4,817	$ 4,485	$ 4,472	$ 4,490	$ 6,169	$ 4,215	$ 3,140	$ 3,083	$ 3,068
Total	$ 188,483	$ 173,605	$ 171,972	$ 171,138	$ 170,103	$ 66,160	$ 48,372	$ 46,849	$ 47,002	$ 47,199	$ 82,740	$ 68,216	$ 64,819	$ 64,957	$ 65,551
Percent Change From Base Conditions	% Change From ECB19		1%	1%	2%	% Change From ECB19		-3%	-3%	-2%	% Change From ECB19		-5%	-5%	-4%
	% Change From Base94		9%	9%	10%	% Change From Base94		-29%	-29%	-29%	% Change From Base94		-22%	-21%	-21%

Table 4-44: Round 3 Agriculture Damage Summary – All Operating Conditions for Each MD-RSM Event Year

Damage Reduction Summary for MD-RSM Wet Year ($1,000 FY19)												
Reaches	Alternatives Vs 1994 Base			Alternatives Vs ECB19			Percent Change from Base Conditions					
	ALTQ VS Base94 ($1,000 FY19)	ALTQm VS Base94 ($1,000 FY19)	ALTQm1 VS Base94 ($1,000 FY19)	ALTQ VS ECB19 ($1,000 FY19)	ALTQm VS ECB19 ($1,000 FY19)	AltQm1 Vs ECB19 ($1,000 FY19)	AltQ vs 94Base	AltQm vs 94Base	AltQm1 vs 94Base	AltQ vs ECB19	AltQm vs ECB19	AltQm1 vs ECB19
C111R1-A	$ (608)	$ (587)	$ (546)	$ 54	$ 76	$ 117	-3%	3%	2%	%	0%	1%
C111R1-B	$ (1,310)	$ (636)	$ (494)	$ (166)	$ 509	$ 651	-4%	2%	1%	1%	2%	2%
C111R1-C	$ (76)	$ (40)	$ (39)	$ (49)	$ (13)	$ (12)	-1%	0%	0%	0%	0%	0%
L31R1-A	$ (230)	$ (375)	$ (445)	$ 196	$ 51	$ (19)	-2%	3%	3%	2%	0%	0%
L31R2-A	$ (5,433)	$ (6,977)	$ (8,232)	$ 685	$ (858)	$ (2,114)	-20%	-25%	-30%	3%	4%	10%
L31R3-A	$ (1,865)	$ (1,850)	$ (1,696)	$ (492)	$ (477)	$ (323)	-14%	-14%	-12%	4%	4%	3%
L31R3-B	$ (2,706)	$ (2,320)	$ (2,205)	$ (820)	$ (434)	$ (319)	-10%	8%	8%	3%	2%	1%
L31R3-C	$ (1,370)	$ (963)	$ (941)	$ (337)	$ 70	$ 93	-8%	6%	6%	2%	0%	1%
L31R3-D	$ (2,913)	$ (3,599)	$ (3,783)	$ (704)	$ (1,390)	$ (1,574)	-15%	-19%	-20%	4%	8%	9%
Total	***$ (16,511)***	***$ (17,346)***	***$(18,380)***	***$ (1,632)***	***$ (2,467)***	***$ (3,501)***	***-9%***	***9%***	***10%***	***1%***	***1%***	***2%***

Table 4-45: Round 3 Risk Assessment by Reach – Alternatives Q, Qm, Qm1 Wet Year

Damage Reduction Summary for MD-RSM Average Year ($1,000 FY19)												
Reaches	Alternatives Vs 1994 Base			Alternatives Vs ECB19			**Percent Change from Base Conditions**					
	ALTQ VS Base94 ($1,000)	ALTQm VS Base94 ($1,000)	ALTQm1 VS Base94 ($1,000)	ALTQ VS ECB19 ($1,000)	ALTQm VS ECB19 ($1,000)	AltQm1 Vs ECB19 ($1,000)	AltQ vs 94Base	AltQm vs 94Base	AltQm1 vs 94Base	AltQ vs ECB19	AltQm vs ECB19	AltQm1 vs ECB19
C111R1-A	$ (1,759)	$ (1,756)	$ (1,736)	$ (243)	$ (240)	$ (220)	-17%	-17%	-17%	3%	3%	3%
C111R1-B	$ (3,474)	$ (3,334)	$ (3,239)	$ (689)	$ (550)	$ (455)	-37%	-35%	-34%	10%	8%	7%
C111R1-C	$ (309)	$ (295)	$ (285)	$ (76)	$ (62)	$ (52)	-3%	3%	2%	1%	1%	0%
L31R1-A	$ (657)	$ (657)	$ (642)	$ 373	$ 373	$ 387	-9%	9%	9%	6%	6%	6%
L31R2-A	$ (1,771)	$ (1,777)	$ (1,767)	$ 197	$ 192	$ 202	-57%	-57%	-56%	17%	17%	17%
L31R3-A	$ (920)	$ (908)	$ (902)	$ (139)	$ (127)	$ (121)	-51%	-51%	-50%	14%	13%	12%
L31R3-B	$ (3,721)	$ (3,717)	$ (3,707)	$ (421)	$ (417)	$ (407)	-50%	-50%	-50%	10%	10%	10%
L31R3-C	$ (3,248)	$ (3,249)	$ (3,236)	$ (193)	$ (194)	$ (181)	-44%	-44%	-44%	5%	5%	4%
L31R3-D	$ (3,453)	$ (3,466)	$ (3,447)	$ (332)	$ (345)	$ (326)	-44%	-44%	-43%	7%	7%	7%
Total	***$ (19,312)***	***$ (19,158)***	***$ (18,961)***	***$ (1,523)***	***$ (1,370)***	***$ (1,173)***	***-29%***	***-29%***	***-29%***	***3%***	***3%***	***2%***

Table 4-46: Round 3 Risk Assessment by Reach – Alternatives Q, Qm, Qm1 Average Year

Damage Summary for MD-RSM Dry Year ($1,000 FY19)												
Reaches	Alternatives Vs 1994 Base			Alternatives Vs ECB19			**Percent Change from Base Conditions**					
	ALTQ VS Base94 ($1,000)	ALTQm VS Base94 ($1,000)	ALTQm1 VS Base94 ($1,000)	ALTQ VS ECB19 ($1,000)	ALTQm VS ECB19 ($1,000)	AltQm1 Vs ECB19 ($1,000)	AltQ vs 94Base	AltQm vs 94Base	AltQm1 vs 94Base	AltQ vs ECB19	AltQm vs ECB19	AltQm1 vs ECB19
C111R1-A	$ (1,324)	$ (1,276)	$ (1,208)	$ 170	$ 218	$ 286	-8%	8%	7%	1%	1%	2%
C111R1-B	$ (2,103)	$ (1,749)	$ (1,569)	$ (96)	$ 259	$ 438	-18%	-15%	13%	1%	3%	4%
C111R1-C	$ (94)	$ (86)	$ (77)	$ (17)	$ (9)	$ (1)	-1%	1%	1%	0%	0%	0%
L31R1-A	$ (641)	$ (792)	$ (799)	$ 420	$ 270	$ 263	-7%	8%	8%	5%	3%	3%
L31R2-A	$ (1,619)	$ (2,041)	$ (2,219)	$ 324	$ (98)	$ (276)	-46%	-58%	-63%	21%	6%	-18%
L31R3-A	$ (1,842)	$ (1,729)	$ (1,573)	$ (742)	$ (629)	$ (473)	-46%	-44%	-40%	-26%	-22%	-17%
L31R3-B	$ (4,059)	$ (3,878)	$ (3,618)	$ (1,396)	$ (1,215)	$ (955)	-38%	-37%	-34%	-18%	-15%	12%
L31R3-C	$ (3,211)	$ (3,146)	$ (3,024)	$ (987)	$ (923)	$ (800)	-48%	-47%	-45%	-22%	-20%	-18%
L31R3-D	$ (3,029)	$ (3,086)	$ (3,101)	$ (1,075)	$ (1,132)	$ (1,147)	-49%	-50%	-50%	-26%	-27%	-27%
Total	***$ (17,921)***	***$ (17,783)***	***$ (17,189)***	***$ (3,398)***	***$ (3,260)***	***$ (2,665)***	***-22%***	***-21%***	***-21%***	***5%***	***5%***	***4%***

Table 4-47 : Round 3 Risk Assessment by Reach – Alternatives Q, Qm, Qm1 Dry Year

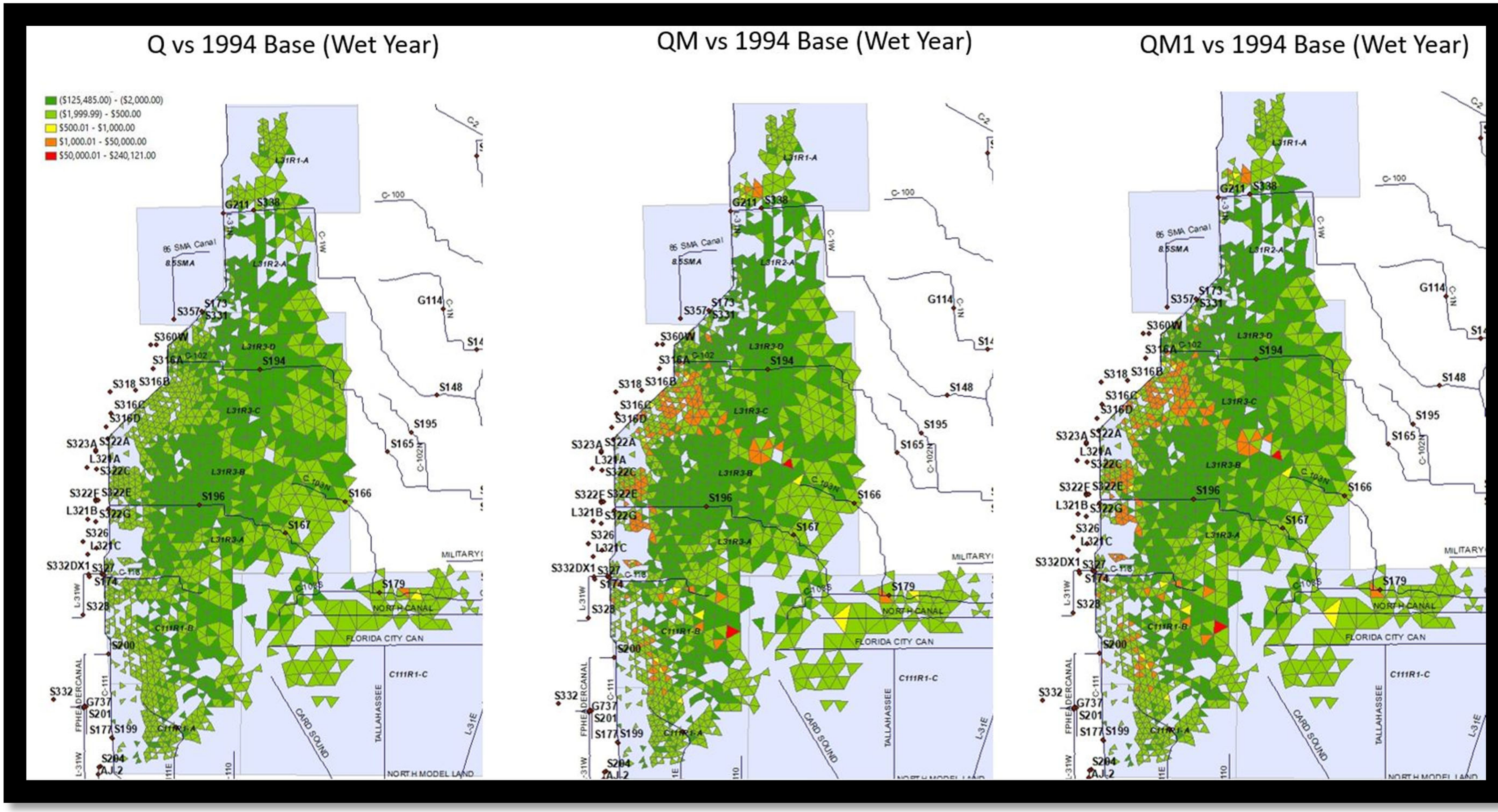

Figure 4-19: Round 3 Risk Map – Alternatives Compared to 1994 Base Condition – Wet Year

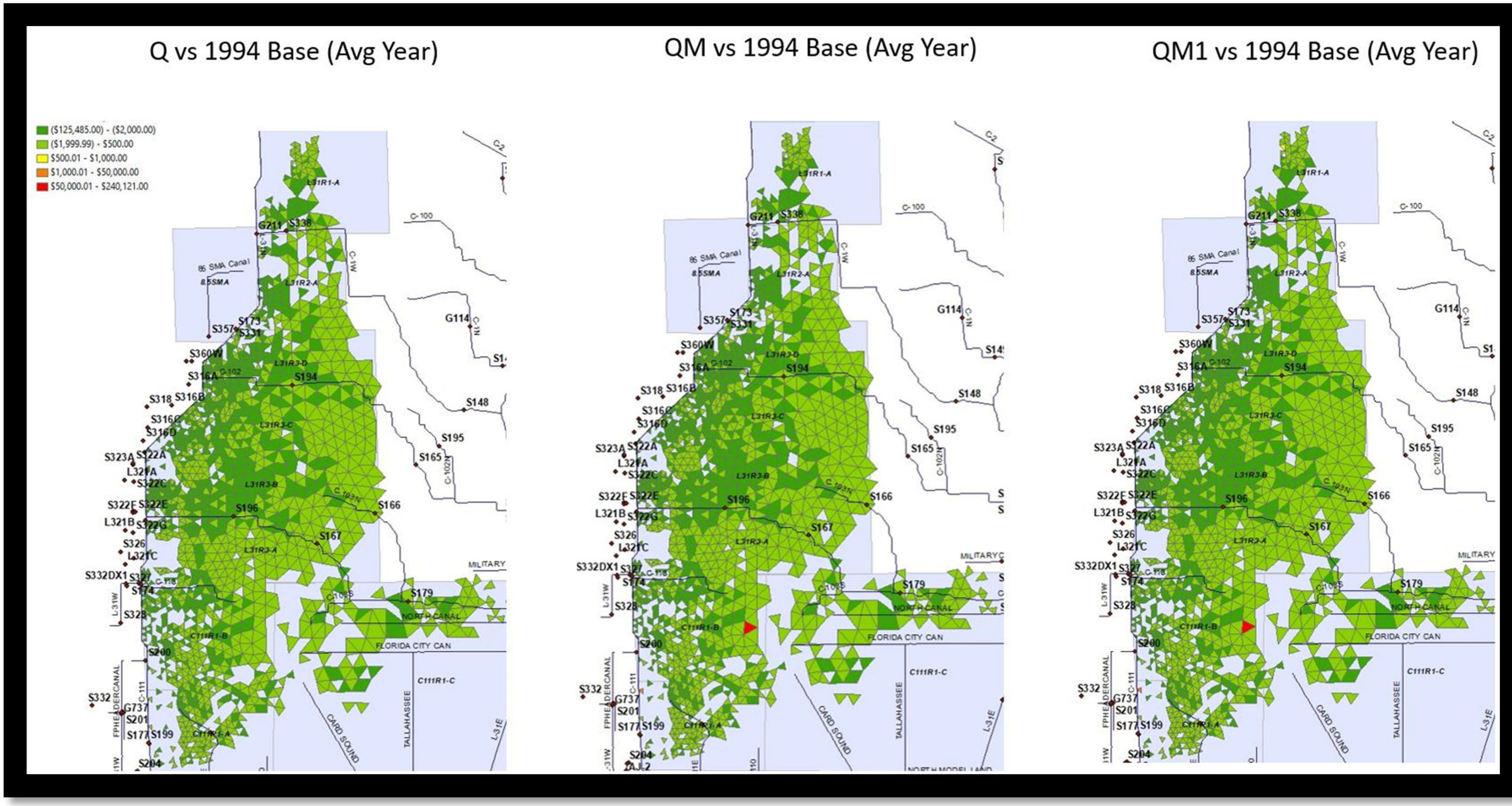

Figure 4-20: Round 3 Risk Map – Alternatives Compared to 1994 Base Condition – Average Year

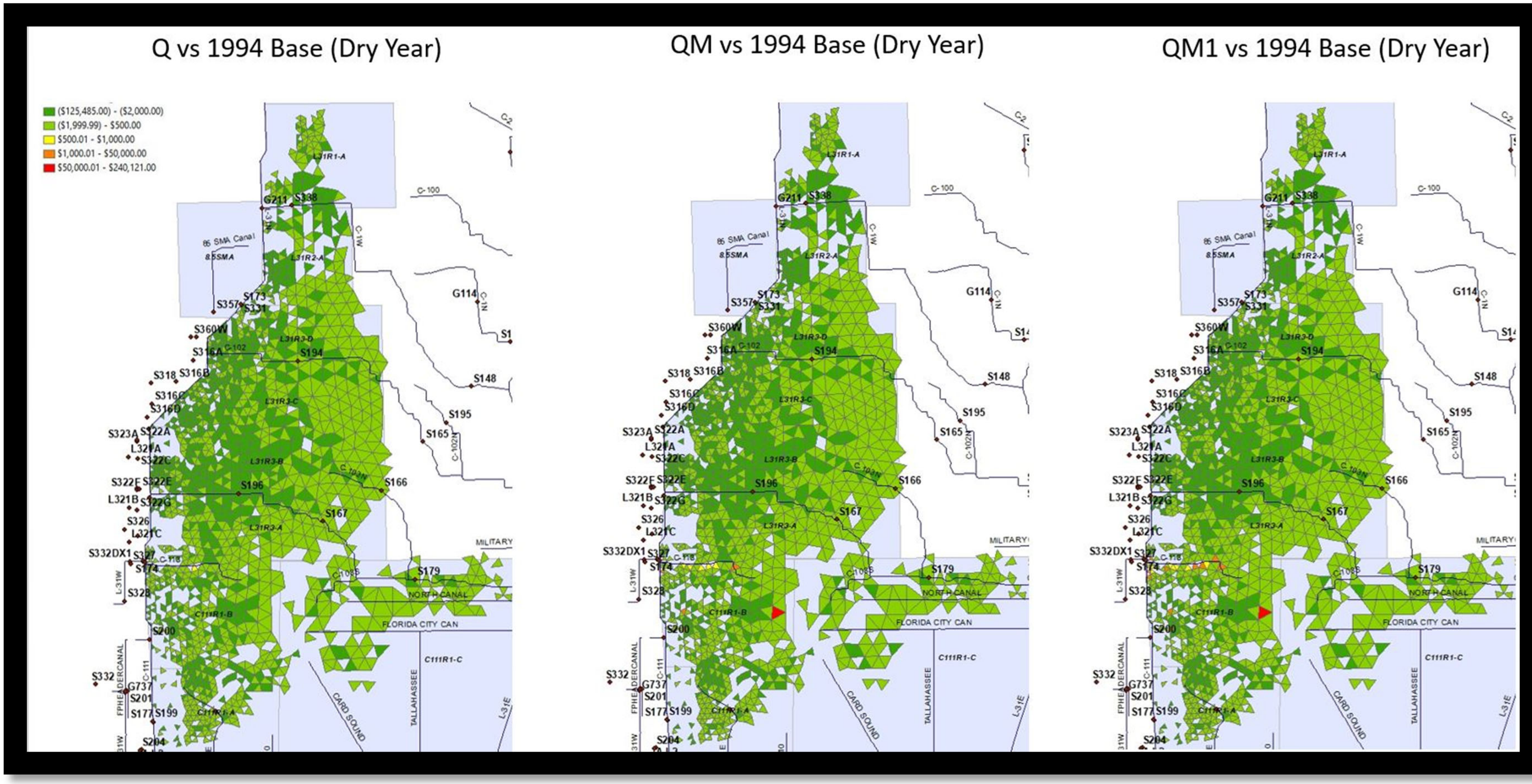

Figure 4-21: Round 3 Risk Map – Alternatives Compared to 1994 Base Condition – Dry Year

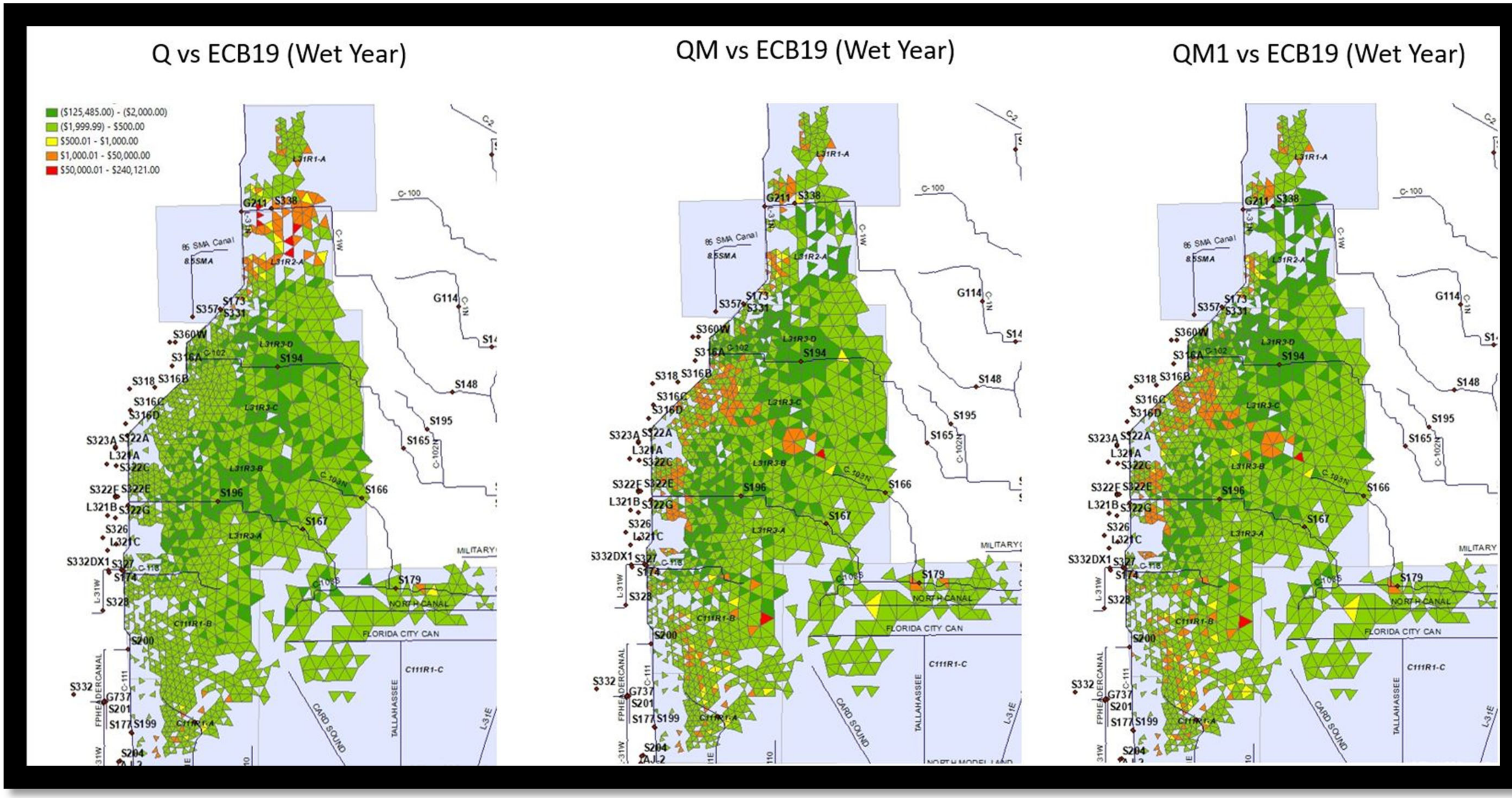

Figure 4-22: Round 3 Risk Map – Alternatives Compared to ECB19 – Wet Year

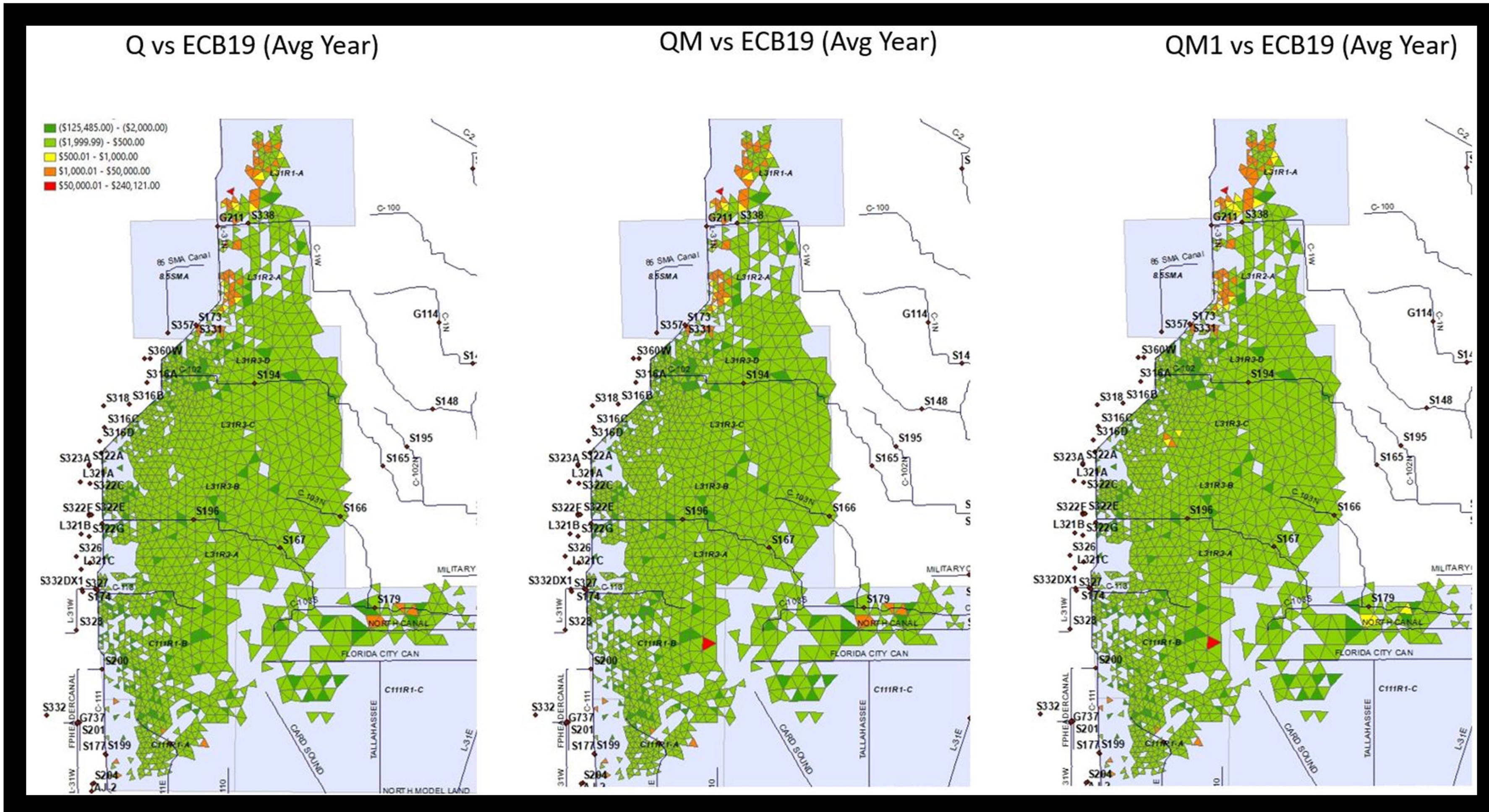

Figure 4-23: Round 3 Risk Map – Alternatives Compared to ECB19 – Average Year

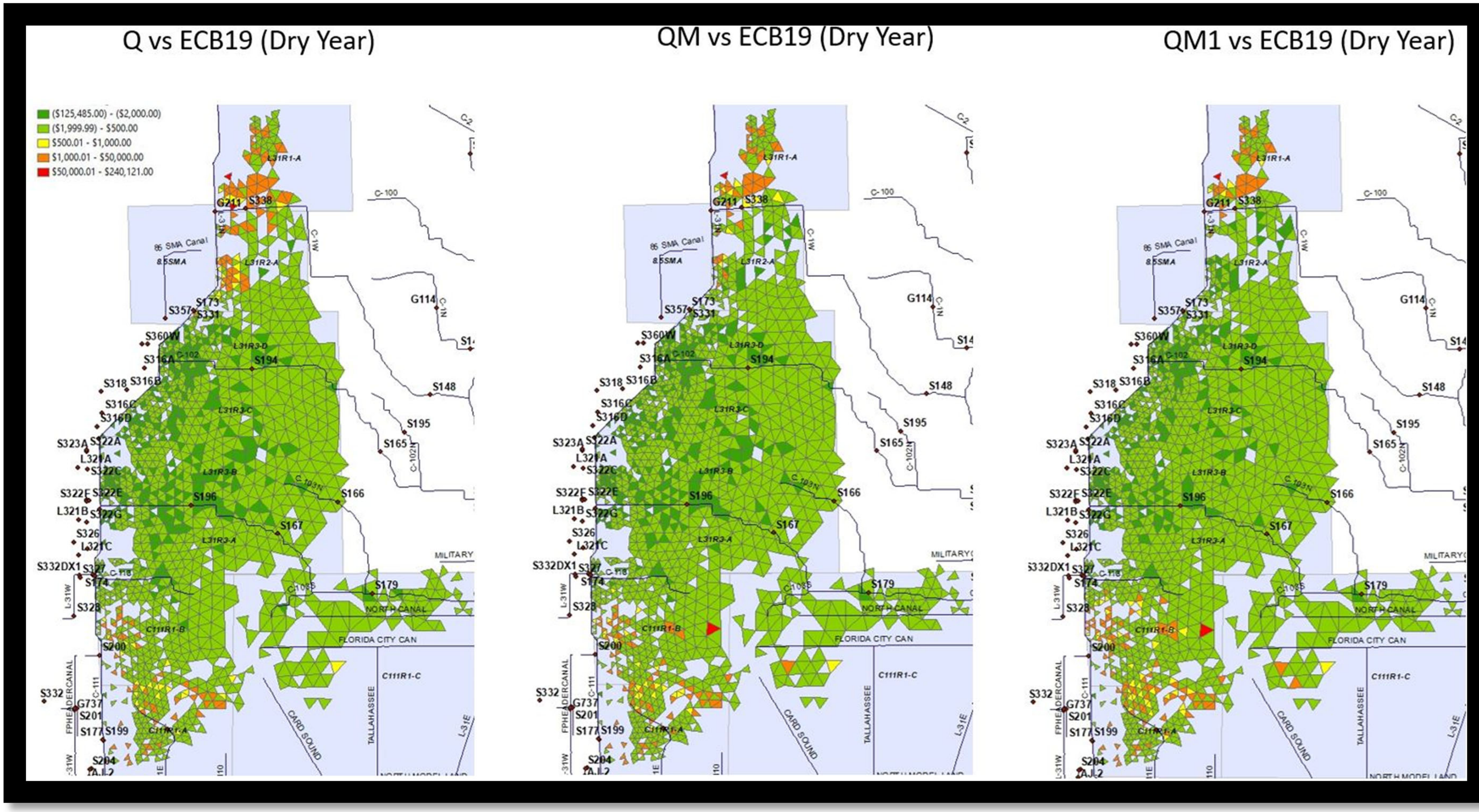

Figure 4-24: Round 3 Risk Map – Alternatives Compared to ECB19 – Dry Year

Round 3 Sensitivity Analyses – 24-Hour Post Peak Stage and 6” Bedding Heights

With the additional resolution provided from the MD-RSM model it was also possible to estimate damages related to the stage exactly 24 hours after the peak stage (i.e. the stage which is modeled above). Modeling 24-hours post peak stage allowed for a slightly more realistic idea of dollar damages (since we have already established that the damaging duration for the most susceptible row and fruit crops is 24 hours) but also allowed the PDT to see if Alternative Q was better than the constraint condition in terms of drawing down elevated groundwater levels. That is, if risk reduction levels were even greater 24 hours after the peak stage that would potentially confer additional benefits from the operations under Alternative Q. As you can see from the results displayed in **Table 4-48** and **Table 4-49,** on the aggregate Alternative Q does show a better drawdown capacity versus the Base94 condition. When measuring damage reduction above for the peak stage the reduction was 9%, 29%, and 22% for the wet, average, and dry year whereas now when looking at the comparison 24-hours after the peak stage the reductions are 17%, 33%, and 24% for the same events. This sensitivity is an additional important check on the propensity for Alternative Q to provide risk reduction and demonstrates that the drawdown capabilities under Alternative Q are greater than those of the Base94 operations.

Impact Areas (Reaches)	MD-RSM TOTAL AGRICULTURE DAMAGES - 24 HOURS POST PEAK STAGE (ALL SIMULATION YEARS)								
	Total Damage Wet ($1,000 FY19)			Total Damage Average ($1,000 FY19)			Total Damage Dry ($1,000 FY19)		
	Base94	ECB19	AltQ	Base94	ECB19	AltQ	Base94	ECB19	AltQ
C111R1-A	$ 18,486	$ 17,789	$ 17,870	$ 7,927	$ 6,761	$ 6,781	$ 12,963	$ 11,042	$ 11,311
C111R1-B	$ 30,242	$ 28,942	$ 28,468	$ 6,377	$ 4,159	$ 3,638	$ 8,388	$ 7,793	$ 6,752
C111R1-C	$ 14,167	$ 14,070	$ 14,024	$ 10,264	$ 10,022	$ 9,942	$ 12,495	$ 12,415	$ 12,264
L31R1-A	$ 13,127	$ 11,892	$ 12,128	$ 6,906	$ 5,328	$ 5,983	$ 8,364	$ 6,674	$ 7,465
L31R2-A	$ 24,760	$ 11,558	$ 12,792	$ 2,631	$ 670	$ 884	$ 2,238	$ 504	$ 789
L31R3-A	$ 11,744	$ 8,564	$ 7,946	$ 1,325	$ 822	$ 758	$ 2,120	$ 1,626	$ 1,233
L31R3-B	$ 24,909	$ 22,037	$ 21,117	$ 6,496	$ 2,962	$ 2,847	$ 8,125	$ 5,783	$ 4,335
L31R3-C	$ 15,876	$ 14,911	$ 14,448	$ 5,982	$ 3,562	$ 3,344	$ 5,435	$ 3,853	$ 3,066
L31R3-D	$ 15,518	$ 11,377	$ 10,749	$ 6,240	$ 2,569	$ 2,242	$ 4,479	$ 2,496	$ 1,864
Total	$ 168,830	$ 141,139	$ 139,543	$ 54,147	$ 36,855	$ 36,420	$ 64,605	$ 52,186	$ 49,079
Percent Change From Base Conditions	% Change From ECB19		1%	% Change From ECB19		-1%	% Change From ECB19		-6%
	% Change From Base94		17%	% Change From Base94		-33%	% Change From Base94		-24%

Table 4-48: Round 3 Sensitivity Analysis – Risk Estimation 24-Hours Post Peak Stage – All Conditions, All Events

Impact Areas (Reaches)	MD-RSM AGRICULTURE DAMAGE DIFFERENCES - 24 HOURS POST PEAK STAGE (ALL SIMULATION YEARS) - Q vs BASELINES											
	Damage Difference Wet ($1,000 FY19)		Damage Difference - Avg ($1,000 FY19)		Damage Difference - Dry ($1,000 FY19)		AltQ Percent Change Wet		AltQ Percent Change - Average		AltQ Percent Change - Dry	
	Alt Q vs Base94 ($1,000)	Alt Q vs ECB19 ($1,000)	Alt Q vs Base94 ($1,000)	Alt Q vs ECB19 ($1,000)	Alt Q vs Base94 ($1,000)	Alt Q vs ECB19 ($1,000)	Alt Q vs Base94	Alt Q vs ECB19	Alt Q vs Base94	Alt Q vs ECB19	Alt Q vs Base94	Alt Q vs ECB19
C111R1-A	$ (616)	$ 81	$ (1,146)	$ 20	$ (1,652)	$ 269	3%	0%	-14%	0%	-13%	2%
C111R1-B	$ (1,774)	$ (473)	$ (2,739)	$ (520)	$ (1,636)	$ (1,042)	6%	2%	-43%	-13%	-20%	-13%
C111R1-C	$ (143)	$ (46)	$ (322)	$ (80)	$ (231)	$ (151)	1%	0%	-3%	-1%	-2%	-1%
L31R1-A	$ (999)	$ 236	$ (923)	$ 655	$ (898)	$ 792	8%	2%	-13%	12%	-11%	12%
L31R2-A	$ (11,968)	$ 1,234	$ (1,747)	$ 214	$ (1,449)	$ 285	48%	11%	-66%	32%	-65%	56%
L31R3-A	$ (3,798)	$ (618)	$ (567)	$ (63)	$ (887)	$ (393)	32%	7%	-43%	-8%	-42%	-24%
L31R3-B	$ (3,792)	$ (920)	$ (3,649)	$ (115)	$ (3,790)	$ (1,448)	15%	4%	-56%	-4%	-47%	-25%
L31R3-C	$ (1,428)	$ (463)	$ (2,637)	$ (218)	$ (2,369)	$ (787)	9%	3%	-44%	-6%	-44%	-20%
L31R3-D	$ (4,769)	$ (627)	$ (3,998)	$ (327)	$ (2,615)	$ (631)	31%	6%	-64%	-13%	-58%	-25%
Total	$ (29,287)	$ (1,596)	$ (17,727)	$ (435)	$ (15,527)	$ (3,107)	17%	1%	-33%	-1%	-24%	-6%

Table 4-49: Round 3 Sensitivity - 24-Hour Post Peak Stage Damage Differences – Q vs Baselines - All Events

Alternative Q was modeled with 6" bedding heights in a similar manner as Alternative O was during Round 2 above. Again, the point of this sensitivity is to measure the potential impacts on risk reduction that some other action aside from operational changes could have on agricultural parcels. The same caveats regarding the uncertainty in costs as outlined in **I.4.2.3.1** remain valid here. Again, the impact that raising crops to a bed height of 6" has is substantial. In an average year, Alternative Q operations coupled with raised bed heights show damage reduction of 63% as compared to the 94Base and 49% as compared to the ECB19.

Reaches	ECB19 Wet	ECB19 Avg	ECB19 Dry	Base94 Wet	Base94 Avg	Base94 Dry	AltQ6 Wet	AltQ6 Avg	AltQ6 Dry
C111R1-A	$ 21,353	$ 8,635	$ 15,041	$ 22,016	$ 10,151	$ 16,535	$ 17,109	$ 4,528	**$ 9,443**
C111R1-B	$ 33,027	$ 6,696	$ 9,976	$ 34,171	$ 9,480	$ 11,984	$ 27,181	$ 2,441	**$ 5,408**
C111R1-C	$ 14,539	$ 11,277	$ 13,423	$ 14,566	$ 11,510	$ 13,499	$ 13,253	$ 7,239	**$ 11,490**
L31R1-A	$ 12,872	$ 6,369	$ 8,699	$ 13,298	$ 7,399	$ 9,760	$ 10,915	$ 3,716	**$ 6,402**
L31R2-A	$ 21,604	$ 1,159	$ 1,570	$ 27,722	$ 3,127	$ 3,513	$ 11,503	$ 462	**$ 578**
L31R3-A	$ 12,258	$ 1,013	$ 2,864	$ 13,631	$ 1,794	$ 3,964	$ 8,171	$ 420	**$ 1,070**
L31R3-B	$ 25,418	$ 4,123	$ 7,906	$ 27,304	$ 7,423	$ 10,569	$ 20,264	$ 1,485	**$ 3,043**
L31R3-C	$ 15,758	$ 4,284	$ 4,523	$ 16,792	$ 7,339	$ 6,747	$ 13,481	$ 2,518	**$ 1,920**
L31R3-D	$ 16,776	$ 4,817	$ 4,215	$ 18,985	$ 7,937	$ 6,169	$ 11,380	$ 1,836	**$ 1,386**
Total	***$ 173,605***	***$ 48,372***	***$ 68,216***	***$ 188,483***	***$ 66,160***	*$ 82,740*	***$ 133,258***	***$ 24,647***	***$ 40,739***
% Change From 94Base							-29%	-63%	-51%
% Change From ECB19							-23%	-49%	-40%

I.4.3.3 Round 3 MD-RSM Results – Residential

Similar to the previous rounds of modeling, there were very limited impacts to residential parcels in the study area governed by the Base94 constraint. However, some of the hydrologic data indicated that within the 8.5 SMA the peak stage was slightly higher under Alternative Q than the Base83 condition. The following paragraphs will discuss these two unique areas separately.

Since Round 3 was the basis of the PPA, it is important to display the limited results and summarize potential impacts in the area governed by the Base94 constraint. The differences between Alternative Q and the ECB19 and Base94 are presented in **Table 4-50.** There were no damages at all in any conditions to residential properties under the average and dry years so the difference between all three conditions is zero. However, there were some small impacts to residential areas under the wet year. Alternative Q performs similarly to the constraint condition and shows some very minor benefit on a per reach basis as well as overall. Compared to the ECB19, Alternative Q also provides an overall benefit but there is one reach in which risk is slightly elevated. However, given the fact that over 44,000 structures were modeled using more than 14,000 discrete stage points, the $390 estimated increase in damages is not statistically significantly different from zero.

Reaches	Residential Damages for All Event Years ($1,000 FY19)					
	Wet Year Damages		Average Year Damages		Dry Year Damages	
	QvBase94	QvECB19	QvBase94	QvECB19	QvBase94	QvECB19
8.5SMA	$	$	$	$	$	$
C111R1-A	$	$	$	$	$	$
C111R1-B	$ (5.35)	$ (2.14)	$	$	$	$
C111R1-C	$ (0.08)	$	$	$	$	$
L31R1-A	$ (3.21)	$ 0.39	$	$	$	$
L31R2-A	$	$	$	$	$	$
L31R3-A	$ (497.45)	$ (335.08)	$	$	$	$
L31R3-B	$	$	$	$	$	$
L31R3-C	$	$	$	$	$	$
L31R3-D	$ (2.87)	$	$	$	$	$
Total	**$ (508.95)**	**$ (336.83)**	**$**	**$**	**$**	**$**

Table 4-50: Round 3 Residential Damage Comparison – Alternative Q vs Base Conditions All Event Years

For the 8.5 SMA, again there were no impacts measured using the actual estimated first floor elevations. However, since the stage duration curves indicated that Alternative Q had a slightly higher peak stage at some of the gauges nearest the property parcels, a sensitivity was again conducted where the first floor was artificially lowered to be equal to the ground surface elevation. Once this artificial lowering occurred the HEC-FIA scenario was rerun to measure the differences. Since the FFE was artificially lowered the impacts were not quantified in terms of dollar damages but instead in terms of stage differences measured at the MD-RSM cell level[29]. The maximum difference in stage was roughly .4-feet for all of the cells estimated and that was during the wet event year. The cells were placed into bins where those at highest risk fell between .25-feet and .5-feet, medium risk between 0-feet and .25-feet, and decreased risk (i.e. benefit) anything greater than 0-feet as measured by the difference in Alternative Q stage and the Base83 stage. In the dry year, seven of the model cells containing residential parcels were counted where the stage increases between 0 and .25 feet under Alternative Q as compared to the Base83 and are spatially shown in **Figure 4-25**. Under the average year, there are no cells in which the stage increases beyond that measured in the Base83 condition (**Figure 4-26)**. In the wet year, there are 10 cells registering increases between 0 and .25 feet and four cells where the increase is between .25 and .5 feet (**Figure 4-27**). Of the 21 combined total cells impacted between the dry and wet years, 7 of which are impacted under both years, the average increase in stage from the 83Base is .2 feet. For the remaining cells that are showing a risk reduction the average decrease in peak stage is approximately .7 feet. This analysis shows that there is some increased in risk of nuisance flooding in select cells but that flood waters do not impact the first floors of the residential properties contained within the cells and that the majority of the residential properties are experiencing a sizeable decrease in the peak stage. Again, these FFEs are based on the average FFE from the elevation certificates obtained throughout the project area since very few

[29] Only cells containing residential parcels were modeled.

certificates were available within the 8.5 SMA[30]. An important note that is not visible here in this analysis of the peak stage is the duration of the elevated stage. Under Alternative Q the elevated stage actually recedes faster than it does under the Base83 condition, meaning the nuisance flooding would be of a shorter duration. These results are almost identical under alternatives Qm and Qm1 as well. So in summary, there is a very minor increase in the peak stage for these parcels but the duration is much shorter[31].

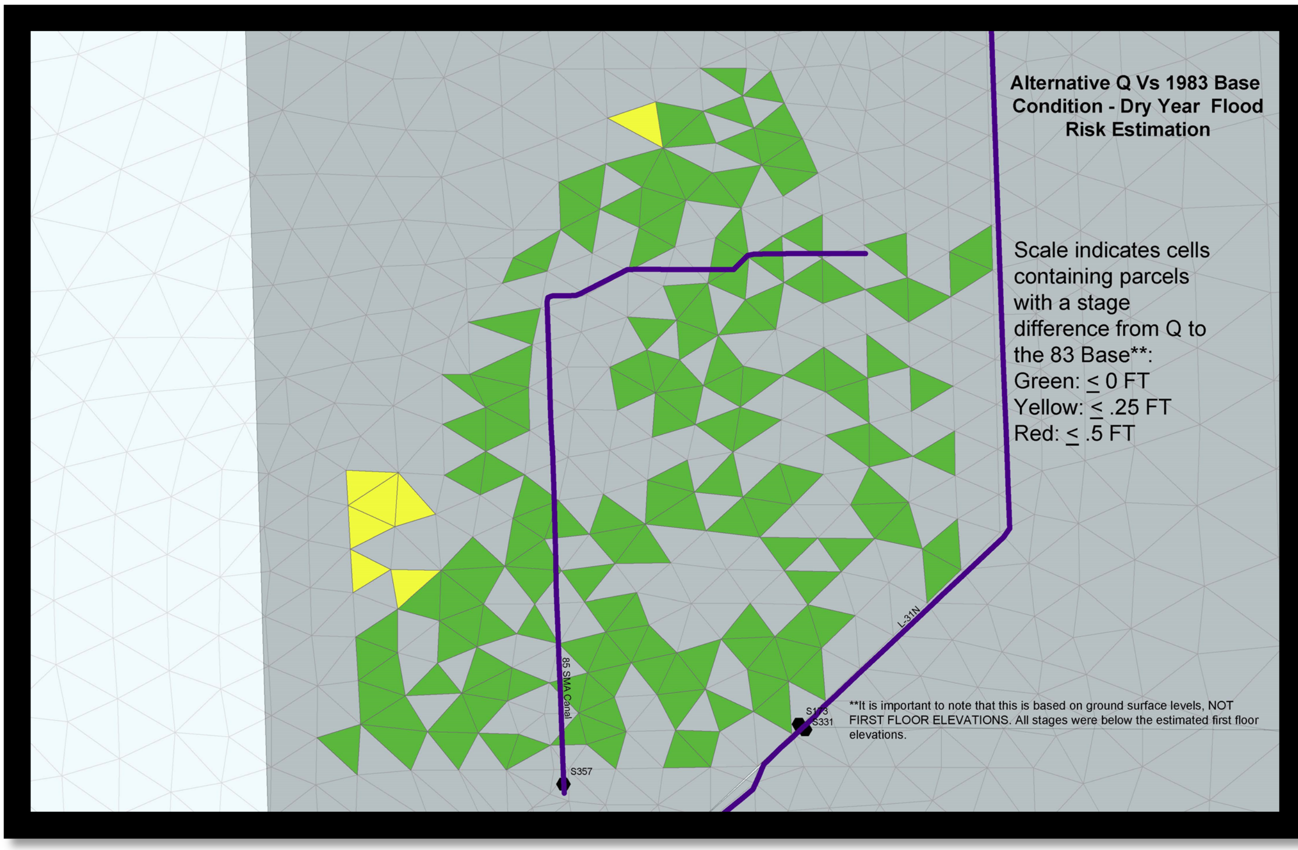

Figure 4-25: 8.5 SMA Dry Year Stage Differences between Alternative Q and 1983 Base

[30] Of the available FFE certificates within 8.5 SMA all showed compliance with county code dictating a FFE 2 feet above the BFE.

[31] See engineering appendix for stage duration curves.

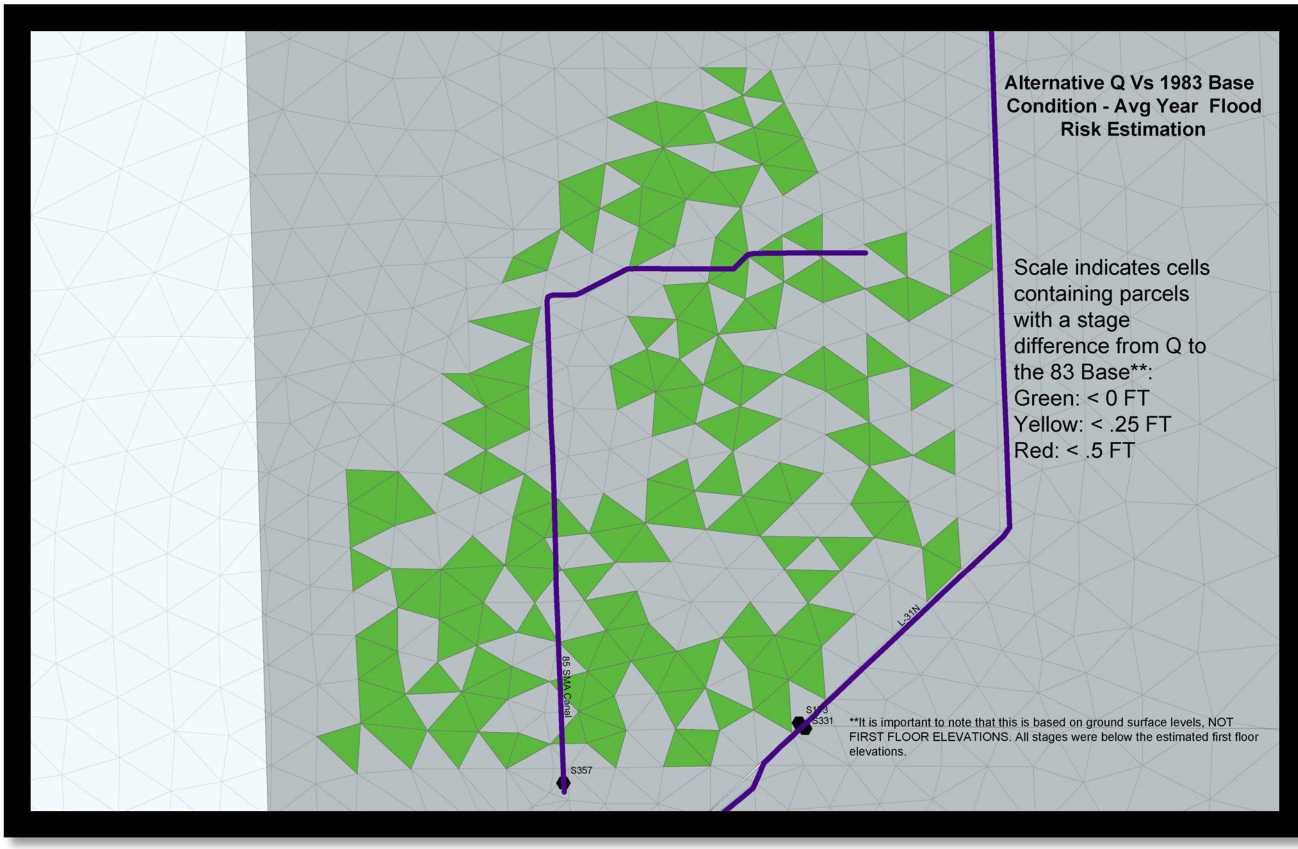

Figure 4-26: 8.5 SMA Average Year Stage Differences between Alternative Q and 1983 Base

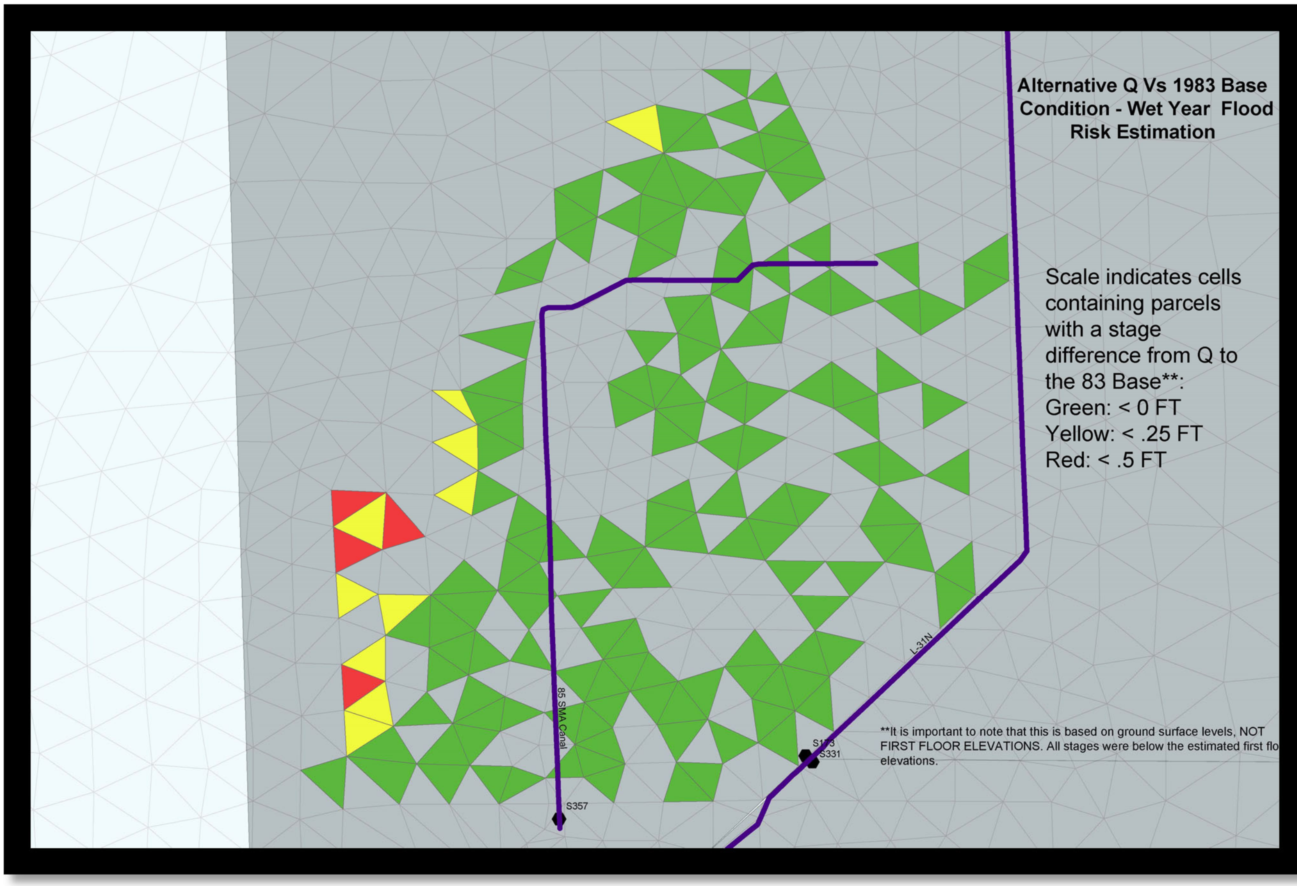

Figure 4-27: 8.5 SMA Wet Year Stage Differences between Alternative Q and 1983 Base

I.4.3.4 Round 3 Summary

Based on all of the results it is clear that Q, Qm, and Qm1 all satisfy the constraint conditions for the socio-economics evaluation within the 8.5 SMA and the South Dade project areas. For the agricultural parcels, not only are the constraints satisfied, but there is an overwhelming benefit on the aggregate when comparing each variant of Q to the Base94. The estimated damage reduction for crop parcels in all event conditions for each of the Q variants is large, averaging almost $18M. There are some specific areas of increased risk when the Q variants are compared to the ECB19, but even then the aggregate is a decrease in risk with an estimated average damage reduction of approximately $2.3M. In terms of residential parcels Q also meets, and improves upon, the Base94 constraint condition for the greater South Dade area. When focusing on the 8.5 SMA again we see that the majority of parcels experience a risk reduction. Those parcels that do see some increase in the potential for nuisance flooding also experience a decreased duration of the nuisance flooding so a tradeoff is present. In addition to the socio-economics evaluation of the 8.5 SMA flood mitigation performance, a comprehensive hydrologic evaluation of the 8.5 SMA flood mitigation criteria is provided in the Hydraulics and Hydrology Appendix (Appendix H), Annex 6. Based on these modeling results the PPA of Q+ has satisfied all of the constraints and has also improved upon the COP No Action alternative (ECB19).

I.4.4 Design Storm Event Results (Round 4)

With Alt Q+ identified as the PPA, further risk modeling was conducted in order to assess events beyond the wet, average and dry year. The H&H modeling team developed a suite of storm events with peak stages that represented the 10-year, 25-year, and 100-year annual exceedance probability via the MD-RSM model. The output peak stages were used in the same fashion as Round 2 and 3 to determine the risk of Alt Q+ via the HEC-FIA representation of Qm and Q. Since Qm1 had very little difference to Qm during Round 3 Qm1 was not modeled under the design storms.

I.4.4.1 Round 4 Agriculture Results

Agricultural modeling results are based on the stage 24-hours after the peak stage. As mentioned in the Round 3 results the 24-hour post stage was thought to be a more accurate representation of damage estimation since most crops do not begin to experience damages until, at the earliest, 24 hours after root zone inundation. The damage estimation for all four conditions were very similar for each of the three storm events as depicted in **Table 4-51,** but it is clear that Q and Qm meet the constraint in all reaches in all events (**Figure 4-28, Figure 4-29, Figure 4-30)**. The Base94 condition had slightly higher damages overall, especially under the two less-frequent events (i.e. 10-year and 25-year). Again, Q and Qm represent a significant risk reduction as compared to the Base94 condition with an average of $21M in estimated damage reduction across all events. Alt Qm slightly outperforms Alt Q under the 10- and 25-year events by further reducing estimated damages compared to the Base94 by 1 and 2 percentage points respectively. Both alternatives also depict a net risk reduction compared to the ECB19, showing a similar pattern with Alt Qm performing slightly better. The dollar damage difference estimates between the two alternatives and the two base conditions are shown in **Table 4-52** and **Table 4-53**. Alternative Qm1 was not evaluated with the design storms since the Round 3 evaluation showed similar performance for the South Dade basin evaluation.

Reaches	10-Year Design Storm Results - Total Damages ($1,000 FY19)				25-Year Design Storm Results - Total Damages ($1,000 FY19)				100-Year Design Storm Results- Total Damages ($1,000 FY19)			
	1994Base	ECB19RR	AltQ	AltQm	1994Base	ECB19RR	AltQ	AltQm	1994Base	ECB19RR	AltQ	AltQm
C111R1-A	$ 17,699	$ 17,096	$ 17,141	$ 17,149	$ 19,835	$ 19,002	$ 19,085	$ 19,102	$ 22,485	$ 21,942	$ 22,008	$ 21,984
C111R1-B	$ 28,534	$ 26,504	$ 25,814	$ 25,580	$ 32,996	$ 31,912	$ 31,588	$ 31,352	$ 37,640	$ 37,362	$ 37,143	$ 36,818
C111R1-C	$ 13,608	$ 13,553	$ 13,528	$ 13,533	$ 14,101	$ 14,029	$ 14,002	$ 14,023	$ 14,592	$ 14,570	$ 14,557	$ 14,563
L31R1-A	$ 11,387	$ 9,211	$ 9,632	$ 9,507	$ 12,811	$ 10,924	$ 11,482	$ 11,410	$ 13,491	$ 13,130	$ 13,275	$ 13,347
L31R2-A	$ 13,768	$ 3,658	$ 3,650	$ 3,528	$ 24,404	$ 10,007	$ 12,397	$ 11,937	$ 30,100	$ 27,271	$ 27,741	$ 28,848
L31R3-A	$ 8,460	$ 7,545	$ 6,421	$ 5,992	$ 11,056	$ 10,257	$ 9,494	$ 9,169	$ 16,107	$ 15,577	$ 14,787	$ 14,167
L31R3-B	$ 21,922	$ 20,036	$ 18,133	$ 17,977	$ 26,154	$ 24,472	$ 23,237	$ 23,280	$ 32,113	$ 31,147	$ 30,322	$ 30,166
L31R3-C	$ 14,854	$ 13,669	$ 12,876	$ 12,803	$ 16,572	$ 15,753	$ 15,338	$ 15,266	$ 19,963	$ 19,373	$ 18,982	$ 18,914
L31R3-D	$ 12,667	$ 10,000	$ 8,904	$ 8,122	$ 17,194	$ 13,877	$ 13,337	$ 12,007	$ 21,715	$ 20,937	$ 20,732	$ 20,308
Total	***$ 142,899***	***$ 121,273***	***$ 116,099***	***$ 114,189***	***$ 175,121***	***$ 150,234***	***$ 149,960***	***$ 147,545***	***$ 208,205***	***$ 201,308***	***$ 199,545***	***$ 199,115***

Table 4-51: Damage Estimation Summary – All Operating Conditions and All Design Storm Events

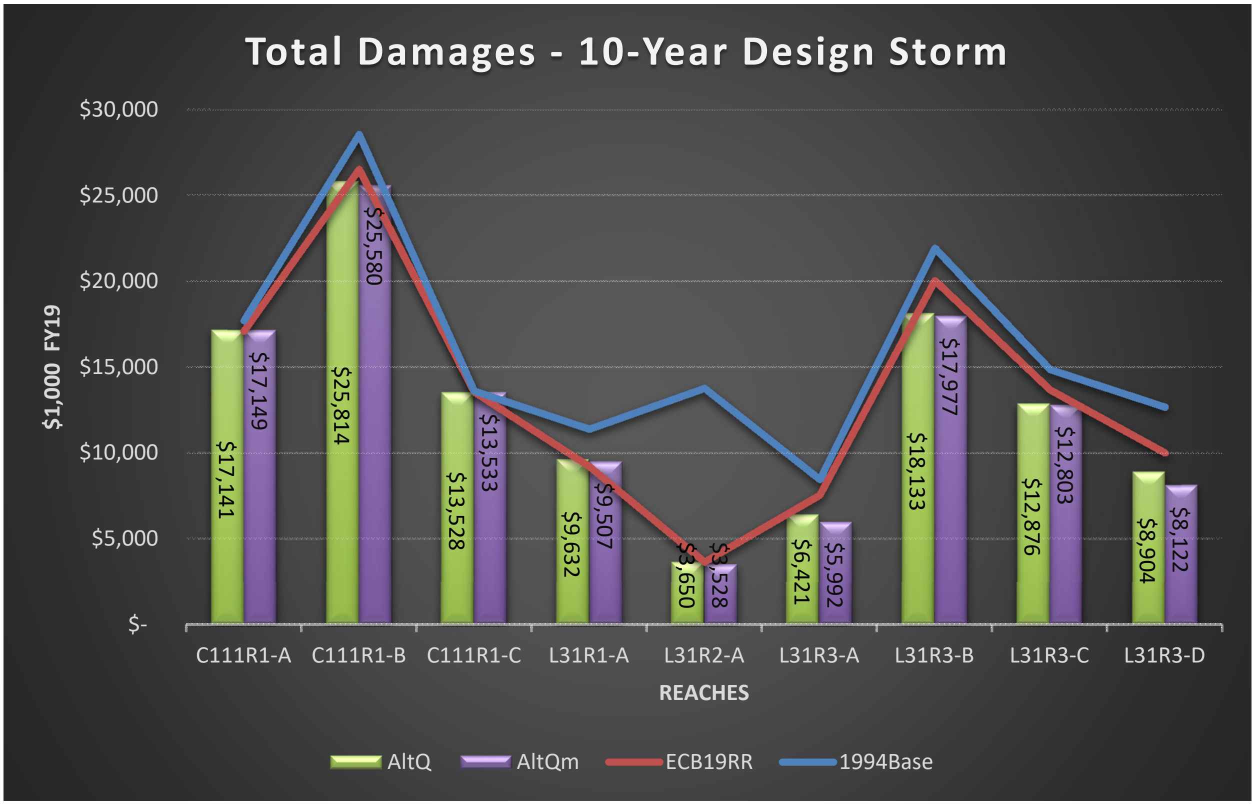

Figure 4-28: Total Damages for All Conditions – 10-Year Design Storm

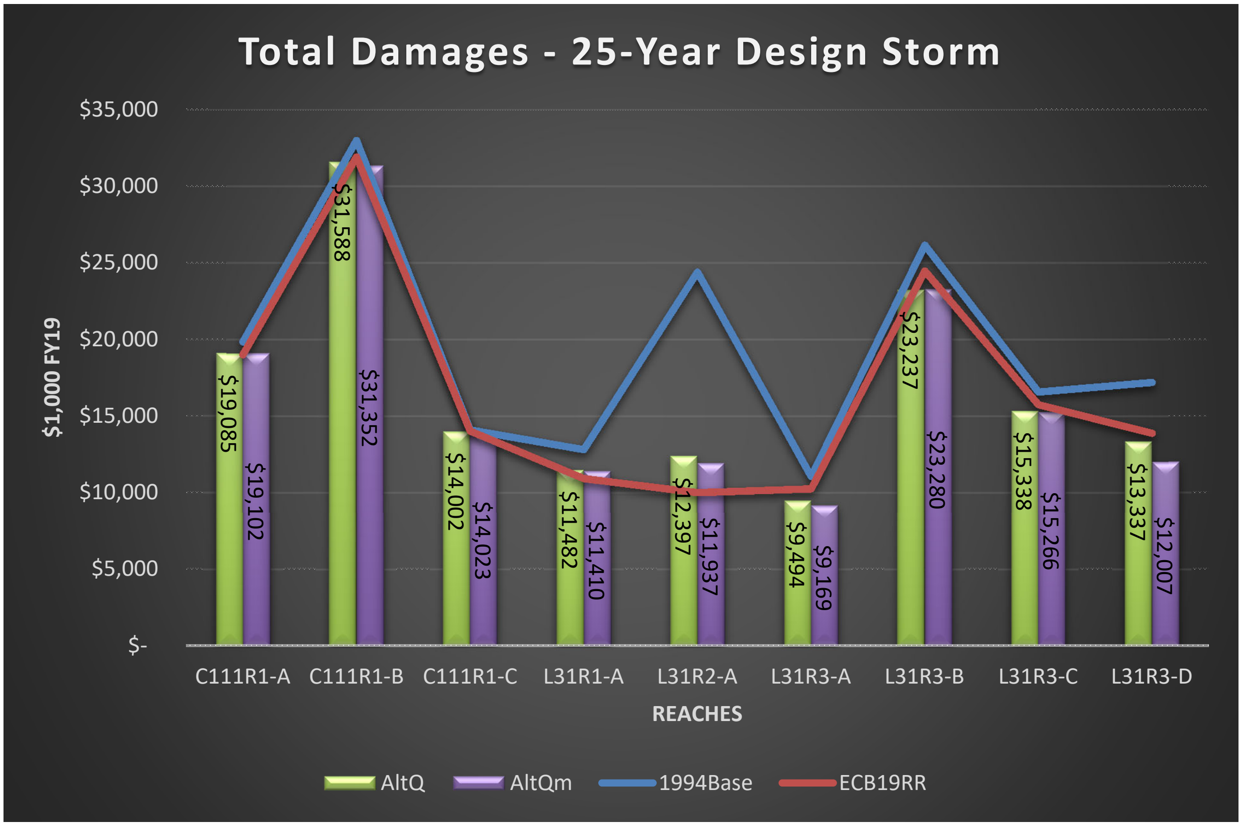

Figure 4-29: Total Damages for All Conditions – 25-Year Design Storm

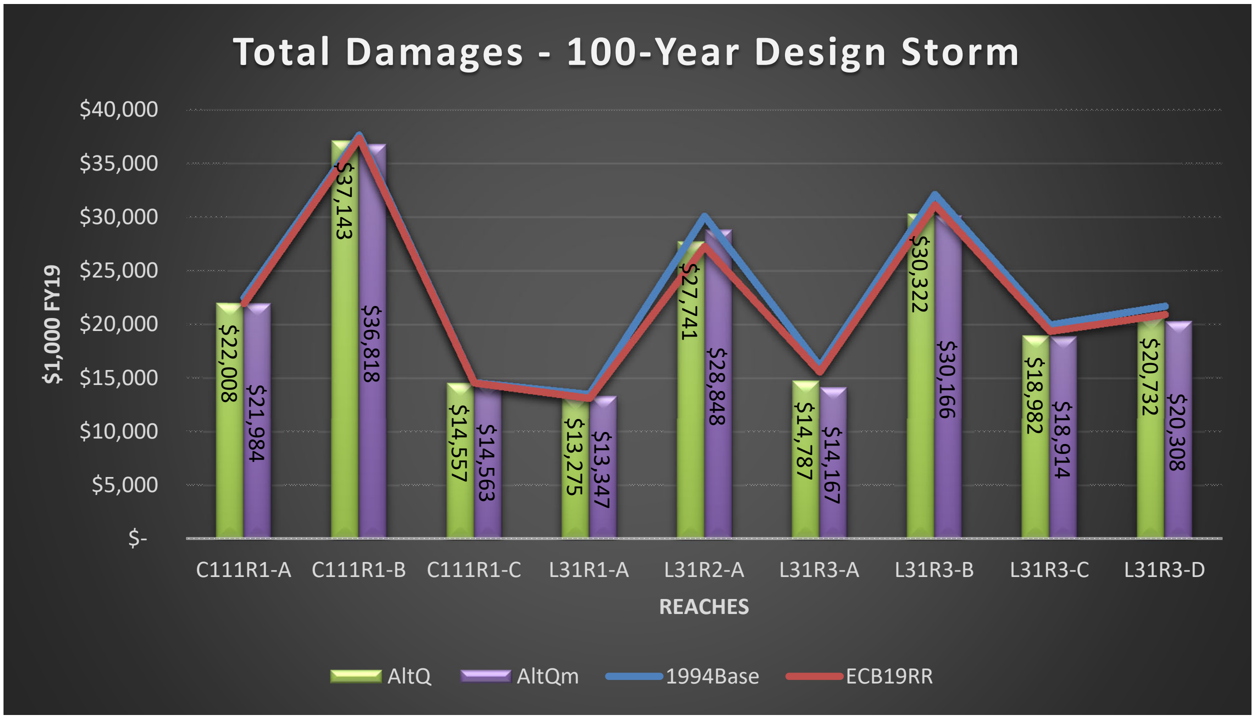

Figure 4-30: Total Damages for All Conditions – 100-Year Design Storm

Reaches	Difference from 1994 GRR Base Condition ($1,000 FY19) - 10-Year Design Storm			Difference from 1994 GRR Base Condition ($1,000 FY19) - 25-Year Design Storm			Difference from 1994 GRR Base Condition ($1,000 FY19) - 100-Year Design Storm		
	ECB19RR	AltQ	AltQm	ECB19RR	AltQ	AltQm	ECB19RR	AltQ	AltQm
C111R1-A	$ (602)	$ (557)	$ (550)	$ (833)	$ (750)	$ (733)	$ (542)	$ (477)	$ (501)
C111R1-B	$ (2,030)	$ (2,721)	$ (2,955)	$ (1,083)	$ (1,407)	$ (1,644)	$ (278)	$ (497)	$ (822)
C111R1-C	$ (55)	$ (80)	$ (75)	$ (71)	$ (98)	$ (78)	$ (23)	$ (36)	$ (29)
L31R1-A	$ (2,176)	$ (1,755)	$ (1,880)	$ (1,887)	$ (1,329)	$ (1,401)	$ (362)	$ (216)	$ (144)
L31R2-A	$ (10,111)	$ (10,119)	$ (10,241)	$ (14,397)	$ (12,007)	$ (12,467)	$ (2,828)	$ (2,358)	$ (1,251)
L31R3-A	$ (915)	$ (2,039)	$ (2,468)	$ (799)	$ (1,562)	$ (1,887)	$ (530)	$ (1,321)	$ (1,940)
L31R3-B	$ (1,885)	$ (3,789)	$ (3,945)	$ (1,681)	$ (2,917)	$ (2,873)	$ (966)	$ (1,791)	$ (1,947)
L31R3-C	$ (1,185)	$ (1,978)	$ (2,051)	$ (819)	$ (1,234)	$ (1,306)	$ (590)	$ (981)	$ (1,049)
L31R3-D	$ (2,667)	$ (3,762)	$ (4,545)	$ (3,317)	$ (3,857)	$ (5,187)	$ (778)	$ (983)	$ (1,407)
Total	$ (21,625)	$ (26,800)	$ (28,710)	$ (24,887)	$ (25,161)	$ (27,576)	$ (6,896)	$ (8,660)	$ (9,090)

Table 4-52: Damage Difference Summary Compared to 1994 Base Condition – All Events

Reaches	Difference from ECB19RR ($1,000 FY19) - 10-Year Design Storm			Difference from ECB19RR ($1,000 FY19) - 25-Year Design Storm			Difference from ECB19RR ($1,000 FY19) - 100-Year Design Storm		
	1994Base	AltQ	AltQm	1994Base	AltQ	AltQm	1994Base	AltQ	AltQm
C111R1-A	$ 602	$ 45	$ 52	$ 833	$ 83	$ 100	$ 542	$ 66	$ 41
C111R1-B	$ 2,030	$ (691)	$ (925)	$ 1,083	$ (324)	$ (560)	$ 278	$ (219)	$ (544)
C111R1-C	$ 55	$ (25)	$ (21)	$ 71	$ (27)	$ (7)	$ 23	$ (13)	$ (6)
L31R1-A	$ 2,176	$ 421	$ 295	$ 1,887	$ 558	$ 486	$ 362	$ 146	$ 218
L31R2-A	$ 10,111	$ (8)	$ (130)	$ 14,397	$ 2,390	$ 1,930	$ 2,828	$ 470	$ 1,577
L31R3-A	$ 915	$ (1,124)	$ (1,553)	$ 799	$ (763)	$ (1,089)	$ 530	$ (791)	$ (1,410)
L31R3-B	$ 1,885	$ (1,903)	$ (2,059)	$ 1,681	$ (1,235)	$ (1,192)	$ 966	$ (825)	$ (981)
L31R3-C	$ 1,185	$ (793)	$ (866)	$ 819	$ (415)	$ (487)	$ 590	$ (391)	$ (459)
L31R3-D	$ 2,667	$ (1,096)	$ (1,878)	$ 3,317	$ (540)	$ (1,870)	$ 778	$ (205)	$ (629)
Total	$ 21,625	$ (5,174)	$ (7,084)	$ 24,887	$ (274)	$ (2,689)	$ 6,896	$ (1,763)	$ (2,194)

Table 4-53: Damage Difference Summary Compared to ECB19 – All Events

I.4.4.2 Round 4 Residential

Since the Round 3 modeling under even the wet year showed very little residential damages in most reaches it is intuitive to think the design storm results would be similar. As is evidenced by **Table 4-54,** this intuition is accurate. In the 10-year storm only two reaches record any damages. From the data it appears the most risk prone area is represented by Reach L31R3-A. This reach has many low lying points, with approximately half of the model cells within that reach with ground surface at or below 6.5’ NGVD. With that said, Alt Q and Qm do a relatively good job in reducing risk in that susceptible reach when compared to both baseline conditions. Again, this points to the fact that simple operational changes to the system will not have a large impact on residual risk but that Alt Q and Qm succeed in doing so to a good degree. For the most risk prone areas it is likely that some other mechanism is required to effectively mitigate the risk much like we saw in the agricultural results with the increase in bed heights. The results in Figure 4-31 also show that, as storm events get more severe, Alt’s Q and Qm show increasing capacity for risk reduction. It is important to note that since neither of these simulations record damage in the 8.5 SMA reach, the Base83 was not modeled with HEC-FIA. There was no need to verify the constraint was upheld in the absence of estimated risk in the alternatives. Further, the above analysis during Round 3 in which the ground surface impacts were measured in the wet year for the alternatives compared to the Base 83 is a sufficient measure of the potential risk to the 8.5 SMA under the PPA operations.

Reaches	10-Year Design Storm Results ($1,000 FY19)				25-Year Design Storm Results ($1,000 FY19)				100-Year Design Storm Results ($1,000 FY19)			
	1994Base	ECB19RR	AltQ	AltQm	1994Base	ECB19RR	AltQ	AltQm	1994Base	ECB19RR	AltQ	AltQm
8.5SMA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
C111R1-A	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3	$ 2	$ 2	$ 2
C111R1-B	$ 19	$ 14	$ 13	$ 13	$ 119	$ 68	$ 39	$ 57	$ 859	$ 735	$ 724	$ 740
C111R1-C	$ -	$ -	$ -	$ -	$ 33	$ 29	$ 25	$ 28	$ 161	$ 158	$ 154	$ 156
L31R1-A	$ 2	$ -	$ -	$ -	$ 4	$ 0	$ 2	$ 1	$ 316	$ 66	$ 123	$ 85
L31R2-A	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-A	$ 2,269	$ 2,209	$ 2,054	$ 2,050	$ 5,285	$ 4,978	$ 4,660	$ 4,904	$ 12,297	$ 11,947	$ 11,636	$ 11,774
L31R3-B	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-C	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-D	$ 0	$ -	$ -	$ -	$ 3	$ 2	$ 1	$ -	$ 6	$ 6	$ 5	$ 4
Total	***$ 2,291***	***$ 2,223***	***$ 2,067***	***$ 2,063***	***$ 5,444***	***$ 5,077***	***$ 4,726***	***$ 4,990***	***$ 13,642***	***$ 12,914***	***$ 12,645***	***$ 12,761***

Table 4-54: Design Storm Damage Summary – Residential

Reaches	Difference from 1994 GRR Base Condition ($1,000 FY19) - 10-Year Design Storm			Difference from 1994 GRR Base Condition ($1,000 FY19) - 25-Year Design Storm			Difference from 1994 GRR Base Condition ($1,000 FY19) - 100-Year Design Storm		
	ECB19RR	AltQ	AltQm	ECB19RR	AltQ	AltQm	ECB19RR	AltQ	AltQm
8.5SMA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
C111R1-A	$ -	$ -	$ -	$ -	$ -	$ -	$ (1)	$ (1)	$ (1)
C111R1-B	$ (5)	$ (6)	$ (6)	$ (51)	$ (79)	$ (62)	$ (124)	$ (135)	$ (119)
C111R1-C	$ -	$ -	$ -	$ (4)	$ (8)	$ (5)	$ (3)	$ (7)	$ (5)
L31R1-A	$ (2)	$ (2)	$ (2)	$ (3)	$ (2)	$ (2)	$ (251)	$ (193)	$ (231)
L31R2-A	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-A	$ (61)	$ (216)	$ (220)	$ (307)	$ (625)	$ (381)	$ (349)	$ (660)	$ (522)
L31R3-B	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-C	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-D	$ (0)	$ (0)	$ (0)	$ (1)	$ (3)	$ (3)	$ (0)	$ (1)	$ (2)
Total	***$ (68)***	***$(224)***	***$(227)***	***$ (367)***	***$(717)***	***$(454)***	***$ (729)***	***$(998)***	***$(881)***

Table 4-55: Design Storm Risk Reduction - Alternatives Compared to 1994 Base Condition - Residential

Reaches	Difference from ECB19RR ($1,000 FY19) - 10-Year Design Storm			Difference from ECB19RR ($1,000 FY19) - 25-Year Design Storm			Difference from ECB19RR ($1,000 FY19) - 100-Year Design Storm		
	1994Base	AltQ	AltQm	1994Base	AltQ	AltQm	1994Base	AltQ	AltQm
8.5SMA	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
C111R1-A	$ -	$ -	$ -	$ -	$ -	$ -	$ 1	$ 0	$ 0
C111R1-B	$ 5	$ (1)	$ (0)	$ 51	$ (28)	$ (11)	$ 124	$ (11)	$ 5
C111R1-C	$ -	$ -	$ -	$ 4	$ (4)	$ (1)	$ 3	$ (4)	$ (2)
L31R1-A	$ 2	$ -	$ -	$ 3	$ 1	$ 1	$ 251	$ 58	$ 20
L31R2-A	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-A	$ 61	$ (155)	$ (159)	$ 307	$ (318)	$ (74)	$ 349	$ (311)	$ (173)
L31R3-B	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-C	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
L31R3-D	$ 0	$ -	$ -	$ 1	$ (2)	$ (2)	$ 0	$ (1)	$ (1)
Total	***$ 68***	***$(156)***	***$(159)***	***$ 367***	***$(350)***	***$ (87)***	***$ 729***	***$(269)***	***$(152)***

Table 4-56: Design Storm Risk Reduction - Alternatives Compared to ECB19 - Residential

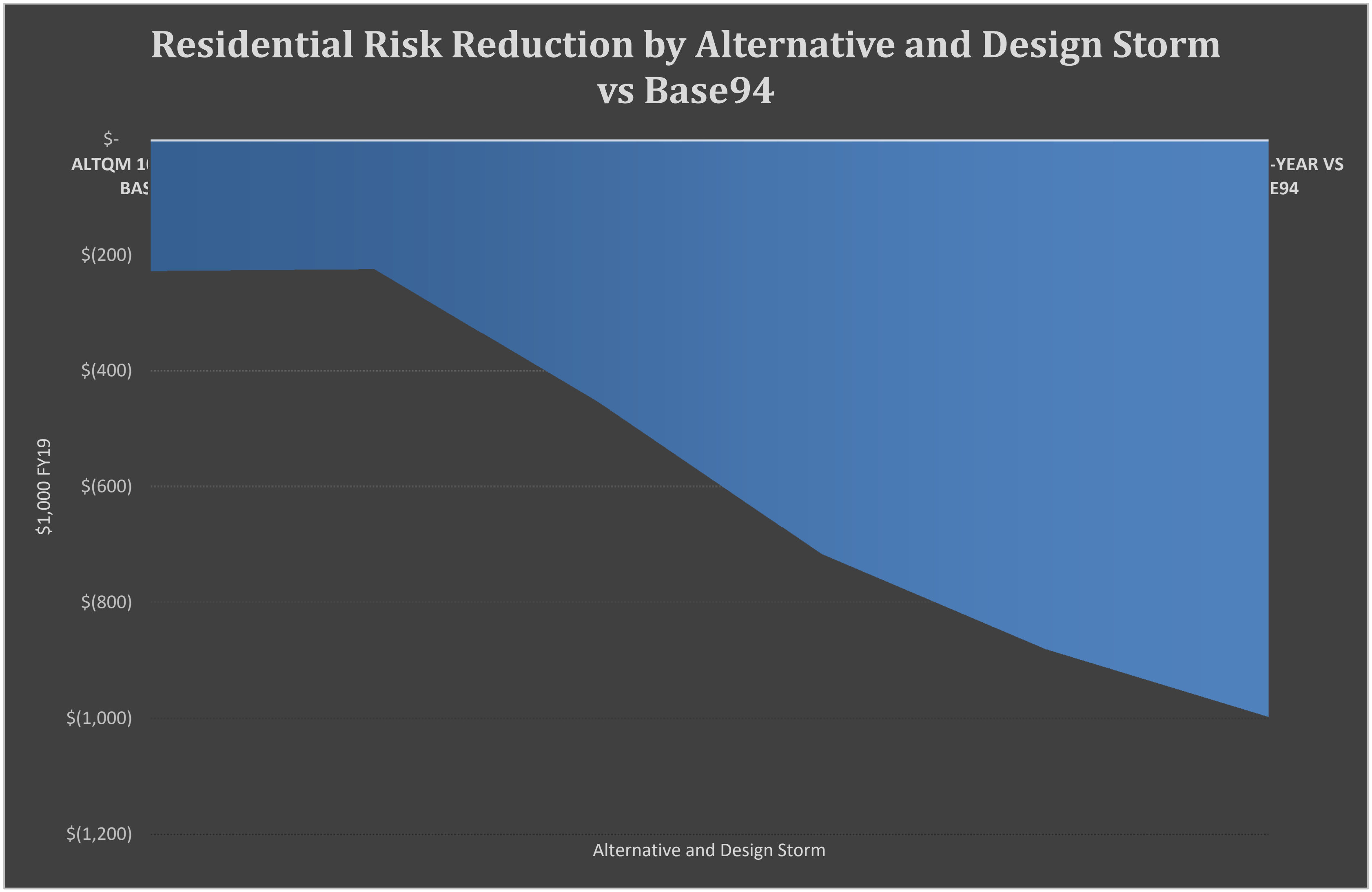

Figure 4-31: Residential Risk Reduction by Alternative and Design Storm

I.4.4.3 Round 4 Summary

Alternatives Q and Qm meet the constraint condition, as well as improving upon the existing condition, for both agriculture and residential and show that Q+ is an acceptable PPA. The damage reduction capacity increases with severity of storm events for residential whereas for agriculture the risk reduction is greatest with the more frequent events. These Round 4 results also fulfill the Corps' requirement from the C-111 Limited Reevaluation Report (LRR, November 2016) to update the economic analysis performed during the 1994 GRR during development of the C-111 South Dade operational plan (now integrated into the COP).

I.5 REFERENCES

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