APPENDIX C
PLAN FORMULATION

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C.1 Initial Array of Alternatives Evaluation

The initial array of alternatives was evaluated both qualitatively and quantitatively to evaluate the alternatives performance in comparison to one another and to the No Action Alternative. The results of this evaluation are available in **Table C.1-1** below. Evaluation criteria of the initial array is as follows:

Does the alternative meet the study objective? The objective of the Central and Southern Florida (C&SF) Flood Resiliency (Section 203) Study for Broward Basins (Section 203 Study) is as follows: enhance the functionality and capacity of C&SF Project water control structures to reduce flood damages and improve resiliency against inundation and changing conditions within the Section 203 Study Area (Study Area) over the 50-year analysis period from 2035 to 2085.

Is the alternative acceptable? The qualitative evaluation of acceptability focused on whether each alternative complies with existing federal laws, authorities, and policies, and whether it avoids reliance on solutions driven solely by local or regional preferences or political expediency.

Is the alternative efficient? The qualitative evaluation of efficiency used available cost data to evaluate how well each alternative addresses the identified problems and achieves the intended opportunities.

Problems of the Section 203 Study include the following:

- Limitations of existing infrastructure not designed to handle compound flooding
- Changing conditions due to increased urbanization
- Sea level rise impacts under low, intermediate, and high scenarios
- Increased rainfall frequency and intensity compounded by sea level rise, raising total water levels
- Storm surge effects compounded by sea level rise, increasing total water levels
- King tides compounded by sea level rise, increasing total water levels
- Elevated groundwater tables compounded by sea level rise, increasing total water levels
- Flood damages resulting from diminished conveyance capacity of the C&SF system due to changed conditions
- Public safety risks associated with diminished conveyance capacity of the C&SF system

Opportunities of the Section 203 Study include the following:

- Manage public safety risk caused by inundation
- Manage risk to historical and cultural resources
- Unifying coordination and building trust with stakeholders and the public

Is the alternative complete? The qualitative evaluation of completeness evaluated the alternative's ability to provide and account for all features, investments, and actions to realize the planned effects, including actions by others.

Is the alternative effective? The quantitative evaluation of effectiveness focused on the observed performance of the structural alternatives to reduce flood depths in the Section 203 Action Area to address the identified problems and achieve the intended opportunities. Nature-based and nonstructural alternatives were qualitatively evaluated.

Table C.1-1. Initial Array of Alternatives Evaluation

Initial Array of Alternatives	Management Measures	Qualitative Evaluation (1) Study Objective (2) Acceptability (3) Efficiency (4) Completeness	Qualitative/Quantitative Evaluation (for structural measures only) (5) Effectiveness (evaluated at the watershed level)	Screening Decision
Alt 1 - Gravity Conveyance Improvements (Canals and Structures)	C-14 East Basin: Increase gate size at S-37A Gated Spillway to 4x25.8 feet and improve canal conveyance to increase gravity flow capacity; raise existing gates/platform, and add floodwalls	(1) Likely to reduce flood damages; prepares, absorbs, recovers at the project and system level (2) Likely; this alternative is formulated in alignment of federal laws, authorities, and public policies (3) Likely; anticipated that first costs and operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) will be less costly than other alternatives (4) Extensive canal conveyance improvements are more costly and may not move forward to the final array of alternatives (5) Partially; gravity conveyance as a stand-alone measure would not fully improve conditions in high sea level rise scenarios. Could be combined with components of Alternative 2.	Not likely; improved conveyance and gravity capacity resulted in no improvement to peak profiles and very minor improvements to flood depths <0.1 foot (ft).	Yes, in combination with other components of Alternative 2
	Pompano Canal Basin: Increase the size of the G-57 Gated Spillway to 3x14 feet and modify the culvert upstream of G-57 Gated Spillway to a triple barrel culvert to increase gravity flow capacity; raise existing gates/platform and add floodwalls		Partially; improves maximum peak profiles in this watershed by about 5/10th of a ft. Not seeing improvement in maximum water levels in the watershed.	
	C-13 West Basin: Increase the size of the S-36 Gated Spillway to 2x25 feet and improve canal conveyance to increase gravity flow capacity; raise existing gates/platform and add floodwalls		Likely; improves maximum water level profiles up to 5/10th of a foot. Noticing reduction of maximum water levels in the watershed up to 1 ft.	
	C-12 West Basin: Increase gate size at S-33 Gated Spillway to 2x20 feet and improve canal conveyance to increase gravity flow capacity; raise existing gates/platform and add floodwalls for extreme weather event		Not Likely; no improvement in canal maximum peak profiles or maximum water levels in the watershed.	
	C-11 West Basin: Improve canal conveyance within Winkopp Bridge area		Not Likely; no noticeable improvements.	
	North New River Canal West Basin: Increase gate size at G-54 Gated Spillway to 5x16 feet and improve canal conveyance to increase gravity flow capacity; raise existing gates/platform and add floodwalls		Likely; improvements in peak profiles not exceeding 3/10th of a foot. Maximum water levels in the watershed show improvement especially in the western part of the watershed not exceeding 5/10th of a foot.	
	Hillsboro Canal Basin: Increase the size of the G-56 Gated Spillway to 5x20 feet to increase gravity flow capacity; to include dredging, storage, raised banks if necessary		Likely; improves peak profiles in the entirety of the canal. Head loss at the G-56 structure and water levels in the canal drop significantly. Maximum water levels in the watershed also show reduction but not exceeding 3/10th of a foot.	
	C-14 West Basin: Increase the size of S-37B Gated Spillway to 2x35 feet and improve canal conveyance to increase gravity flow capacity; include tie-back floodwalls/barriers		Partially; minor improvements to peak profiles and peak flood depths, likely because the structure is limited by C-14 East Basin performance. Suggest carry forward in combination with C-14 East Basin pumping.	
	C-11 East Basin: Increase gate size at S-13 Pump Station and Gated Spillway to 5x16 feet; raise existing gates/platform and add floodwalls		Partially; not effective at storm peak (spillway remains closed) Minor improvements to peak canal profile and peak flood depths can be seen due to blocking backflow.	
Alt 2 - Pumps at Structures and Hardening needed	C-14 East Basin: Increase pump station capacity to 4,000 cfs; structure hardening; pre-storm drawdown	(1) Likely to reduce flood damages; prepares, absorbs, recovers at the project and system level (2) Likely; this alternative is formulated in alignment of federal laws, authorities, and public policies (3) Likely; although pump station costs may be higher, the performance of the alternative may be greater and may provide more benefits within the Study	Likely; adding pumps to conveyance improvements allows for drawdown to lower low range more efficiently prior to storm and increase the volume discharged just prior to storm. The peak headwater is decreased. Pump sizes >= 1,500 cfs have shown that pre-storm drawdown can be achieved and this helped in lowering peak headwater at S-37A Gated Spillway. Significant reduction in maximum water depth (~2 ft) are achieved in this watershed by implementing this alternative.	Yes, given relatively higher costs, will consider opportunities to optimize with components in Alternative 1
	Pompano Canal Basin: Increase pump station capacity to 375 cfs; structure hardening; pre-storm drawdown		Not Likely; no notable improvements in reduction of water levels overall in the watershed. When pumps are added with conveyance (culvert) improvements, significant drop in peak headwater is seen, timing is changed, and flow volume is increased. Notable improvements in reduction of water levels overall in the watershed is not seen. The reduction in water levels is most noticed between G-57 Gated Spillway and G-65 Gated Spillway.	

Initial Array of Alternatives	Management Measures	Qualitative Evaluation (1) Study Objective (2) Acceptability (3) Efficiency (4) Completeness	Qualitative/Quantitative Evaluation (for structural measures only) (5) Effectiveness (evaluated at the watershed level)	Screening Decision
	C-13 West Basin: Increase pump station capacity to 1,100 cfs; structure hardening; pre-storm drawdown	(4) Area. Pump stations may also help to address drainage problems in watersheds with gravity conveyance constraints. Likely; pumping provides opportunity to operate in a variety of conditions, especially with pre-storm drawdown	C-13 West Basin; Adding pumps to conveyance improvements allows for drawdown and maintain low range more efficiently prior to storm and increase the volume discharged just prior to storm. Peak canals profiles are lowered more than a foot and noticeable improvements were seen in peak flood depths. Pump sizes ≥ 600 cfs have shown to be good measures for pre-storm drawdown applications.	
	C-12 West Basin: Increase pump station capacity to 1,000 cfs; structure hardening; pre-storm drawdown		Partially; improving conveyance and structure gravity capacity along with pumping can lower the peak canal profile by ~1 ft. One significant issue seen in this watershed (C-12 West Basin) is that the secondary is not effectively getting the water to the canal, particularly in the southern part of the watershed. This limits the benefits.	
	North New River Canal West Basin: Increase pump station capacity to 1,500 cfs; structure hardening; pre-storm drawdown		Likely; adding pumps to conveyance improvements allows for drawdown and maintain low range more efficiently prior to storm and increase the volume discharged just prior to storm. The peak canal profile is decreased and some decreases in peak flood depths in western watershed. Pump sizes >= 800 cfs have shown to be useful for pre-storm drawdown applications. Application of pre-storm drawdown also helped shift the time when peak headwater occurs.	
	Hillsboro Canal Basin: Increase pump station capacity to 3,600 cfs; structure hardening; pre-storm drawdown		Partially; peak flood depths were not significantly improved with pumping, only slight increase in area improved.	
	C-14 West Basin: Structure hardening, unspecified; evaluate pre-storm drawdown operations		Partially; the C-14 (Cypress Creek) Canal peak profile was lowered due to lower tailwater because of pumping downstream at S-37A Gated Spillway. Flood depths were improved. May further improve with operational changes at the structure.	
	C-11 East Basin: Increase pump station capacity to 1,080 cfs; structure hardening; pre-storm drawdown		Likely; increasing the pump capacity lowered the canal peaks substantially in the entire C-11 (South New River) Canal. The additional pumps along with hardening and drawdown was effective in decreasing peak flood depths, in some locations as much as 1-1.5 ft.	
Alt 3 - Removal of Coastal Structures	C-14 East Basin: Remove S-37A Gated Spillway and allow for natural flow	(1) Not likely; would have tradeoffs with impacts to water supply and damages associated with surge conditions (2) Not likely; not consistent with requirements of authorized C&SF project; would promote saltwater intrusion in canals, which has indirect impacts to aquifer; could compromise water supply	Likely; removing S-37A Gated Spillway decreased head loss at the S-37A Gated Spillway location on the order of 0.1-0.2 ft and resulted in decrease of peak flood depths in the range of less than or equal to 0.3 ft over land adjacent to the channel.	No; does not meet study objective and has policy concerns
	Pompano Canal Basin: Remove G-57 Gated Spillway and allow for natural flow		Not Likely; removing G-57 Gated Spillway did not result in any improvement to canal peak profiles or peak flood depths in the Pompano watershed.	
	C-13 West Basin: Remove S-36 Gated Spillway and allow for natural flow		No evaluation.	
	C-12 West Basin: Remove S-33 Gated Spillway and allow for natural flow		Not likely; removal of S-33 Gated Spillway resulted in no improvement in canal peak profile or peak flood depths in the C-12 West Basin watershed.	
	C-11 West Basin: Remove S-13AW Gated Culvert and allow for natural flow		Not likely; no changes to peak profiles.	
	North New River Canal West Basin: Remove G-54 Gated Spillway and allow for natural flow		Not likely; removal of G-54 Gated Spillway resulted in no head loss at the structure location which lowered peak canal profile between 0.2-0.3 ft. There are some localized improvements in peak flood depths but no improvement overall.	

Initial Array of Alternatives	Management Measures	Qualitative Evaluation (1) Study Objective (2) Acceptability (3) Efficiency (4) Completeness	Qualitative/Quantitative Evaluation (for structural measures only) (5) Effectiveness (evaluated at the watershed level)	Screening Decision
	Hillsboro Canal Basin: Remove G-56 Gated Spillway and allow for natural flow	(3) Not likely; may be efficient from a cost standpoint but would have flood risk tradeoffs in the watersheds (4) Not likely; the alternative does not meet the study objectives and does not allow support for managing surge conditions and saltwater intrusion	Partially; peak flood depths were not significantly improved, only minor local improvements along areas adjacent to the canal with decrease of less than or equal to 0.1 ft.	
	C-14 West Basin: Remove S-37B Gated Spillway (non-coastal) and allow for natural flow		Partially; removal of S-37B Gated Spillway still showed losses at the S-37B Gated Spillway location likely due to conveyance limitations, but peak canal profile in west part of canal changed very little. Peak flood depths not significantly different - localized differences both positive and negative but on the order of 0.1 ft.	
	C-11 East Basin: Remove S-13 Pump Station and Gated Spillway and allow for natural flow		Likely; removing S-13 Pump Station and Gated Spillway caused increases in peak canal profiles of as much as 1 ft and peak flood depths in some cases equal and/or greater than 0.5 ft.	
Alt 4 - Relocation of Coastal Structures (to the East) low risk	C-14 East Basin: Relocate S-37A Gated Spillway downstream of confluence with Pompano Canal and increase capacity to accommodate discharge from Pompano and C-14 East Basin; structure hardening; pre-storm drawdown	(1) Likely; absorb and recover at the project and system level (2) Not likely; limited relocation opportunities for structures; may increase flood risk in areas dependent on performance of existing primary and secondary systems; may also cause tradeoffs associated with navigation constraints; locks would impede traffic flow which would require additional study efforts outside of flood risk management (3) Not likely; new water control features may have significantly increasing project costs (4) Not likely; while the alternative meets the study objectives, it likely an unacceptable and ineffective flood risk management solution for the community, but could be considered for a new coastal storm risk management study.	Likely; observed benefits (reduced water levels and peak profiles) in this watershed as well as downstream of the proposed location of S-37A Gated Spillway.	No; is not acceptable as the study would require multi-purpose effort
	Pompano Canal Basin: Tie-in to S-37A Gated Spillway relocation downstream of confluence with Pompano Canal Basin and increase capacity to accommodate discharge from G-16 (Pompano) Canal and C-15 (North New River) Canal; structure hardening; pre-storm drawdown		Likely; maximum peak profiles are improved significantly but not seeing notable improvements in reduction of water levels overall in the watershed.	
	C-13 West Basin: Relocate S-36 Gated Spillway downstream (control elevation 1.5-3 ft) in C-13 (Middle River) Canal and increase capacity (3,500 cfs) to accommodate additional runoff at proposed location; structure hardening; pre-storm drawdown		C-13 West Basin: Seeing peak profiles go down by 1.0 ft in the C-13 (Middle River) Canal. Also seeing more benefits in the watershed as well as downstream of the proposed location for S-36 Gated Spillway.	
	C-12 West Basin: Remove connection between C-11 (South New River) Canal and South Fork New River Canal and add auxiliary structure downstream of North New River Canal and C-12 (Plantation) Canal confluence with the same control elevation as S-33 Gated Spillway; structure hardening; pre-storm drawdown		Not likely; no observed benefits for this watershed.	
	C-11 West Basin: Modify operation of S-13AW Gated Culvert to increase operational capacity		Not likely; no observed benefits for this watershed.	
	North New River Canal West Basin: Add auxiliary structure for G-54 Gated Spillway downstream of the North New River Canal and C-12 (Plantation) Canal confluence with same control elevation as S-33 Gated Spillway and increase capacity (4,500 cfs) to accommodate additional runoff at proposed location		Likely; maximum water levels in this watershed improved significantly.	
	Hillsboro Canal Basin: Relocate G-56 Gated Spillway upstream of the 2C1 confluence and increase capacity to handle additional discharge from Lake Worth Drainage District; to include dredging/storage/raised banks if necessary; structure hardening; pre-storm drawdown		Not likely; no observed benefits for this watershed.	
	C-14 West Basin: Conceptualize storage and divert water from C-14 (Cypress Creek) Canal; operation of G-65 Gated Spillway for flood control		Not likely; no observed benefits for this watershed.	
	C-11 East Basin: Relocate S-13 Pump Station and Gated Spillway downstream on Dania Cut-off Canal and increase capacity to 5,000 cfs; remove connection between C-11 (South New River) Canal and South Fork New River Canal; add auxiliary		Likely; observed lower peak profiles and water levels.	

Initial Array of Alternatives	Management Measures	Qualitative Evaluation (1) Study Objective (2) Acceptability (3) Efficiency (4) Completeness	Qualitative/Quantitative Evaluation (for structural measures only) (5) Effectiveness (evaluated at the watershed level)	Screening Decision
	structure downstream of North New River Canal and C-12 (Plantation) Canal confluence; structure hardening; pre-storm drawdown			
Alt 5 - Alternative to Discharging East on Peak	C-14 East Basin: Divert water from C-14 (Cypress Creek) Canal; operation of G-65 Gated Spillway for flood control	(1) Likely; absorb and recover at the project and system level (2) Not likely; discharging water to the west will likely not meet water quality requirements and would not be acceptable; would require additional water quality management requirements (3) Likely; requires further evaluation of alternative to identify efficiency opportunities; infrastructure needs are higher for this alternative and may be more costly (4) Not likely; do not have capacity to route water west	Not likely; no observable differences in watershed.	Yes, opportunities would be combined with Alternative 6
	Pompano: Divert water from C-14 (Cypress Creek) Canal; operation of G-65 Gated Spillway for flood control		Not likely; no observable differences in watershed.	
	C-13 West Basin: Fully open S-125 Gated Culvert for interbasin flow, connecting C-13 (Middle River) Canal to North New River Canal		Not likely; no observable differences in watershed.	
	C-12 West Basin: Modify operation of Old Plantation pump station to discharge into upstream C-12 (Plantation) Canal when elevation is 8.5 ft NGVD		Not likely; no observable differences in watershed.	
	C-11 West Basin: Maximize operation of C-11 (South New River) Canal impoundment to pump at lower elevations and earlier in a storm event (3.5 ft NGVD)			
	North New River Canal West Basin: Fully open S-125 Gated Culvert for interbasin flow, connecting C-13 (Middle River) Canal to North New River Canal		Not likely; no observable differences in watershed.	
	Hillsboro Canal Basin: Conceptualize storage and re-route to site 1 impoundment		Likely; Modifying canal conveyance (in addition to upgrading G-56 Gated Spillway, roughness coefficient of the canal has been modified) improves peak profiles in the entirety of the canal. Water levels in the canal drop significantly.	
	C-14 West Basin: Conceptualize storage and divert water from C-14 (Cypress Creek) Canal; operation of G-65 Gated Spillway for flood control		Not likely; no observable differences in watershed.	
Alt 6 - Nature-Based Only	Increase or enhance surface storage in basin through created or restored wetlands, stormwater parks, conversion of developed land into lakes/ponds, floodway enlargement/restoration.	(1) Not likely; limited suitable real estate available for nature-based solutions to enhance C&SF Project (2) Likely; however, would only address storage for limited local areas (3) Not likely; does not enhance the functionality of the existing project to meet future conditions and not suitable due to lack of real estate (4) Not likely; does not fully address study objectives as a stand-alone alternative.	(5) Not likely; does not alleviate problems across all watersheds due to limited opportunities for storage enhancements.	Yes; in combination with other components of Alternatives 1 and 2
Alt 7a - Nonstructural Only	In lieu of water control structure improvements, elevate or dry floodproof structures within the Study Area to address changing conditions and implement flood warning system with real-time flood forecasting.	(1) Not likely; does not allow water to drain (2) Not likely; would not support maintenance of the coastal	(5) Partially; may not build trust with community if forgoing improvements to water control structures and the duration of flooding would not be reduced.	No; screen as not an acceptable solution

Initial Array of Alternatives	Management Measures	Qualitative Evaluation (1) Study Objective (2) Acceptability (3) Efficiency (4) Completeness	Qualitative/Quantitative Evaluation (for structural measures only) (5) Effectiveness (evaluated at the watershed level)	Screening Decision
		structures for managing water flowing into primary canals (3) Partially; does not enhance the functionality of the existing project to meet future conditions (4) Not likely; does not fully address the study objective as a standalone alternative		
Alt 7b - Nonstructural to support residual risk	Elevate and/or dry floodproof existing structures vulnerable to residual risk and implement a flood warning system with real-time flood forecasting.	(4) Not likely; does not allow water to drain (5) Likely; however, would likely create inequitable distribution when elevating high-risk homes to policy required design flood elevation heights (6) Partially; does not enhance the functionality of the existing project to meet future conditions and may be slower to implement based on landowner willingness (7) Partially; does not fully address study objective as a stand-alone alternative; combinable with another alternative	(8) Partially; may not build trust with community if forgoing improvements to water control structures; duration of flooding may not be reduced; likely if paired with structural alternative.	Yes; may provide opportunities to address localized residual risk in combination with Alternatives 1 and 2
Alt 8 - No Action	No Action			

Note: cfs = cubic feet per second