

**PROFESSIONAL SERVICES AGREEMENT**  
**(Multi-Jurisdictional Climate Change Vulnerability Assessment)**

THIS PROFESSIONAL SERVICES AGREEMENT (“Agreement”) is entered on \_\_\_\_ day of \_\_\_\_\_, 2020, by and between the **City of Lake Worth Beach**, a Florida municipal corporation (“City”) and **Collective Water Resources, LLC**, a limited liability company authorized to do business in the State of Florida (“Consultant”).

**RECITALS**

**WHEREAS**, the City, the City of Boca Raton, the City of Boynton Beach, the City of Delray Beach, the Town of Highland Beach, the Town of Lantana, the Town of Ocean Ridge, and Palm Beach County entered into a partnership, through an interlocal agreement, to obtain a Climate Change Vulnerability Assessment to determine the potential danger caused by climate change; and

**WHEREAS**, through the interlocal agreement, the City issued a Request for Proposal number 20-203 (hereinafter “RFP”), for a Multi-Jurisdictional Climate Change Vulnerability Assessment; and

**WHEREAS**, Consultant has provided the City with a written proposal in response to the RFP to provide the services as described and set out in the RFP; and

**WHEREAS**, the City desires to accept Consultant’s proposal in order for Consultant to render the services to the City as provided herein; and

**WHEREAS**, Consultant further warrants that it is experienced and capable of performing the tasks hereunder in a professional and competent manner; and

**WHEREAS**, the purpose of this Agreement is to set forth certain terms and conditions for the provision of services by Consultant to the City.

**NOW, THEREFORE**, in consideration of the premises and mutual covenants herein contained, the sufficiency of which is hereby acknowledged by the parties, the City and Consultant agree as follows:

**SECTION 1: INCORPORATION OF RECITALS.** The foregoing Recitals are incorporated into this Agreement as true and correct statements.

**SECTION 2: CONSULTANT’S SERVICES.** As more specifically set forth in Consultant’s proposal (dated January 28, 2020) which is attached hereto as **Exhibit “A”** and incorporated herein, Consultant shall provide Multi-Jurisdictional Climate Change Vulnerability Assessment to the City. In addition, Consultant specifically agrees to engage in at least three (3) interactive workshops with the working group as defined in the interlocal agreement, during the implementation of the Climate Change Vulnerability Assessment.

**SECTION 3: INDEPENDENT CONTRACTOR RELATIONSHIP.** No relationship of employer or employee is created by this Agreement, it being understood that Consultant will act hereunder as an independent contractor and none of Consultant’s, officers, directors, employees, independent contractors, representatives or agents performing services for Consultant pursuant to this Agreement shall have any claim under this Agreement or otherwise against the City for compensation of any kind under this Agreement. The relationship between the City and Consultant is that of independent contractors, and neither shall be considered a joint venturer, partner, employee, agent, representative or other relationship of the other for any purpose expressly or by implication.

**SECTION 4: TERM, TIME AND TERMINATION.**

a. Term. The term of this Agreement shall commence upon the approval of this Agreement by the City Commission and shall be for the term necessary to complete all services as set forth in Consultant's proposal (**Exhibit "A"**) unless earlier terminated as stated herein. The term may be extended by written agreement of the parties for further services related to those services identified herein.

b. Time for Completion. Time is of the essence in the performance of this Agreement. Consultant shall at all times carry out its duties and responsibilities as expeditiously as possible and in accordance with the project schedule set forth in **Exhibit "A"**.

c. Force Majeure. Neither party hereto shall be liable for its failure to perform hereunder due to any circumstances beyond its reasonable control, such as acts of God, wars, riots, national emergencies, sabotage, strikes, labor disputes, accidents, and governmental laws, ordinances, rules, or regulations. The Consultant or City may suspend its performance under this Agreement as a result of a force majeure without being in default of this Agreement, but upon the removal of such force majeure, the Consultant or City shall resume its performance as soon as is reasonably possible. Upon the Consultant's request, the City shall consider the facts and extent of any failure to perform the services and, if the Consultant's failure to perform was without its or its subconsultants' fault or negligence, the schedule and/or any other affected provision of this Agreement may be revised accordingly, subject to the City's rights to change, terminate, or stop any or all of the services at any time. No extension shall be made for delay occurring more than seven (7) days before a notice of delay or claim therefore is made in writing to the City. In the case of continuing cause of delay, only one (1) notice of delay or claim is necessary.

d. Termination without cause. Either party may terminate this Agreement at any time with or without cause by giving not less than thirty (30) days written notice of termination.

e. Termination for cause. Either party may terminate this Agreement at any time in the event that the other party engages in any act or makes any omission constituting a material breach of any term or condition of this Agreement. The party electing to terminate this Agreement shall provide the other party with written notice specifying the nature of the breach. The party receiving the notice shall then have three (3) days from the date of the notice in which to remedy the breach. If such corrective action is not taken within three (3) days, then this Agreement shall terminate at the end of the three (3) day period without further notice or demand.

f. Early Termination. If this Agreement is terminated before the completion of all services by either party, the Consultant shall:

1. Stop services on the date and to the extent specified including without limitation services of any subconsultants.
2. Transfer all work in progress, completed work, and other materials related to the terminated services to the City in the format acceptable to City.
3. Continue and complete all parts of the services that have not been terminated.

g. Effect of Termination. Termination of this Agreement shall not affect any rights, obligations, and liabilities of the parties arising out of transactions which occurred prior to termination. Notwithstanding the foregoing, the parties acknowledge and agree that the City is a municipal corporation existing under the laws of the State of Florida, and as such, this Agreement (and all Exhibits hereto) are subject to budgeting and appropriation by the City of funds sufficient to pay the costs associated herewith in any fiscal year of the City. Notwithstanding anything in this Agreement to the contrary, in the event that no funds are appropriated or budgeted by the City's governing board in any fiscal year to pay the costs associated with the City's obligations under this Agreement, or in the event the funds budgeted or appropriated are, or are estimated by the City to be, insufficient to pay the costs associated with the City's



obligations hereunder in any fiscal period, then the City will notify Consultant of such occurrence and either the City or Consultant may terminate this Agreement by notifying the other in writing, which notice shall specify a date of termination no earlier than twenty-four (24) hours after giving of such notice. Termination in accordance with the preceding sentence shall be without penalty or expense to the City of any kind whatsoever; however, City shall pay Consultant for all services performed under this Agreement through the date of termination.

#### **SECTION 5: COMPENSATION.**

a. **Payments.** The City agrees to compensate Consultant in accordance with the rate schedule set forth in **Exhibit "A"**; **provided that, the total amount to be paid to Consultant under this Agreement shall not exceed Three Hundred Sixty Four Thousand, Three Hundred Twenty Dollars (\$364,320.00).** The City shall not reimburse Consultant for any additional costs incurred as a direct or indirect result of Consultant providing services to the City under this Agreement and not set forth in **Exhibit "A"**.

b. **Invoices.** Consultant shall render invoices to the City for services that have been rendered in conformity with this Agreement, the RFP and **Exhibit "A"**. The invoices shall specify the services performed and the time spent on such work. All reimbursable expenses shall also be clearly identified on the invoice with supporting documentation. Invoices will be reviewed for approval and if an invoice is not approved, the City will notify Consultant within ten (10) days of deficiencies in the invoice. Once the deficiencies are corrected and a new or amended invoice submitted, the City shall make payment within twenty (20) days. Invoices will normally be paid within thirty (30) days following the City's receipt of Consultant's invoice.

**SECTION 6: INDEMNIFICATION.** Consultant, its officers, employees and agents shall indemnify and hold harmless the City, including its officers and employees from liabilities, damages, losses, and costs, including but not limited to, reasonable attorney's fees (at the trial and appellate levels), to the extent caused by the negligence, of Consultant, its officers, directors, employees, representatives and agents employed or utilized by Consultant in the performance of the services under this Agreement. The City agrees to be responsible for its own negligence. Nothing contained in this Agreement shall create a contractual relationship with or a cause of action in favor of a third party against either the City or Consultant, nor shall this Agreement be construed as a waiver of sovereign immunity for the City beyond the waiver provided in section 768.28, Florida Statutes.

**SECTION 7: COMPLIANCE AND DISQUALIFICATION.** Each of the parties agrees to perform its responsibilities under this Agreement in conformance with all laws, regulations and administrative instructions that relate to the parties' performance of this Agreement.

**SECTION 8: PERSONNEL.** Consultant represents that it has, or will secure at its own expense, all necessary personnel required to perform the services under this Agreement. Such personnel shall not be employees of or have any contractual relationship with the City. All of the services required hereunder shall be performed by Consultant or under its supervision, and all personnel engaged in performing the services shall be fully qualified and authorized or permitted under federal, state and local law to perform such services.

**SECTION 9: SUB-CONSULTANTS.** The City reserves the right to accept the use of a sub-consultant or to reject the selection of a particular sub-consultant and approve all qualifications of any sub-consultant in order to make a determination as to the capability of the sub-consultant to perform properly under this Agreement. All sub-consultants providing professional services to Consultant under this Agreement will also be required to provide their own insurance coverage identical to those contained in this Agreement. In the event that a sub-consultant does not have insurance or does not meet the insurance limits as stated in this Agreement, Consultant

shall indemnify and hold harmless the City for any claim in excess of the sub-consultant's insurance coverage, arising out of the negligent acts, errors or omissions of the sub-consultant.

**SECTION 10: FEDERAL AND STATE TAX.** The City is exempt from payment of Florida State Sales and Use Tax. Consultant is not authorized to use the City's Tax Exemption Number.

**SECTION 11: INSURANCE.** Prior to commencing any services, Consultant shall provide proof of insurance coverage as required hereunder. Such insurance policy(s) shall be issued by the United States Treasury or insurance carriers approved and authorized to do business in the State of Florida, and who must have a rating of no less than "excellent" by A.M. Best or as mutually agreed upon by the City and Consultant. All such insurance policies may not be modified or terminated without the express written authorization of the City.

<b><u>Type of Coverage</u></b>	<b><u>Amount of Coverage</u></b>
Professional liability/ Errors and Omissions	\$1,000,000 per occurrence
Commercial general liability (Products/completed operations Contractual, insurance broad form property, Independent Consultant, personal injury)	\$1, 000,000 per occurrence  \$2,000,000 annual aggregate
Automobile (owned, non-owned, & hired)	\$ 1,000,000 single limits
Worker's Compensation	\$ statutory limits

The commercial general liability and excess liability policies will name the City as an additional insured and proof of all insurance coverage shall be furnished to the City by way of an endorsement to same or certificate of insurance prior to the provision of services. The certificates shall clearly indicate that Consultant has obtained insurance of the type, amount, and classification as required for strict compliance with this section. Failure to comply with the foregoing requirements shall not relieve Consultant of its liability and obligations under this Agreement.

**SECTION 12: SUCCESSORS AND ASSIGNS.** The City and Consultant each binds itself and its partners, successors, executors, administrators, and assigns to the other party of this Agreement and to the partners, successors, executors, administrators and assigns of such other party, in respect to all covenants of this Agreement. Except as agreed in writing by all parties, this Agreement is not assignable.

**SECTION 13: DISPUTE RESOLUTION, LAW, VENUE AND REMEDIES.** All claims arising out of this Agreement or its breach shall be submitted first to mediation. The parties shall share the mediator's fee equally. The mediation shall be held in Palm Beach County. Agreements reached in mediation shall be enforceable as settlement agreements in any court having jurisdiction thereof. This Agreement shall be governed by the laws of the State of Florida. Any and all legal action necessary to enforce the Agreement will be held in Palm Beach County. No remedy herein conferred upon any party is intended to be exclusive of any other remedy, and each and every such remedy shall be cumulative and shall be in addition to every other remedy given hereunder or now or hereafter existing at law or in equity or by statute or otherwise. No single or partial exercise by any party of any right, power, or remedy hereunder shall preclude any other or further exercise thereof.

**SECTION 14: WAIVER OF JURY TRIAL.** TO ENCOURAGE PROMPT AND EQUITABLE RESOLUTION OF ANY LITIGATION, EACH PARTY HEREBY WAIVES ITS RIGHTS TO A TRIAL BY JURY IN ANY LITIGATION RELATED TO THIS AGREEMENT.

**SECTION 15: ACCESS AND AUDITS.** Consultant shall maintain adequate records to justify all payments made by the City under this Agreement for at least three (3) years after completion of this Agreement and longer if required by applicable federal or state law. The City shall have access to such books, records, and documents as required in this section for the purpose of inspection or audit during normal business hours, at Consultant's place of business. In no circumstances will Consultant be required to disclose any confidential or proprietary information regarding its products and service costs.

**SECTION 16: NONDISCRIMINATION.** Consultant warrants and represents that all of its employees are treated equally during employment without regard to race, color, religion, disability, sex, age, national origin, ancestry, marital status, or sexual orientation.

**SECTION 17: AUTHORITY TO PRACTICE.** Consultant hereby represents and warrants that it has and will continue to maintain all licenses and approvals required to conduct its business and provide the services required under this Agreement, and that it will at all times conduct its business and provide the services under this Agreement in a reputable manner. Proof of such licenses and approvals shall be submitted to the City upon request.

**SECTION 18: SEVERABILITY.** If any term or provision of this Agreement, or the application thereof to any person or circumstances shall, to any extent, be held invalid or unenforceable, to remainder of this Agreement, or the application of such terms or provision, to persons or circumstances other than those as to which it is held invalid or unenforceable, shall not be affected, and every other term and provision of this Agreement shall be deemed valid and enforceable to the extent permitted by law.

**SECTION 19: PUBLIC ENTITY CRIMES.** Consultant acknowledges and agrees that a person or affiliate who has been placed on the convicted vendor list following a conviction for a public entity crime may not submit a bid, proposal, or reply on a contract to provide any goods or services to a public entity; may not submit a bid, proposal, or reply on a contract with a public entity for the construction or repair of a public building or public work; may not submit bids, proposals, or replies on leases of real property to a public entity; may not be awarded or perform work as a contractor, supplier or sub-contractor under a contract with any public entity; and may not transact business with any public entity in excess of the threshold amount provided in Section 287.017, Florida Statutes, for CATEGORY TWO for a period of 36 months following the date of being placed on the convicted vendor list. The Consultant will advise the City immediately if it becomes aware of any violation of this statute.

**SECTION 20: NOTICE.** All notices required in this Agreement shall be sent by hand-delivery, certified mail (RRR), or by nationally recognized overnight courier, and if sent to the City shall be sent to:

City of Lake Worth Beach  
Attn: City Manager  
7 N. Dixie Highway  
Lake Worth Beach, FL 33460

and if sent to Consultant, shall be sent to:

Collective Water Resources, LLC.  
Attn: Elizabeth Perez, President  
8461 Lake Worth Road, Suite 231  
Lake Worth Beach, FL 33467

The foregoing names and addresses may be changed if such change is provided in writing to the other party. Notice shall be deemed given upon receipt.

**SECTION 21: ENTIRETY OF AGREEMENT.** The City and Consultant agree that this Agreement sets forth the entire agreement between the parties, and that there are no promises or understandings other than those stated herein. None of the provisions, terms and conditions contained in this Agreement may be added to, modified, superseded or otherwise altered, except by written instrument executed by the parties hereto.

**SECTION 22: WAIVER.** Failure of a party to enforce or exercise any of its right(s) under this Agreement shall not be deemed a waiver of that parties' right to enforce or exercise said right(s) at any time thereafter.

**SECTION 23: PREPARATION AND NON-EXCLUSIVE.** This Agreement shall not be construed more strongly against either party regardless of who was more responsible for its preparation. This is a non-exclusive Agreement and the City reserves the right to contract with individuals or firms to provide the same or similar services.

**SECTION 24: MATERIALITY.** All provisions of the Agreement shall be deemed material. In the event Consultant fails to comply with any of the provisions contained in this Agreement or exhibits, amendments and addenda attached hereto, said failure shall be deemed a material breach of this Agreement and City may at its option provide notice to Consultant to terminate for cause.

**SECTION 25: LEGAL EFFECT.** This Agreement shall not become binding and effective until approved by the City. The Effective Date is the date this Agreement is executed by the City.

**SECTION 26: NOTICE OF COMPLAINTS, SUITS AND REGULATORY VIOLATIONS.** Each party will promptly notify the other of any complaint, claim, suit or cause of action threatened or commenced against it which arises out of or relates, in any manner, to the performance of this Agreement. Each party agrees to cooperate with the other in any investigation either may conduct, the defense of any claim or suit in which either party is named, and shall do nothing to impair or invalidate any applicable insurance coverage.

**SECTION 27: SURVIVABILITY.** Any provision of this Agreement which is of a continuing nature or imposes an obligation which extends beyond the term of this Agreement shall survive its expiration or earlier termination.

**SECTION 28: COUNTERPARTS.** This Agreement may be executed in one or more counterparts, each of which shall be deemed an original, and will become effective and binding upon the parties as of the effective date at such time as all the signatories hereto have signed a counterpart of this Agreement.

**SECTION 29: PALM BEACH COUNTY IG.** In accordance with Palm Beach County ordinance number 2011-009, Consultant acknowledges that this Agreement may be subject to investigation and/or audit by the Palm Beach County Inspector General. Consultant has reviewed Palm Beach County ordinance number 2011-009 and is aware of its rights and/or obligations under such ordinance.

**SECTION 30: AGREEMENT DOCUMENTS AND CONTROLLING PROVISIONS.** This Agreement consists of this Agreement and **Exhibit "A"**. This Agreement also includes the RFP, which is incorporated by reference. The parties agree to be bound by all the terms and conditions set forth in the aforementioned documents. To the extent that there exists a conflict between the terms and conditions of this Agreement, the RFP, and **Exhibit "A"**, the terms and conditions of this Agreement shall prevail with the RFP next taking precedence and then **Exhibit "A"**. Wherever possible, the provisions of such documents shall be construed in such a manner as to avoid conflicts between provisions of the various documents.

**SECTION 31: OWNERSHIP OF DELIVERABLES.** The deliverables, work product, specifications, calculations, supporting documents, or other work products which are listed as deliverables by Consultant in **Exhibit "A"** to the City shall become the property of the City. Consultant may keep copies or samples

thereof and shall have the right to use the same for its own purposes. The City accepts sole responsibility for the reuse of any such deliverables in a manner other than as initially intended or for any use of incomplete documents.

**SECTION 32: REPRESENTATIONS AND BINDING AUTHORITY.** By signing this Agreement, on behalf of Consultant, the undersigned hereby represents to the City that he or she has the authority and full legal power to execute this Agreement and any and all documents necessary to effectuate and implement the terms of this Agreement on behalf of Consultant for whom he or she is signing and to bind and obligate such party with respect to all provisions contained in this Agreement.

**SECTION 33: PUBLIC RECORDS.** Consultant shall comply with Florida's Public Records Act, Chapter 119, Florida Statutes, and, if determined to be acting on behalf of the City as provided under section 119.011(2), Florida Statutes, specifically agrees to:

- (a) Keep and maintain public records required by the City to perform the service.
- (b) Upon request from the City's custodian of public records or designee, provide the City with a copy of the requested records or allow the records to be inspected or copied within a reasonable time at a cost that does not exceed the cost provided in Chapter 119, Florida Statutes, or as otherwise provided by law.
- (c) Ensure that public records that are exempt or confidential and exempt from public records disclosure requirements are not disclosed except as authorized by law for the duration of this Agreement and following completion of this Agreement if Consultant does not transfer the records to the City.
- (d) Upon completion of this Agreement, transfer, at no cost, to the City all public records in possession of Consultant or keep and maintain public records required by the City to perform the service. If Consultant transfers all public records to the City upon completion of the Agreement, Consultant shall destroy any duplicate public records that are exempt or confidential or exempt from public records disclosure requirements. If Consultant keeps and maintains public records upon completion of the Agreement, Consultant shall meet all applicable requirements for retaining public records. All records stored electronically must be provided to the City, upon request from the City's custodian of public records or designee, in a format that is compatible with the information technology systems of the City.

**IF CONSULTANT HAS QUESTIONS REGARDING THE APPLICATION OF CHAPTER 119, FLORIDA STATUTES, TO CONSULTANT'S DUTY TO PROVIDE PUBLIC RECORDS RELATING TO THIS AGREEMENT, PLEASE CONTACT THE CUSTODIAN OF PUBLIC RECORDS OR DESIGNEE AT THE CITY OF LAKE WORTH BEACH, ATTN: DEBBIE ANDREA, AT (561) 586-1662, DANDREA@LAKEWORTHBEACHFL.GOV, 7 N. DIXIE HIGHWAY, LAKE WORTH BEACH, FL 33460.**

**SECTION 34: CONFIDENTIAL AND PROPRIETARY INFORMATION.** Each party (the "Receiving Party") will keep confidential and not disclose to any other person or entity or use (except as expressly and unambiguously authorized by this Agreement) information, technology or software ("Confidential Information") obtained from the other party (the "Disclosing Party"); provided, however, that the Receiving Party will not be prohibited from disclosing or using information (i) that at the time of disclosure is publicly available or becomes publicly available through no act or omission of the Receiving Party, (ii) that is or has been disclosed to the Receiving Party by a third party who is not under, and to whom the Receiving Party does not owe, an obligation of confidentiality with respect thereto, (iii) that is or has been independently acquired or developed by the Receiving Party without access to the Disclosing Party's Confidential Information, (iv) that is already in the Receiving Party's possession at the time of

disclosure, or (v) that is required to be released by law.

**SECTION 35: EXPORT ADMINISTRATION.** Each party agrees to comply with all export laws and regulations of the United States ("Export Laws") to assure that no software deliverable, item, service, technical data or any direct product thereof arising out of or related to this Agreement is exported directly or indirectly (as a physical export or a deemed export) in violation of Export Laws.

**SECTION 36: SCRUTINIZED COMPANIES.**

- a. Consultant certifies that it and its subcontractors are not on the Scrutinized Companies that Boycott Israel List and are not engaged in the boycott of Israel. Pursuant to section 287.135, Florida Statutes, the City may immediately terminate this Agreement at its sole option if Consultant or any of its subcontractors are found to have submitted a false certification; or if Consultant or any of its subcontractors, are placed on the Scrutinized Companies that Boycott Israel List or is engaged in the boycott of Israel during the term of this Agreement.
- b. If this Agreement is for one million dollars or more, Consultant certifies that it and its subcontractors are also not on the Scrutinized Companies with Activities in Sudan List, Scrutinized Companies with Activities in the Iran Petroleum Energy Sector List, or engaged in business operations in Cuba or Syria as identified in Section 287.135, Florida Statutes. Pursuant to Section 287.135, the City may immediately terminate this Agreement at its sole option if Consultant, or any of its subcontractors are found to have submitted a false certification; or if Consultant or any of its subcontractors are placed on the Scrutinized Companies with Activities in Sudan List, or Scrutinized Companies with Activities in the Iran Petroleum Energy Sector List, or are or have been engaged with business operations in Cuba or Syria during the term of this Agreement.
- c. Consultant agrees to observe the above requirements for applicable subcontracts entered into for the performance of work under this Agreement.
- d. Consultant agrees that the certifications in this section shall be effective and relied upon by the City for the term of this Agreement, including any and all renewals.
- e. Consultant agrees that if it or any of its subcontractors' status changes in regards to any certification herein, Consultant shall immediately notify the City of the same.
- f. As provided in Subsection 287.135(8), Florida Statutes, if federal law ceases to authorize the above-stated contracting prohibitions then they shall become inoperative.

**REMAINDER OF THIS PAGE LEFT BLANK**  
**SIGNATURE PAGE FOLLOWS**

IN WITNESS WHEREOF, the parties hereto have made and executed this Professional Services Agreement (**Multi-Jurisdictional Climate Change Vulnerability Assessment**) as of the day and year set forth above.

**CITY OF LAKE WORTH BEACH, FLORIDA**

ATTEST:

By: \_\_\_\_\_  
Deborah M. Andrea, City Clerk

By: \_\_\_\_\_  
Pam Triolo, Mayor

APPROVED AS TO FORM AND  
LEGAL SUFFICIENCY:

APPROVED FOR FINANCIAL  
SUFFICIENCY

By: \_\_\_\_\_  
Glen J. Torcivia, City Attorney

By: \_\_\_\_\_  
Bruce T. Miller, Financial Services Director

**COLLECTIVE WATER RESOURCES, LLC**

By: \_\_\_\_\_

[Corporate Seal]

Print Name: \_\_\_\_\_

Title: \_\_\_\_\_

STATE OF \_\_\_\_\_ )  
COUNTY OF \_\_\_\_\_ )

The foregoing instrument was acknowledged before me this \_\_\_\_\_ day of \_\_\_\_\_, 2020, by \_\_\_\_\_, who was physically present, as \_\_\_\_\_ (title), of Collective Water Resources, LLC, a limited liability company, which is authorized to do business in the State of Florida, and who is personally known to me or who has produced the following \_\_\_\_\_ as identification.

Notary Public

\_\_\_\_\_  
Print Name: \_\_\_\_\_  
My commission expires: \_\_\_\_\_

**EXHIBIT “A”**

**(Consultant’s Proposal)**





# MULTI-JURISDICTIONAL CLIMATE CHANGE VULNERABILITY ASSESSMENT

City of Lake Worth  
RFP NO. 20-203



Collective  
WATER RESOURCES



FERNLEAF  
INTERACTIVE



BRIZAGA  
ASSESS. COMMUNICATE. ADAPT.

ATM

DESIGN  
ENGINEERING  
CONSULTING  
APPLIED TECHNOLOGY & MANAGEMENT, INC.

ERIN L. DEADY, P.A.

CHEN • MOORE  
& ASSOCIATES

Sea Grant  
Florida

AC  
DISASTER CONSULTING

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### 2. Qualifications

#### 2.2 Expertise for Key Staff, Including Resumes

##### Organizational Chart

##### Resumes

Liz Perez, Project Manager  
Matt Hutchins, Deputy Project Manager  
Stephanie Dunham, Analysis Manager  
Alec Bogdanoff, Outreach Lead  
Erin Deady, Legal Review  
Emily McBryan, QA/QC Manager  
Jim Fox, QA/QC  
Thomas Ruppert, QA/QC  
Anna Leitschuh, Community Captain/Analyst  
Brent Whitfield, Community Captain/Implementation Lead  
Michael Antinelli, Community Captain  
Michael Albert, Infrastructure Expert

#### 2.3 Firm Bios

Collective Water Resources, LLC  
NEMAC+Fernleaf  
Brizaga  
Applied Technology & Management, Inc.  
Chen Moore & Associates, Inc.  
Erin L. Deady, PA  
AC Disaster Consultants, Inc.  
Florida Sea Grant  
Proposed Split of Compensation for Work

#### 2.4 Sample Work Products

- Land of Sky Regional Resilience Assessment: Phase II Report
- Triangle Regional Resilience Partnership Resilience Assessment: Executive Summary
- City of Asheville Personal Action Guide
- West Palm Beach TM-9: Hydrologic Baseline

### 3. Schedule

### 4. References

### 5. Cost Proposal

### 6. Licenses + Insurance Certificate

### 7. Forms

**City of Lake Worth Beach  
Financial Services  
7 North Dixie Highway, 2<sup>nd</sup> Floor  
Lake Worth Beach, FL 33460**

**RE: RFP #20-203 Multi- Jurisdictional Climate Change Vulnerability  
Assessment**



**Dear Members of the Selection Committee:**

Southern jurisdictions within Palm Beach County are cooperatively embarking on a critical and landmark Climate Change Vulnerability Assessment (CCVA) to better understand and plan for the future of our communities based on targeted scientific analyses, effective and meaningful communication, and careful deliberation. We are pleased to submit a proposal for this work. Given the nature of the project, it is important for the Southeast Palm Beach County Coastal Resilience Partnership (CRP) to have a team of experts who are invested full time and daily in the issues at hand – and who are local and highly accessible as questions arise. This is our team. Collective Water Resources (Collective) has assembled a team of focused and highly-qualified experts with a deep understanding of the various aspects of this project and will be your reliable partner as you move forward. Our team includes the following firms: NEMAC+Fernleaf, Brizaga, Chen Moore & Associates, Inc., Applied Technology & Management, Inc. (ATM), Erin L. Deady, PA, AC Disaster Consulting, Inc., and Florida Sea Grant. Our team offers the following unique characteristics:

- **A TEAM THAT EMBODIES THE SPIRIT OF THIS PROJECT** – This is not just another project to the Collective Team. We are a close-knit team of small, focused firms – many that work on issues of resiliency together day in and day out, and many of us call Palm Beach County home. The tight and proven relationships amongst the experts on our team will allow us to provide timely, innovative, and meaningful analyses on this project. Our promise to you is that the full depth of our resources will be dedicated to data verification, analysis, and refinement – and aligning that process with the broader stakeholder aspects of the project. As owner-operated companies, we have no shareholders to satisfy – we are only accountable to ourselves and our clients. The team that put this proposal together is the team that will work on this project. It is also fortunate that this project will take place in Collective’s home County – and will support many of the communities that our firm’s leadership and our team members call home. We are approaching this CCVA from many angles – technical experts, active community members, and as family members and parents working to ensure that the future will provide our children with the same quality of life that we love here in South Florida now.
- **WE WROTE THE BOOKS** – As dedicated resiliency experts and modelers, we wrote many of the references relevant to this project and pioneered many of the methodologies that will be used on this project. For our team, these methodologies are not theoretical: we have applied these concepts leading to transformative outcomes for numerous local governments and have navigated the unique challenge of applying these approaches in cross-jurisdictional collaborative projects. The combined team of NEMAC+FernLeaf and Collective have worked together on two successful climate change vulnerability assessments, including multiple phases of assessments for West Palm Beach. Brizaga was created for

projects like this, and their firm leadership leads regional and state resiliency committees for multiple professional organizations. Collective has worked with Brizaga since their founding. Team member and Palm Beach County resident, Erin Deady, is widely recognized as the “go-to” legal expert on sea level rise and Adaptation Action Areas (AAAs). Our team also includes deeply local and practical knowledge via ATM and Chen Moore – you will be hard pressed to find engineers that know the County’s infrastructure and coastline better than these firms via their 25 local experts. However, we will not rely on previous achievements for this project – enclosed in this proposal you will find a fresh and detailed approach where we harness the best of what we’ve learned and the unique needs of this micro-region. We will never stop pushing for better outcomes for Palm Beach County – both as technical experts and as community members.

- **CAPTAINS FOR EACH COMMUNITY** - As shown in our Organizational Chart, our Community Captains are a true differentiator and key part of our team. Each of our Community Captains are “GIS Power Users” and have a strong link to each community. In fact, we specifically selected our Community Captains from among our firms that live or work extensively in the jurisdiction indicated. Each Community Captain will be the technical advocate for their respective jurisdiction throughout the entire project. Our use of Community Captains will also allow each community to have a direct line of communication to the technical team via an expert that understands their unique issues. Our Community Captains will report to our Lead Community Captain and Outreach Lead - Alec Bogdanoff - at Brizaga. Alec is known as not only an expert in sea level rise and climate change, but also as an outreach expert who will distill both communication and technical issues for the Working Group and larger consultant team. However, each Community Captain will be on call to each Community and can advocate freely as questions arise during analysis and preparation of deliverables. We believe this style of communication will provide both the specificity and high-level coordination that will be necessary on a project of this nature. Each Community Captain will document these external communications and share information across the consultant team to ensure no details are lost.

Collective Water Resources, LLC is the lead firm on this team, and I am the President and sole owner of the firm. I will also serve as the project manager and have the full resources of my firm and collaborative team members that we can bring to bear on this important project. We are headquartered in Lake Worth at 8461 Lake Worth Road, Suite 231, Lake Worth, 33467. I am available at 561-779-3552 or 561-713-1320 – or via email at [lperez@collectivewater.com](mailto:lperez@collectivewater.com). Thank you for this opportunity.

Sincerely,



Elizabeth Perez, PE, D.WRE, CFM  
President  
Collective Water Resources, LLC



# 1. APPROACH

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## 1. Proposed Scope of Services/Approach

*As a highly local and experienced team, we have provided a customized and flexible approach to this Climate Change Vulnerability Assessment (CCVA). We feel that it is important to satisfy both the collective and unique goals of the partner communities engaged in this process. This section will provide our suggested approach to this important project – both in terms of your mutual goals and the unique needs of each member community. Our team does this every day, we have intimate working knowledge of the area, a tool that has been tested and custom-tailored to do precisely these kinds of analyses, and we know that we can meet the March 2021 timeline because we can point to examples of providing results similar to this project in shorter timeframes.*

Collective, NEMAC+FernLeaf, and Brizaga are all firms that work on issues of resiliency and sustainability every day. On this team, there is no learning curve in terms of literature searches, data hunts, research on each community, and/or software development. There is no need for our team to fit tangential experience into the process outlined in this RFP: this team has specifically been assembled because we have an extensive track record of applying this exact process throughout the Southeast in general and in South Florida in particular. **Furthermore, this team has applied this exact process in more than one multi-jurisdictional project and has learned many lessons that this will benefit this project and jurisdictions participating.**

Our promise to you is that the full depth of our resources will be dedicated to data verification, analysis, and refinement – and aligning that process with the broader stakeholder aspects of the CCVA. **As owner-operated companies, we have no shareholders to satisfy - we are only accountable to ourselves and our clients.** The team that put this proposal together is the team that will work on this project. It is also fortunate in this instance that this project will take place in Collective's home County – and in many of the communities that our firm's leadership and our team members call home. We are approaching this project from many angles – technical experts, active community members, and in this very special case – as family members and parents working to ensure that the future will provide our children with the same quality of life that we love here in South Florida now.

It is difficult to explore our approach without briefly addressing the structure of our team. Since this project is GIS driven, **most of our team is fully GIS-enabled** (see staff denoted with \* in our organizational chart). This ability to work with GIS and data directly will be a powerful catalyst for each jurisdiction in refining datasets (while maintaining data integrity) and making the analysis more accurate and meaningful – all while maintaining schedule for each community. Our team does not advise using data that has not been reviewed and mined as part of this project. Because our team includes many GIS experts and local subject matter experts, an intensified and localized review will be possible on the Collective Team. Our team can also create and facilitate a SharePoint or cloud sharing site based on the Working Group's preferences early in the project. With projects of this nature where living deliverables and datasets are being generated and used – the Collective Team has found that digital engagement via a cloud platform is a helpful way to keep the entire team informed regarding project progress and more fully engaged with the technical team.

As shown in our Organizational Chart (see the following pages), **our Community Captains are a true differentiator and key part of our team.** Each of our Community Captains are "GIS Power Users" and have a strong link to each community. In fact, we specifically selected our Community Captains from among our firms who live or work extensively in the jurisdiction indicated. Each Community Captain will be a technical advocate for their respective jurisdiction throughout the entire project. Our use of Community Captains will also allow each community to have a direct line of communication to the technical team via an expert that understands their unique issues. Our Community Captains will report to our Lead Community Captain and Outreach Expert – Alec Bogdanoff - who will

distill both outreach and technical issues for the larger Collective Team. However, each Community Captain will be “on call” to each community and can advocate freely as questions arise during analysis and preparation of outreach tasks. We believe this style of communication will provide both the specificity and high-level coordination that will be necessary on a project of this nature. Our team’s internal communication structure will ensure that information provided to any team member will be shared with all appropriate team members.

## **MEET YOUR COMMUNITY CAPTAINS**

### **Stephanie Dunham, PE: Boca Raton**

*“Identification and implementation of resiliency actions will support the excellent quality of life the City of Boca Raton works hard to maintain for its residential areas, which makes up the majority of the City’s area; the strong and growing commercial centers such as Downtown, Midtown, and the Park at Broken Sound; and preservation of the abundant natural and cultural resources like Red Reef Park, Lake Wyman Park, Gumbo Limbo Nature Center, and Sugar Sands Park to name a few. Unique community assets to be addressed in the vulnerability analysis for Boca Raton include the airport that averages over 70,000 operations annually with increasing international traffic since opening a U.S. Customs and Border Protection (CBP) facility in 2018 as well as the proposed Brightline/Virgin train station near the Downtown Public Library. Similar to Ocean Ridge, Boca Raton also faces the potential increased climatic vulnerability from high tide and storm surge flooding due to the ocean inlet located within the City limits.”*

### **Liz Perez, PE, CFM, D.WRE: Boynton Beach**

*“Boynton Beach has abundant infrastructure data in GIS but for many reasons - has a majority of undesignated flood zones (Zone X). These X Zones are primarily due to lack of data on FEMA’s part – not actual low flood risk and this is concerning. The City also has significant changes pending in FEMA’s preliminary flood hazard (coastal) maps and regularly experiences both coastal and inland flooding (and compound flooding). With the rapid development in areas subject to complex coastal conditions, like the new Town Square, the City is in dire need of high quality and localized analyses. Boynton is also focused on reducing greenhouse gas emissions and has a robust and multi-pronged sustainability program. Most recently, the City brought several businesses online as Green Businesses and routinely makes time to listen to a diversity of voices on issues related to the environment. It is an exciting time to live in Boynton Beach and an even more exciting time to study the City as we evolve together.”*

### **Anna Leitschuh, PE: Delray Beach**

*“While the City of Delray Beach, like many others in Palm Beach County, is vulnerable to coastal flooding the City has worked with its residents to identify the City’s areas of concern and completed detailed stormwater models of the top flooding areas of concern as part of the Stormwater Master Plan in 2018. Furthermore, the majority of sea walls in Delray Beach are privately owned with private docks – with complex property issues. These challenges make raising seawalls more challenging for the City to retrofit. The City also has a challenging environment for outreach and education, and we can expect to hear from a variety of voices as this study progresses.”*

### **Stephanie Dunham, PE: Highland Beach**

*“Due to its location between the Intracoastal Waterway and Atlantic Ocean and relatively small size, Highland Beach’s primary vulnerability is associated with tidal and storm surge flooding to residential properties (ranging from slab-on-grade single family homes to high-rise condominiums) as well as to its travelling public along A1A, swells in population during the Winter of approximately double the year-long population, and key Town assets such as the water plant. The Collective Team believes the CCVA should build upon recent efforts such as the Town’s Complete Streets Master Plan to further evaluate how proposed A1A/Ocean Drive alternatives can address mobility and flooding issues into the future given projected climatic changes.”*

**Brent Whitfield, PE: Lake Worth Beach**

*“Lake Worth Beach is the only City in Palm Beach County that does not utilize FP&L for power. Although the City does have an aging power plant and a new solar field that can generate power, the primary source of power for the City is the connection to the regional grid at the Hypoluxo substation. If debris from high winds took out the “tie-in” line from the grid to this substation the whole City would be without their primary source of power. The tie-in line and the Hypoluxo substation are vulnerabilities unique to the City of Lake Worth Beach that exemplify how we will need to consider the entire breadth of issues related to aging infrastructure in the City.”*

**Michael Antinelli, PE, CFM: Lantana**

*“The Town of Lantana has 5+ miles of waterfront, filled with docks and piers including a marina and a brand new public fishing pier. Many of these docks and piers are located on single family lots and the waterfront access provides the Town with its character, quality of life, and Old Florida charm. While the entirety of the Town’s waterfront is within the 100-year floodplain, it is outside of the coastal high hazard area. However, since we’ve been attending the FEMA meetings for the coastal risk study, we are keeping an eye on Lantana’s flood zones and will use the latest datasets and our team of analysts to examine this – we know this is a key threat for Lantana that we need to understand better.”*

**Michael Antinelli, PE, CFM: Ocean Ridge**

*“A family-oriented community, the Town of Ocean Ridge is surrounded by water and is one of the lower-lying communities in South Palm Beach County. The Town is comprised in part of over 700 single family homes on septic service and is exploring a transition to either a gravity or vacuum sewer system to mitigate health and water quality concerns in the future. The cost of this transition is estimated at approximately \$30 million or more, with service to be supplied by Boynton Beach Utilities. My firm, Brizaga, has been keeping a close eye on the resiliency challenges facing Ocean Ridge (including speaking at your public events) and we are excited to bring that knowledge to bear as part of this study.”*

**Brent Whitfield PE: Palm Beach County**

*“My firm, Chen Moore, recently completed a hydraulic model of the potable water distribution system for the Palm Beach County Water Utilities Department, which included a set of scenarios to see the impact on the distribution system if one of the County water plants was to go offline. Although this analysis was done only for the County utility service area, the results demonstrate the pressure available at each of the County’s interconnects with adjacent municipalities which can be critical during high risk events. This type of analysis illustrates how interconnectivity between communities can provide adaptability and resilience, but the interconnecting infrastructure should also be evaluated for vulnerabilities at the regional scale.*

*A service offered by Palm Beach County that is often overlooked is Palm Tran Connection which provides paratransit for disadvantaged populations throughout the County. This transit service is critical and the ability of Palm Tran Connection to reach users can be significantly impacted by inundated roadways. Our team can collect routing data from Palm Tran and incorporate higher priorities for those corridors in the analysis.”*



While the goals of the project are a collective regional approach, many aspects of government are confined to their jurisdictional and/or utility boundaries. **Our approach to the project and to outreach is both multi- jurisdictional and local.** This is not just a typical regional assessment, and our team understands what that means, because we have done assessments across multiple jurisdictions before. This is especially relevant as potential actions are identified: climate change does not heed political boundaries, and, in many ways, this project is the kickoff for a longer-term inter-jurisdictional collaboration. Decisions that each of you make affect your neighbors and our team has expertise to help highlight and facilitate this understanding. This team will balance the need to have appropriate municipal-level stakeholder engagement, while also ensuring the information is used on a regional level.

Our proposed outreach includes both unique products for each participating community and regional materials that complement and provide an overarching. This allows the region to move forward on addressing climate risk, but also provides each community with powerful tools to make the local decisions needed on an individual basis. Our approach also considers modern outreach, including social media graphics, assistance with blog posts, mobile-first presentations, and finding opportunities, like the City of Boca Raton’s “Behind the Scenes” podcasts, to share the great worth of the Coastal Resilience Partnership. Our team has obtained the domain name [www.CoastalResiliencePartnership.org](http://www.CoastalResiliencePartnership.org), which can be used as a gateway to a page that can live on a community’s existing website to ensure the assessment results and work of the Partnership are available to the general public.

## THE IMPORTANCE OF INCLUSION

No one is immune to the challenges we face as a community in a changing climate and it is central to our values that we are inclusive in both gathering input to inform the assessment and in communicating those findings. The deputy project manager on our team is colorblind and has continually pushed our team to improve the accessibility of our insights. We agree with the intent and are prepared to fully support this effort’s compliance with the Americans with Disabilities Act (ADA) and will do so by supplementing all map and data graphics in the report with alternate presentations of content that can be accessed by a wider range of audiences. Our team also can offer communities assistance with many languages other than English – including and not limited to Spanish and Creole.

## STEP 1: EXPLORE CLIMATE THREATS

The Collective Team knows that this CCVA scope was developed based on best practices as described by the Florida Adaptation Planning Guidebook, US Climate Resilience Toolkit, the American Flood Coalition, and the Southeast Florida Regional Climate Change Compact. **Our team is not just intimately familiar with these documents but has been part of their development. For example, NEMAC+Fernleaf developed the US Climate Resilience Toolkit and Alec Bogdanoff (Brizaga) has been instrumental in the formation of the American Flood Coalition and many of their subsequent publications and contributions.**

### Brizaga

#### Outreach Lead

*Brizaga is a national leader in outreach and resiliency. Firm Principal, Dr. Alec Bogdanoff, will work with the Working Group personally to create a catered, modern, and effective program for outreach on this project. Outreach is engrained in our process and not just an independent item on a list for our team. With complex topics like climate risks and sea level rise, building public understanding and the will to act is an essential component of resilience.*

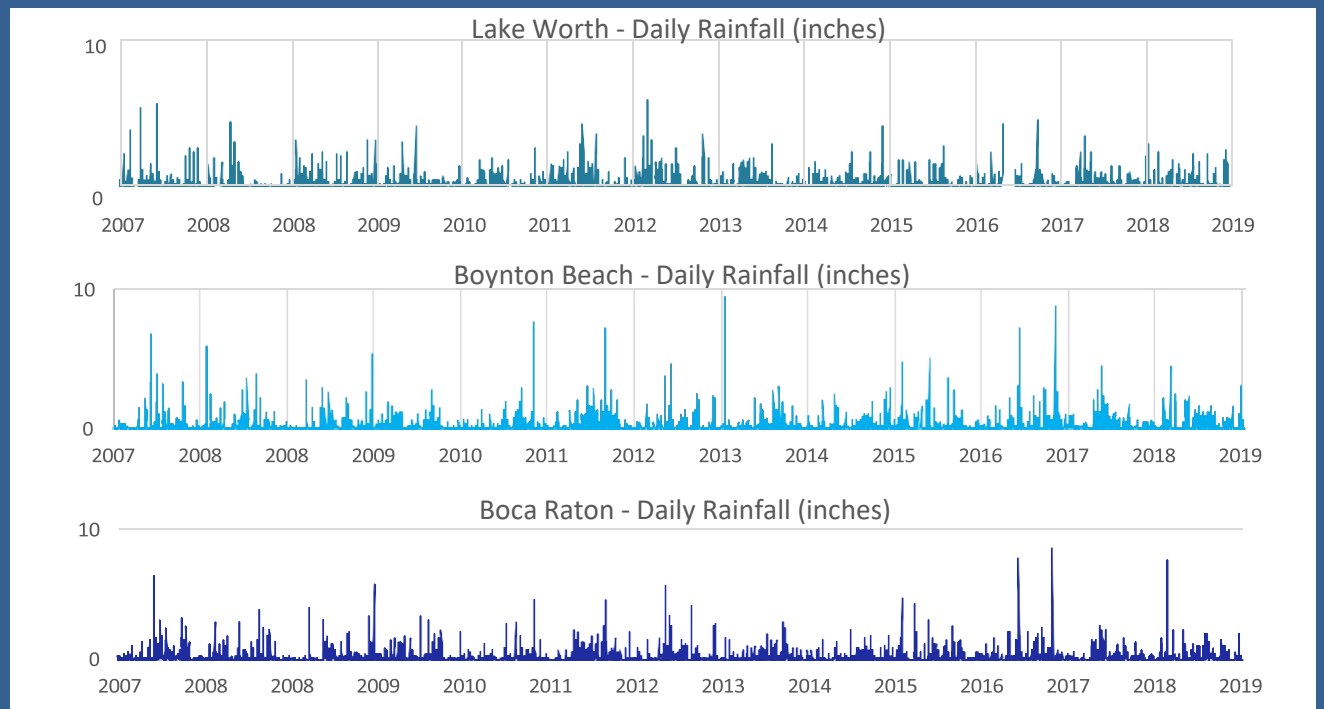


## IDENTIFYING CLIMATE THREATS AND IMPACTS

The Collective Team will first create a complete assessment of climate-related threats and hazards affecting the geographic area of all participating jurisdictions. Both direct and indirect climate change impacts will be evaluated and those deemed by the working group to be of most concern will be included in the CCVA. Our PM team, Outreach Lead, and Community Captains will first help each jurisdiction create a list of threats from a menu that the Collective Team pre-prepared for discussion based on our local knowledge and experiences with other clients. During this process, subject matter experts on our team will be available to provide additional insight. Our experienced coastal, hydrological, and climate modelers will be fully engaged as needed – and the many environmental and climate change scientists between NEMAC+FernLeaf and Brizaga will be instrumental.

### *Telling the Entire South County Story...*

*As a team with a deep bench of local yet highly technical subject matter experts, we will offer the Working Group a team that already understands the commonalities, subtleties, and differences of the South County culturally, economically, spatially, and temporally. Our team will not neglect the differences in how threats vary between jurisdictions and in turn, how communities may respond. So, while we understand that this is a regional study, we are prepared to mine the subtleties of the data as a true scientific team to make the most of the process as your technical advocates. For example, the plots below provide a simple visual representation of how daily rainfall varies north to south throughout the study area over recent years.*



The RFP listed the following climate-related threats: extreme precipitation events, storm surge, high winds, lightning, beach erosion, sea level rise, saltwater intrusion, drought, extreme heat, wildfire, pest and disease outbreaks, economic losses, and human migration. Other extreme events may include: high-tide flooding, algal blooms, red tide, habitat loss, hazardous materials/HAZMAT releases, water and air pollution, changes in growing season – among others. **We also have experience with various combinations of these threats** and suggest potential combinations and compound threats be explored during the scoping process – particularly when exploring types of flooding and water threats. Compound flooding, when more than one type of flooding occurs at once, is an important consideration and occurs regularly in Palm Beach County. Members of our team are

leading cutting-edge projects in economic resilience aiming to better identify and communicate the business case of climate and flooding vulnerability. The Working Group can also lean heavily on the combined expertise of Collective's modelers (inland compound flooding) and ATM (coastal threats and flooding) as part of this compound threat discussion.

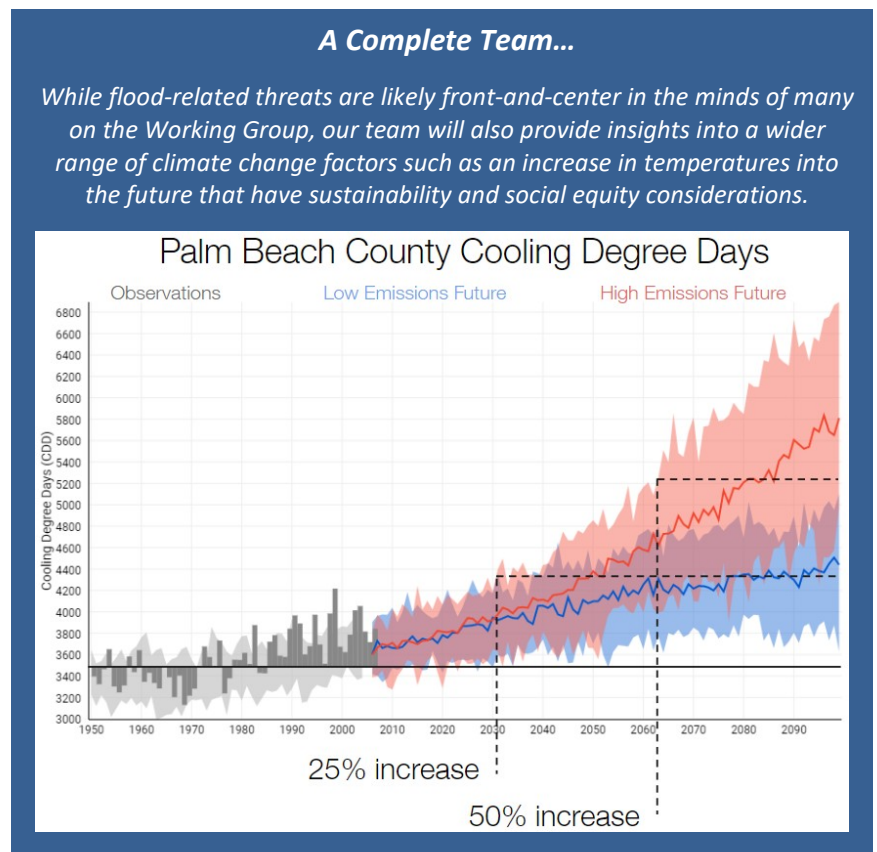
## REVIEWING CLIMATE SCIENCE FOR SCENARIO PROJECTIONS

This project is particularly timely in that our team will be able to take advantage of the recently released South Florida Regional Climate Change Compact sea level rise curves. While sea level rise may be a challenging threat in and of itself or stressor to other inundation types such as stormwater flooding, there are several additional threats that our team will provide the best available information about. Via ATM and Collective, our team will also be available to provide detailed feedback on data related to FEMA's preliminary coastal flood risk study for Palm Beach County. Collective has been intimately involved as a technical advocate on all recent FEMA digital FIRM activity in the County and has been advising Palm Beach County and the League of Cities regarding these proposed datasets. This is an important differentiator for our team that bears mentioning – **none of the firms on our team work for FEMA - so we will objectively provide feedback regarding the use of this information for all coastal threat analyses.**

Our team is well equipped to assist the Working Group make a data-informed decision about the climate impacts that are of most concern and should be included in the CCVA. Team-member NEMAC+FernLeaf has an extensive track record of helping to make leading-edge climate science decision-relevant. They have either led or supported development of the data processing and visualization tools for national standard resources including the National Climate Assessment, Climate.gov, the US Climate Resilience Toolkit, and Drought.gov.

With a firm background in the science and with experience applying it within Palm Beach County, our team can meaningfully and efficiently inform and advise scenario selection. Furthermore, based on our experience, we can help identify where there is uncertainty in the science or where additional academic collaboration can help bridge gaps.

Concurrent to this process, Community Captains will begin examining the data available to each jurisdiction and greater Palm Beach County so that a baseline of available data is carefully considered as threats are explored. **Our team does not advise that the Working Group delay any data review so that threats and system data can be examined concurrently – and to allow for the most time for data verification.** Once each list is assembled, our PM and Outreach Lead will facilitate exercises with the Working Group to explore the threats and to determine which should make the cut for inclusion in the master CCVA. However, all the data and information mined for



each community will be recorded by each Community Captain in GIS, spreadsheet, and written formats – as appropriate and requested by the Working Group and each community.

### Step 1 Recommended\* Deliverables

*\*We assume deliverable lists would be further refined during negotiations but wanted to provide this list to further clarify our approach.*

- Task 1 Summary Report:
  - Archive and inventory of literature, data, and model reviews as a Word Document or Excel Spreadsheet. All items will be provided electronically for future use. This will be a “living” deliverable since it is very likely that new information will become available throughout the project. Sources will be clearly cited for future reference and deeper review.
  - Selected climate threats (with approach and process for selection) – to be provided for each community and as a micro-region. Time horizons will also be selected and discussed.
  - Projected changes for at least two scenarios spanning the selected time horizons
- Draft geodatabase schema for review by GIS experts from each jurisdiction – draft features will be populated with raw data from Phase 1.
- Inventory of climate threat data (GIS and tabular) to be used in the rest of the assessment
- Suggested menu for outreach and outreach plan, including plan for website. Climate-threats document to educate staff and stakeholders, and, if desired, for the public.
- Interactive Workshop with the Working Group on the Results of Step 1 and transition to Step 2.

### STEP 2: ASSEMBLE DATA ON COMMUNITY SYSTEMS

Our team knows that the Working Group made the preliminary determination that the following asset categories should be included in the CCVA: people, property, critical facilities, water infrastructure, transportation infrastructure, economy, and natural resources. We appreciate the work that has already been done to build consensus on the major asset categories. By thinking about major categories of assets in parallel, insight into specific systems that may be more vulnerable than others across communities helps to direct action effectively.

#### INTO THE WEEDS...

*Matt Hutchins and Stephanie Dunham will design a geodatabase schema for use during this project. This means that the data will maintain spatial integrity and that appropriate metadata can be generated and passed back to each jurisdiction at project milestones and at the completion of the project for further use and analyses.*

At the outset of the project, we will recommend a handful of subcategories within these larger groups that, in our experience, has helped to drive deeper levels of insight. For example, homes and residences often require different considerations and interventions that may not be relevant to businesses and industry.

These specific groups and divisions, as well as making determinations about specific asset types to go into each group will be researched and proposed to the Working Group for approval and acceptance. We want the assessment to be enlightening without being overwhelming and will endeavor to strike the right balance with the needs of the Working Group.

We also appreciate the investments that have been made to date to gather data to fit within these major asset categories. We have carefully reviewed the data inventory provided in Appendix A of the RFP. Since the Collective Team works with this data every day as part of other projects, we are prepared to dive into discussions on these systems. We have also noted other areas for improvement in the data inventory that we would like to discuss with the Working Group. Community Captains will be deployed once again as part of this task to organize, review, mine, and summarize datasets for each community.

Every effort will be made to make the analysis simple to update by taking advantage of data sources routinely updated by the jurisdictions themselves or by Palm Beach County GIS such as property assessor data. By basing the assessment off of asset data that are kept current, as new assets are built in the area, the basic framework of the assessment remains relevant but the specific findings can be refreshed in the future to reflect the new construction and changing risk profiles.

We recognize that this task should run concurrent with Task 1 to some extent – as well as the overall interconnection of the project. We also think the Working Group was very wise to consider the issue of data scale in the RFP. For local VAs, scale is key to the success of the study. Uniformity, availability, and many issues of data integrity are very important for local governments as it relates to issues of resiliency – therefore our team doesn't generally use GIS or tabular data as it is provided. **Data must be reviewed, mined, and prepared by capable GIS AND subject matter experts before analyses begin.**

At the conclusion of this task, the Collective Team will prepare a Summary Report and collaborative presentation to the Working Group with recommendations on asset categorization and categorization schemes clearly documented. With properties for example, individual property classification codes that may be used to differentiate different sub- types will be clearly described and enumerated. A battery of data quality assessments will be performed and reported on so that potential issues or limitations in the analysis can be identified and communicated early in the project.

PowerPoint slides for each community will also be created by the Project Manager, Deputy PM, and Community Captains so that each jurisdiction can relay the findings of this task back to staff, elected officials, and stakeholders (based on preference). The Version 1 of the geodatabase for each community will also be issued at the conclusion of this task, complete with relevant feature population and metadata.

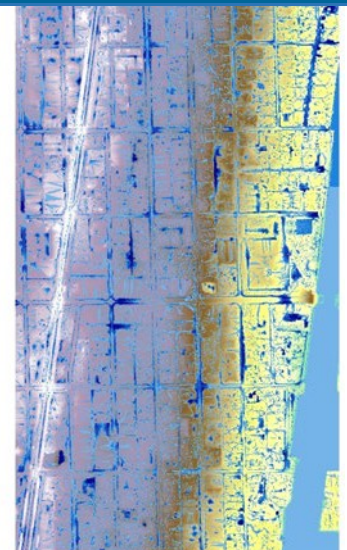


## No Community Left Behind...

The jurisdictions involved in this study vary greatly in terms of flood hazard data quality. Between Collective and ATM, our team has a complete suite of independent modelers for this critical family of threats. For this project, we suggest using several steps to prepare data for the regional assessment for all threats that relate to the many types of flooding (both upland and coastal – and compound). These simple steps summarized below will measurably improve the CCVA – particularly as it relates to communities like Boynton and Delray where numerous areas are designated as Special Flood Hazard Zone X on the current FEMA flood maps (these areas are mapped by FEMA as low risk because no data was available to FEMA to create more high quality flood maps). Here are suggested steps that can be used to elevate our team's assessment for flood vulnerability and risk, which would only take a few weeks to complete because Collective and ATM already work with most of these datasets daily:

- **Organize latest flood studies and FEMA datasets in GIS** (Collective has most of these datasets right now and reviewed most of them as part of previous/current projects and the preparation of this proposal). We believe that new coastal flood analysis and mapping will be available for Palm Beach County from FEMA by the kickoff of this project and that data will go to the experienced modelers at ATM. We also know Lake Worth Drainage District is conducting a flood study and that Delray recently completed the modeling of several areas for their Stormwater Master Plan – among other detailed studies.
- **Triage the best and most relevant datasets for all communities.** The team will also coordinate with the Working Group to understand what they expect out of the final flood assessments (for example - rainfall depths, required level of service, surge conditions, etc.).
- Interview knowledgeable staff and review associated datasets (repetitive losses, areas of concern/community reports of flooding, areas flagged by staff, etc.) for each jurisdiction. **These datasets will be used by Collective's and ATM's modelers to do "sanity checks" for the various models and flood mapping that are available.**
- **Perform a 2D flood inundation simulation for areas with no or low-quality rainfall-induced flood hazard data.** Collective will run the CAFLOOD mapping tool developed by the Exeter University Centre for Water Systems, a public domain model. The model requires a DEM, a rainfall input file, and boundary condition data. Collective will use the new 2017/2018 Palm Beach County terrain for this analysis. CAFLOOD will produce both depth and elevation grids to map flood inundation for the selected rainfall event(s). **This analysis will standardize and fill the gaps for missing flood data throughout the project area. This analysis means no community will be "left behind" for lack of data.**
- **Present the final flood hazard data to the Working Group.** If necessary, Community Captains will contact communities as specific questions arise.
- **Submit the analysis to the Working Group and consulting team for inclusion in the CCVA – once final datasets have been reviewed and accepted by all parties.**

Below are sample results generated by Collective for Delray Beach using the CAFLOOD tool (raw terrain, inundation areas, and final mapped areas from left to right). The area shown is bounded by NE 4<sup>th</sup> Street (N), NE 3<sup>rd</sup> Street (W), SE 3<sup>rd</sup> Street (S), and the Intracoastal Waterway. This analysis could easily be compared to model output from Collective's Marine Way model (a 2D ICPR model) as well as the ICPR models generated for the City's Stormwater Master Plan to assemble projections of various storm events for Delray Beach.



## Step 2 Recommended Deliverables

- Task 2 Summary Report:
  - Revised archive and inventory of literature, data, and model reviews as a Word Document or Excel Spreadsheet. All items will be provided electronically for future use.
  - Complete data sources, uses, and quality assessment. This will contain clear documentation on what data will be used for the asset assessments along with clear classification models and commentary on completeness and corresponding viability of assessment methodologies with proposed alternatives in the face of limitations.
- Draft geodatabase for review and use by each jurisdiction. Tabular and non-GIS formats will also be made available.
- Presentation of the findings geared towards the Working Group that can also be used by the partners to update their respective local government staff and officials (based on preference).
- Each Community Captain will be available for an in-person or virtual meeting with the key staff from the partners. Each Captain will document the findings of these meetings and summarize them for inclusion in the Task 2 Summary Report, as appropriate and requested by each community.
- Interactive Workshop with the Working Group on the Results of Step 2 and transition to Step 3.

## STEP 3: ASSESS VULNERABILITIES AND RISKS

We understand that the central task of the CCVA is to evaluate the vulnerability to climate threats across asset categories and to estimate the likelihood and magnitude of potential losses.

This assessment begins by understanding exposure. In performing this type of work in other areas, we have found that separating exposure into distinct asset-threat pairs enables decision relevance for later phases. Each general asset category determined in Step 2 will be spatially intersected with each relevant threat identified in Step 1 to determine exposure.

### *Moving from Exposure to Vulnerability and Risk...*

*This image illustrates the critical need to have a more sophisticated understanding than exposure. Both homes are exposed to storm surge but the house on the right is much more vulnerable and at risk than the house on the left.*



We recognize from the maps in the RFP that service areas may be desired for some jurisdictions and we will apply that exact project boundary early in the project. Because we work with data across the County every day, we can

hit the ground running: the domain of nearly 200,000 properties for the area south of West Palm Beach to the county line and east of Florida's Turnpike is shown in our analysis engine. With minimal work, the domain can likewise be expanded, exact jurisdictional boundaries adjusted, and assets classified. The elements are all in place; all that remains to move this analysis forward is your input.

**Early in this phase, our team will gather input from the Working Group to identify the criteria for sensitivity** (as defined in the Climate Resilience Toolkit (CRT) as “the degree to which a system, population, or resource is or might be affected by hazards”) and the criteria for adaptive capacity (using the CRT's definition of “the ability of a person, asset, or system to adjust to a hazard, take advantage of new opportunities, or cope with change”), along with critical thresholds (or tipping points) for the asset-threat pairs.

The identified criteria/thresholds will then be used to define areas of vulnerability (or, as defined in the CRT, “the propensity or predisposition of assets to be adversely affected by hazards” that “encompasses exposure, sensitivity, potential impacts, and adaptive capacity”). In parallel with vulnerability, risk scoping is assessed which is the chance of a loss and the negative consequence of the loss. During this phase, the risk scoping is an estimate of the magnitude as opposed to a detailed (and costly) risk assessment.

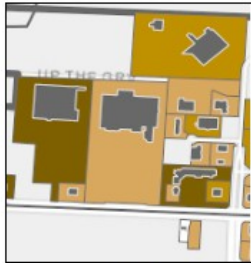
Based on input from the Working Group, design standards, criticality of the asset, indicators of sensitivity, adaptive capacity, and consequence will be determined. Using best-available climate science, our team will also determine the probability of threat events occurring.



## Tying It All Together...

To illustrate this process, the following graphic provides an example from West Palm Beach of how the sensitivity and adaptive capacity of exposed assets are incorporated to assess vulnerability, and how risk probability and consequence are used to scope risk.

### Vulnerability and Risk Scoping Example Commercial Property and Rainfall-induced Flooding



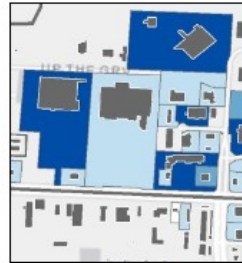
**Potential Impact**

High (dark tan): business structure exposed  
Med: storage structure exposed  
Low (light tan): only land inundated



**Adaptive Capacity**

Low (dark green): exposed structure built before BFE requirement  
Med: exposed structure at BFE  
High (light green): exposed structure built 1-2ft above BFE



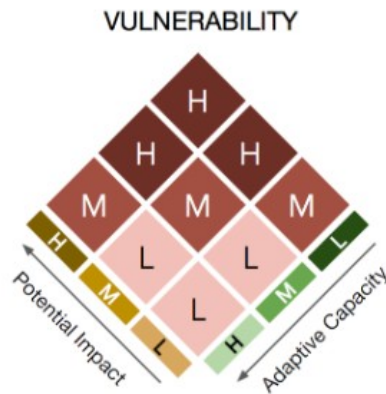
**Probability**

High (dark blue): in 10-yr inundation extent  
Med: In 100-yr inundation extent  
Low (light blue): in 500-yr inundation extent

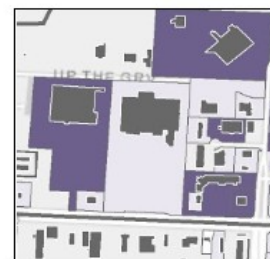
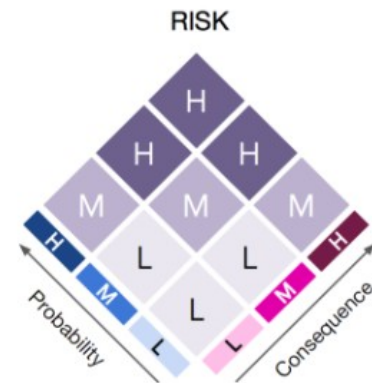


**Consequence**

High (dark purple): exposed structure > median value  
Med: exposed structure < median value  
Low (light purple): no exposed structure



**Vulnerability**



**Risk Scoping**

Socioeconomic variables will be gathered to present another lens to assess vulnerability of human systems and as a way of assessing equitable distribution of adaptation and resilience solutions. Some examples include median household income, percent Hispanic or Latino origin population, households receiving SNAP benefits, and others. For ease of comparison with neighborhood-level socioeconomic metrics, we recommend aggregating these asset-scale assessments to the census tract scales.

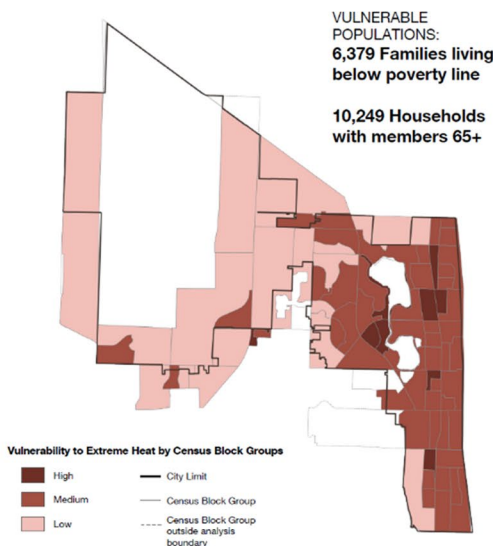
## Aggregate Assessment Example

*This example aggregate-scale presentation of people vulnerable to extreme heat from West Palm Beach shows (on the right) how sensitivity (potential impact) and adaptive capacity rules combine to determine risk. These rules are determined in full consultation with the Working Group and then are plotted spatially (on the left). Alternative commentary is provided above and below the map in order to support users who may be using a screen reader.*

### People & Extreme Heat

#### Vulnerability Assessment

The vulnerability of residents to extreme heat considers socially vulnerable populations using metrics from the U.S. Census Bureau and the American Community Survey—which include families living below the poverty line, and households with members 65 years of age and older—that live in proximity to developed land cover.



Areas with the highest sensitivity have a relatively high social vulnerability and high developed land cover. The amount of tree canopy was used as a measure of adaptive capacity to an extreme heat event. Socially vulnerable populations in areas with a high percentage of developed land cover and low tree canopy are most vulnerable to negative health effects related to heat stress and due to the urban heat island effect.

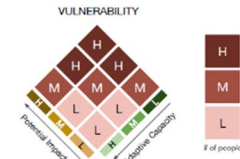
66

### People & Extreme Heat

#### VULNERABILITY

Potential Impact	Adaptive Capacity
High	Low
Med	Med
Low	High

**VULNERABLE POPULATIONS:**  
**6,379 Families living below poverty line**  
**10,249 Households with members 65+**



67

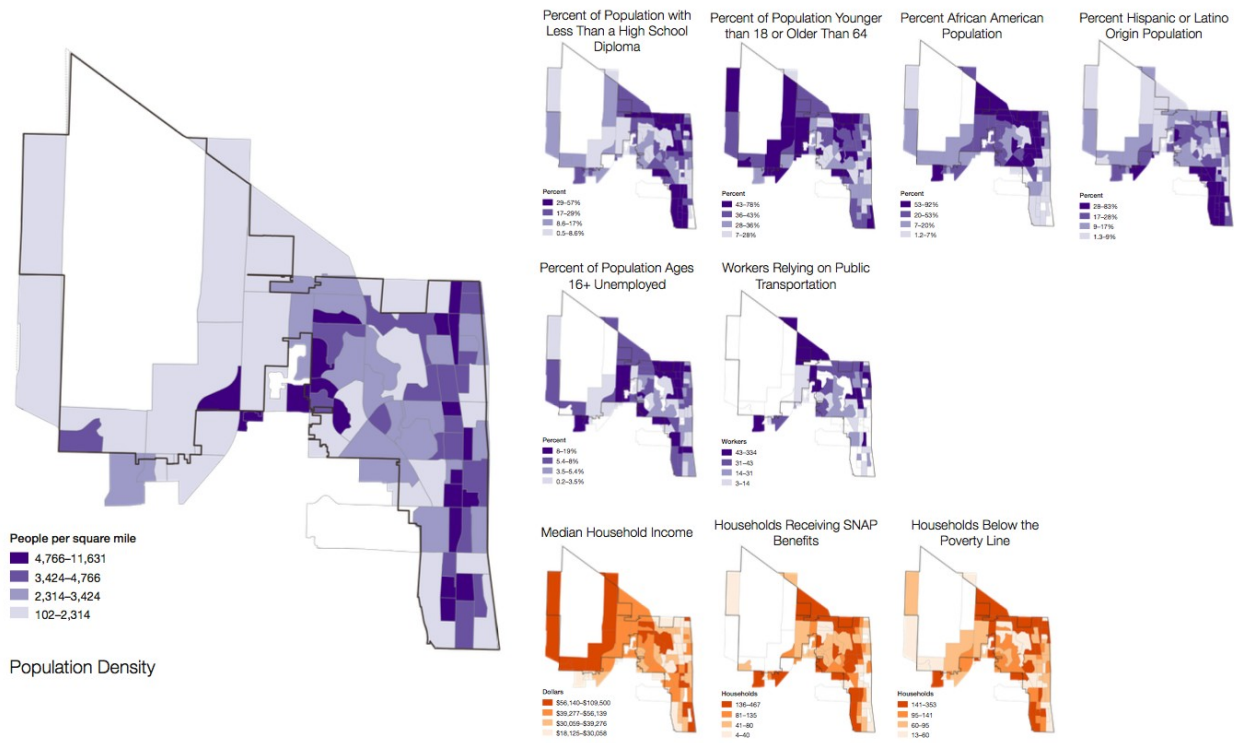
## Bringing It Back to Social Equity

When the analysis is aggregated to the same scale as socioeconomic factors, cross-comparison between asset-threat vulnerability is possible with indicators of social equity.

### West Palm Beach Social Equity

DRAFT 3/14/2018

NOTE: This is a preliminary analysis and should not be used for any official or legal purposes.



City of West Palm Beach

Data Sources: 2011-2015 American Community Survey, 5-yr Estimates

*The Collective and Fernleaf Team at a public meeting in West Palm Beach.*



### The Importance of High-Level Risk Summaries

As a component of the risk scoping assessment, high-level summaries of the entire region or individual jurisdictions can be developed such as the one above, helping to identify the count, proportion, and high-level values/cost estimates of assets at risk to specific threats.

Asset Group	Rainfall-Induced Flooding	Sea Level Rise	Storm Surge	Wildfire
<b>NATURAL (parcels)</b>				
Natural Areas, Parks, and Greenways	207 (22.6%) \$30.5MM	16 (1.8%) \$2.44MM	19 (2.1%) \$14.6MM	242 (26.5%) \$4.89MM
<b>PROPERTIES (parcels)</b>				
Commercial Property	357 (28%) \$960MM	Low Exposure	31 (2.4%) \$255MM	47 (3.7%) \$198MM
Cultural Property	53 (29.9%) \$50.4MM	Low Exposure	8 (4.5%) \$28.5MM	No Exposure
Industrial Property	299 (51.1%) \$166MM	No Exposure	No Exposure	7 (1.2%) 19MM
Mixed-Use Property	16 (11.3%) \$16.5MM	Low Exposure	Low Exposure	No Exposure
Residential Property	6,468 (25.4%) \$1.4B	10 (<1%) \$1.25MM	811 (3.2%) \$288MM	2,253 (8.8%) \$846MM
<b>PUBLIC SERVICES AND PEOPLE (parcels)</b>				
Critical Facilities	88 (37.4%) \$449MM	Low Exposure	9 (3.8%) \$108MM	22 (9.4%) \$86MM
Government-Owned Property	131 (23.6%) \$115MM	Low Exposure	8 (1.4%) \$3MM	29 (5.2%) \$13.2MM
Hospitals and Medical Facilities	3 (33.3%) \$1.91MM	Low Exposure	1 (11.1%)	1 (11.1%)

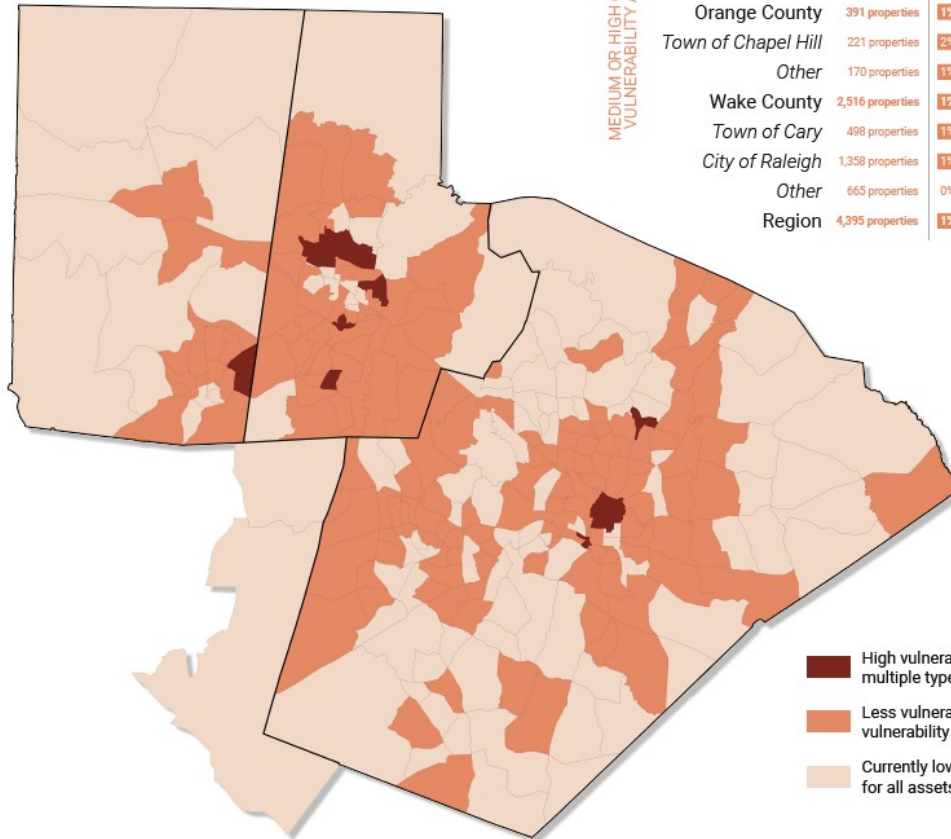


# Properties / Flooding

DRAFT 3/26/2018

NOTE: This is a preliminary analysis and should not be used for any official or legal purposes.

The types of properties in this asset category include commercial, industrial, and residential. Vulnerability considers how certain property uses/types are more sensitive than others and how buildings on these properties are able to cope and withstand flooding events. Varying levels of risk were also considered based on the consequence and probability of a flood event.



MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK

Chatham County	9 properties	0%
Town of Cary	0 properties	0%
Other	9 properties	0%
Durham County	1,479 properties	2%
City of Durham	1,285 properties	2%
Other	194 properties	1%
Orange County	391 properties	1%
Town of Chapel Hill	221 properties	2%
Other	170 properties	1%
Wake County	2,516 properties	1%
Town of Cary	498 properties	1%
City of Raleigh	1,358 properties	1%
Other	665 properties	0%
Region	4,395 properties	1%

- High vulnerability and risk for multiple types of assets
- Less vulnerability and risk, or high vulnerability for one type of asset
- Currently low vulnerability and risk for all assets

## Commercial Property

Chatham County	0 properties	0%
Town of Cary	0 properties	0%
Other	0 properties	0%
Durham County	160 properties	4%
City of Durham	153 properties	4%
Other	7 properties	2%
Orange County	29 properties	2%
Town of Chapel Hill	25 properties	1%
Other	4 properties	1%
Wake County	169 properties	2%
Town of Cary	17 properties	1%
City of Raleigh	127 properties	4%
Other	25 properties	1%
Region	388 properties	1%

MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK

## Industrial Property

Chatham County	4 properties	1%
Town of Cary	0 properties	0%
Other	4 properties	1%
Durham County	12 properties	2%
City of Durham	5 properties	1%
Other	7 properties	2%
Orange County	0 properties	0%
Town of Chapel Hill	0 properties	0%
Other	0 properties	0%
Wake County	98 properties	2%
Town of Cary	1 properties	1%
City of Raleigh	46 properties	4%
Other	9 properties	1%
Region	72 properties	2%

MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK

## Residential Property

Chatham County	9 properties	0%
Town of Cary	0 properties	0%
Other	9 properties	0%
Durham County	1,367 properties	2%
City of Durham	1,127 properties	2%
Other	180 properties	1%
Orange County	362 properties	1%
Town of Chapel Hill	198 properties	2%
Other	166 properties	1%
Wake County	3,291 properties	1%
Town of Cary	498 properties	1%
City of Raleigh	1,180 properties	1%
Other	637 properties	0%
Region	5,665 properties	1%

MEDIUM OR HIGH COMBINED VULNERABILITY AND RISK

Triangle Region of North Carolina

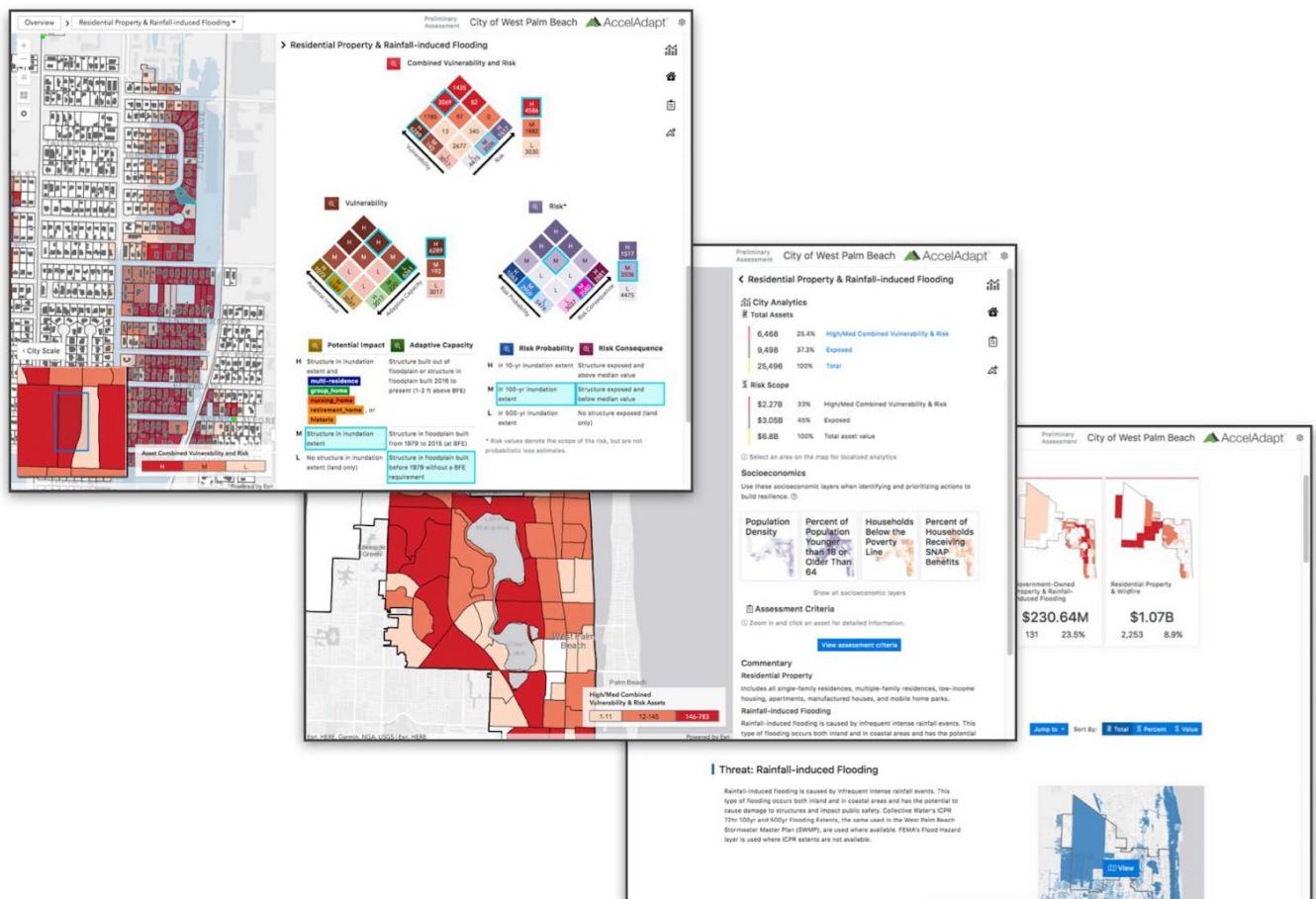
Above: While these assessments provide a regionally relevant understanding, our process also preserves insight on the impact to individual jurisdictions. In this example poster, from a workshop with the multi-jurisdictional Triangle Regional Resilience Partnership, regional impacts are shown while preserving insights about impacts within individual jurisdictions. Our process is likewise responsive to the needs of incorporating input from those separate jurisdictions into a cohesive whole.

## ACCELDAPT

AccelAdapt is both the engine of analysis and the platform for shared understanding between the project team and Working Group. AccelAdapt will be the primary tool used to assess vulnerability for all asset types in this assessment and has the demonstrated capacity to run assessments on a regional scale.

Many Asset-Threat analyses in this assessment will be performed using AccelAdapt, a proprietary tool developed by NEMAC+FernLeaf to deepen and simplify vulnerability and risk scoping assessments. The core engine within AccelAdapt has been designed from the ground-up to perform the assessment approach (with corresponding assumptions) detailed in this proposal of adaptive capacity, sensitivity, risk probability, and consequence with transparent client input for climate-system threats and a full range of asset types. NEMAC+FernLeaf is closely partnered with Esri to seamlessly and securely ingest and output data in standard patterns that local governments use for GIS data. Because the tool is powered by client-hosted feature services, any updated or adjusted findings are seamlessly available.

In addition to being the engine of the analysis for the project, AccelAdapt simplifies generation of graphics to be used for reports and posters (all map and tabular data shown in the description of this task are examples of AccelAdapt outputs), and includes a tailored interactive viewer specifically built to maximize insights to be gained from vulnerability assessments.

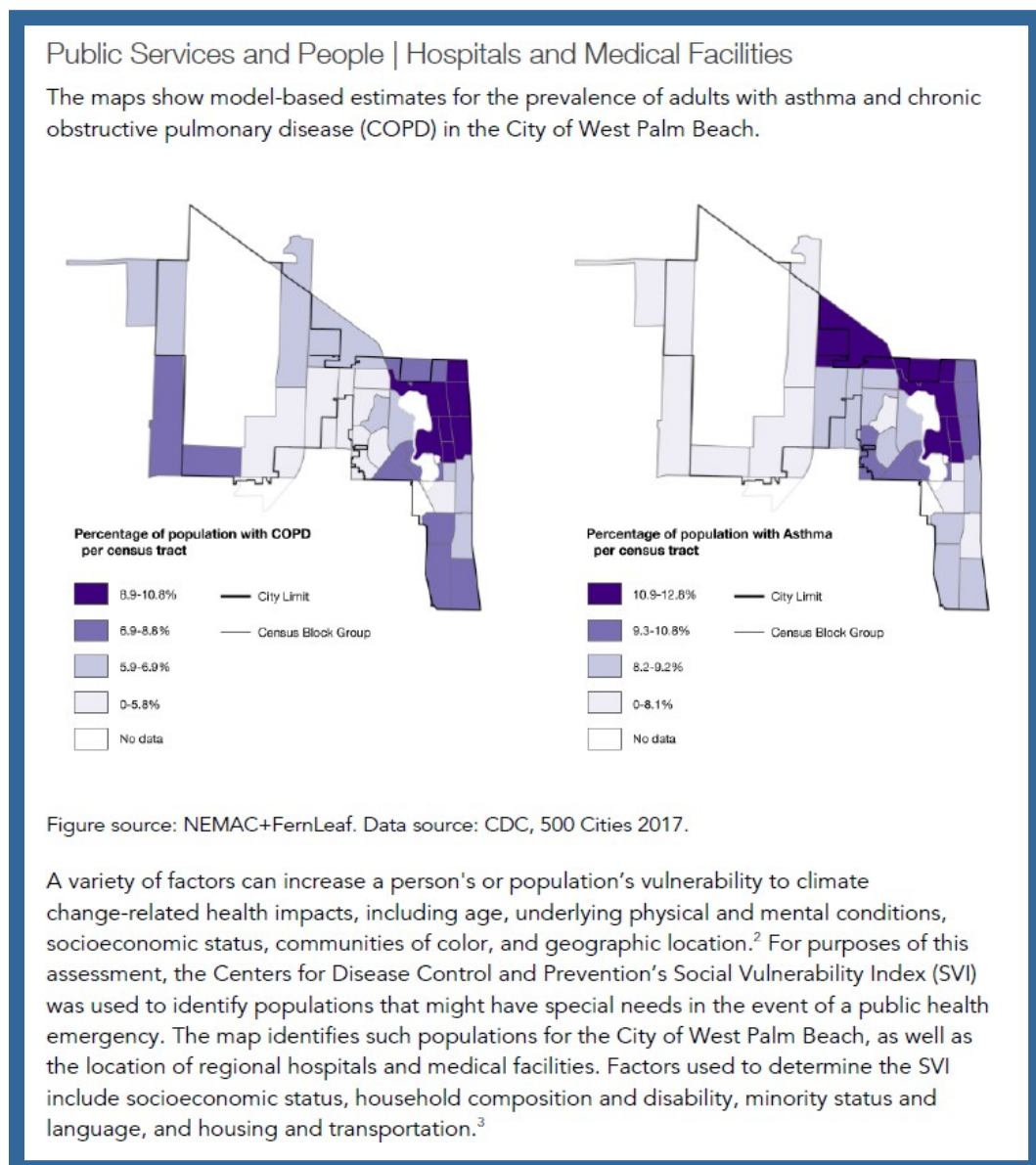


Above: Several images of the AccelAdapt Online interface displaying interactive exploration of adaptive capacity, sensitivity, risk probability, and consequence at an asset scale; study-area scale analytics for individual asset-threat pairs; and high-level overview analytics for key findings at a glance.

## ADDITIONAL TOOLS

We recognize that while AccelAdapt is highly tailored to meet the needs of spatially-assessable impact assessments for physical assets and additional aspects such as urban heat islands, there are a wide array of resources available to meet the needs of understanding broader asset categories and threats that express themselves regionally. Our approach is to provide narrative assessments that include custom data graphics or tabular outputs (with clear data source citations) so that technical information is both easily understood, and the narratives are more easily digested by users relying on screen readers. These graphical outputs are fundamentally GIS map outputs or charts and tables developed using tools such as Excel.

***In this example excerpt from West Palm Beach (below), Centers for Disease Control and Prevention's 500 Cities product was used to help understand where populations may be particularly susceptible to air quality issues exacerbated by climate extremes.***



## SPECIFIC ASSET APPROACHES

Throughout the process, specific tools and approaches will be detailed and documented for transparency. The specific tools that will be drawn upon depends somewhat on the asset-threat pairs that will be determined in Steps 1 and 2. While the exact combination of assets and threats is yet to be determined, we can highlight several approaches that we have found successful in previous analyses:

### People

Population-level information is usually available at an aggregate scale and so a variety of tools from the US Census Bureau (specifically, the American Community Survey) and the Centers for Disease Control's ("CDC") Social Vulnerability Index will be used as a proxy for this "Asset" category as these are the most complete assessments of population-level demographics and statistics broadly and freely-available. There are some statistical limitations that will be discussed further in the methodology.

Specific approaches for People will vary by threat. AccelAdapt will be used for several analyses such as extreme heat and potential job impacts because it was specifically designed based on guidance from CDC and Urban Land Institute to perform assessments that provide guidance on potentially vulnerable neighborhoods on a comparative basis. Additional threats such as pest and disease outbreaks can rely on additional products available from CDC and factors such as human migration can be proxied by looking at locally provided indicators of climate gentrification or higher-level findings in peer-reviewed sources.

### Properties, Critical Facilities

Direct-impact assessments of physical assets such as Properties and Critical Facilities is exactly what AccelAdapt was designed to perform. Regularly-updated data on these assets such as property parcels provided by the Property Assessor will be used in conjunction with best- available spatial threat data. The preceding approach section details how AccelAdapt is used.

### Water Infrastructure

Water infrastructure is varied by definition and function - and this team is prepared to take a "deep dive" on this asset class. Data have been gathered about Water Infrastructure by a previous consultant but will be supplemented by our team. In addition to direct-impact assessments of Water Infrastructure physical assets performed by AccelAdapt, several additional factors such as water shortage due to drought, extreme precipitation events, and saltwater intrusion are particularly relevant. Our complete team of water resources experts will assemble the most relevant references and datasets for these components of the analysis. We will

### *A Limitless Passion for Quality Data and Analyses...*

*Our team has an intense focus on data quality – this is in fact how the key partnerships on this team formed – we all wanted to markedly improve this type of analysis for cities through datasets that are focused on local issues. We carefully reviewed the Inventory and Gap Analysis provided as Appendix A of the RFP. We have many thoughts on this inventory but wanted to mention that initially we believe the following datasets are key for this analysis (and were previously overlooked) – our team uses many of these datasets daily:*

- *Topography and bathymetry for the entire study area.*
- *Flow data and measurements, for example data from the Boynton and Boca Inlets are key.*
- *Tidal gauge readings.*
- *Flood studies and digital FEMA datasets for flood zones.*
  - *Delray SWMP Model and Floodplains*
  - *LWDD Flood Study (Ongoing)*
  - *Boca's SD2MM Model and Floodplains*
- *Repetitive Loss data (we know this data is protected for public distribution by Federal law and are experienced with working with sensitive data ).*
- *Flood complaint "measle maps" and various associated records.*
- *Data on infrastructure failures.*
- *Green and gray infrastructure locations and CIPs.*



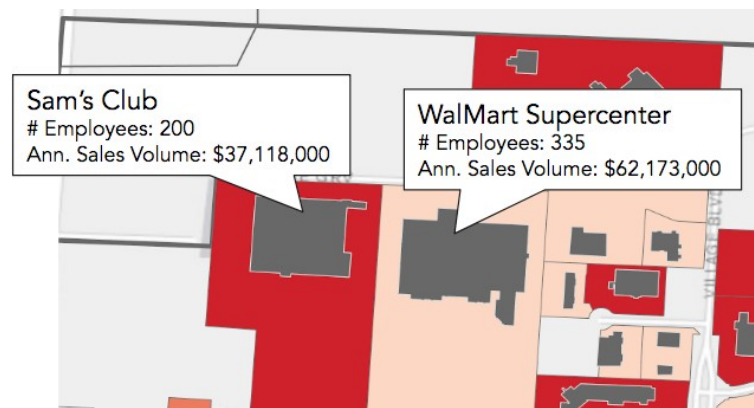
also draw on a wealth of standard trusted resources co-developed by NEMAC+FernLeaf such as Climate at a Glance, Climate Explorer, Storm Events Database, the US Drought Monitor, and the Severe Weather Data Inventory to help illuminate the frequency and severity of specific threats, in accordance with standard planning guidance from NOAA for water resource managers.

### Transportation Infrastructure

In addition to direct-impact assessments of Transportation Infrastructure physical assets performed by AccelAdapt, the tool can also perform multiple road access and mobility analyses to help identify assets that may become inaccessible during hazard events.

### Economy

NEMAC+FernLeaf has partnered closely with Esri to incorporate Business Analyst data into AccelAdapt so that individual business-level information about annual revenue and jobs can be meshed with vulnerability information. By combining these factors, the potential daily lost tax revenue and number of people out of work during threat events can be estimated.



### Natural Resources

The importance of our natural resources is critical to this assessment. Here in Palm Beach County, our natural resources are a significant part of our quality of life. AccelAdapt is well-suited to perform several direct impact assessments on Natural Resources; helping to highlight where assets may be vulnerable to threats such as wildfire and saltwater intrusion. Expanding on these analyses, the National Climate Assessment and the federal interagency tool “Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment” led by National Wildlife Federation provide useful guidance that can be applied in this context. We also suggest considering water quality as part of this analysis – as we have unfortunately learned the impacts of algae and red tide in recent years.

Using this framework, the assessment provides a wealth metrics and insights on different themes of vulnerability and risk including impacts to properties and public services, roads and mobility, economic factors, and people and socioeconomics. This assessment framework also provides a foundation for prioritizing vulnerabilities, developing adaptation strategies, and creating a resilience plan.

## ADAPTATION ACTION AREAS

Furthermore, this approach is conducive to simplifying identification and characterization of Adaptation Action Areas. Erin Deady (ELD PA) will lead this aspect of the project, supported by the team and the results of previous tasks. By performing this assessment, cross-cutting summaries of vulnerability and risk with themes of social vulnerability can be integrated into streamlined analyses of particularly vulnerable neighborhoods.

The Collective Team will identify potential Adaptation Action Areas (AAAs), Restoration Areas and Growth Areas<sup>1</sup>, based upon recommendations in the Regional Climate Action Plan (2.0). It should be noted that this recommendation stemming from the Regional Climate Action Plan 2.0 could be interpreted two ways: 1) to mean that the Restoration Areas and Growth Areas are separate designations from AAAs; or 2) that Restoration Areas and Growth Areas are a subset of a specific type of AAA. This will have to be clarified with the Working Group. The team can also provide policy-level language that can be used in local ordinances to advance the designation of AAAs (as well as priority programs and projects that will be targeted within the AAAs) in participating jurisdictions.

The focus of ELD PA in this deliverable will be to bring experience beyond the approach for the establishment of AAAs beyond the recommendations from the Regional Climate Action Plan 2.0 to help hone a methodology for these designations that is less course and tailored to the individual participating jurisdictions. For instance, a “Growth Area” or “Restoration Area” may not be entirely applicable within a fully built out community, but an AAA, or other designation, that addresses “Redevelopment”, “Vulnerable Populations”, “Protected Areas or Shorelines” or “Vulnerable Infrastructure or Assets” may be more applicable. The output of the vulnerability assessment will dictate the appropriate designations under this Task and those should be refined to fit the individual community needs.

Additionally, policy-level language that would implement AAAs or other similar designations, would take the form of draft goals, objectives and policies for individual Comprehensive Plans. Given that the optional AAA designation is authorized within the Coastal Element Section of Chapter 163, F.S. (Section 163.3177(6)(g)10., F.S.), AAA goals, objectives and policies would likely be located in that element. Other similar designations, depending on further direction from the Working Group, may be located in other elements of a Comprehensive Plan.

At the conclusion of this task the Collective Team will prepare a Summary Report and presentation for the Working Group on the findings. Additionally, to share the great work of the Working Group, a two-page regional summary designed for consumption by the general public will be created. This summary can focus on hard copy and/or electronic distribution – depending on preference.

### Step 3 Recommended Deliverables

- Task 3 Summary Report:
  - Summary and results of vulnerability and risk scoping assessments, profiles for each threat-asset pair and planning-level summaries of potential losses by asset. This includes graphical and text summaries of findings along with commentary from our team’s assembled panel of experts.
  - Clear documentation with citations on assessment methodology and tools used, corresponding assumptions, and asset/threat attributes used as indicators of vulnerability and risk factors.

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<sup>1</sup>ST-4 Designate adaptation action areas, restoration areas, and growth areas as a priority setting tool for vulnerable areas, and as a means to maximize benefits to natural systems while guiding people and commerce to less vulnerable places in the region, Regional Climate Action Plan 2.0.

- Information will be documented for entire assessment area and for individual jurisdictions.
- Spatial designation of proposed AAAs, Restoration Areas, and Growth Areas and a summary of assets included within each. These will be discussed and provided as maps with tabular summaries within the Task 3 Report.
- Draft potential goals, objectives, and policies for AAA per jurisdiction.
- Revised archive and inventory of literature review as a Word Document or Excel Spreadsheet. All items will be provided electronically for future use.
- Access to AccelAdapt with assessment findings.
- Draft/revised geodatabase for review and use by the members of the Working Group. AAAs, Restoration, and Growth Areas will be included – as well as detailed results of the analyses.
  - All spatial outputs of the vulnerability and risk assessment will be provided in GIS/tabular form. This includes asset-scale assessments of all attributes (exposure, adaptive capacity, sensitivity, probability, consequence, vulnerability, and risk) and aggregate scale summations of the findings.
  - All socioeconomic data in GIS/tabular form.
- PowerPoint presentations, and a two-page document for the general public that discusses the findings of the vulnerability assessment.
- Each Community Captain will be available for an in-person or virtual meeting with the key staff from each jurisdiction.
- Interactive Workshop with the Working Group on the Results of Step 3 and transition to Step 4.

#### STEP 4: INVESTIGATE POTENTIAL ADAPTATION STRATEGIES

The Collective Team will leverage the results of Steps 1-3 as we enter Step 4 – which includes identifying an extensive list of adaptation strategies. Based on the preferences of the Working Group, strategies will be identified as addressing vulnerability and risk by either (1) reducing exposure (removing assets from harm's way), increasing adaptive capacity (increasing the asset's ability to cope with impacts), or (3) supporting preparedness, response, and recovery.

As part of Step 4, the Collective Team will develop a suite of adaptation strategies ranging from constructing new infrastructure (such as raising roads that are harmonized both with regards to engineering considerations but also regulatory, environmental, and legal requirements) to communicating adaptation strategies to stakeholders (such as providing detour routes). As evidenced by our team's experience, we understand the true cost and effort to invest capital and resources into grey, blue, and green infrastructure to address coastal flooding. Not only can the cost of the new infrastructure be significant, but there is substantial effort required to harmonize the new infrastructure with adjacent private property while not violating legal, regulatory, and insurance requirements. In the case of raising existing roads, the adjacent private driveways often require reconstruction outside of the public right-of-way to accommodate the higher grades and lower slopes. Even in cases where less costly improvements

#### ***A Complete Toolbox of Strategies...***

*It will take an entire toolbox of strategies to address adaptation in Palm Beach County. Through our diverse team of planners, attorneys, engineers, scientists, and landscape architects, we will identify a complete and creative list of strategies that is:*

1. *SPECIFIC and APPLICABLE to the needs of the partnering jurisdictions.*
2. *INNOVATIVE beyond the typical lists that appear in so many Florida reports.*
3. *COMPLETE to ensure that we exhaust the resources of our experts (i.e. go beyond engineering considerations).*
4. *HARMONIZED to ensure that we proposed strategies that work together to produce better results AND that do not conflict with regulatory, legal, and insurance requirements – among other considerations.*

such as installing exfiltration trenches may be applicable, it is recommended that the new infrastructure be designed for phased adaptation. In the case of an exfiltration trench, the effectiveness will be diminished as groundwater levels increase with sea level rise. Our team recommends exfiltration trench improvements be designed in a manner that can accommodate the inclusion of a pump station in the stormwater management system at a later date – and only when necessary (and with all considerations towards sustainability and water quality).

In developing the potential adaptation strategies, each strategy should have a path to implementation through the jurisdiction's Comprehensive Plan, Code of Ordinances or development of a policy for a new program or initiative. To develop this implementation, the Comprehensive Plans, Code of Ordinances and policy structures of each jurisdiction will have to be evaluated. Funding should also be a key component of an overall implementation component of the adaptation strategies. The path for implementation and funding can, in certain instances, be prioritized to the extent that strategies can be evaluated for cost benefit return or feasibility of execution.

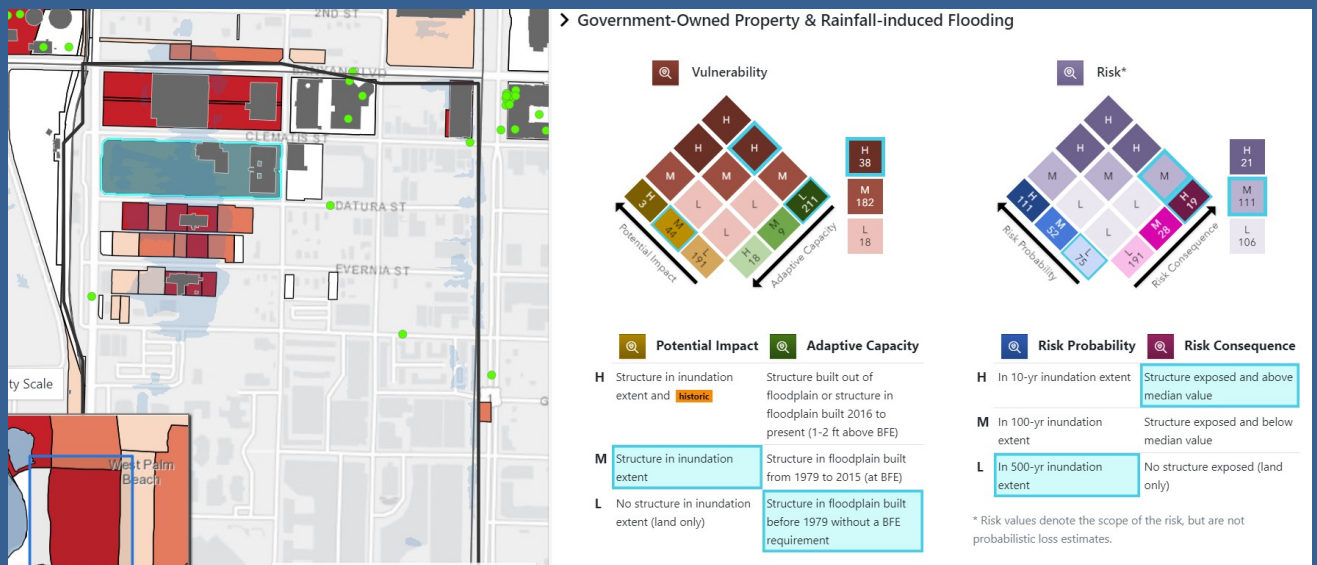
ELD PA will be one of the lead team members in this task for nonstructural adaptation strategies given the background and experience of the firm in Comprehensive Plan, Code, policy and funding alternative development for resiliency and adaptation strategies.

Once the suite of available adaptation strategies has been developed each vulnerability will be reviewed and evaluated to determine which approach is most appropriate for that location. One major advantage of the vulnerability quantification method used in this project over methods is that the most vulnerable assets can be triaged, and adaptation strategies can be highly targeted to the most pressing issues they face. For example, an asset that is quantified as low risk because the threat probability is low could be highly vulnerable if it has low adaptive capacity. In this case, adaptive measures may be the most cost-effective short-term intervention as opposed to moving the asset. On the other hand, if climate change is expected to increase the frequency of the impacting event, consideration should be made to whether the asset will eventually need to be moved and if it would be cost-prohibitive to do so in the future.

The team envisions strategies on two levels: strategies common to all jurisdictions and strategies specific to individual jurisdictions. Some adaptation strategies may also necessitate steps or phases to secure more detailed datasets from which to build upon for final implementation. A monitoring and progress reporting protocol will also be important to manage public and elected official expectations.

## Understanding Adaptive Capacity

By preserving the factors of vulnerability and risk for each asset, transparency and targeted interventions are made possible. In this case, this government-owned asset (highlighted in blue on left) has low adaptive capacity due to its construction predating BFE requirements but has a low-probability of being affected. This structure may be a good candidate for elevation or wet-proofing, but climate change may increase the frequency of inundation.



Considering our team's extensive experience with designing, bidding and overseeing the construction of infrastructure in the public right-of-way, we thoroughly understand the associated costs of project implementation and we maintain an archive of recent bid prices from similar projects. This information will be used to develop conceptual costs for each of the adaptation strategies. The costs of adaptation are a critical characteristic during the evaluation and prioritization phases of Step 4.

It has been our experience that interventions without prioritization can become a "laundry list" that is hard to take action on or that significant barriers are discovered at implementation stage that could have been uncovered earlier. In order to overcome this issue, the Collective Team will also gather staff input (via Community Captains) to help each jurisdiction evaluate the ability to implement identified adaptation strategies. Example criteria could include:

1. *Financial: Is the option financially feasible with current resources?*
2. *Political: Does the option have current political support?*
3. *Staff Capacity: Is there existing staff capacity available to implement?*
4. *Social Responsibility: Is the option socially responsible? Does it help to address social equity goals?*
5. *Permitting/Funding: Does this option have a high likelihood to be accepted by regulatory agencies – or even better – obtain funding support? Our experts will also consider grant funding and potential collaboration as part of this criteria.*
6. *Legal: Is this legally feasible?*
7. *Scale: Does this option need to be implemented regionally or locally?*

Each action or strategy will be assessed using a simple "traffic light" matrix with criteria determined most meaningful by input gathered about community values. Actions where all criteria have green lights are highly desirable and could be pursued immediately; actions with some yellow lights could be investigated further to determine if the barriers can be overcome; actions with many red lights should be prioritized lower on the list. As an outcome of this exercise, the partners will have clarity on effective actions that can be taken without regrets



and clear reasoning why some actions have been de-prioritized.

### Example Prioritized Inventory of Actions

	Landslides	Bridges and Roads	Determine other points of access				Public Works		N	2	1	1	1
19a-2	Flooding	Bridges and Roads	Create detours and educate public on alternative access and evacuation plan (i.e. prepare to be temporarily stranded)	City wide	Response and recovery	Possible Project	Public Works - Streets Division	CAPE + Fire and Rescue	Y	3	2	3	2
19a-3	Flooding	Transit - Bus Routes	Create detour/alternate bus routes map and create communications plan for reduced service (Use I-ride, ABC alert)		Increase adaptive capacity	Possible Project	Transportation	CAPE + Fire and Rescue	Y	2	1	3	3
19b-1	Flooding	Greenways	Evaluate greenways located in flood prone areas	City wide	Response and recovery, adaptive capacity	Strategy	Transportation	IT/GIS	N	1	1	2	2
19b-2	Flooding	Greenways	Plan for and communicate alternate routes/info source if closed due to flooding	City wide	Increase adaptive capacity	Strategy	Transportation	IT/GIS	Y	1	1	3	2
19c	Flooding	Food Locations	More frequent transit options and food routes	Sensitive populations	Increase adaptive capacity	Strategy	Transit	Office of Sustainability	N	2	2	3	2
19d	Landslides	Greenways	Plan for alternate routes/info source if closed due to landslides		Increase adaptive capacity	Strategy	Parks and Recreation + Transportation	CAPE	N	1	1	1	1
<b>FUEL MANAGEMENT</b>													
5	<b>Create policy to address controlled burning requests to better mitigate wildfire risk</b>												
5b	Wildfire	Residential Property	Identify locations of controlled burns and keep in database		Adaptive capacity/red use risk	Plan/strategy	Fire and Rescue		N	2	1	2	3
5d	Wildfire	People and Places	Policy about how to address controlled burn requests and requirements of the owner moving forward (future use of the property) (future purpose and timeline)	City Parks, US Forests, Parkway, Biltmore	Adaptive capacity, exposure	Policy	Fire and Rescue		N	3	2	2	2
<b>Further analysis</b>													
6	<b>Conduct additional studies as necessary to determine detailed strategies for flood and landslide hazard mitigation</b>												
6a	Flooding	City-Owned Facilities	Detail exposed assets and determine whether they house critical functions to determine next steps	Citywide	Reduce exposure	Project	General Services	Facilities + Real Estate	Y	2	1	2	3
6b	Flooding	Bridges and roads	Incorporate information on bridge and road vulnerability into CIP Planning process	City wide	Adaptive capacity, response recovery	Strategy	Public Works	Finance Department	Y/N	3	2	3	2
6c	Flooding; Nuisance Flooding, Runoff, Erosion	All Properties	Develop watershed plans to guide infrastructure and improvement projects							3	3	3	3
	Flooding	Commercial / Industrial / Residential Properties	Watershed plans: prioritize plans; influence zoning	City wide	Exposure	Project/Strategy (Project)	Public Works	Stormwater Division	Y	3	3	3	3
	Nuisance Flooding, Runoff, Erosion	Residential Properties	Watershed Plans - infrastructure evaluations - Prioritize plan for improvement projects - Infrastructure - Stream Restoration	City wide	Exposure, Adaptive capacity	Project/strategy							
6d	Flooding	Commercial / Industrial / Residential Properties	Create flood maps based on build out of watershed (use Charlotte as example), update ordinance to reflect support planning and policy regulation	City wide	Exposure	Project	Public Works + Stormwater		N	2	1	1	1
6e	Flooding	Bridges and roads	Localized flood mitigation master plan to identify detailed mitigation options such as storage areas, stream restoration w/ relocation	City wide	Adaptive Capacity, exposure	Strategy	Public Works + Stormwater	Cross Jurisdictional (County and town within the County)	Y	3	3	3	3

The quantitative results provided by the team can be used in conjunction with stakeholders to develop a stakeholder-inclusive prioritization. Brizaga has developed an Adaptation Prioritization Exercise (APEX) that includes direct engagement to allow residents and stakeholders (including municipal and county staff) input on prioritizing vulnerabilities. Sometimes a purely quantitative assessment can miss the cultural or community importance of an asset. While the results of a quantitative assessment are important from a vulnerability and risk point of view, when it comes to adaptation, other factors should be considered. The tool was designed to be easy-to-use and can be provided to the Partnership in an Excel Spreadsheet. It is a living document where the users can adjust weighting of different risk and vulnerability factors and the number of stakeholder engagements.

During this task, two (2) workshops will be held to educate staff, elected officials, and stakeholders on adaptation options and provide a facilitated discussion on those options. Using the APEX, the facilitated conversations can be used to develop an updated prioritization that includes stakeholder engagement creating an updated prioritized asset list for adaptation purposes. Additionally, Brizaga has developed an Adaptation Roundtable Exercise, which is an educational tool designed to help stakeholder understand types of adaptation options, associated costs, and usefulness of different options. Using this engagement tool builds good will with the public through the adaptation planning process. Adaptation actions that are applicable to the region will be explored during the workshops.



In addition to public adaptation strategies, the Collective Team through Brizaga has significant experience with personal adaptation and has worked with throughout the Southeast to understand how the public sector can also help the private sector adapt to changing conditions.

#### Step 4 Recommended Deliverables

- Task 4 Summary Report:
  - Approach used to identify adaptation measures.
  - Comprehensive list of applicable adaptation strategies for each jurisdiction and for the region as compiled by Community Captains and then distilled by the Working Group.
  - Review of materials for each jurisdiction and resulting matrix of adaptation strategies with funding mechanisms and implementation path (through Comprehensive Plan, Code of Ordinances or new program / initiative).
  - Funding strategies for major measures/strategic combinations of measures.
  - Planning-level cost estimates by jurisdiction and region.
  - Prioritized list of adaptation strategies organized by community with opportunities for collaboration identified.
  - Revised archive and inventory of literature review as a Word Document or Excel Spreadsheet. All items will be provided electronically for future use.
- For outreach purposes (and depending on the preferences of the Working Group): An adaptation menu for six (6) to eight (8) representative adaptation strategies (to be determined with input), infographics can be created to explain the actions.
- If desired, materials on personal adaptation strategies can be included for each jurisdiction and/or the entirety of the South County.
- Two (2) facilitated workshops with municipal/county staff, elected officials, and stakeholders to provide education about and discuss adaptation options, and the final results of the APEx.
- Interactive Workshop with the Working Group on the Results of Step 4 and upcoming final tasks of the project.

#### Step 5: Final Report and Interactive Map/Tool

At this final stage of the project, the Collective Team will synthesize all tasks into a cohesive, visually appealing, and actionable plan. Our team will provide a draft document for Working Group input that will have all sources and background information clearly demarcated. The Outreach Lead and Project Manager will be available for phone calls and personalized meetings with staff and leadership to receive input, if desired – in addition to our usual personalized coordination through our Community Captains.

*Taking the input gathered, a final report will be drafted, and a full layout produced that is both visually appealing and - for ADA compliance - accessible to a wide range of audiences and needs. For example, maps and charts will be provided with commentary and tabular analogs in order to serve a range of abilities in consumers such as those using a screen reader due to visual impairment.*

Regional, jurisdictional, and key neighborhood findings will be presented with clear methodological sources and documentation. The key vulnerabilities identified as a part of the assessment will be used to orient discussion of potential strategies that can be taken regionally and locally.

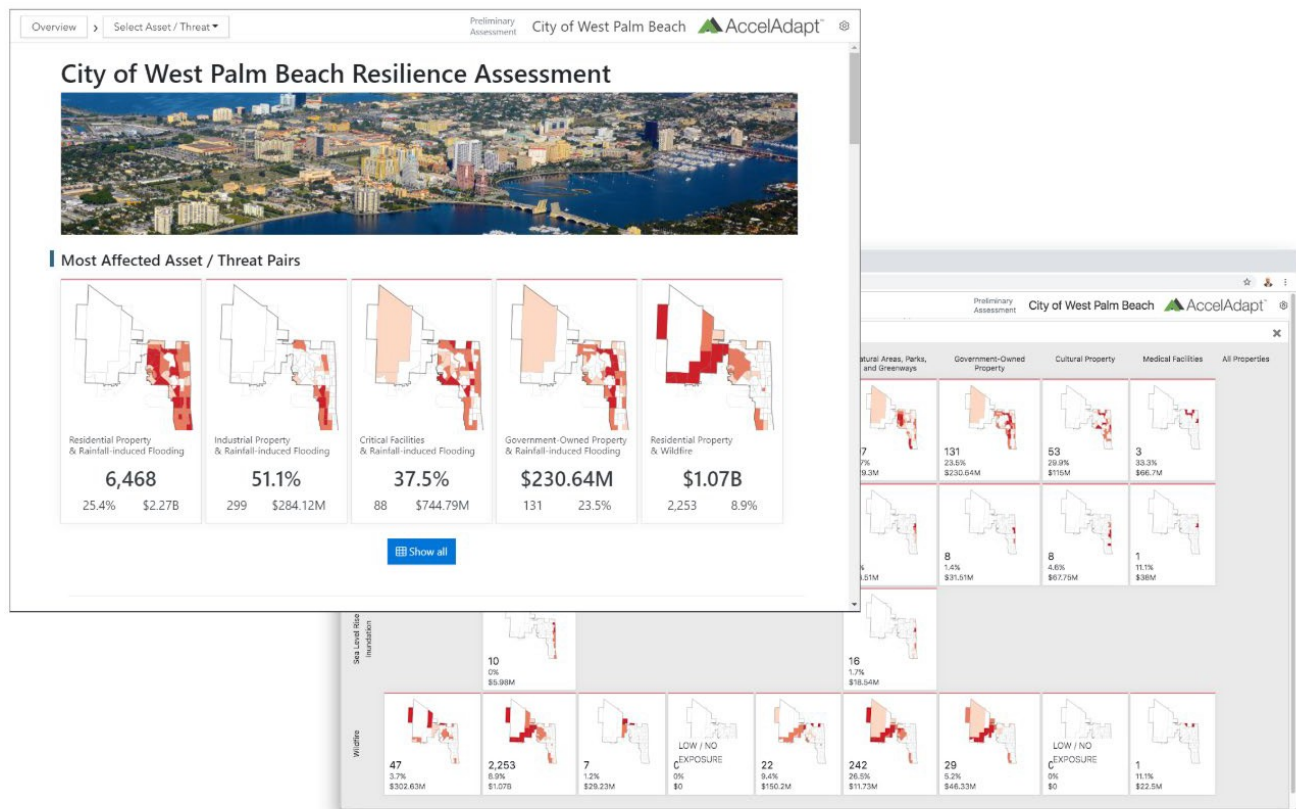
## INTERACTIVE MAPS AND ACCELADAPT ONLINE

Through the engagement of Fernleaf+NEMAC, the Working Group will have access to one of the most widely used and refined interactive tools available, AccelAdapt. Initially described in Step 3, AccelAdapt is a tool that has been purpose-built for performing these exact assessments in contexts exactly like this project. For the duration of this project and for one year after final delivery, NEMAC+FernLeaf will provide complimentary access to AccelAdapt Online.

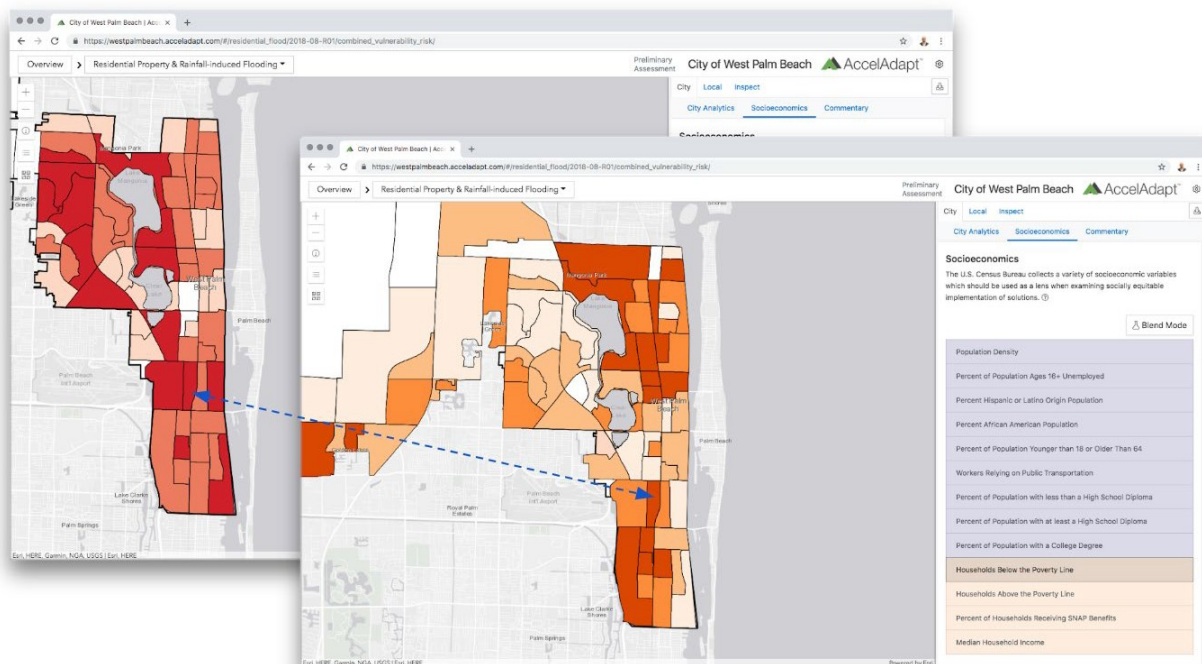
Ongoing access to AccelAdapt Online and analysis refreshes are handled by an optional and affordable subscription relationship that continues after the project ends. As desired, the subscription expenses can be detailed for the Working Group or any individual jurisdictions who may want access to a tailored tool for decisions within their boundaries.

While there is an expense for continual use of our tools, we believe strongly that all analysis outputs paid for by a client should be theirs to keep—forever. All analysis outputs will be published to a GIS enterprise of a participating Working Group jurisdiction and a companion interactive viewer will be provided for perpetual use without additional expense incurred by the Collective Team.

With both pathways (AccelAdapt) and the perpetual web viewer, all data are managed as feature services within the Esri stack jurisdictional GIS departments already use. These departments will have full control of the data, access controls and security, and can readily update, replace, supplement assessment findings as needed on a perpetual basis and without interaction with the Collective Team.



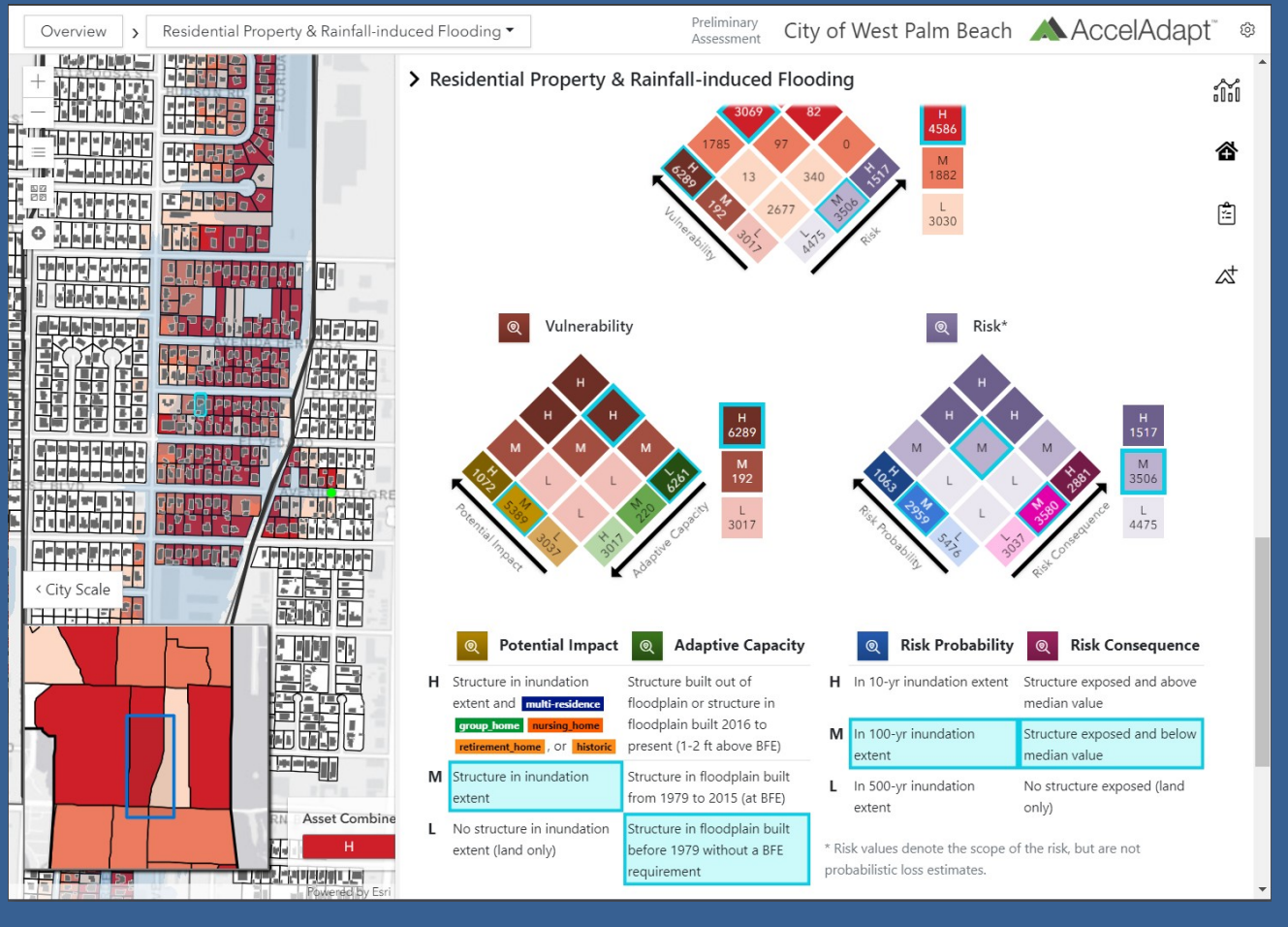
Above: At the overview screen of AccelAdapt Online, a variety of key findings are provided at a glance to help understand primary vulnerabilities and risks.



Above: At the study area scale, neighborhoods most vulnerable (in darker red) are directly comparable with a suite of socioeconomic metrics (such as this neighborhood in dark orange, indicating a high proportion of houses below the poverty line).

## Complete Transparency...

*In the interest of full transparency, all assets are selectable and the full context of adaptive capacity, sensitivity, risk probability, and consequence are clearly presented.*



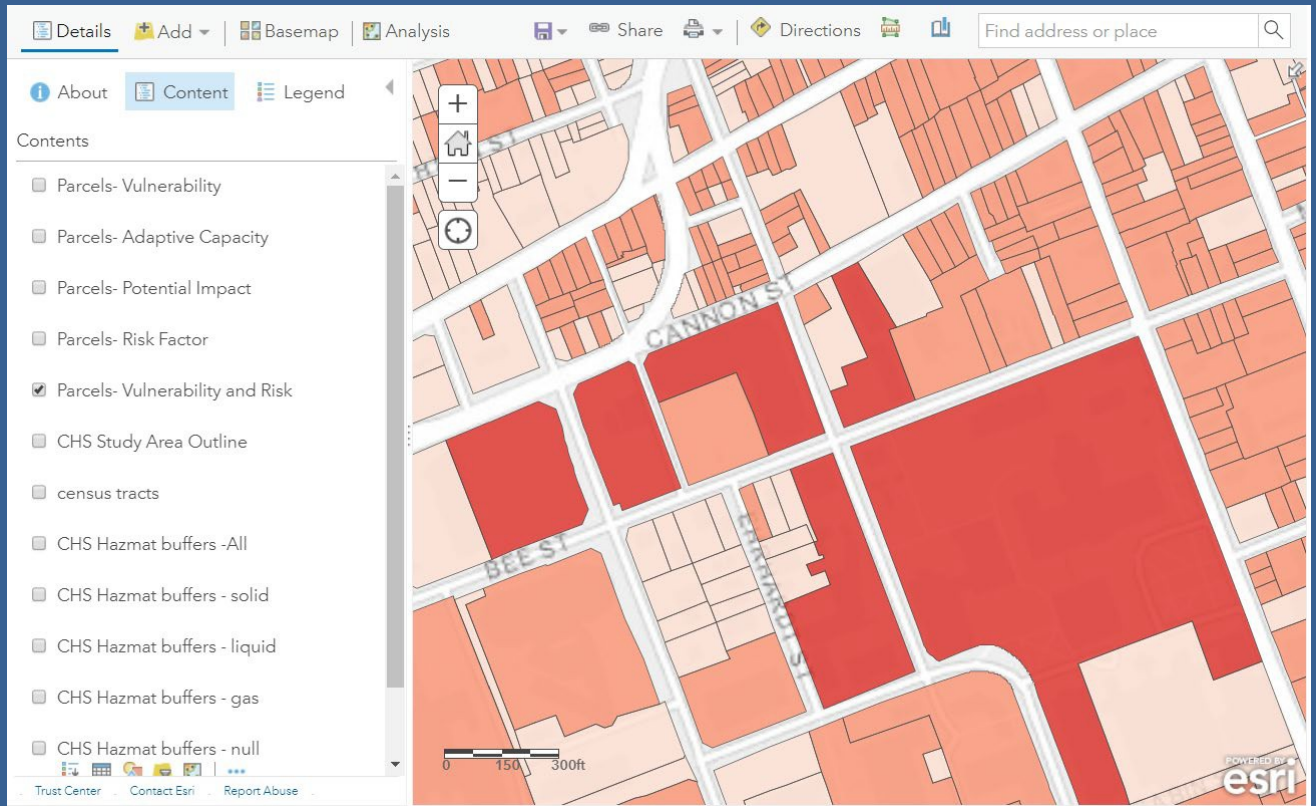
## INTERACTIVE TOOL AND PERPETUAL ACCESS

In order to provide a solution for perpetual access, NEMAC+FernLeaf will draw on its intimate working knowledge of the most up-to-date platform solutions offered by Esri. Our team will work closely with the jurisdiction that will handle long-term hosting to ensure all data are transferred securely and that a series of ArcGIS Online web maps are created that will provide interactive exploration of the results.



## Let's Bring the Data Home...

*Example stand-alone web map displaying the outputs of a vulnerability and risk assessment in Charleston. A map like this can be easily managed by a jurisdictional GIS department without the need for purchasing new solutions or managing new software by using existing resources.*



### Step 5 Suggested Deliverables

- Final CCVA Report that includes appropriate Working Group and public input. The report will include but not be limited to:
  - A visually appealing summary designed to highlight the key points of the Plan for the entire region. One-page summaries will also be provided for each jurisdiction. Summaries will include color maps and graphics for each participating jurisdiction. Key Adaptation Strategies will also be included.
  - Methodology for Steps 1-4.
  - Adaptation strategies by region and community, complete with cost estimates and key implementation information (including opportunities for collaboration).
  - Funding opportunities
  - Project Summary Appendix for Each Jurisdiction
  - Visually appealing maps and tables
  - Complete archive of literature reviewed and bibliography. Final archive and inventory of literature, data, and model reviews will also be provided as a Word Document or Excel Spreadsheet. All items will be provided electronically to each jurisdiction for future use.

- Final geodatabase for review and use by each jurisdiction. This geodatabase will contain all final GIS data products created during the development of the project and the datasets we used throughout the life of the project (with metadata).
- Collective Team assistance transferring all analysis output feature services to a participating jurisdictional GIS enterprise; long-term interactive web map solution implemented on top of jurisdictional GIS enterprise
- AccelAdapt access, support, and maintenance for 1 year following project end (until March 31, 2022).
- Two (2) public meetings to share the results. These meetings should be held prior to the finalization of the Final CCVA Report so that public input can be included. Comment cards and other means for feedback can be provided during the draft to final stage of the Report.
  - A presentation geared towards the general public will be created for use in the public meetings. This presentation can also be used by municipal/county staff to share the results of the assessment.
- Final sets of documentation of staff interviews with Community Captains.
- Final Interactive Workshop with the Working Group.



## 2. QUALIFICATIONS

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## 2. Qualifications

*The Collective Team was carefully assembled to offer the Working Group the most capable experts in the many areas that will be required for this RFP. However – we did not stop there. All of the firms selected for our team possess high levels of integrity and have a history of working with Collective in various capacities. The experts highlighted in this proposal excel in their respective fields but are also easy to work with and strong communicators.*

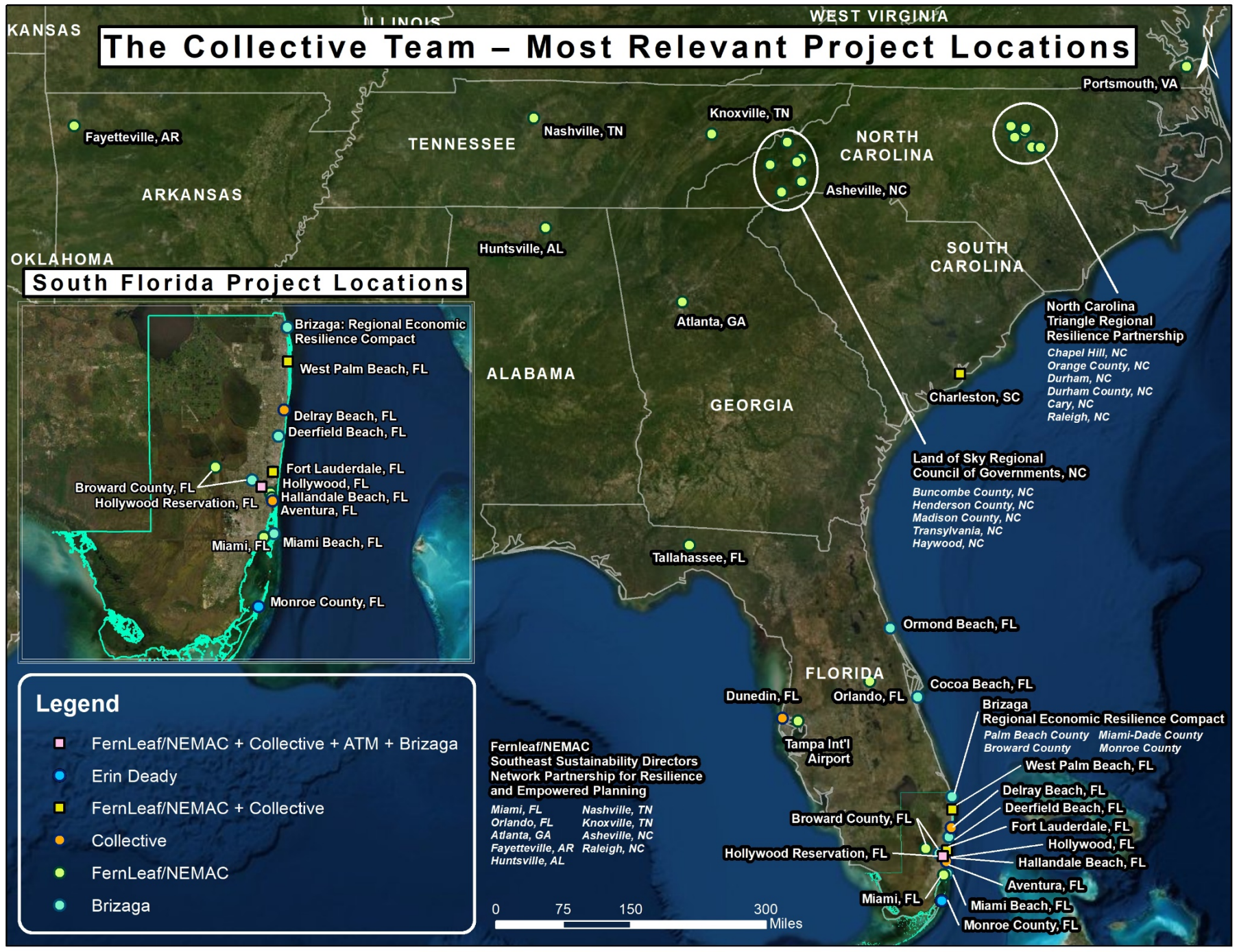
The following pages will provide the selection committee with a summary of our experience with projects of similar scale and complexity. The map that follows summarizes locations of major projects with similar scopes of work and tasks that are relevant to this CCVA.

### WHY THE COLLECTIVE TEAM?

- A TEAM THAT EMBODIES THE TRUE SPIRIT OF THIS PROJECT
- BEST OF BOTH WORLDS: LOCAL AND HIGHLY EXPERIENCED EXPERTS – ALL FROM SMALL FIRMS WHERE OUR TOP LEADERSHIP WILL BE ENGAGED
- A TEAM WITH “COMMUNITY CAPTAINS” TO BE SURE BOTH REGIONAL AND LOCAL NEEDS ARE MET
- EXPERTS THAT WORK ON RESILIENCY EVERYDAY. THESE ARE CORE SERVICES FOR SEVERAL MEMBERS OF OUR TEAM – AND RESILIENCY IS ALL THAT MANY OF US DO
- A DEEP AND COMPLETE BENCH FOR UNBIASED GIS AND MODELING ASSISTANCE
- A PASSIONATE EYE TOWARDS DATA INTEGRITY
- ONE OF THE MOST EXPERIENCED TEAMS IN THE SOUTHEAST FOR VULNERABILITY ASSESSMENTS
- A BALANCED TEAM OF BOTH TECHNICAL EXPERTS AND STRONG COMMUNICATORS



# The Collective Team – Most Relevant Project Locations





# Stormwater Master Plan and Design Implementation

(2014–2017)

Client: City of West Palm Beach, Florida

LARGE WATER RESOURCES STUDY

MULTIPLE MODELS

SEA LEVEL RISE ASSESSMENT

AWARD-WINNING PROJECT

URBAN & COASTAL AREAS

Many stormwater master plans focus solely on the development of Capital Improvement Projects (CIPs). Beginning in 2014, the City had the vision to incorporate a holistic approach to master planning to assist with needs across several City Departments. The Collective Team assisted the City with traditional SWMP elements, but also helped the City complete several significant and notable tasks in parallel.

This Stormwater Master Plan included a comprehensive and progressive scope - especially aspects of hydrologic/ hydraulic analysis and modeling, GIS, outreach, grant funding, rehab prioritization for storm sewer, CRS program enhancements, water quality analysis, climate change/ sea level rise analyses, BMP implementation, CIP refinement and many other considerations for enhancement of the City's water resources. The 2014 SWMP has become a flagship project for the City and has received awards and both FDEP and SFWMD grants in response.

## More specifically, the project achieved the following:

- Winner, Honorary Mention, US Conference of Mayors, Large City Category
- First study of its type to include sea level rise and climate change in a master plan
- City-wide pollutant loading analysis (SIMPLE Model)
- Modernization of Water Quality Data Management at the City
- Citywide ICPR3 (now converted to ICPR4) model for stormwater management
- FDEP and SFWMD Grants obtained from the project
- Extensive consideration of CIPs throughout the City
- **\$13 Million in annual savings from FEMA map revisions + CRS Rating Increase**



## Stormwater Master Plan



## Project Details

Aug 2017—Present

NF fee: \$199,013

## Key Team

Jeff Hicks (Co-lead)

Jim Fox (Co-lead)

Matt Hutchins

Aashka Patel

Liz Perez

Emily McBryan

Stephanie Dunham

## Project Contact

Penni Redford

Sustainability Manager

(561) 804-4981

predford@wpb.org

## Similar Features

- ✓ Same quantitative multiple-threat approach
- ✓ Stakeholder involvement
- ✓ Workshops with jurisdictional staff
- ✓ Actionable options
- ✓ Assessed risks to wide range of assets in city
- ✓ Interactive GIS tool for increased capacity

## Key Partners



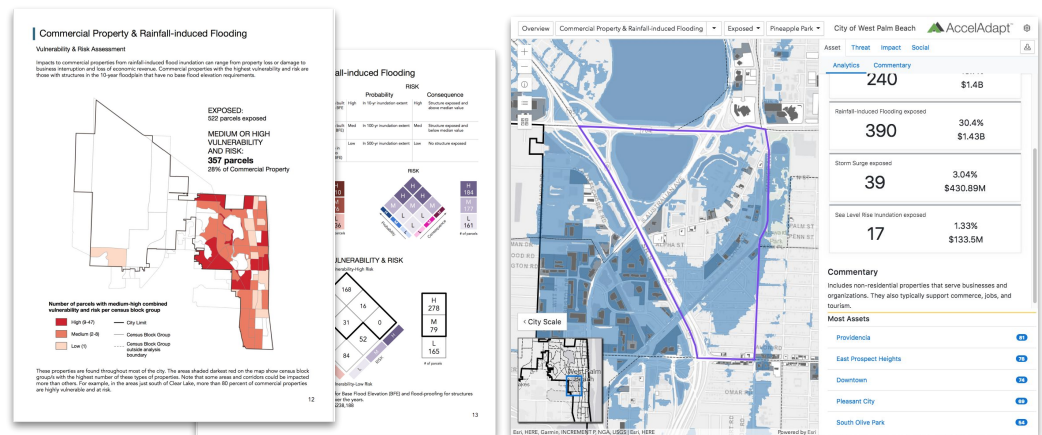
# West Palm Beach, FL Vulnerability Assessment & Resilience Plan



## Summary

NEMAC+FernLeaf with support from Collective Water Resources is currently guiding staff from the City of West Palm Beach—with representatives from nearly every municipal department—through the five-step Steps to Resilience planning process in a series of facilitated workshops. The project is assisting City staff and leadership in prioritizing limited resources available in order to build maximum resilience to existing hazards and possible future change. The project benefits from extensive collaboration with Collective Water Resources.

The team is currently providing an economic impact scoping assessment along with public communication and internal process alignment to take advantage of the full assessment findings.



(Left) excerpt from vulnerability and risk scoping assessment report. (Right) Screenshot from AccelAdapt that enables asset-level vulnerability exploration.

## Actionable results

As a coastal community, West Palm Beach is facing a number of acute inundation hazards caused by heavy precipitation, tidal events, and storm surge—all being exacerbated by gradual sea level rise. Additionally, the city faces a number of chronic challenges, such as water shortage and vulnerability to heat stressors, and non-climate stressors, such as recent population growth and resultant pressure on infrastructure capacity.

One major finding: inland precipitation-driven flooding is, and will likely continue to be, a greater challenge than coastal flooding for near- and mid-term planning horizons. With this important insight, our team is currently working with the City on developing options that address the most pressing challenges they face such as flooding and lack of critical access.

## Project Details

Mar 2019—Jan 2020

Fee: \$194,000

## Key Team

Matt Hutchins (Lead)

Jim Fox

Aashka Patel

Jeff Hicks

Liz Perez

Stephanie Dunham

## Project Contact

Mark Wilbert

Chief Resilience Officer

(843) 619-6118

wilbertm@charleston-sc.gov

## Similar Features

- ✓ Same quantitative multiple-threat approach
- ✓ Stakeholder involvement
- ✓ Workshops with jurisdictional staff
- ✓ Actionable options
- ✓ Assessed risks to wide range of assets in city
- ✓ Interactive GIS tool for increased capacity

## Key Partners



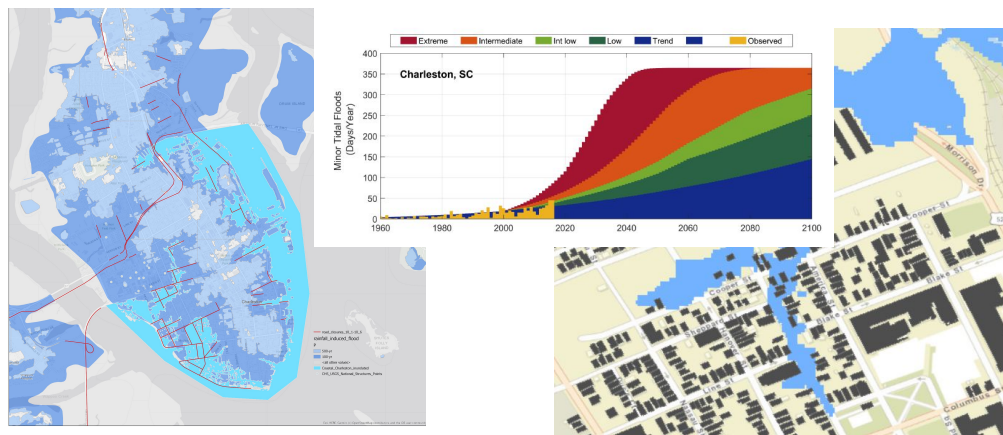
# Charleston, SC

## Vulnerability Assessment & Resilience Plan



### Summary

NEMAC+FernLeaf is currently guiding staff from the City of Charleston through the a series of facilitated workshops. The project is using a phased approach addressing multiple types of flooding and other challenges while examining critical projects to build resilience in the City. Workshops utilizing decision making under uncertainty is assisting staff to first recognize key areas of the city, and second, to prioritize limited resources available in order to build maximum resilience to existing hazards and possible future change. The workshops have helped build shared understanding that projects that build better access and mobility are just as important as stormwater and armoring projects. This project is being supported by key sub-consultants including Collective Water Resources.



*(Left) Flood impacts to key road corridors. (Middle) Tidal flooding levels based on various scenarios (Right) Impact of nuisance flooding on the City.*

### Actionable results

In Charleston, the threats of tidal flooding and heavy rainfall flooding (city wide) are in the near term and have less uncertainty associated with them. In a recent workshop involving city staff and the mayor of Charleston, scenario planning shows that protecting main assets that would prevent cascading failures take precedent for near term funding.

Near-term options linked to storm surge will likely be related to emergency management and evacuation. Longer term, large dollar investments need to wait until a few critical uncertainties are clarified.



## Project Details

Feb 2017—Sept 2018

Fee: \$100,000 (plus cost-share from NOAA and in-kind support)

## Key Team

Matt Hutchins (Lead)

Jim Fox

Jeff Hicks

## Project Contact

Tobin Fried

Sustainability Manager

Durham City & County

(919) 560-7999

tfried@dconc.gov

## Similar Features

- ✓ Multi-jurisdictional project
- ✓ Same quantitative multiple-threat approach
- ✓ Stakeholder involvement
- ✓ Workshops with jurisdictional staff
- ✓ Actionable options
- ✓ Assessed risks to wide range of assets in city

# Triangle Region, NC

## Raleigh/Triangle Regional Resilience Partnership



Population growth has a major impact on development patterns



Increased extreme precipitation events that lead to local flooding



Increasing night-time temperatures and other temperature variability



Increased frequency and duration of drought conditions

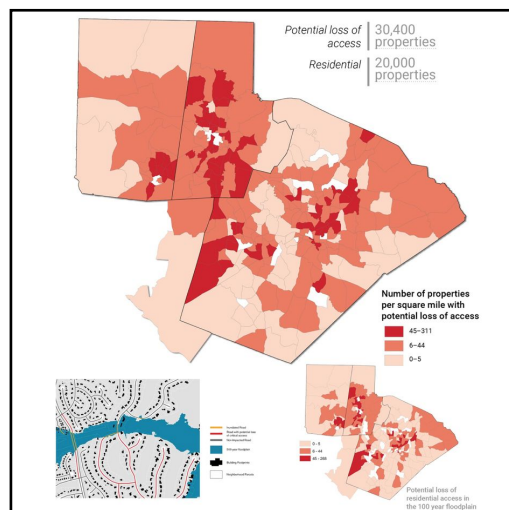
## Summary

The Triangle Regional Resiliency Partnership (TRRP) was formed from six distinct government entities in the Triangle region—Cary, Chapel Hill, Raleigh, Orange County, Durham, and Durham County—to address the need for a regional resilience assessment. NEMAC+FernLeaf guided the partnership in assessing, planning, and prioritizing resilience-building strategies. We performed a quantified assessment to help regional decision makers understand which assets are most vulnerable to specific threats and then provided guidance on potential solutions. Using results from the assessment, the TRRP project team developed a number of options and strategies to help guide the region as it responds to climate and non-climate threats while providing an improved quality of life and supporting regional vitality and livability.

## Key findings

The assessment shows a trend toward increased vulnerability and risk for some assets and threats, particularly these key issues:

- Properties and Flooding—With an expectation of increased precipitation and continued development comes the reality of increased localized flooding
- Road Access and Flooding—A flooding event in the region could result in more than 30,000 properties becoming inaccessible to residents and emergency vehicles due to either inundated or damaged roads
- Water Supply and Water Shortage—Changes in the amount and intensity of rainfall will affect the quality and quantity of regional water supplies
- Residents and Extreme Heat—Extreme heat can cause negative health impacts, which causes concern for the region's socially vulnerable populations



Depending on the circumstances, a flooding event in the region could result in more than 30,000 properties becoming inaccessible to residents and emergency vehicles due to either inundated or damaged roads.

## Project Details

Mar 2019—Jan 2020

Fee-to-date: \$1.4M

## Key Team

Jim Fox (Lead)

Jeff Hicks

Matt Hutchins

## Project Contact

David Herring  
Communication,  
Education, &  
Engagement Manager,  
NOAA Climate Program  
Office

(301) 734-1207

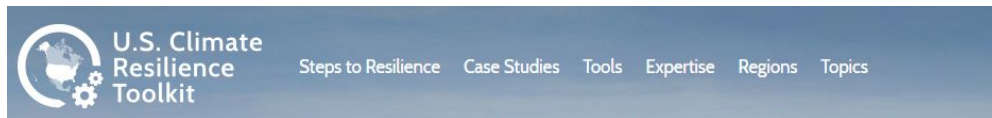
david.herring@noaa.gov

## Similar Features

- ✓ Steps to Resilience
- ✓ National datasets and best practices
- ✓ Interactive GIS tool for increased capacity

# NOAA

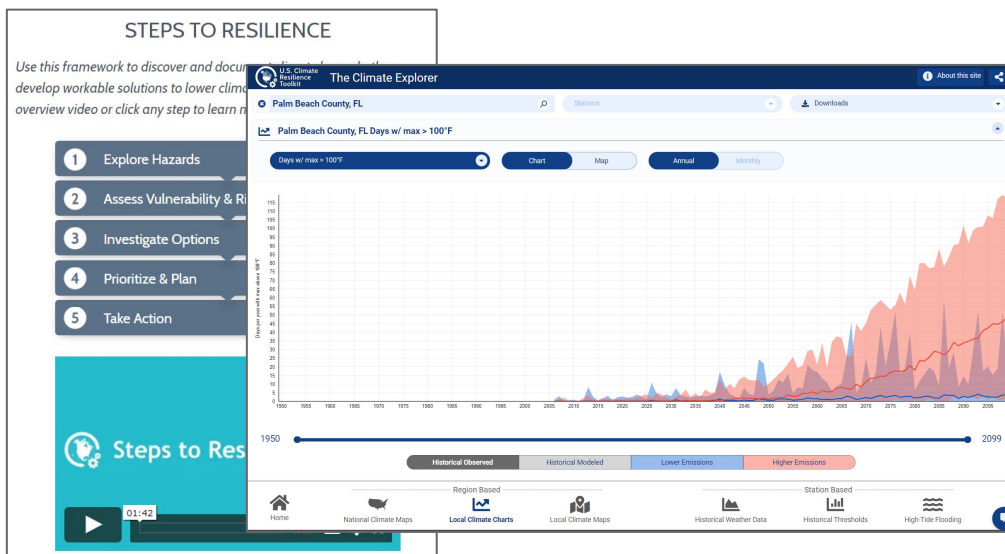
## US Climate Resilience Toolkit



### Summary

The U.S. Climate Resilience Toolkit (CRT) ([toolkit.climate.gov](http://toolkit.climate.gov)) provides scientific tools, information, and expertise to help people manage their climate-related risks and opportunities, and improve their resilience to extreme events. The site is designed to serve interested citizens, communities, businesses, resource managers, planners, and policy leaders at all levels of government.

NEMAC+FernLeaf is an integral part of the CRT development and editorial team. NEMAC staff partnered with NOAA personnel for the site's initial conception and development, working from conceptual development through design, content development, and initial launch. We continue to work closely with NOAA to manage the site's design, development, and content. One of the cornerstones of the Toolkit is the "Steps to Resilience", the nationally accepted risk analysis framework that our team will use in the Vulnerability Assessment. In addition to the Toolkit's website, NEMAC+FernLeaf also developed its featured tool: Climate Explorer. Climate Explorer is a visualization tool that offers maps of climate stressors and impacts, as well as interactive graphs showing daily observations and long-term averages from thousands of weather stations across the nation, and climate projection data on a county scale in interactive graphs and maps.



### Actionable results

Communities across the nation are using the CRT to help them build resilience. National groups including the Association of Climate Change Offices, the American Society of Adaptation Professionals, The United States Sustainability Directors Network, the American Planning Association, the American Meteorological Society, the National Council of Mayors and many others are utilizing the Toolkit as a trusted source of information to guide their Community Resilience.

# Support and Advocacy for Digital Flood Insurance Rate Maps

(2013 – Current, During Various FEMA Review Periods)



**Client: City of West Palm Beach, Palm Beach County, and City of Greenacres Florida**

URBAN AND COASTAL SOUTH FLORIDA

HEC & ICPR MODELING

GIS DATA PREPARATION

FEMA ADVOCACY FOR LOCAL GOVERNMENTS

COASTAL & UPLAND REVIEWS

Collective Water was retained by various municipalities to assist with the local response to the proposed preliminary Digital Flood Insurance Rate Maps (DFIRMs) that were released for comments by FEMA in 2013. This extensive effort included technical advocacy for refinement and correction of the DFIRMs. Collective reviewed and used several models and GIS throughout this process, including the District's HEC-RAS C-51 model and various ICPR models. Collective acted as an extension of staff to respond to FEMA's inquiries and requests for data in a timely manner under very tight deadlines.

To date, it is estimated that this effort resulted in flood insurance savings to constituents of more than \$15+ million annually. Collective met several strict Federal deadlines throughout the process between 2013 and 2016. Some of these deadlines were a few days in length and extensive modeling and mapping was required. Modeling, mapping, and documents were prepared for several stakeholders as requested by FEMA. To date, none of the datasets or recommendations prepared by Collective were rejected by FEMA. Collective was one of the only local firms that was readily able to provide fully enabled GIS-based deliverables that FEMA used. The provided data was also fully compliant with the extensive FEMA Guidelines and Specifications.

**As a result of these efforts, Collective received the 2016 Palm Beach League of Cities Associate Member of the Year Award. Collective has remained engaged as an advocate for local governments into 2019 with regards to FEMA. Collective recently provided comments to the City regarding the FEMA Risk (Coastal) Maps that FEMA is currently revising.**

## Breakers West Subdivision



May 2013

- Inundation not realistic
- Waterbodies not flooded
- No QC from County Experts



June 2014

- Inundation more realistic
- Waterbodies corrected
- SFHAs QCed by Technical Group



# Marine Way - Conceptual Design Stormwater Analyses

(2017–Current)

**Client: City of Delray Beach, Florida**

(subconsultant to **WGI**)

SEA LEVEL RISE

FLOOD RISK ASSESSMENT

HYDROLOGIC & HYDRAULIC MODELING

ICPR4 1D & 2D MODELING

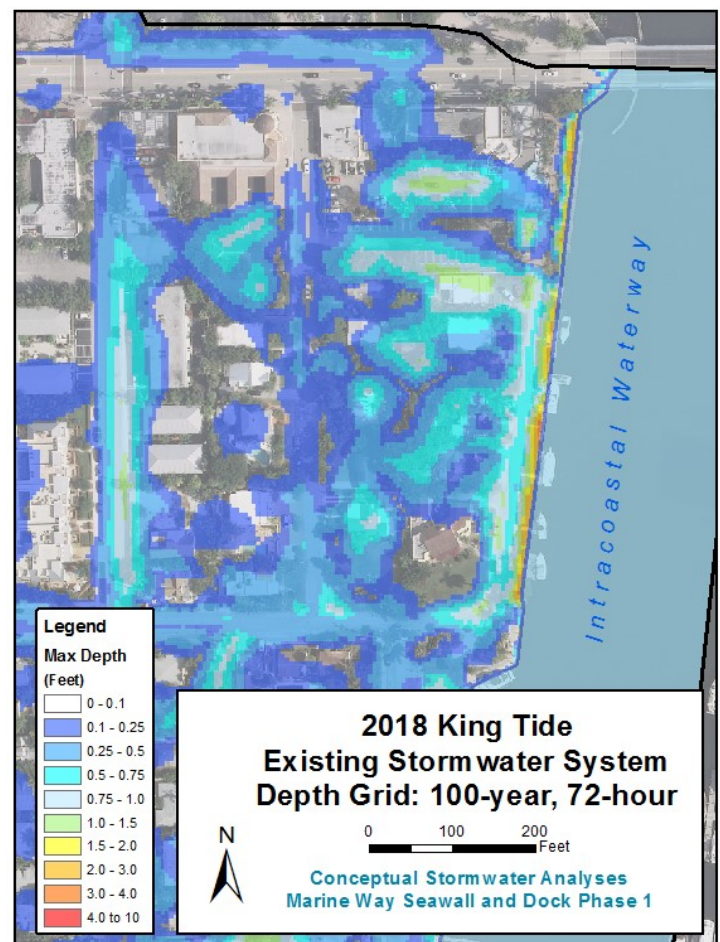
OUTREACH AND EDUCATION

Collective (as a subconsultant to WGI) is providing stormwater analysis for WGI's conceptual design of stormwater improvements along Marine Way in the City of Delray Beach, Florida. This area is routinely flooded during King Tides and is subject to numerous concerns from homeowners in the area. The project aims to improve the stormwater system and elevate seawalls to mitigate localized flooding and strengthen community resilience. Collective used ICPR4 with a combination of one- and two-dimensional surface water components to analyze the existing and proposed stormwater systems to assess the feasibility of proposed seawall and pump alternatives under existing and future tidal conditions.

The City has now requested a more detailed level of modeling and assistance with educating the residents regarding flood management, flood insurance, and King Tides. Detailed design is commencing.

## More specifically, Collective is/has provided:

- 1- and 2D Modeling to support detailed design
- Alternatives Analysis and Detailed Design
- Sea Level Rise and High Tide Analysis for a visible area in Palm Beach County
- Regulatory Coordination (SFWMD)
- Support to staff during numerous and complex public meetings
- Extensive coordination to provide City staff with flood risk exhibits and graphical aids



# Stormwater Master Plan and Design Implementation

(2016–Current)

**Client: City of Fort Lauderdale, Florida**  
(subconsultant to Hazen & Sawyer)

LEAD MODELER FOR LARGE PROJECT

INTEGRATED SW/GW MODELING

BROWARD COUNTY

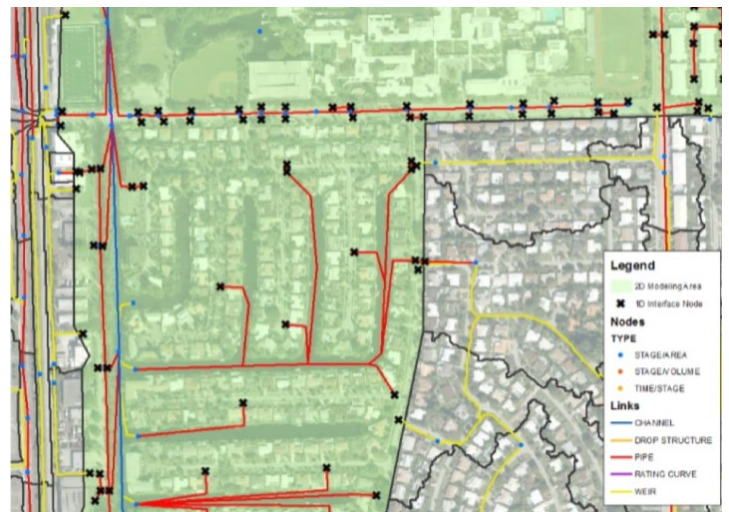
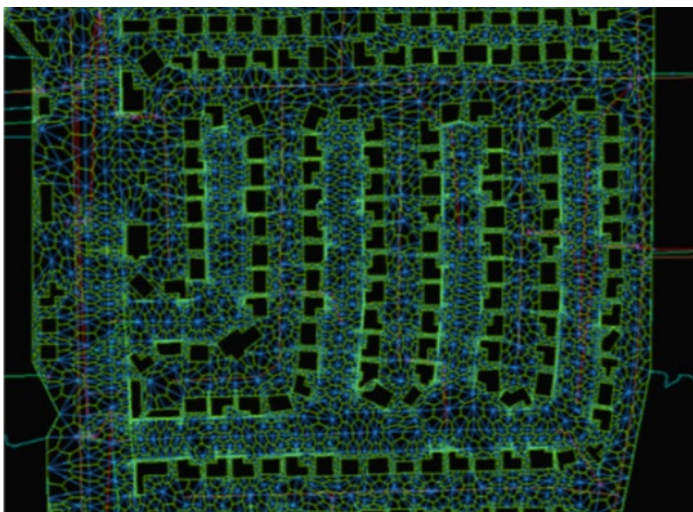
COASTAL AND URBAN AREAS

MULTIPLE WORKSHOPS AND TRAINING

Collective is a sub-consultant serving as the modeling lead for the City of Fort Lauderdale's Stormwater Master Plan Modeling and Design Implementation supporting the development and implementation of a stormwater model of the City to address chronic flooding and other stormwater management issues. The City is composed of ten individual watersheds ranging in size from approximately 2,100 to 10,500 acres characterized by urban development, low-lying topography and intersected by numerous canals and rivers. Collective is developing models for three of these watersheds (Cypress Creek, S-37A, and Intracoastal Waterway North). Recognizing the significant extent of flat topography intersected with a network of interconnected canals in the City, a combination of one-dimensional and two-dimensional surface water modeling is being applied. **This, integrated with groundwater modeling of the surficial aquifer, is developed for each of the City's watersheds using Interconnected Pond and Routing model, version 4 (ICPR4). Additionally, the effects of rising sea levels and associated effect of reduced soil storage on runoff are being evaluated for six, potential future tidal conditions.**

## More specifically, Collective is/has:

- Supported the modeling task kick-off meeting with City staff
- Completed a review of existing studies and models including the City's previous SWMM model, USGS SEAWAT model of Broward County for evaluating hydrologic alterations, and Broward County's Mike SHE/11 integrated model
- Developed the conceptual modeling approach and standards for hydrologic, hydraulic, groundwater, and model parameterization that are being applied City-wide
- Developed future water table elevations and hydrogeologic parameters based on the USGS SEAWAT model for Broward County
- Established flow and stage boundary conditions for South Florida Water Management structures
- Performed integrated surface and groundwater modeling for three City watersheds
- Performed independent quality control reviews for other City watersheds
- Executing five design storms for seven existing and future conditions scenarios – totaling 35 simulations per watershed
- Performing the flood protection level-of-service analysis throughout the City
- Identifying areas of concern for future alternative analysis
- Conducting a modeling results workshop with City staff
- Developing and implementing training to City staff on the model; and Supporting the conceptual permitting of the watershed models so these may be used for evaluating capital improvement projects.





## Stormwater Master Plan Update

City of Miami (2018 – Present, ongoing)

Brizaga, along with its strategic partner, MAGBE Consulting Services, directed and provided the outreach and education associated with the City of Miami's Stormwater Master Plan Update. Alec Bogdanoff served as project manager for the communications and outreach team. This included the development of a communication strategy, assistance with creation of materials for print, social media, and newsletters, and planning and execution of the public outreach meetings. The materials developed were non-technical and designed for consumption by the general public. Our team ensured that all meetings were informative and interactive. Alec and the team had to be intimately familiar with the work of the City of Miami and that of the Southeast Florida Regional Climate Change Compact.

A new challenge for the Master Plan Update was the direct consideration of sea level rise and future changes in storm intensity. This required careful and clear communication. Additionally, the Master Plan Update is being used to inform the next tranche of the Miami Forever Bond, so communications were coordinated across departments and designed with the understanding that public support for future bond projects is essential.



### Brizaga staff on project:

- Alec Bogdanoff, Ph.D. (Lead for Brizaga/MAGBE)
- Michael Antinelli, PE, CFM (Outreach and Engineering Support)

Dr. Alec Bogdanoff assisting community members identify types of flooding and where they have observed it.

### Reference:

- Name: Sylejman Ujkani, Bond Manager
- Email: [sujkani@miamigov.com](mailto:sujkani@miamigov.com)
- Phone: (305) 416-1267

**Cost:** \$67,779 (our portion of total project with MAGBE)





## **Cemetery Master Plan**

City of Fort Lauderdale (2018-2019, 1-year engagement)

Brizaga was part of the team that completed the City of Fort Lauderdale's Cemetery Master Plan and led the implicit consideration of sea level rise and changes in groundwater in the development of the Plan. Brizaga assisted in developing a geo-spatial database that examined the scale of flooding and groundwater inundation as it relates to the current number of gravesites.

Brizaga utilized the flooding data, present and future, as well as groundwater levels to assist in the overall site plans for the four cemeteries, specifically considering the projections of the Southeast Florida Regional Climate Change Compact. Alec and Michael developed guidance materials to assist the Keith team in understanding the anticipated longer-term sea level rise scenarios and how these affect the rate at which the groundwater table rises, and the resulting surface water inundation. The work involved the evaluation of any existing groundwater monitoring wells as well as tidal and rainfall records to develop a relationship in the vicinity of the various cemeteries.

The groundwater and surface water flooding extents were utilized to analyze the influence and inform decision-making for various asset classes, specifically critical infrastructure, gravesite management, and future siting.

### **Brizaga staff on project:**

- Alec Bogdanoff, Ph.D. (Science Lead & Resilience Specialist)
- Michael Antinelli, PE, CFM (Resilience Specialist)

### **Reference:**

- Name: Stacy Spates, Cemetery Administrator
- Email: [SSpates@fortlauderdale.gov](mailto:SSpates@fortlauderdale.gov)
- Phone: (954) 524-2947

**Cost:** \$9,750 (our portion of total project)

## Vulnerability Assessment & Adaptation Strategies

Village of Key Biscayne Community Foundation (2017, 1-year engagement)

*\*At previous firm*

Brizaga's strategic partner, Irela Bagué (of MAGBE Consulting Services, Inc.), served as the lead on the project, tasked to plan, coordinate, conduct and moderate two (2) public town hall style meetings for the Key Biscayne Community Foundation. Brizaga's founders supported these meetings by participating in a panel and in one-on-one discussions with community stakeholders to present the preliminary findings of a vulnerability assessment performed for the Village, designed to identify specific areas within the neighborhood that may experience



Community meeting in the Village of Key Biscayne.

nuisance flooding in the near future along with timelines of their potential occurrences. The public meetings included a review of resident surveys, flood projections and sea level rise science, and engaged the community members in planning for the next steps in concert with the Village. As part of the project, Michael and Alec prepared the final sea level rise vulnerability assessment and adaptation strategy report for the Village that examined roadway elevations with consideration for local sea level rise projections and outlined possible mitigation strategies.

### Brizaga staff on project:

- Alec Bogdanoff, Ph.D. (Project Lead/Manager)
- Michael Antinelli, PE, CFM (Resilience Specialist)

### Reference:

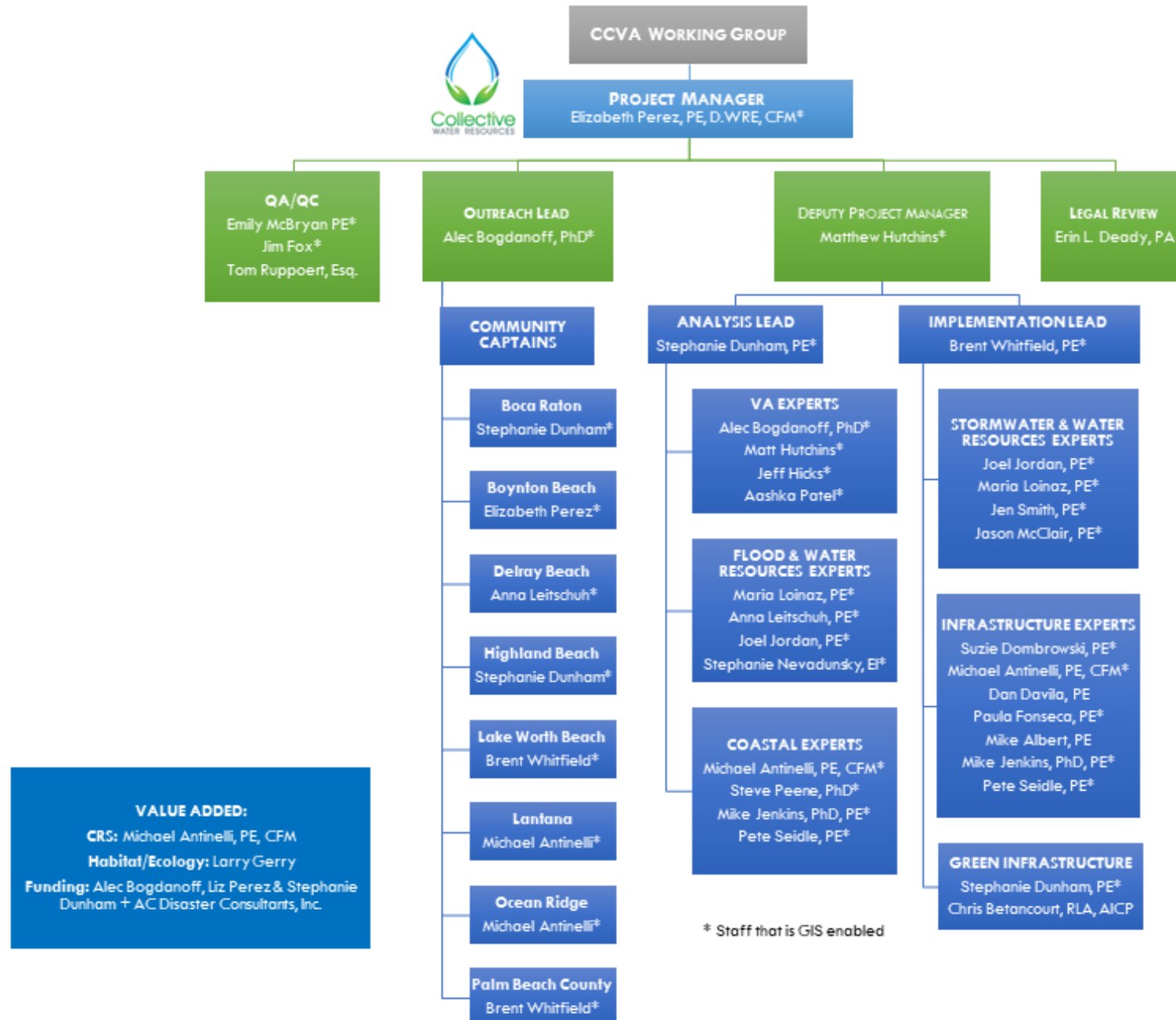
- Name: Rumya Sundaram, Citizen Science Coordinator
- Email: [rumya@keybiscaynefoundation.org](mailto:rumya@keybiscaynefoundation.org)
- Phone: (305) 361-2770

## 2.2. Expertise – Resumes for Key Staff

Our approach (provided in Section 1) provided some information on team roles and how key staff would work together on this CCVA. A breakdown of key staff and an organizational chart follow. Resumes for key staff (for the past 3 years) follow our organizational chart.

<b>Project Manager</b>  Boynton resident, Liz Perez, will be the primary contact for the Working Group and will tend to major project details (scope, schedule, budget, and QC). She will be available for project communications at all times and work with the leadership team to deliver an outstanding CCVA.	<b>QA/QC Team</b>  An engineer (Emily McBryan), scientist (Jim Fox), and attorney (Thomas Ruppert) will be responsible for creating and enforcing quality assurance and quality control on the project. They will act as <u>objective reviewers</u> for both methodology and deliverables as they will not be embedded in the day-to-day activities on the project.	<b>Deputy PM</b>  Due to their significant role on our team, an experienced project manager from Fernleaf will be the Deputy PM (Matt Hutchins) for this assessment. Matt and Liz have worked together on two major assessments previously and will provide a balanced team approach to the management and technical aspects of the project.	<b>Lead Community Captain</b>  Alec Bogdanoff will be the dedicated director of our Community Captains team. Alec is also an experienced and tested communicator with regards to climate change. This role will leverage both his outstanding technical background and excellent communication style.
<b>Community Captains</b>  An expert has been assigned to each community to act as an embedded technical advocate for each jurisdiction. All of our Community Captains are GIS “Power Users” and experienced technical experts – and all are local.	<b>Analysis Lead</b>  Boca Resident and experienced analyst, Stephanie Dunham, will direct the analysis team. She was one of the first engineers in Florida to work on assessments of this type and has over 20 years of experience with multi-objective environmental projects.	<b>Implementation Lead</b>  Lake Worth Resident and experienced engineer, Brent Whitfield, will direct the implementation team. This is the team that will work on the asset, costing, and final tasks of the CCVA. His team will provide a practical counterbalance to the analysis team.	<b>Legal Review</b>  Lantana resident and pioneering legal expert, Erin Deady, will work with the team throughout all tasks to assist with legal, Comp Plan, AAA, and related questions.

# Organizational Chart



# ELIZABETH M. PEREZ, PE, D.WRE, CFM

## President

Project Role: Project Manager



*Elizabeth Perez, P.E., D.WRE, is President and Founder of Collective Water Resources, LLC. Liz has established a strong reputation as a technical expert throughout Florida, not only for her project work but also for her dedication to professional service and involvement in various technical publications. Most notably, she has served as a member of the National Energy, Environment, and Water Policy Committee within the American Society of Civil Engineers and is a co-author on the 8th and upcoming 9th Editions of the well-known textbook Water Supply and Pollution Control. Liz's involvement*

*in analyzing climate change started during work on her MS at the Georgia Institute of Technology in 2000 and she has been passionate about contributing to high quality analyses to address this issue ever since. She has also designed and taught classes on stormwater design and modeling both at the University of Florida's TREEO Center and in conjunction with various professional organizations. A sampling of Liz's broad professional experience follows, which includes sea level rise/climate change, water supply planning, watershed management, surface water modeling/analysis, GIS, regulatory advocacy, and the creation of various guidance documents for various public agencies.*

## RELEVANT PROJECT EXPERIENCE

### All Hazards Vulnerability and Risk Assessment

#### City of Charleston, SC

##### *Lead Water Resources/Water Threat Analyst and Engineer*

Collective is currently assisting NEMAC+Fernleaf with a comprehensive assessment for the City. Ms. Perez led the team in securing and then analyzing best available water resources data and advised the City on many decisions involving flooding and stormwater. She also consulted with the team on drought and contributed to project reports and presentations.

### Various Ongoing Resiliency/Stormwater/Water Resources/Water Quality Projects

#### City of West Palm Beach, Florida

Since founding Collective Water Resources, Ms. Perez has consistently worked for the City of West Palm Beach. City project highlights include:

## EDUCATION

M.S.C.E., Civil Engineering,  
Georgia Institute of  
Technology

B.S., Environmental  
Engineering, University of  
Florida

## REGISTRATIONS

PE, Florida (61023)

Diplomate, American  
Academy of Water  
Resources Engineering

Certified Floodplain  
Manager

## AFFILIATIONS

Current  
Secretary/Treasurer, Florida  
Stormwater Association

Private Representative:  
Palm Beach County LMS  
Steering Committee

Class of 2015, Leadership  
Palm Beach County



- **Since 2017, Ms. Perez has worked with NEMAC+Fernleaf on various phases of resiliency planning.** She provided data, refined analyses as needed, and engaged in workshops to assist the City with decision making. She has also contributed to the team's reports and provided quality control for data and analyses.
- Collective Water Resources was the prime consultant that coordinated and managed the City of West Palm Beach's Stormwater Master Plan. The project included a comprehensive and progressive scope - especially aspects of hydrologic/ hydraulic analysis and modeling, GIS, stormwater atlas enhancements, outreach, grant funding, CRS program enhancements, water quality analysis, **climate change/ sea level rise**, BMP implementation, CIP refinement and many other considerations for enhancement of the City's stormwater resources. Ms. Perez was the Project Manager and Lead Engineer for this project. This project served to provide the Hydrologic Baseline analysis that was eventually used by NEMAC+Fernleaf for their analyses and work products.
- Ms. Perez coordinated the response to the 2017 Effective Digital Flood Insurance Rate Maps (DFIRMs) on behalf of the City. This extensive effort included the coordination of comprehensive responses the DFIRMs on a City-wide basis and technically advocating for the City to FEMA and their consultants. Acted as an extension of staff to respond to FEMA's inquiries and requests for data in a timely manner. **Ms. Perez was also just asked by the City, County, and League of Cities to assist with the review of the draft Coastal Risk Maps, which are currently pending with FEMA.**
- Coordinating updates to the City's Floodplain Management Plan as part of interdepartmental work between the Utilities Department, Planning Department, and Engineering and Public Works. Required extensive facilitation of planning efforts between staff, elected officials, City's Water Advisory Board, County officials, and Northern Palm Beach County Improvement District. Also coordinating numerous meetings for Floodplain Management Committee (comprised of citizens and local business officials) and drafting Plan Update for approval by City Commission. As a result of the success of this effort, Collective was brought onto another contract in 2017 to assist with updates to the Plan. **Ms. Perez works consistently with the City to maintain their CRS Rating (currently at a 5) and relevant datasets.**

## **Marine Way Seawall and Docks Conceptual Stormwater Analysis (Phases 1 and 2)**

### *Outreach Assistance and Strategy/Water Resources Engineer*

Collective Water Resources is worked as a subconsultant to Wantman Group, Inc (WGI) to develop plans for the Marine Way corridor. Collective is responsible for assessing stormwater quantity as input for the design of a seawall, pump, and other stormwater improvements. The modeling includes analysis of effects of high tide, king tide, and sea level rise on the existing and proposed project site. Collective is responsible for assessing stormwater quantity as input for the design of a seawall, pump, and other stormwater improvements. The modeling includes analysis of effects of high tide, king tide, and sea level rise on the existing and proposed project site. The project is now moving into the final design phase. Ms. Perez has attended outreach events and assisted the City in the preparation of these events via various exhibits.

## KEY PUBLICATIONS, PROFESSIONAL INVOLVEMENT, AND AWARDS

- Diplomate, American Academy of Water Resources Engineers
- Certified Floodplain Manager
- Current Secretary/Treasurer/Board of Directors: Florida Stormwater Association
- Former Committee Chair: Florida Stormwater Association's Membership Committee
- Current Member: National Association of Floodplain Managers
- Private Representative/Volunteer: Palm Beach County LMS Steering Committee
- Former Member of National Energy, Environment, and Water Policy Committee within the American Society of Civil Engineers (2008-2009)
- Former Environmental and Water Resources Institute (EWRI) Chair, Water Resources Planning Committee (2006-2008)
- Former EWRI Task Committee Chair, Role of Technology in Water Resources Planning and Management (2006-2007)
- Former Statewide Director at Large for Mutual Organizations, FWEA (2007-2012)
- Past Chair, *Florida Watershed Journal* (2009-2012)
- Board Member, Gale Environmental Academy at Forest Hill High School, West Palm Beach, Florida (2017)
- Associate Member of the Year, Palm Beach County League of Cities (2016)
- Athena Award Winner from the Chamber of Commerce of the Palm Beaches (Business Category), 2017
- Speaker and Coordinator: Florida Stormwater Association's Annual Conference, Pre-Conference Summer Seminar: Sea Level Rise and Climate Change
- Co-Author of Undergraduate Textbook: "Water Supply and Pollution Control (8<sup>th</sup> Edition)", published by Pearson/Prentice-Hall in June 2008
- Co-Author, "Toward a Sustainable Water Future: Visions for 2050" (Book Published by the American Society of Civil Engineers, 2012)
- Editor, Task Committee Leader, and Co-Author "The Role of Technology in Water Resources Planning and Management" (Book Published by the American Society of Civil Engineers, April 2008)
- Presentation: "New Functionality for Watershed Management. What is Possible?" Florida Floodplain Managers Association Conference in Stuart, Florida, 2007
- Co-Author, "The Status of State Water Resources Planning in the United States 2005" (Book Published by the American Society of Civil Engineers, March 2006)
- Florida Stormwater Association Annual Conference, Presentation: "GIS-Based Interdisciplinary Modeling for Stormwater Wetlands", 2005
- Editor and Chair, *Florida Watershed Journal*, 2007-2010, Florida Water Environment Association



NEMAC+FernLeaf

## Matt Hutchins

Services Lead and Senior Resilience Analyst

### Expertise

Vulnerability and Risk Assessment

GIS Technologies for Decision Support

Project Management

Workshop Facilitation

### Experience

12 total years

10 years with firm

### Professional Activities

American Society of Adaptation Professionals

### Education

MLAS Climate Change and Society, University of North Carolina Asheville, 2015

BS Environmental Studies, University of North Carolina Asheville, 2008

*Matt has over a decade of experience supporting groups and communities in planning and making informed decisions. He has specialized expertise in quantitative resilience assessments supported by GIS, and working with communities on implementing options to build resilience.*

### **All Hazards Vulnerability and Risk Assessment, City of Charleston, SC March 2019-January 2020**

Project Manager and Lead Resilience Analyst for NEMAC+FernLeaf.

Hutchins has managed the Assessment Team and led the development of the vulnerability and risk analysis in AccelAdapt. The City is using the assessment to develop and prioritize options to build resilience. Outputs of the assessment will also be integrated with the City's new Hazard Mitigation Plan.

### **Climate Resilience Plan, City of West Palm Beach, FL August 2017-January 2020**

Resilience Analyst and co-facilitator for NEMAC+FernLeaf. Hutchins has developed the detailed rulesets that drive the vulnerability and risk analysis in AccelAdapt. The team has used his products to conduct workshops with West Palm Beach leadership and municipal staff to develop a detailed local-scale vulnerability and risk analysis. The City is using the vulnerability analysis to develop and prioritize options.

### **Resilience Partnership Resilience Assessment, Triangle Region, NC February 2017-September 2018**

Lead resilience analyst for a team working with staff from six jurisdictions in a series of facilitated workshops to develop a regional vulnerability and risk analysis with AccelAdapt and formulate strategies for building resilience. Hutchins worked with stakeholders at several government agencies to localize the assessment by including local ordinances and existing capital improvements.

### **Process Development, U.S. Climate Resilience Toolkit February 2014-Present**

Member of a project team that developed content and process for the Steps to Resilience, a five-step framework for communities to use in resilience planning. Hutchins' focus was on the development of how communities can consider the concepts of vulnerability and risk to conduct quantified assessments and use them to identify resilience strategies.

# STEPHANIE Y. DUNHAM, PE

Vice President, Engineering

Project Role: Analysis Lead



*For over 20 years, Stephanie has supported comprehensive water resource management for public entities ranging from local, county, state, as well as Federal clients. In 2014, she became one of Florida's first engineers to start modeling sea level rise and considering resiliency as a routine part of her projects. Throughout her career, Stephanie has managed, developed, and reviewed surface water models as well as integrated surface-groundwater models using tools such as: ICPR, SWMM, MIKE SHE/11, HEC-HMS, and HEC-RAS, often coupled with ArcGIS tools and data management protocols such as ArcHydro. Ms.*

*Dunham modeling experience includes dendritic, non-dendritic, lake, and urbanized/managed systems throughout central and south Florida. Additionally, Ms. Dunham developed an independent peer review technical approach utilized by SWFWMD for hydrologic and hydraulic models to determine whether they had sufficient resolution and accuracy for use in its Environmental Resource Permit review process. Model reviews incorporated both geospatial analysis using ArcGIS as well as statistical analyses using SAS. Throughout her career, Ms. Dunham has collaborated on as well as synthesized results from hydrologic, hydraulic, water quality, natural systems, and economic assessments to develop and prioritize strategies that address flood protection, water supply, natural systems, and public use priorities.*

## RELEVANT PROJECT EXPERIENCE

### Comprehensive Stormwater Management Plan, City of Aventura

#### *Project Manager*

Collective Water Resources was a sub-consultant supporting the City of Aventura's Comprehensive Stormwater Management Plan and **was responsible for preparing a Climate Change and Sea Level Rise Plan** and associated model input parameters to support evaluation of future flood protection level of service and adaptation strategies. Specifically, Collective Water prepared a technical summary of how climate change may impact stormwater management; current science and climate models appropriate for local and regional projections of impacts to sea level, precipitation, and tropical cyclone frequency and intensity; and how climate change projections have been applied by other public entities within South Florida to stormwater planning and design. Additionally, Collective Water prepared a Climate Change and Sea Level Rise Plan specific to the City with recommendations on sea level rise projections and their application in

## EDUCATION

BS, Civil Engineering, Texas A&M University

MS, Civil Engineering, The University of Texas at Austin

## REGISTRATIONS

PE, Florida (59782)

PE, Texas (Inactive, 90915)

## AFFILIATIONS

Florida Stormwater Association

Florida Floodplain Managers Association

American Water Resources Association

evaluating future flood protection level of service as well as analysis of stormwater adaptation alternatives. Ms. Dunham serves as the project manager and was responsible for preparing the technical summary and developing the Climate Change and Sea Level Rise Plan.

## **Stormwater Master Plan Modeling and Design Implementation, City of Fort Lauderdale**

### *Project Manager*

Collective Water Resources is a sub-consultant serving as the stormwater modeling lead for the City of Fort Lauderdale's Stormwater Master Plan Modeling and Design Implementation supporting the development and implementation of a hydraulic/hydrological stormwater model of the entire City of Ft. Lauderdale. **The model will consist of a comprehensive basin by basin analysis of the existing and proposed stormwater systems, and how they react to different boundary conditions, including future projected climatological conditions.** Based on the model results, conceptual solutions for individual neighborhood capital improvement projects (CIP) will be developed, specifically in the areas found to be most susceptible to chronic flooding. Collective Water is responsible for supporting the modeling task kick-off meeting, completing a literature review, developing the conceptual modeling approach and standards that will be applied City-wide, performing hydrologic and hydraulic modeling for three City watersheds (Cypress Creek, S-37, and Intracoastal Waterway North), preparing the City-wide model by integrating watersheds developed by other team members, executing design storm and future conditions simulations, performing the level-of-service analysis throughout the City, conducting a modeling results workshop, and developing and implementing training to City staff on the model. Ms. Dunham is Collective Water's project manager.

## **Marine Way Conceptual Design Stormwater Analyses, City of Delray Beach**

### *Technical Lead and Quality Assurance.*

Collective Water Resources, as a subconsultant, provided stormwater analysis for conceptual design alternatives of stormwater improvements along Marine Way in the City of Delray Beach, Florida. Area residences have experienced reoccurring flooding due to king tides and the project aims to improve the stormwater system and elevate seawalls to mitigate localized flooding and strengthen community resilience. Collective used ICPR4 with a combination of one- and two-dimensional surface water components to **analyze the existing and proposed stormwater systems to assess the feasibility of proposed seawall and pump alternatives under existing and future tidal conditions.** Ms. Dunham directed the technical approach for parameterization and model development and performed quality assurance reviews.

## **General Engineering Services: Datura Green Street Improvements, City of West Palm Beach**

### *Project Manager*

As Project Manager for the Datura Green Street Improvements Alternatives Analysis Work Authorization, Ms. Dunham coordinated a diverse team to perform pre-design analysis services to improve stormwater management and integrate green stormwater infrastructure within the northern right-of-way of Datura Street, located in downtown West Palm Beach. Specifically, Ms. Dunham managed a team of civil design, landscape design, and surveying professionals; collected and reviewed site data, identified additional services from other technical professionals necessary to design, permit, and/or manage construction of the proposed improvements; reviewed and performed a comparative analysis of green stormwater/street improvements applicable to the project area; and developed documents to present applicable design criteria, alternative solutions, general economic analysis, and recommendations.



## ALEC S. BOGDANOFF, PH.D.



**Position:** Principal, Director of Science & Communications

**Specialization:** Resilience Policy and Communications, Public Outreach and Engagement, Outreach Strategy, Meteorology and Oceanography

**Education:** **Ph.D.**, Physical Oceanography, Massachusetts Institute of Technology (MIT) / Woods Hole Oceanographic Institute (WHOI), 2016  
**M.S. & B.S.**, Meteorology, Florida State University, 2010/2008

**Affiliations:** Resilience Committee (Chair, Greater Fort Lauderdale Chamber of Commerce); American Meteorological Society; American Geophysical Union; Urban Land Institute (Co-Chair, Resilience Committee, SE Florida)

### KEY QUALIFICATIONS

**Alec Bogdanoff, Ph.D.** is a policy-trained oceanographer and meteorologist with nearly two decades of political experience, including managing campaigns. He has extensive experience in simplifying and effectively communicating complex scientific processes with private citizens and other interested parties. As Director of Science and Communication, he is responsible for monitoring and identifying scientific research and advances in the areas of sea level rise and extreme weather, including datasets and models, to further develop internal technologies, as well as strategic communications and public outreach and engagement for Brizaga.

### SELECT PROFESSIONAL EXPERIENCE

#### **Fort Lauderdale Cemetery Master Plan, City of Fort Lauderdale, FL, 2018-2019**

Led the sea level rise vulnerability component of the master planning process, evaluating the risks of sea level rise to site layouts and proposed programming. Conducted research of precedent and provided strategic recommendations and timelines for implementation of best management practices.

#### **Community Outreach for Rising Above, City of Miami Beach, FL, 2017**

Directed a team of scientists and engineers in the science communication element of a community outreach program hosted by the City as part of its "Rising Above" campaign for sea level rise adaptation. Developed customized materials for homeowners to understand the expected effects of sea level rise specific to their community, as well actions that could be taken on an individual basis. Performed quality control for the supplemental report to the City providing specific elevations, sea level rise projections, and illustrations to visualize the effects of sea level rise on a property level.

#### **Vulnerability Assessment & Adaptation Strategies, Village of Key Biscayne Community Foundation, 2017**

Prepared the final sea level rise vulnerability assessment and adaptation strategy report for the Village of Key Biscayne. Specifically examined roadway elevations and sea level rise projections to identify and communicate the areas within the Village most vulnerable to flooding due to sea level rise and storm surge. Participated as a key panel member in a town-hall style community outreach event to discuss findings of the assessment and answer questions from stakeholders.

#### **John A. Knauss Sea Grant Fellow, Office of Senator Edward J. Markey, 2016-2017**

Coordinated relevant policy with senior staff; Drafted speeches, legislation, amendments, policy briefs, oversight letters, and press releases on issues pertaining to the environment, oceans, fisheries, water, and wildlife. Drafted and introduced legislation to improve federal water infrastructure statutes; Prepared statements, memos and questions, and handled relevant legislation in Committees. Drafted hearing memos and helped facilitate witnesses for EPW subcommittee.

*Presentation list available upon request.*



NEMAC+FernLeaf

**Jeff Hicks**

Resilience Analytics Lead and CEO

### Expertise

Climate Resilience  
Risk Analysis  
GIS and Visualization  
Software Development  
for Resilience

### Experience

14 total years  
6 years with firm

### Professional Activities

American Society of  
Adaptation Professionals

### Education

BS Environmental  
Studies, University of  
North Carolina at  
Asheville, 2008

*Jeff has over 13 years of experience in climate and environmental data-driven decision support and analysis for a wide range of stakeholders. He has led and supported quantitative vulnerability assessments that have helped target the best investments to build resilience throughout the Southeastern US.*

### **Climate Resilience Plan, City of West Palm Beach, FL August 2017-January 2020**

Project lead for NEMAC+FernLeaf. The team is conducting a detailed local-scale vulnerability and risk analysis with AccelAdapt and leading a series of workshops with West Palm Beach municipal staff to develop actionable projects and strategies to build resilience. The analysis included a transportation barrier analysis to identify limited points of access that isolate people and assets during inundation events.

### **Citywide Vulnerability Assessment and Adaptation Plan, City of Hollywood, Florida // February 2019-Present**

Performed technical analysis and mapping for the extreme heat vulnerability assessment focusing on indicators of potential urban heat islands and social vulnerability. Jeff helped lead a workshop for City staff in Hollywood focused on aspects of potential temperature change issues. Provided technical guidance to the prime firm about considering climate change in the overall assessment.

### **Community Resilience Assessment, Tallahassee, FL February 2018-April 2019**

Lead developer of analyses and visualizations with AccelAdapt that helped city staff understand the regional trends and trajectories in climate and socioeconomic threats that affect change at a local level. At the neighborhood scale, Mr. Hicks led development of the analyses that are helping City staff understand their vulnerability and risk to various climate threats. This analysis included identifying which sections of the city isolated from emergency management vehicles due to roads being flooded.

### **Data Analysis and Software Development, U.S. Climate Resilience Toolkit // April 2014-Present**

Lead data analyst and software engineer for the Climate Explorer, the featured resilience tool that supports the site's Steps to Resilience framework. In a recent expansion, Hicks led development of a county-scale projection time series tool that makes it possible for users to interact with terabytes of climate data. He has also conducted workshops for local government using the site's content to assist in local resilience planning efforts in South Florida.

## Summary/Profile

### EDUCATION

BA Marine Science Affairs, University of Miami

MPA, Florida Atlantic University

JD, Nova Southeastern University

### PROFESSIONAL REGISTRATIONS

Florida Bar, American Institute of Certified Planners, US Green Building Council

### YEARS EXPERIENCE

Total: 22

Erin L. Deady, P.A., is a full service legal and consulting firm. Firm President, Erin Deady, is a licensed attorney in Florida, a certified land planner by the American Institute of Certified Planners (“AICP”) and a LEED AP. Ms. Deady's practice is primarily focused on public sector government representation but also includes numerous private sector and agricultural clients. Ms. Deady's practice includes sustainability environmental restoration initiatives, water, energy, climate, local government, administrative law and land use issues.

Ms. Deady's experience includes litigation, public finance, special purpose governmental representation and creation and land use planning. Erin is a frequent lecturer and author on climate change, energy, environmental restoration and public finance issues statewide and nationally.

## Project Experience

### ***Sustainability Action Plan Update and Comprehensive Plan, West Palm Beach, FL (2012-Present)***

#### ***Project Manager***

The firm was the project manager for the development of the City's Sustainability Action Plan developed in 2012 and currently works with the City updating its Sustainability Action Plan coordinating with the new LEED for Cities framework. The firm previously achieved a 4 STAR rating for the City through the Sustainability Tools for Assessing and Rating Communities in late 2016. Companion with the effort, the firm also drafted Comprehensive Plan Amendments to the Coastal Element of the City's Comprehensive Plan to address the Peril of Flood (SB 1094) legislation passed in 2015. The current scope of work includes the development of a new separate Resiliency Element of the Comprehensive Plan. The current update project is projected to be completed by mid-2020 ultimately resulting in an update document for the City's original Sustainability Action Plan.

### ***Monroe County Roads and Stormwater Vulnerability Assessment (2019-present)***

#### ***Subconsultant- Policy, Legal Issues & Outreach***

The firm is a subconsultant on a two-year in Monroe County developing the legal, policy and technical framework for a short, medium and long-range roads and stormwater capital planning program specifically to address sea level rise impacts and flooding issues. The firm leads the portion of the planning process including numerous legal and policy deliverables related to level

of service for flood resilience, capital programming driven by future growth projections, an overview of the regulatory environment, funding strategies and legal obligations related to maintenance and upgrades of infrastructure. The firm also leads the public outreach component including numerous stakeholder meetings and internal coordination.

### ***Comprehensive Plan Update, Monroe County, FL (2019-present)***

#### ***Project Manager***

The firm successfully secured a FDEP Resiliency Planning Grant for Monroe County to update its Comprehensive Plan to comply with Peril of Flood (SB 1094) legislation passed in 2015. The scope of services includes edits primarily focused on the Coastal and Conservation Element, the Energy and Climate Element and the Capital Improvements Element. Beyond compliance with the Peril of Flood legislation, the scope of work includes integration with the last 6 years of sea level rise vulnerability planning and modeling work into the Comprehensive Plan. The firm was also a team member from 2011-2013 to update the County's Comprehensive Plan in its last evaluation and appraisal report process and was the lead on development of a separate Energy and Climate Element of the Comprehensive Plan.

### ***Comprehensive Plan Update, Delray Beach, FL (2019)***

#### ***Planning Consultant***

The firm coordinated with City Planning Director and staff as well as sustainability staff to extensively reorganize the City's Conservation Element and expand it to the Conservation, Sustainability and Resiliency Element. The element addresses greenhouse gas management, City operations, waste management and citywide resiliency and adaptation. The firm also led the development of amendments to the Coastal Element to comply with Peril of Flood (SB 1094) legislation passed in 2015 incorporating new data from the City's Seawall Assessment and Stormwater Master Plan Update both addressing sea level rise. The firm also assisted with the development of the Public Facilities and Capital Improvements Elements.

### ***Sustainability Action Plan, City of Sunrise, FL (2017-2019)***

#### ***Project Manager***

Erin L. Deady, P.A. was the project manager for the development of a Sustainability Action Plan for the City of Sunrise including a Greenhouse Gas Inventory, capital project identification, initial vulnerability assessment, public outreach (including stakeholders with a specific focus on the business community) and ultimate plan development. The firm led multiple subcontractors to complete the work on time and on budget with final presentation to the City Commission.

### ***NOAA Grant: "Advancing Understanding of Risk: Increasing Accuracy of Hazard Damage Assessment Tools by Improving Base Data and Analyzing Opportunities and Barriers for Use in Adaptation Planning" in four (4) states (Florida, Georgia, North Carolina and South Carolina) (2016-2019)***

#### ***Florida Co-Investigator***

The firm worked to develop the scope and secure NOAA grant funds to complete numerous technical and policy deliverables related to the integration of Monroe County's vulnerability and FEMA Community Rating System Planning. Building on previous dataset development in

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the GreenKeys Planning process, the effort catalogued stormwater structures across the County and developed an approach to create a Class 4 compliant Watershed Management Plan approved by FEMA. As part of 4-part effort to improve the County's CRS Class Rating from 5 to 4 (anticipated in 2020), the Watershed Management Plan approval is a cornerstone of that effort. The project also included a 4-State Legal and Policy analysis related to maintenance and upgrades of infrastructure focusing on roadways.

***Monroe County Pilot Roads Project: The Sands and Twin Lakes Communities, FL (2016-2017)***

***Project Manager***

The firm led team to create the Pilot Roads project which evaluated adaptation responses to sea level rise and persistent King Tide flooding in two neighborhoods in Key Largo and Big Pine Key. The County undertook the effort to create a standard methodology for future road improvement (elevation) projects. The methodology was also incorporated into a Draft Ordinance for Environmentally Compromised Roads to be considered later this year for adoption by the County. Multiple community presentations, outreach and communications and a final report with a comprehensive legal and policy analysis were all included. The Final presentation to the Board of County Commissioners was to accept the final report and adopt the design methodology in January 2017.

***GreenKeys, Monroe County, FL (2014-2016)***

***Project Manager***

Erin led a multi-firm team to develop the GreenKeys Plan, a climate and sustainability plan for the Florida Keys. The effort included a greenhouse gas inventory, extensive vulnerability modeling, public outreach, web based communications using My Sidewalk and development of the ultimate planning document. A one page plan overview document, Technical Support document regarding sea level rise vulnerability and a Five-Year Work Plan was included estimating staff hours and project costs to prioritize recommendations. The firm also led the effort to achieve a Sustainability Tools for Assessment and Rating Communities ("STAR") certification for a 3-Star rating. The effort was presented to the Board of County Commissioners in June 2016.

**Recent Publications**

- New Evolutions in the Law of Climate Change and Sea Level Rise, *Florida Bar Journal*, January 2020
- Putting Resiliency Planning into Action to Address Climate Change and Sea Level Rise, *Environmental and Land Use Law Section Reporter*, October 2019
- Roads to Nowhere in Four States: State and Local Governments in the Atlantic Southeast Facing Sea-Level Rise (Co-Author), *Columbia Journal of Environmental Law*, January 17, 2019
- Update on the Legal and Planning Issues of Climate Change Facing Florida, *Environmental and Land Use Law Section Reporter*, July 2018
- Why the Law of Climate Change Matters: From Paris to a Local Government Near You, *Florida Bar Journal*, November 2017



# EMILY MCBRYAN, PE

Vice President

Project Role: QA/QC Lead



*Emily McBryan, P.E., serves as Vice President at Collective Water Resources. Ms. McBryan has successfully managed and conducted project engineering for multiple-disciplinary projects in Florida since 1999. Ms. McBryan has led project teams associated with multi-million-dollar contracts, accelerated project schedules and multiple stakeholders.*

*Ms. McBryan's specific project experience is diverse and includes hydrologic/hydraulic modeling, geographical information systems, watershed assessments, water supply, feasibility studies, data management, field data collection, field studies associated with nutrient removal technologies, master plan development, asset management, stormwater system and best management practice evaluations, and permitting. Ms. McBryan is known for her passionate approaches to data integrity and overall quality of work products.*

## RELEVANT PROJECT EXPERIENCE

### **Stormwater Master Plan, City of West Palm Beach, Florida** *Quality Control*

Provided quality control for various components of the holistic Stormwater Master Plan document and many associated deliverables.

### **Water Quality Baseline Report, City of West Palm Beach, Florida** *Project Manager*

Developing a Baseline Water Quality Report that documents the City's hydrologic/hydraulic and water quality data within its source water network. The Report included the objectives of the City's data collection efforts (regulatory/non-regulatory), identify sample collection, analytical methods, quality assurance methods, data summaries, and recommendations for enhancements to the City's source water network program.

### **Stormwater Master Plan Modeling and Design Implementation, City of Fort Lauderdale, Florida** *Quality Control/Engineering*

Ms. McBryan is providing quality control of project deliverables and hydraulic model parameterization as a part of the Project Team developing a City-wide stormwater model (ICPRv4). Part of the quality control effort included the development of a model delivery structure that will be used by the multi-firm team to ensure work products, including model and GIS files, are delivered to the client in a consistent and usable format.

## EDUCATION

BS, Environmental Engineering, University of Florida

## REGISTRATIONS

PE, Florida (60774)

## AFFILIATIONS

President, Board of Directors, Resource Depot

Committee Member, EWRI, Palm Beach County Chapter

American Water Resources Association



**Jim Fox**

Senior Resilience Associate

## Expertise

Climate Resilience  
Workshop Facilitation  
Risk Analysis  
GIS and Visualization

## Experience

42 total years  
15 years with firm

## Professional Activities

American Society of  
Adaptation Professionals  
American Meteorological  
Society

## Education

MS Information  
Technology for Informal  
Education, American  
University, 2004  
BS Geology/Geophysics,  
Communication Minor,  
University of Missouri,  
1979

*Jim helps people understand and make decisions in a complex and changing world. He has expertise in leading decision makers in the process of developing vulnerability assessments and resilience plans; facilitating dynamic and data-driven workshops for decision support; and delivering complex information in an easy-to-understand format.*

## Climate Resilience Plans and Workshops

**State of North Carolina (September 2019-March 2020)**

**City of Charleston, SC (March 2019-January 2020)**

**City of West Palm Beach, FL (August 2019-January 2020)**

**City of Tallahassee, FL (February 2018-April 2019)**

**Triangle Regional Resilience Partnership, NC (2/2017-9/2018)**

**City of Asheville, NC (June 2016-September 2019)**

Senior Resilience Associate and co-facilitator for numerous workshops for FernLeaf Interactive. The team has conducted workshops with each of these jurisdictions' leadership and municipal staff to develop a detailed local-scale vulnerability and risk analysis and formulate strategies for building resilience. Strong growth plus a changing climate that yields more hazards are increasing the risk to each of these city's people and infrastructure. More important than just knowing what to do to build resilience, these workshops build internal capacity for staff in how to integrate resilience activities into their other workflows and relevant planning documents including comprehensive plans.

## U.S. Climate Resilience Toolkit (CRT) (February 2014-present)

Content manager for the national website since its launch in 2014, and a key member of its editorial team. The site was developed and is managed by NOAA's Climate Program Office, and operates under the auspices of the U.S. Global Change Research Program. Fox led the development of two important site features: the Steps to Resilience, the nationally adopted framework for resilience planning; and the Climate Explorer, an interactive map and graph viewer that allows any community in the U.S. to explore its risk exposure. Fox and the toolkit's editorial team have partnered with the Association of Climate Change Officers (ACCO) to conduct workshops for local government using the site's content to assist in local resilience-planning efforts.

# THOMAS K. RUPPERT

## Florida Sea Grant College Program

work: (352) 294-6916

cell: (352) 213-6777

e-mail: truppert@ufl.edu

### SUMMARY

Innovative attorney that has built a research, outreach, and education program on sea-level rise and coastal hazards within the Florida Sea Grant College Program. Mr. Ruppert has worked on projects with local governments and helped shape state and national conversations and legal analysis on the importance of infrastructure as part of legal and financial risk for local governments confronting coastal hazards exacerbated by sea-level rise.

### WORK EXPERIENCE

#### **Coastal Planning Specialist, Florida Sea Grant      Gainesville, Largo & Miami, Florida**

Design and execute Florida Sea Grant's Coastal Planning Program. Evaluate needs by engaging communities in dialogue about coastal planning issues. Plan and host professional development workshops for local government planners, attorneys, managers, staff, and private consultants on legal issues in adaptation to sea-level rise. Develop collaborative grant proposals focused on identified community needs and research involving coastal hazards. Conduct legal research and publish on issues arising from adaptation planning for sea-level rise. Develop, populate, and maintain a website on coastal planning legal resources and news related to current issues. Hire and supervise student research assistants and interns. Lead the Florida Sea Grant Climate Change Working Action Group. 2010-present

#### **Assistant in Environmental Law, Center for Governmental      Gainesville, Florida Responsibility and Inst. for Food and Agricultural Sciences, University of Florida**

Act as liaison between UF IFAS and College of Law for programmatic legal needs of IFAS extension programs. Work with the Program for Resource Efficient Communities in IFAS to develop legal strategies to allow for long-term implementation of low-impact development techniques. Collaborate with UF faculty and extension agents on marine and boating law projects by providing legal research component. Manage grants and contracts. Assist director of UF Law's Conservation Clinic to supervise Conservation Clinic student projects both at UF Law and in San José, Costa Rica for UF Law and the University of Costa Rica's Joint Program in International Environmental Law. 2007-2010.

### EDUCATION

**University of Florida College of Law, J.D. *magna cum laude*, Dec. 2003      Gainesville, Florida**  
GPA: 3.67    Class Rank: 6 of 160    Order of the Coif

**Southwest State Univ., B.A. Lit./Phil., *summa cum laude*, May 1995      Marshall, Minnesota**

### PUBLICATIONS

**BOOK CHAPTER:** Thomas Ruppert, *Take Out the Trash When You Leave: Cleaning Up Properties Abandoned to Rising Seas*, in *A BLUEPRINT FOR COASTAL ADAPTATION* (Carolyn Kousky, Billy Fleming, & Alan Berger, eds., forthcoming 2020, Island Press)

**GUEST COLUMN:** Thomas Ruppert, Governments are beginning to realize they can't protect everyone from the rising sea, but are buyouts the best solution? (Dec. 13, 2019) *The Invading Seas*, available at <https://www.theinvadingsea.com/2019/12/13/governments-are-beginning-to-realize-they-cant-protect-everyone-from-the-rising-sea-but-are-buyouts-the-best-solution/>

**ARTICLE:** Thomas Ruppert, *Sea-Level Rise and Infrastructure: A Challenge for Local Government*, American Bar Association Section on Environment, Energy, & Resources, Science & Technology Committee (Sept. 24, 2019), [https://www.americanbar.org/groups/environment\\_energy\\_resources/publications/st/20190924-sea-level-rise-and-infrastructure/](https://www.americanbar.org/groups/environment_energy_resources/publications/st/20190924-sea-level-rise-and-infrastructure/)

## SELECTED REPORTS

*Summary and Commentary on Sea-Level Rise Adaptation Language in Florida Local Government Comprehensive Plans and Ordinances*, (coauthored with A. Stewart), at [https://www.flseagrant.org/wp-content/uploads/Ruppert-Updated-Sea-Level-Language\\_7.2.15.pdf](https://www.flseagrant.org/wp-content/uploads/Ruppert-Updated-Sea-Level-Language_7.2.15.pdf)

*Sea-Level Rise Adaptation Financing at the Local Level in Florida* (2015) (co-authored with Alexander Stewart), available at [https://www.flseagrant.org/wp-content/uploads/Local-Gov-Financing\\_FINAL\\_10.8.15.pdf](https://www.flseagrant.org/wp-content/uploads/Local-Gov-Financing_FINAL_10.8.15.pdf)

*Environmentally Compromised Road Segments—A Model Ordinance* (2015) (co-authored with Alexander Stewart and John Fergus), available at [https://www.flseagrant.org/wp-content/uploads/Envirtly-Comp-Rds-FINAL\\_10.20.15.pdf](https://www.flseagrant.org/wp-content/uploads/Envirtly-Comp-Rds-FINAL_10.20.15.pdf)

*Select Background on the National Flood Insurance Program* (2013), available at [www.flseagrant.org/wp-content/uploads/NFIP-bkgrnd\\_Ruppert\\_letterhead\\_10.24.131.pdf](http://www.flseagrant.org/wp-content/uploads/NFIP-bkgrnd_Ruppert_letterhead_10.24.131.pdf)

## GRANTS AND CONTRACTS (9 of 21)

Principal Investigator, *Citizen-Driven Flood Risk Management and Adaptation: Empowering Florida's Underserved Communities to Improve Resilience*. \$39,397 National Sea Grant Office. 2019-2020

Associate Investigator, *Optimizing the coupled human and natural system benefits for public land acquisitions in the east central Florida coastal zone: An applied spatial planning and ecosystem services approach*. \$300,000 Florida Sea Grant. 2020-2022

Associate Investigator, *From the Bottom Up: Implementing Resiliency at the Local Government Level Through Data-Driven Analyses and Community Engagement*. \$200,000 Florida Sea Grant. 2016-2018

Associate Investigator, *Advancing Understanding of Risk: Increasing Accuracy of Hazard Damage Assessment Tools by Improving Base Data and Analyzing Opportunities and Barriers for Use in Adaptation Planning*. \$428,590 NOAA and the SE Atlantic Region Sea Grant Programs. 2016-18

## PROFESSIONAL ACTIVITIES AND AWARDS

Florida Climate Institute Faculty Fellow, University of Florida. 2019-21

Article *Roads to Nowhere in Four Jurisdictions: States and Local Governments in the Southeast Facing Sea-Level Rise*, 44 COLUMB. J. ENVTL. L. 67 (2019) selected as one of the top 4 environmental law articles of the year for inclusion in the Environmental Law and Policy Annual Review (ELPAR), a joint publication of the Environmental Law Institute's Environmental Law Reporter and Vanderbilt University Law School. 2019

# ANNA LEITSCHUH, PE

## Project Manager

Project Role: Delray Beach Community Captain, Analyst Team



*Anna Leitschuh, P.E., is a Project Manager at Collective Water Resources. She is a water resources engineer experienced in hydrologic/hydraulic modeling and GIS analyses and mapping. Anna is also known for her excellent cartography and ability to communicate complex water resources concepts in her maps. Her project experience includes stormwater master planning, flood control assessment, data management, hydrologic and hydraulic analyses, watershed planning and assessment, and sea level rise analyses.*

## EDUCATION

B.S., Ecological Engineering,  
Oregon State University,  
2013

## REGISTRATIONS

PE, Florida (84415)

## RELEVANT PROJECT EXPERIENCE

### **Marine Way Seawall and Docks Stormwater Analyses, City of Delray Beach, Florida**

#### *Project Manager*

Collective Water Resources is currently working as a subconsultant to Wantman Group, Inc (WGI) to develop plans for the Marine Way corridor. The project aims to improve the stormwater system to mitigate localized flooding and strengthen community resilience. Collective is responsible for assessing stormwater quantity as input for the design of a seawall, pump, and other stormwater improvements. The modeling includes analysis of effects of high tide, King tide, and sea level rise on the existing and proposed project site. Ms. Leitschuh is project manager for this project (for Collective) and was also responsible for gathering and reviewing existing data in GIS; developing catchments and connectivity; setting up and parameterizing model features; developing an existing conditions ICPR4 (1D, 2D) model; incorporating proposed design elements into the model; analyzing the existing and proposed conditions model results; and documenting data inputs, model development standards, and results in a technical memorandum.

### **Fort Lauderdale Stormwater Master Plan Modeling and Design Implementation, City of Fort Lauderdale, Florida**

#### *Water Resources Specialist*

Collective Water Resources is currently working as a subconsultant to Hazen & Sawyer to develop the Fort Lauderdale Stormwater Master Plan Modeling and Design Implementation approaches. The project will develop a city-wide watershed level stormwater model to and provide solutions for individual neighborhood capital improvement projects. Ms. Leitschuh's specific contributions have involved: compiling topographic and feature model input data; evaluating and refining topographic data using ArcGIS and ArcHydro to preprocess the digital elevation model (DEM) and define catchments and connectivity; setting up model features in ArcGIS; developing model parameters in ArcGIS, ArcHydro, and the Interconnected Channel and Pond Routing (ICPR4) model;



parameterizing hydrologic and hydraulic ICPR4 model inputs (1D and 2D parameters) for import into ICPR; modeling bridges in HEC-RAS for import into ICPR as rating curves; maintaining model data sources and references and geodatabase metadata; importing data from GWIS to ICPR4; analyzing model results; stabilizing model; mapping and analyzing floodplains from model outputs; and documenting model inputs and results.

### **West Palm Beach Stormwater Master Plan, City of West Palm Beach, Florida**

#### *Water Resources Specialist*

Ms. Leitschuh assisted the City in analyzing areas for future infrastructure replacement and with analyzing the added impact of sea level rise on coastal infrastructure. Ms. Leitschuh constructed future (30 year) model scenarios for sea level rise and groundwater; analyzed model results; mapped floodplain inundation polygons and depth grids for the future sea level rise scenarios; and used the results to identify future risk to critical infrastructure. She also helped with GIS analysis and mapping for the Community Rating System (CRS) program and prepared all of the maps for the SWMP.

### **26<sup>th</sup> Street and Flagler Drive Stormwater Improvements, City of West Palm Beach, Florida**

#### *Project Manager*

Collective Water Resources worked as a subconsultant to Holtz Consulting Engineers to develop plans for the 26th Street and Flagler Drive area in West Palm Beach. The existing stormwater pipe along 26th Street was evaluated as part of a condition assessment. Collective was responsible for assessing the hydraulic capacity for the existing and future conditions. The modeling included analysis of effects of sea level rise and future build out on the existing and proposed project site. Ms. Leitschuh was project manager for this project and was also responsible for gathering and reviewing existing data in GIS; downscaling a city-wide model; incorporating proposed design elements into the model; analyzing the existing and proposed conditions model results; and documenting data inputs, model development standards, and results in a technical memorandum.

### **Peer Review Support for Vulnerability Analyses and Adaptation Planning, City of West Palm Beach, Florida**

#### *Data Analyst*

Collective Water Resources is working with NEMAC+Fernleaf to assist the City of West Palm Beach in examining vulnerability to stormwater and sea level rise. Collective is responsible for reviewing reports, data, models, plans or calculations, and providing supporting datasets. Ms. Leitschuh is responsible for managing datasets in GIS to be provided for the vulnerability analysis.

**Brent M. Whitfield, P.E., ENV  
SP**  
**Director of Water  
Resources/Senior Engineer**

#### **Education**

Master of Science, Civil  
Engineering, University of  
Florida, 2003  
Bachelor of Science, Civil  
Engineering, University of  
Florida, 2001

#### **Registration**

Professional Engineer,  
Florida, 65720, 2007

#### **Professional Affiliations**

American Society of Civil  
Engineers  
American Water Resources  
Association  
College Park Neighborhood  
Environment and Water  
Resources Institute  
Florida Engineering Society  
Leadership Florida

#### **Certifications**

Florida Stormwater  
Association (FSA)  
Stormwater Operator  
Certification Level 2  
Statewide Airport  
Stormwater Study  
Envision Sustainability  
Professional

#### **Civic Organizations**

Lake Worth Community  
Redevelopment Agency  
Leadership Florida  
Leadership Palm Beach  
County  
Leadership Palm Beach  
County  
Neighborhood Associations  
Presidents Council

#### **Awards**

ASCE Region 5 Engineer of  
the Year Award - 2019  
ASCE State Section -  
Engineer of the Year - 2018  
National Engineers' Council  
Outstanding Engineering  
Achievement Merit - 2019

Mr. Whitfield is a licensed civil engineer in the State of Florida. With over 17 years of professional experience, Mr. Whitfield has worked for a variety of public sector clients at the City, County and State level. As a life-long resident of Palm Beach County and 15-year resident of the City of Lake Worth, Mr. Whitfield has maintained a commitment to serving the community both professionally and personally serving on the boards of professional societies and civic organizations. In an academic capacity, Mr. Whitfield's previous experience includes a research assistantship at the University of Florida where he was the primary author on a December 2006 paper in the Journal of Hydrometeorology.

#### **Project Experience**

**Neighborhood Street Program - District 4 Year 3 TWO 4.** CMA designed proposed improvements for the roadway, potable water distribution and stormwater management systems for Year 3 of the Neighborhood Street Program in District 4 of the City of Lake Worth.

The scope of services included coordination with the City; public outreach meetings with residents and stakeholders; and detailed design of all features within the right-of-way for 39 city blocks with a total project length of 15,250 linear feet.

For the stormwater management improvements, CMA prepared several alternative scenarios within the EPA-SWMM software to determine the potential for upsizing existing pipes and constructing an additional outfall within the region of 15th Ave South, 17th Ave South and Lakeside Drive, the final design incorporated improvements to local flooding and an adaptable design to accommodate an additional outfall to Lake Worth Lagoon, when funding becomes available.

The design also included replacement of existing water main south of downtown and the reconstruction of several blocks of roadway, sidewalk, curb and gutter. For several locations, the Cold In-place Recycling approach was used to reconstruct existing pavement where the limerock base showed significant failure.

**Worth Avenue - 400 Block.** Chen Moore and Associates was requested by the Town of Palm Beach to provide civil engineering and bidding assistance services for the installation of drainage infrastructure and underground utilities in the 400 block of Worth Avenue. The project was identified by an earlier study, the Mid-Town Drainage Basin Report, which documented the benefits to flood protection that could be realized by the installation of a 1,050-ft long, 36-inch diameter drainage "trunk-line" connecting the 300 block of Worth Avenue more directly to the D-7 Pump Station. As part of this effort, Chen Moore also designed the replacement of the 6-inch AC water main and lining replacement of the 8-inch and 12-inch VCP sewer.

In addition to underground utility design, Chen Moore designed a modification to the roadway typical section to resolve localized drainage issues in front of residential properties. As part of the public outreach effort Chen Moore also coordinated meetings with residents of the Royal Park Homeowners Association and management of the Everglades Club.

**South County Reclaimed Water Transmission Pipeline Phase 1A (R2018-0296) with PBCWUD.** Palm Beach County and Broward County have an Interlocal Agreement related to the construction, ownership, operation, and maintenance of a Regional Reclaimed Water System to deliver reclaimed water from Broward County's northern wastewater treatment plant to the Palm Beach County Water Utilities Department service area. The service initiation to Palm Beach County will be 2 MGD of annual average daily flow by April 2021.

The expansion is being designed in phases for multiple competitively bid construction sub-projects. Detailed construction documents and related permits will be provided to allow the construction of approximately 3.7 miles of reclaimed water pipeline and related facilities to be completed and placed into service before April 2021. The design includes pipe of various size and material, with the transmission main being 24-inch ductile iron pipe and the service lines varying from 10-inch to 12-inch with some sections designed to use C-900 PVC due to corrosion potential. The design also includes a 500 ft horizontal directional drill to cross Glades Road and a private lake. Preliminary field investigations included as-built records review, site investigation and photo study; environmental assessments; subsurface utility engineering; geotechnical investigation; a cultural resources investigation; and survey. The design includes lake discharge facilities to meet irrigation demand at each golf course being served. The permitting process requires a Hillsboro Canal Crossing with the SFWMD; permitting for impacts to County roads; permitting for impacts to trees and wellfields; permitting of reclaimed pipeline; permitting for dewatering during construction. In addition to design, permitting and construction services, Chen Moore will be applying for ENVISION Certification (Institute for Sustainable Infrastructure) on behalf of Palm Beach County.

*The following project was completed by Mr. Whitfield while with another firm.*

**PBIA Conceptual Stormwater Management Master Plan (SMMP).** Palm Beach County Department of Airports. Mr. Whitfield was the Lead Project Engineer responsible for developing a stormwater management system to meet the needs of PBIA and related properties over the course of the "Year 2013/2025 Future Airport Layout Plan (ALP)". The primary features of the ALP that impacted the existing stormwater management system involved significant modifications to two of the three existing runways (Runway 13/31 and Runway 9R/27L), associated changes to the taxiway system, modifying existing airside development on the south side of the airfield and the addition of the Golfview Facilities (new apron and airside development). The stormwater management system was developed using the Interconnected Channel and Pond Routing (ICPR) software. The resulting SMMP document was utilized by ADA as the basis for the DOA's Conceptual Environmental Resources Permit (ERP) application to the South Florida Water Management District. The permit application was approved and has been since utilized as the basis for subsequent construction permits, such as the stormwater management system associated with the Taxiway F Extension project.

## MICHAEL A. ANTINELLI, PE, CFM



**Position:** Principal, Director of Projects & Engineering

**Specialization:** Project Management, Civil and Coastal Engineering, Floodplain Management, Public Outreach and Engagement

**Education:** M.Sc., Coastal & Oceanographic Engineering, Univ. of Florida, 2011  
B.Sc., Civil Engineering, Univ. of Florida, 2010

**Licensure:** Professional Engineer, State of Florida (#78513)  
Certified Floodplain Manager (US-17-09709)

**Affiliations:** Sustainability and Resilience Committee (Chair, American Society of Civil Engineers, FL Section); Coasts, Oceans, Ports and Rivers Institute (Chair, South FL Regional Chapter); Association of State Floodplain Managers

### KEY QUALIFICATIONS

Michael A. Antinelli, PE, CFM is the Vice President and Director of Projects & Engineering of Brizaga, responsible for the oversight and management of all projects and engineering practices conducted by the firm. He has extensive experience in the practices of coastal, waterfront, and site civil engineering and has managed projects at every level, from initial project planning and conceptual design through construction and project closeout. As a Certified Floodplain Manager, he couples the technical components of engineering with the laws and regulations enforced by the local, state, and federal governing bodies to provide clients with the most comprehensive planning tools in preparation of flood related incidents and disasters, including sea level rise and storm surge.

### SELECT PROFESSIONAL EXPERIENCE

#### **Adaptation Guide Prototype for the Bloomberg Mayor's Challenge, City of Miami, FL, 2018**

Developed content for a prototypical mobile application to provide sea level rise adaptation alternatives to residents of the City of Miami. Developed the prioritization structure to present appropriate adaptation alternatives based upon user responses and flood risk information queried from relevant geodatabases.

#### **Flood Protection Design and Engineering, Private Clients, New York and Florida, 2018**

Performed vulnerability analyses, designed and coordinated strategies for multiple flood protection projects for private clients in the New York and Miami metropolitan areas. Developed appropriate flood loading conditions based upon potential storm conditions with sea level rise. Designed flood barrier solutions utilizing cutting edge flood protection technologies for flood depths in excess of six feet.

#### **Charleston Flood Protection Concept, For a National Resilience Org., Charleston, SC, 2018**

Designed flood protection concepts over 1.5 miles in length to protect the western portion of the Charleston Peninsula from flooding in the worst-case Category 1 condition. Concept consisted of a series of berms, seawalls, road-raising and revetments. Concept development considered evacuation routes, current stormwater management and shoreline protection projects currently in development or construction.

#### **Community Outreach for Rising Above, City of Miami Beach, FL, 2017**

Authored a supplemental report to the City providing specific elevations, sea level rise projections, and illustrations to visualize the effects of sea level rise on a property level. Participated in the science communication element of a community outreach program hosted by the City as part of its "Rising Above" campaign for sea level rise adaptation. Developed handouts and take-home documents for homeowners to understand expected effects of sea level rise to their community.

**Michael A Albert, P.E.**  
**Senior Engineer**

**Education**

Master of Science,  
Hydrology from College of  
Agricultural & Biological Eng,  
University of Florida, 2002  
Bachelor of Science, Geology  
from College of Liberal Arts  
& Science, University of  
Florida, 1996

**Registration**

Professional Engineer,  
Florida, 68598

Michael Albert, P.E. is a Senior Engineer for Chen Moore and Associates. He has more than 17 years of professional experience including an 8 year career at the SFWMD. His key experience includes project management of design and construction management activities for Everglades Restoration projects, water impoundments and water control structures. Mr. Albert also has experience with water and wastewater pipeline projects utilizing various installation methods. In addition, his technical skills include project management, design, permitting, planning and construction management.

**Project Experience**

**Potable Water Hydraulic Model Update with PBCWUD - R2017-0816 - WUD-18-004.** CMA is responsible for updating Palm Beach County's existing potable water hydraulic model in InfoWater software. This modeling effort includes the revision and update of the current physical and operating conditions, system calibration, and evaluation of existing and future demands. Physical conditions to be updated as part of the scope include piping layout, system controls and water demand projections. The updated model will be used to determine the adequacy of the system in relation to fire flow, meeting future demand and water age. CMA is responsible for performing data review and investigation, potable water model update, model calibration, potable water model evaluation, and complete a technical memorandum.

**South County Reclaimed Water Transmission Pipeline Phase 1A (R2018-0296) with PBCWUD.** Palm Beach County and Broward County have an Interlocal Agreement related to the construction, ownership, operation, and maintenance of a Regional Reclaimed Water System to deliver reclaimed water from Broward County's northern wastewater treatment plant to the Palm Beach County Water Utilities Department service area. The service initiation to Palm Beach County will be 2 MGD of annual average daily flow by April 2021.

The expansion is being designed in phases for multiple competitively bid construction sub-projects. Detailed construction documents and related permits will be provided to allow the construction of approximately 3.7 miles of reclaimed water pipeline and related facilities to be completed and placed into service before April 2021. The design includes pipe of various size and material, with the transmission main being 24-inch ductile iron pipe and the service lines varying from 10-inch to 12-inch with some sections designed to use C-900 PVC due to corrosion potential. The design also includes a 500 ft horizontal directional drill to cross Glades Road and a private lake. Preliminary field investigations included as-built records review, site investigation and photo study; environmental assessments; subsurface utility engineering; geotechnical investigation; a cultural resources investigation; and survey. The design includes lake discharge facilities to



meet irrigation demand at each golf course being served. The permitting process requires a Hillsboro Canal Crossing with the SFWMD; permitting for impacts to County roads; permitting for impacts to trees and wellfields; permitting of reclaimed pipeline; permitting for dewatering during construction. In addition to design, permitting and construction services, Chen Moore will be applying for ENVISION Certification (Institute for Sustainable Infrastructure) on behalf of Palm Beach County.

**Orange Blvd FM Extension and Seminole Pratt Whitney RD FM Pigging Stations with PBCWUD - WUD-18-**

**076.** Palm Beach County Water Utilities Department (WUD) requested that CMA provide survey, design and permitting for sewer improvements along Seminole Pratt Whitney Road to mitigate sedimentation issues in the 20-inch sewer force main. Improvements to the existing sewer transmission system included approximately 1000 ft of new 6-inch force main along Orange Blvd from Seminole Pratt Whitney Road east to redirect additional flows towards the 20-inch force main to improve scour velocities; new pig launching station at the intersection of Banyan Road and Seminole Pratt Whitney Road at the upstream extent of the existing 20-inch force main; and new pig receiving pit at the intersection of Mead Hill Road and Seminole Pratt Whitney Road.

**CSA-10 Mahogany Lane Water Main Extension - R2017-0816 - WUD-19-043.** CMA was contracted by Palm Beach County Water Utilities Department (PBCWUD) to provide design and permitting services for a water main extension to service properties currently on well water. The water main was designed along Mahogany Lane from Atwell Drive on the west to the termination of Mahogany Lane on the east in Unincorporated Palm Beach County.

**Westlake City Engineering Services.** CMA is providing engineering and landscape architecture services for the City of Westlake. The scope includes review of permit applications; review of plans; coordination with the City's planner; coordination with the City's staff members; and coordination with Seminole Improvement District.

**Seacoast Utility Authority Western Community Pipeline Extension.** CMA was contracted by Seacoast Utility Authority for surveying and engineering services for the design, permitting, bidding, construction administration and permit certification of force main and water main improvements within easements along Northlake Boulevard. Phase I is located from the eastern boundary of Ancient Tree to the eastern boundary of Osprey Isles and will consist of approximately 1,650 linear feet of 10-inch water main and 6-inch force main, connections to existing mains, and disconnect with the City of West Palm Beach. Phase II will be located from the western side of Memorial Park Drive to the eastern boundary of the Carleton Oaks property and will consist of approximately 1,000 linear feet of 10-inch water main and 4-inch force main, related tie ins to existing and interconnect meter station with City of West Palm Beach.

## 2.3 Firm Bios

### Collective Water Resources, LLC

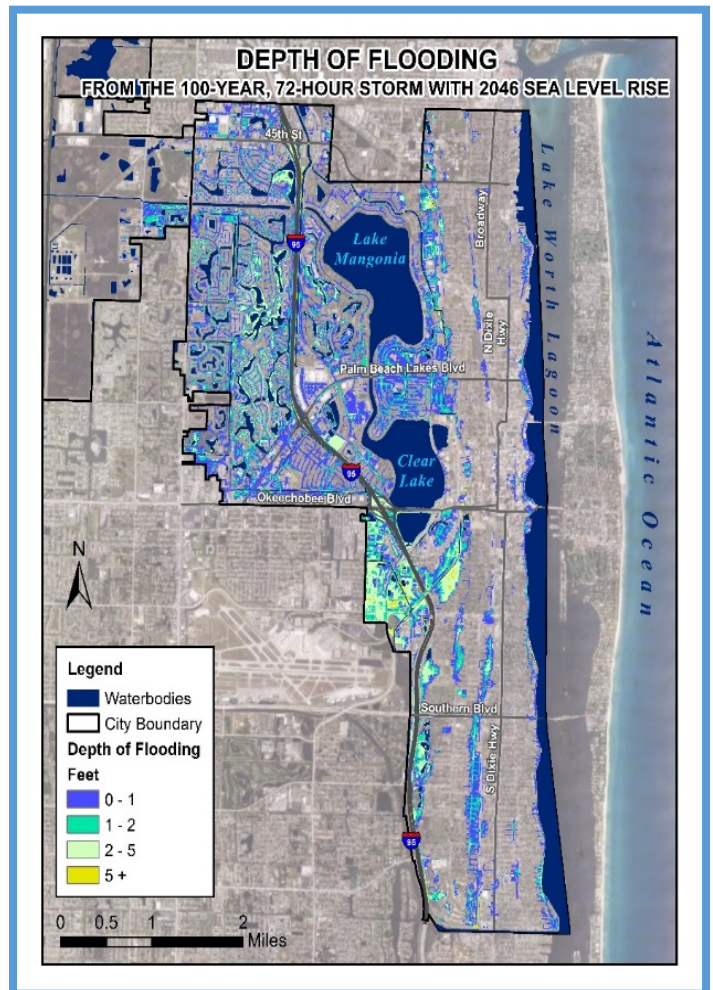
*Collective is the lead firm on this team and is a small, woman-owned, all Florida based firm dedicated to issues of resiliency, water resources, and analysis. We've worked throughout the Southeast on resiliency projects and most recently worked on several phases of adaptation planning for West Palm Beach and modeled sea level rise as part of the Marine Way project in Delray. Our firm's leadership is all Palm Beach County based and we have been waiting for this important project so that we can serve the communities we call home with our passionate approach to high quality analysis.*



Collective was founded in 2012 to serve Florida's public agencies with customized and holistic solutions to water resources challenges through the effective application of technology. We employ eight water resources experts (six of which are licensed professional water resources engineers/modelers). We are focused on:

- Being unbiased and effective technical advocates.
- Providing practical, professional, and insightful assistance – regardless of project size.
- Providing agile leadership on emerging water resources technologies and GIS.

As a local, niche firm we stand prepared to assist the Working Group with challenges at all levels. Our Lake Worth headquarters will be the primary office to serve this project. We were one of the first firms to start considering issues of resiliency as part of our work for West Palm Beach in 2012 – and since then virtually all of our projects have included that consideration to various degrees. Our firm is known as one of the most experienced and robust modeling and sustainability firms in water resources, stormwater, water supply, GIS, floodplain mapping/modeling, and vulnerability analyses – to name a few. Our Project Manager, Elizabeth Perez (Liz), lives in Boynton Beach and can respond to the working



Collective Water created one of the first sea level rise analyses in Florida that leveraged calibrated stormwater models. These analyses have been widely used by West Palm Beach for several projects and planning efforts.

group within minutes. Liz has a history of working on successful and complex water resources projects with diverse stakeholder groups throughout the Southeast. Since 2013, she has been deeply engaged with water resources issues on the municipal side – particularly as it relates to technical advocacy with FEMA for floodplain accuracy throughout Palm Beach County. She is also known for her enthusiastic approach to analyses, sense of humor, community involvement, and ease of communications. She is a fully licensed professional engineer and modeler with over 20 years of experience. Liz will be closely assisted by the other leaders at the firm (Stephanie Dunham and Emily McBryan) to ensure that the jurisdictions we are serving receive a flexible and cost-effective project delivery.



The leadership of Collective Water Resources: Emily McBryan (left), Elizabeth Perez (second from left), and Stephanie Dunham (right). This photo was taken after the firm received the Athena Award in 2017. This is an award for outstanding woman-owned businesses in Palm Beach County.

## NEMAC+Fernleaf

*We selected NEMAC+Fernleaf for our team due to their national leadership in analysis for various aspects of resiliency and strong working relationships with Collective. We've worked on flagship resiliency projects with NEMAC+Fernleaf and know we can trust them to deliver top-tier analysis and visualization.*



# NEMAC+FernLeaf

NEMAC+FernLeaf (NF) is a public-private partnership that delivers localized quantitative climate resilience solutions and consists of private solutions firm FernLeaf Interactive ("FernLeaf") and University of North Carolina-Asheville's National Environmental Modeling and Analysis Center (NEMAC), a



university research center. NF is based in Asheville, North Carolina, home of the world's largest repository of weather and climate data.

FernLeaf was formed in 2014 on the vision that data-driven decision making can maximize the effectiveness and equitability of climate adaptation. We are vulnerability and risk assessment specialists and have purpose-built our products and services entirely for community resilience. FernLeaf has built its reputation by leading and delivering quantitative assessments for clients on time and within budget.

To assist local and regional governments in maintaining the relevance of their resilience plans, FernLeaf has developed AccelAdapt, a software product that provides communities affordable, interactive, and regularly updated vulnerability assessments for a full range of climate threats. The assessments are powered by a community's local asset data, such as buildings and property parcels, and the best available hazard data from trusted sources. AccelAdapt delivers a "living" vulnerability assessment that can respond to new information and data.

UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) specializes in decision support methodologies for local, regional, and national decision makers, planners, and the public. As an applied research center, NEMAC implements science in real-world settings.

NF excels in climate and resilience assessment and communication by helping people to understand their region's main issues and make decisions in a complex and changing world. We co-developed the federal-standard Steps to Resilience Framework (in the US Climate Resilience Toolkit) with NOAA and have led or supported development of flagship climate analysis and communication conduits such as Climate.gov, the National Climate Assessment, Drought.gov, and others. We have an extensive track record for applying these principles to support actionable and localized adaptation throughout the South Florida.



Most of the NEMAC+FernLeaf team gathered at their holiday party.



A public meeting led by NEMAC+Fernleaf in West Palm Beach. NF leveraged the analyses created by Collective Water for three detailed phases of analysis and resiliency planning for the City.

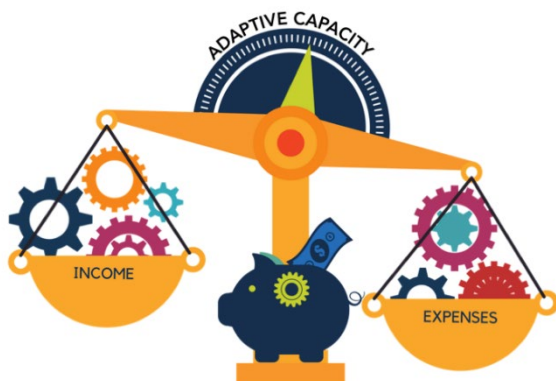
## Brizaga

*Brizaga is known throughout the United States as a leader in developing outreach materials and formats for issues related to resiliency – and it is fortunate that they call neighboring Broward County home. Brizaga is a key part of our communications team and a proven partner for Collective (we have worked together since Brizaga was formed).*

**Brizaga** was founded to help individuals, businesses, and governments understand and address the effects of a changing environment, with an emphasis on sea level rise. We bring a unique perspective by weaving the worlds of science, engineering, policy and communications to foster innovative and unique solutions to some of our greatest challenges. These challenges can also present great opportunities for our community. We distill these complex technical topics to help policymakers and the general public better understand their interdependencies and make the best choices to adapt. With over 40 combined years of political, environmental, science and engineering experience, our team is here to help create a vibrant, viable, and better tomorrow.



Through our experiences, we have seen firsthand that effective communication is critical to driving widespread positive change, especially when it relates to complicated topics like sea level rise. That is



why communication is at the center of our process. Not only does our staff specialize in flooding and sea level rise communication, but we also have world-class partners in science communication and public outreach ready to help break down the complexities of sea level rise to provide a clear and concise message.

Our team examines risk and solutions through an 'Adaptive Capacity' framework. This means that any action must not



only improve the resilience of a community but must also make financial sense to ultimately improve a community ability to adapt.

Most times, these challenges require interdisciplinary teams including landscape architects, land use specialists, water resource engineers, and individuals well-versed in how government works. **Brizaga** was built to partner with organizations and companies ready for the paradigm shift in using tomorrow's conditions today and creating for tomorrow.

**Brizaga** is nearing its 3rd anniversary and is proud to have projects with the Cities of Fort Lauderdale, Miami, Miami Beach, Cocoa Beach, and Ormond Beach, as well as local and national developers, businesses, non-profit organizations, condominium associations, and residential clients.

*We define **Brizaga** as the overwhelming feeling of pride and accomplishment when individuals, business, and governments work together to create a more resilient community.*

### **Applied Technology & Management, Inc. (ATM)**

*ATM is a Florida-based design, engineering, and consulting firm that has been providing coastal, waterfront and water resources engineering services to coastal communities within Florida since 1984. ATM is a recognized national industry leader in coastal engineering and hydrodynamic modeling. ATM has maintained an office within Palm Beach County for over 25 years that is specifically focused on meeting the needs of coastal communities within South Florida.*



ATM has been a leading provider of coastal, waterfront and water resources engineering services throughout Florida and worldwide for more than 35 years. ATM's West Palm Beach office is primarily dedicated to supporting coastal and waterfront projects. ATM maintains additional full-service offices in Gainesville, Florida (our corporate office) as well as St. Augustine, Florida, and Charleston, South Carolina. Satellite offices are located in Melbourne Beach, St. Petersburg, and Tallahassee, Florida. ATM also maintains one international office in Dubai, United Arab Emirates (UAE). Our 39 domestic employees include 14 licensed professional engineers, four PhD level scientists, a licensed professional coastal geologist (PG), a licensed professional surveyor and mapper (PSM), a certified land planner (AICP), and four engineering interns (EIs). More than half (23) of our employees have advanced degrees in a coastal engineering or marine science discipline. Our four managing principals each have advanced degrees in coastal engineering, including two PhDs. ATM's workforce is notably stable, with an average company staff tenure of over 10 years. This stability is further mirrored in our four managing principals, who together have over 95 years of collective experience working for ATM.

ATM's history is intimately linked to the evolution of coastal management programs within the state of Florida and provides significant contributions to multiple coastal programs within South Florida including extensive efforts in Palm Beach County. Our coastal engineering projects involve a spectrum of planning, modeling, design, permitting, geological investigations, environmental investigations and construction

management services. Our team provides services relating to the development, enhancement and maintenance of coastal projects including privately and government-funded projects such as beach nourishment, shoreline stabilization, erosion control structure analysis and design, inlet management planning, dredging, habitat restoration, and sand source identification. We routinely provide hydrodynamic modeling, engineering design, impact assessment, mitigation planning and execution, construction document development, contractor bid support, construction management, and performance monitoring. *ATM is especially knowledgeable of the Boca Raton coastal program having supported it through a coastal engineering consulting continuing services contract since 2008 (over 10 years). Key staff associated with this effort will assist the Collective Team including ATM's coastal engineering principal (Michael Jenkins, PhD, PE) and primary project manager/ senior coastal engineer (Peter Seidle, PE).*

### **Modeling Expertise – Resiliency and Vulnerability Assessments**

*While we understand that coastal modeling is not explicitly included in this RFP, Collective wanted to bring an independent group of highly capable modelers onto the team to assist with the threats where coastal models and data types would be needed. We want to mine, scrub, and use the best available data types for each analysis – and ATM is the perfect firm to help us get “under the hood” with these critical datasets. Therefore, we have provided a description of ATM's modeling capabilities below.*

Understanding the risks of wind, waves, and storm surge is integral to coastal resiliency and vulnerability assessments. ATM estimates hurricane hazards by using computer models to simulate historical hurricanes that have occurred over the past 100+ years. By adding sea level rise projections to the modeling, ATM estimates tailwater conditions and future coastal flood risks associated with increased storm surge elevations and wave heights based on future 100-year flood hazards.

Applications and models used by ATM to evaluate the combination of effects of wind, waves and storm surge:

- Historical hurricane characteristics are computed from data contained in the National Oceanic and Atmospheric Administration's (NOAA) National Hurricane Center's Database (HURDAT) of tropical storm events.
- Wind fields for these hurricanes are simulated with the Hurricane Planetary Boundary Layer (PBL) model.
- Tides and surge are simulated using the Advanced Circulation long-wave hydrodynamic model (ADCIRC).
- Storm surge elevations are combined with tidal phasing and analyzed to develop combined event stage versus frequency-of-occurrence relationships using the Empirical Simulation Technique (EST).
- Hurricane waves are simulated using the SWAN (Simulating Waves Nearshore) wave model.

For simpler analyses, ATM identifies potential future coastal hazards due to waves (only) by analyzing the effective Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) and NOAA sea level rise projections through site-specific modeling using FEMA's Coastal Hazard Analysis and Mapping

Program (CHAMP) Version 2.0 model suite, including the FEMA Wave Height Analysis for Flood Insurance Studies (WHAFIS) overland wave propagation model.

### **Palm Beach County Experience**

ATM has been actively supporting coastal communities within Palm Beach County for over 25 years. Specific to this proposal, ATM's local experience includes:

Coastal Inlets: ATM has significant programmatic experience with the three coastal inlets within the area of study. Since 2008, ATM has overseen the management of Boca Raton Inlet for the City of Boca Raton. ATM currently provides annual monitoring of shoreline conditions and sand bypassing associated with Lake Worth (Port of Palm Beach) and has been analyzing this data on an annual basis for over ten years. ATM developed and permitted the expansion of the inlet sand trap within South Lake Worth (Boynton) Inlet for Palm Beach County.

Numerical Modeling: ATM oversaw the last major feasibility study associated with South Lake Worth (Boynton) Inlet which included measurement of tidal prism (currents) associated with the inlet and numerical modeling of storm surge within the study area. ATM recently completed a comprehensive hydrodynamic study of Boca Inlet for the City of Boca Raton. ATM has conducted numerous numerical studies of coastal erosion and sediment transport processes within the county.

Lagoon Dredging and Habitat Restoration: ATM is currently overseeing the maintenance dredging of navigation channels within the Lake Worth Lagoon Estuary for residents of the Town of Palm Beach. Dredged material is being beneficially utilized as source material for Palm Beach County's Tarpon Cove Restoration Project. ATM is also supporting planned rehabilitation and habitat restoration within the Rutherford/Lake Wyman Park area which represent the largest remaining stand of mangrove habitat within the City of Boca Raton.

Data Collection and Analyses: ATM has supported the collection and analysis of extensive coastal-related datasets within the study area including bathymetry, beach profiles, water quality, seagrass extent, nearshore hardbottom extent, currents and wave datasets. Much of this data remains within ATM's internal files and ATM is very familiar with the extent and location of historic datasets within the study area.

Hurricane Impact Assessments: ATM conducts coastal damage and erosion assessments for local communities including Boca Raton, the Town of Palm Beach and Palm Beach County. Efforts have included storm restoration planning including the development of FEMA funding applications and coordination of restoration efforts through final construction. ATM is currently supporting post-hurricane beach restoration efforts in Boca Raton and the Town of Palm Beach.

Coastal Construction: ATM has served as the engineer-of-record for coastal construction projects cumulatively valued over \$100 million within Palm Beach County, including dredging, beach nourishment, coastal structure, seawall and marina projects.

### **Chen Moore & Associates, Inc**

*Chen Moore is one of the foremost civil engineering firms in South Florida. They were selected for the Collective Team due to their depth of technical knowledge within the jurisdictions that will be involved in this study and their ability to consult on multiple infrastructure types.*

Founded in 1986, Chen Moore and Associates (CMA) specializes in civil engineering, water resources, water and sewer utilities, landscape architecture, transportation, planning and irrigation, environmental and construction engineering services. With 69 full time staff across Central and South Florida and a staff of 15 in the West Palm Beach office including 4 licensed professional engineers, 4 registered landscape architects and 2 certified planners, the firm is committed to providing responsive quality services in Palm Beach County while meeting the schedules and specific project needs of our clients. Our local knowledge regarding infrastructure vulnerabilities and approaches to improve resiliency is significant as we are currently working on infrastructure design and planning studies for 9 different municipalities and utilities in Palm Beach County including the City of Lake Worth and the Palm Beach County Water Utilities Department.



In 2017, our Water Resources Department was founded in the West Palm Beach office to align our expertise with municipal infrastructure with the regional needs regarding flood protection, resiliency and sustainability. Our approach applies equal measures of innovative technologies, non-traditional delivery methods, hard-earned experience, unending ambition and continuous effort. Because our West Palm Beach office has engineering, planning and landscape architecture professionals, we provide a unique perspective on “grey” and “green” infrastructure and how decisions made today can affect the resiliency of a community tomorrow.

### **Erin L. Deady, P.A.**

**ERIN L. DEADY, P.A.** 

*Erin Deady is a tried and true legal expert on climate change, AAAs, and Comprehensive Planning - among other topics. Erin is local yet one of the national experts on these topics. We are pleased to offer the services of Ms. Deady as part of our team and have worked with her on successful projects for West Palm Beach.*

Erin L. Deady, P.A., is a full service legal and consulting Small Business Administration federally and state-certified Woman-Owned firm. Firm President, Erin Deady, is a licensed attorney in Florida, a certified land planner and a LEED AP. The Firm’s practice is focused on public sector government representation but also includes numerous private sector and agricultural clients. The Firm’s practice includes water, energy, climate, environmental, local government, administrative law, utility and land use issues. The Firm’s experience includes litigation, public finance, special purpose governmental representation and

creation as well as land use planning. Ms. Deady has authored and co-authored numerous sustainability or climate plans for local governments throughout Florida. Erin is a frequent lecturer and author on climate change, energy and public finance issues statewide and nationally.

### **AC Disaster Consultants, Inc.**

*The Collective Team knows that providing a complete toolbox for funding solutions is key to this project. As such, we have included AC Disaster Solutions on our team to broaden and deepen the grant and funding experience on our team. As experts in the entire grant life cycle, they will be available to jurisdictions as the tough funding questions arise.*



**AC Disaster Consulting** is a full-service emergency management firm. As a **woman-owned and led firm**, we take pride in the diversity of our team. Each member brings a unique skill set, background and perspective, which allows us to create a dynamic team of experts for our clients. **AC Disaster Consulting** works directly with the top executives and decision-makers to develop strategic approaches to each client's unique capabilities, risk profile, and anticipated needs.

### **Florida Sea Grant/Thomas Ruppert, Esq.**

*As a part of our independent QC Team, Mr. Ruppert will be available for high level review of legal issues as potential adaptation strategies are developed. Mr. Ruppert is a pioneer in the legal issues related to sea level rise and climate change and will provide feedback to the technical team as we examine menus of options for each jurisdiction and the micro-region as a whole.*



Thomas Ruppert, Esq., coastal planning specialist at the Florida Sea Grant College Program, is a licensed attorney developing legal and policy analysis for local governments on aspects of adaptive planning for sea-level rise, community resilience, and associated long-term challenges and opportunities for Florida's coastal communities. Areas of expertise include beach and coastal policy in Florida, Florida's coastal construction control line permitting, comprehensive planning law, sea turtle habitat protection, the Endangered Species Act, coastal and marine permitting programs, Florida's statutory property protections, and U.S. Constitutional property protections. Mr. Ruppert has authored and co-authored numerous legal articles and frequently serves as an invited presenter at events in Florida and in other coastal states. He has worked with over a dozen partners to organize and host legal workshops on coastal issues and flood insurance around the state. Mr. Ruppert is currently involved with several initiatives within Florida communities planning for sea-level rise and maintains a website of original resources at [www.flseagrants.org/climatechange/coastalplanning/](http://www.flseagrants.org/climatechange/coastalplanning/).



## Proposed Split of Compensation for Work:

- Collective Water Resources, LLC: 24%
- NEMAC+Fernleaf: 40% (this higher percentage is due to tool refinement and deployment issues primarily)
- Brizaga: 13%
- ATM: 4%
- Chen Moore & Associates, Inc. 6%
- Erin L. Deady, PA: 11%
- Thomas Ruppert and AC Disaster Consultants, Inc: 1% each

## 2.4 Sample Work Products

*On the following pages, the Collective Team provided sample work products from outside Palm Beach County so that the Selection Committee can review work samples that you may not have seen before. We also wanted the Selection Committee to see work products for other multi-jurisdictional vulnerability assessments. We strongly encourage you to contact our West Palm Beach reference, Penni Redford, for more information on our work in West Palm Beach. Furthermore, two of the projects that Collective and NEMAC+Fernleaf recently worked on together for West Palm Beach and Charleston have deliverables that are currently under review by both City Commissions and were not available for public use as of this submittal. We have provided one deliverable from West Palm Beach that was an early work product from Collective for the City of West Palm that later supported the current NEMAC+Fernleaf assessment that we are currently working on.*



# Land of Sky Regional Resilience Assessment

Phase II Report

November 2019



NEMAC+FernLeaf

## Disclaimer

This draft analysis is a working document and should not be considered final; all information contained herein is subject to change. The analysis is based on the best available information for specific threats and assets at the time the analysis was conducted. Quantitative results presented herein are preliminary and are based on data with inherent uncertainties and generalized assumptions; site-specific evaluations of vulnerability and risk are beyond the scope of this assessment and should be reserved for a detailed evaluation of specific adaptation measures. Updates will be provided as new information is made available and key findings are re-assessed accordingly.

## Suggested citation

*Phase II Regional Resilience Assessment Report for the Land of Sky Regional Council.* Asheville, NC: NEMAC+FernLeaf, November 2018.

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# Introduction

Starting in October 2017, the Land of Sky Regional Council partnered with UNC Asheville’s National Environmental Modeling and Analysis Center, or NEMAC, to lead its planners and jurisdictional representatives through a series of workshops and activities aligned with the “Steps to Resilience” outlined in the U.S. Climate Resilience Toolkit.<sup>1</sup> This phased approach provides communities, municipalities, and organizations with a blueprint for climate resilience planning. As an initial focus, this work between NEMAC and LOSRC focused on economic issues facing the region. This initial phase of work was completed in October 2018 and is summarized in a Phase I Report titled “Land of Sky Region Economic Resilience Exposure Analysis.”<sup>2</sup>

In 2014, NEMAC established a collaborative partnership with FernLeaf Interactive (referred to as “NEMAC+FernLeaf”) in order to provide a scalable suite of products and services. FernLeaf is a team of vulnerability and risk assessment specialists and have purpose-built products and services entirely for community resilience. Also based in Asheville, North Carolina, FernLeaf was formed in 2014 on the vision that data-driven decision making can maximize the effectiveness and equitability of climate adaptation. Also, in order to support the development and use of resilience assessments, FernLeaf developed AccelAdapt in collaboration with NEMAC. AccelAdapt is an interactive software product that regularly ingests new local asset data to provide a “living” assessment. Thus, with AccelAdapt, as a community changes, so does its assessment.

The purpose of the initial phase (Phase I) of the resilience project was to determine the threats on which to focus and to examine their potential impacts on the economic development/transportation asset set—how threats negatively affect these assets in the region. This phase also involved considering trends and future changes in climate conditions and determining exposure. Building on the work from Phase I, a Phase II work program was started in June 2018 with the purpose of expanding the types of assessments that were completed in Phase I (moving beyond exposure for one asset) and to make all assessments available in the AccelAdapt tool for internal purposes.

Key terms or concepts from Phase I
<b>Asset:</b> regional values including infrastructure, services, people and other resources
<b>Exposure:</b> the presence of assets in harm’s way
<b>Vulnerability:</b> the susceptibility of assets to threat or hazard events which is determined by their potential impact and adaptive capacity
<b>Risk:</b> the likelihood and negative outcome of a threat or hazard event

This report outlines elements and outcomes of Phase II, including an expanded exposure analysis (beyond the initial asset set), vulnerability and risk for one asset (commercial property and flooding), and the AccelAdapt tool to interactively explore and use all assessments. Since the Phase I report covered the topics of What is Resilience? and the “Steps to Resilience”, this report will not cover those topics again, but please refer to that report for additional background.

## Project teams

A team from NEMAC+FernLeaf worked with a core team from LOSRC to provide facilitation of the process as well as technical support and scientific analysis.

### Core project team

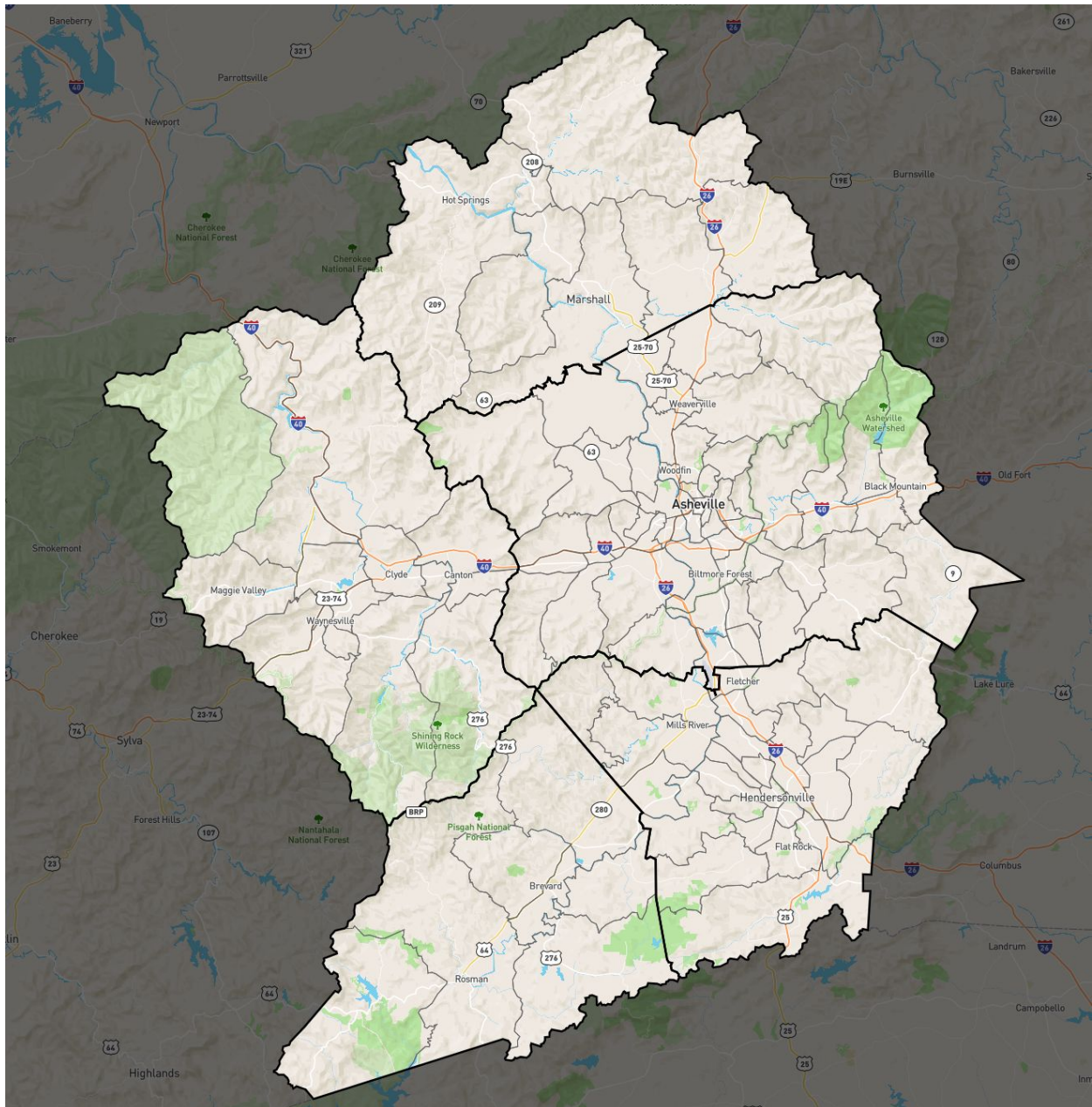
Erica Anderson	Economic and Community Development Director, Land of Sky Regional Council
Mary Roderick	Regional Planner, Land of Sky Regional Council
Jon Beck	GIS Planner, Land of Sky Regional Council

### NEMAC+FernLeaf team

Matt Hutchins	Project Lead, Resilience Analyst
Jim Fox	Resilience Analyst, Facilitator
Josh Wilson	Data Analyst
Nina Hall	Writer/Editor
Dalton Nickerson	Data Analyst
Karin Rogers	Resilience Analyst
Aashka Patel	Resilience Specialist
Ben Hicks	Data Technician (Student Intern)
Sarah Hamilton	GIS Analyst

## Regional scale overview

Keeping with the same regional study area as Phase I, the project region includes the western North Carolina counties of Buncombe, Haywood, Henderson, Madison, and Transylvania and is referred to herein as the Land of Sky region.



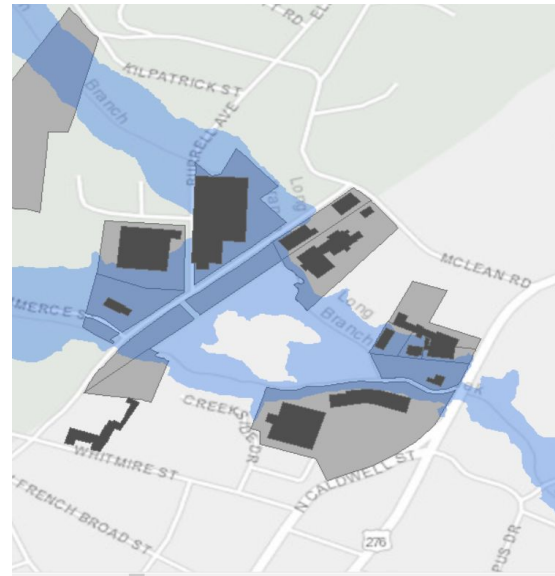
# Threats

Consistent with Phase I, the Phase II assessment focused on the same threats including flooding, landslides, and wildfire. More information on how regional threats were determined and threat data sources can be found in Appendices A and B.

## Flooding

For purposes of this assessment, the threat of flooding was defined by the flood hazard areas as determined by FEMA and the North Carolina Floodplain Mapping Program (NCFMP)<sup>3</sup>; assets within any of these flood hazard zones were determined as being exposed to flooding.

The FEMA floodplains are made up of different flood zones, including the floodway, the 100-year flood zone (area with a 1-percent chance of occurring every year), and the 500-year flood zone (areas with a 0.2-percent chance of occurring in any given year).



FEMA floodplains with commercial properties exposed to flooding

## Landslides

Landslides in western North Carolina are, like flooding, associated with climate stressors related to the amount and timing of precipitation. The primary non-climate stressors contributing to the threat of landslides are development and the removal of vegetation on steep slopes.

For purposes of this assessment, the threat of landslides was defined by potential debris flow areas in Buncombe and Henderson counties, as determined by the North Carolina Department of Environmental Quality (NCDEQ).<sup>4</sup> Assets within any of these potential debris flow



NCDEQ debris flow pathways with properties exposed to landslides.



pathways were determined as being exposed to landslides. Note that the landslides threat model data does not cover the entire region; asset totals are for the extent of the data available (Buncombe and Henderson counties).

## Wildfire

Wildfire is a natural disturbance that provides benefits to ecosystems and natural systems, but it can become a threat when it negatively impacts communities and the assets we value. Drought conditions can lead to a greater chance of wildfire. The primary non-climate stressor related to the threat of wildfire is the management of fuels and vegetation. Lack of active fuel management can contribute to a decline in fire-resilient ecosystems, an increase in wildfire burn severity, and increased risk of destructive wildfires that damage landscapes and threaten people and communities.

The threat of wildfire was defined by areas with Wildland Urban Interface (WUI) risk, as defined by the Southern Group of State Foresters (SGSF).<sup>5</sup> Assets within areas with any WUI wildfire risk were determined as being exposed to the threat of wildfire.



SGSF WUI wildfire risk area with properties exposed to wildfire.

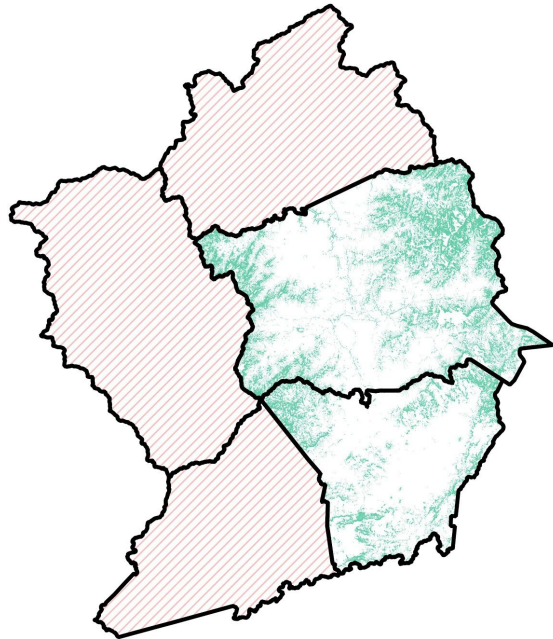
## Threats

The maps below display the threats for the study area (see Appendix B for data sources).

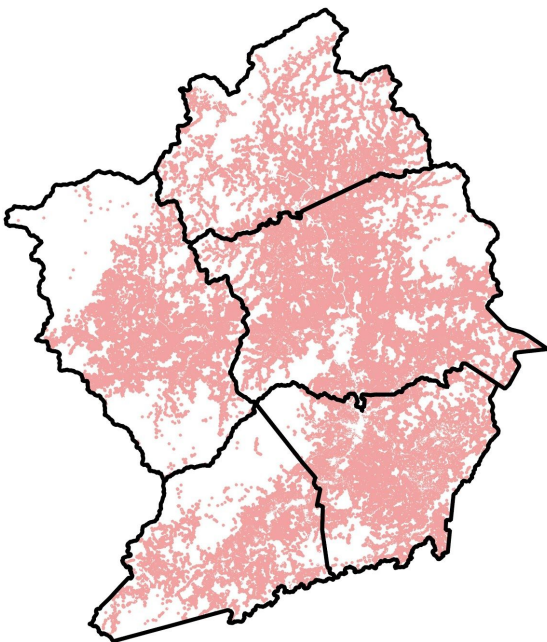
Flooding



Landslides



Wildfire



# Assets

The following asset categories were used for the Phase II assessment. These include an expansion of the asset categories used in Phase I. These asset categories were identified in collaboration with the participant team. The following list of asset categories were used for the exposure analysis. Each asset category was represented based on property parcels from each of the five counties in the LOSRC regional study area. More information about data sources and asset classifications can be found in Appendices B and C. Below is a summary table and maps of the Phase II assets:

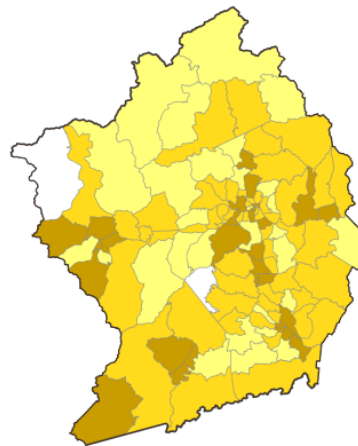
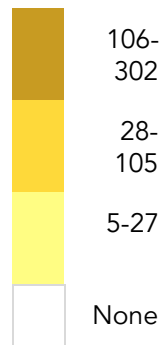
Asset Category	Description	Total Assets
Commercial Property	Includes non-residential properties that serve businesses and organizations, including industrial, retail, offices, restaurants, and hotels. These assets typically support commerce, jobs, and tourism.	8,994 parcels
Government-Owned and Critical Facilities	Includes fire and police stations that aid in emergency response, medical facilities, schools, energy and utility facilities, and transportation-related facilities.	3,656 parcels
Residential Property	Includes all single-family residences, multiple-family residences, low-income housing, apartments, manufactured houses, and mobile home parks.	189,208 parcels
Natural Property	Includes all farms and forestland, protected natural areas (including undeveloped parks), and developed parks (including cemeteries and golf courses).	11,946 parcels
Roads	All major and minor roads in the region.	9,450 linear miles

## Assets

*Note: In the maps below, colors indicate the total number of assets in each census tract. Also, no adjustment has been made for differing area sizes:*

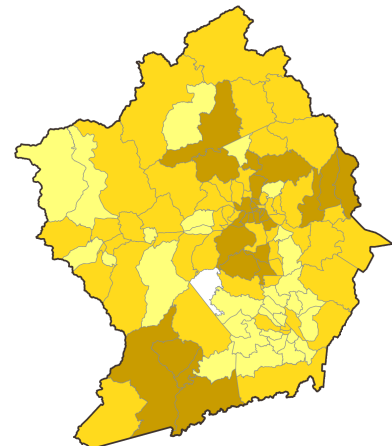
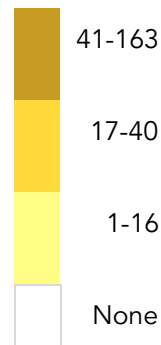
### Commercial Property

Total Properties



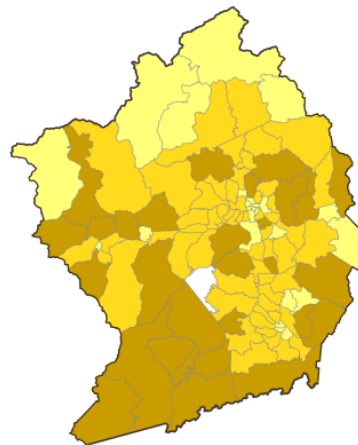
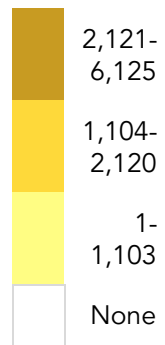
### Government-Owned and Critical Facilities

Total Properties



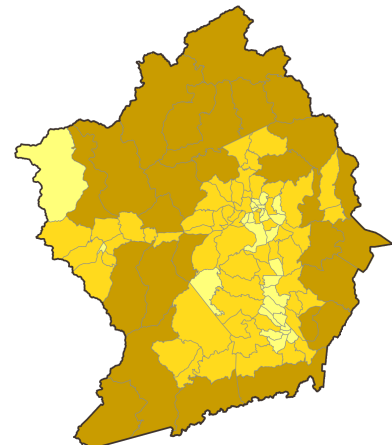
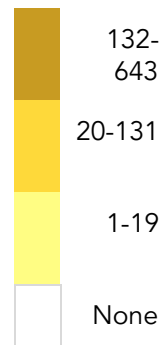
### Residential Property

Total Properties




### Natural Property

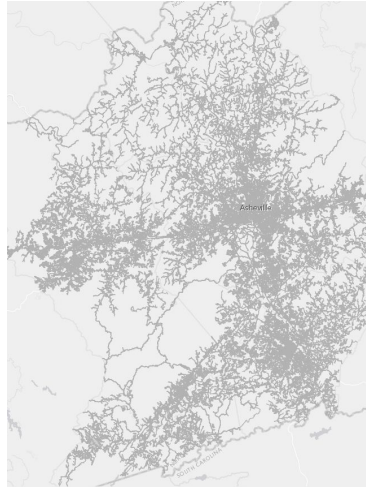
Total Properties



## Assets

### Roads

 All roads  
(major and  
minor)





## Asset-threat pair exposure

This section of the report presents the results of the Phase II exposure assessment. *Exposure* is the presence of people, assets, and ecosystems in places where they could be adversely affected by hazards. For each of the identified major assets and threats, the spatial intersection was assessed to determine the proportion of asset categories that are exposed to specific threats. This assessment was performed at the specific asset level (e.g., a property parcel or road segment) and then aggregated to the census tract scale, enabling comparison with socioeconomic data. This process is further described in Appendix A.

Key findings from the exposure assessment include:

- Landslides are a significant region-wide threat, therefore, counties outside of Buncombe and Henderson may consider an investment in landslide mapping.
- Commercial and residential properties are exposed to flooding and wildfire across most areas of in region.
- Commercial property has the highest percentage of exposure to flooding in the region, compared to other assets assessed.
- Regional exposure to wildfire is very high, especially for residential property.
- Roads/transportation and economic factors (such as job and business interruption) are important to consider when examining exposure (and subsequent vulnerability and risk).

Comparing exposure across the collection of assets and threats begins to highlight the presence of assets in harm's way. The table below lists the number and percentage of assets exposed:

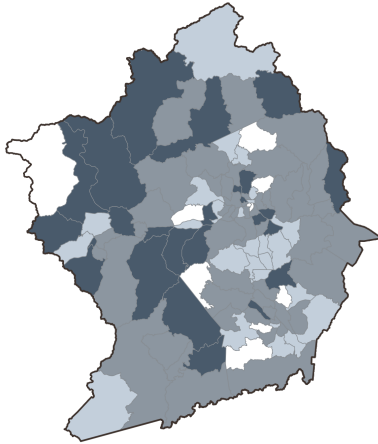
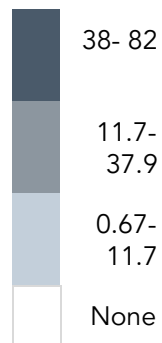
Asset Group	Flooding	Landslides*	Wildfire
Commercial Property	2,049 (23%)	905 (10%)	7,593 (84%)
Government-Owned and Critical Facilities	710 (19%)	663 (18%)	3,258 (89%)
Residential Property	13,443 (7%)	18,259 (10%)	182,078 (96%)
Natural Property	2,267 (19%)	2,954 (25%)	11,180 (94%)
Roads	567 (6%)	884 (15%)	N/A

*\* Note that the landslides threat model data does not cover the entire region; asset totals are for the extent of the data available (Buncombe and Henderson counties).*

## Commercial Property Exposure

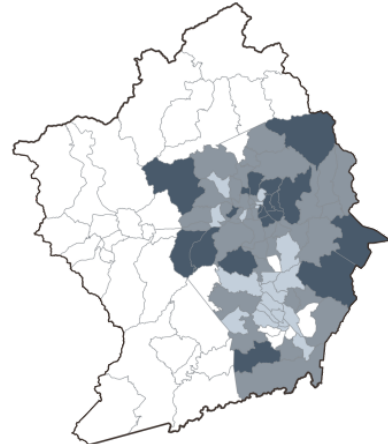
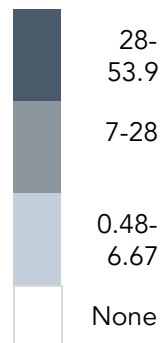
### Flooding

Percent of  
assets  
exposed



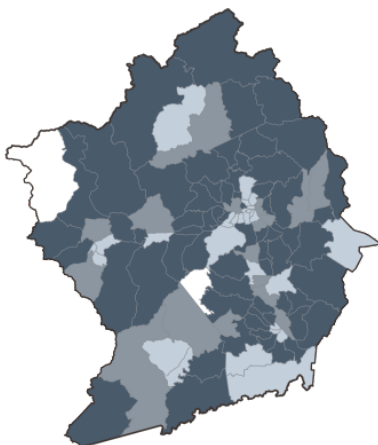
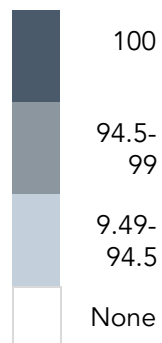
### Landslides\*

Percent of  
assets  
exposed



### Wildfire

Percent of  
assets  
exposed

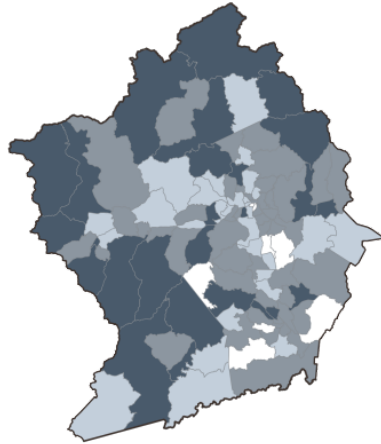
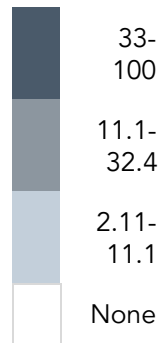


*\* Note that threat model data does not cover the entire region; asset totals are for the extent of the data available (Buncombe and Henderson counties).*

## Government-Owned and Critical Facilities Exposure

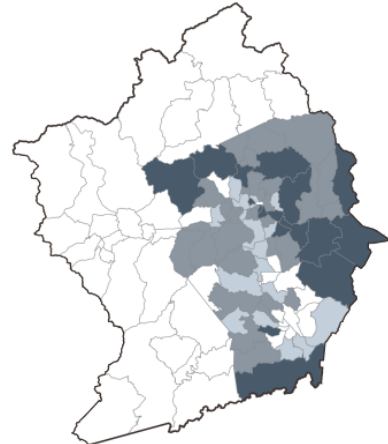
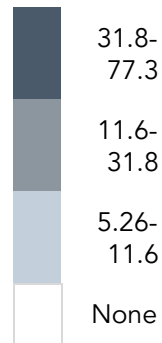
### Flooding

Percent of  
assets  
exposed



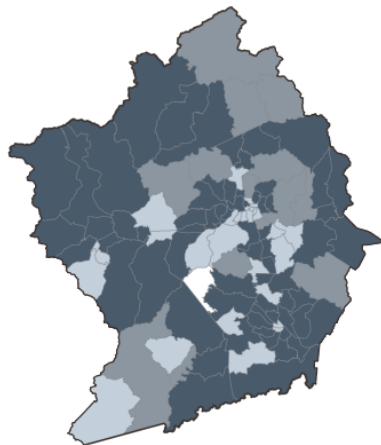
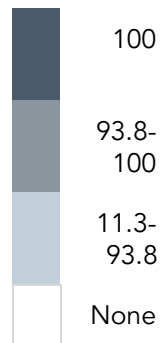
### Landslides\*

Percent of  
assets  
exposed



### Wildfire

Percent of  
assets  
exposed

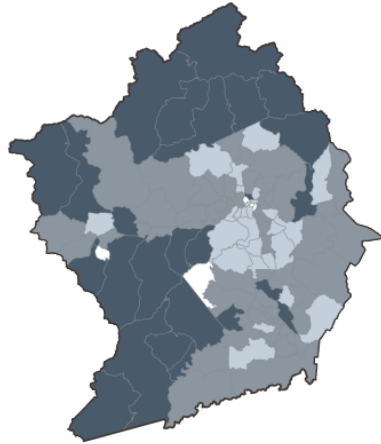
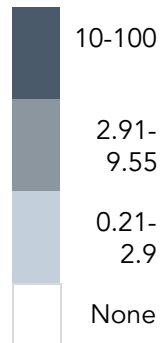


*\* Note that threat model data does not cover the entire region; asset totals are for the extent of the data available (Buncombe and Henderson counties).*

## Residential Property Exposure

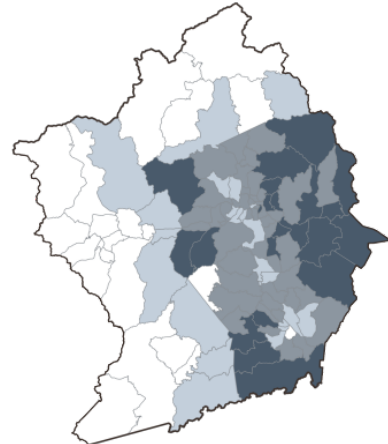
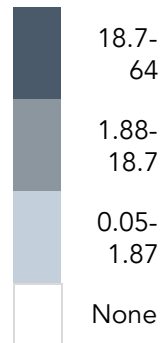
### Flooding

Percent of  
assets  
exposed



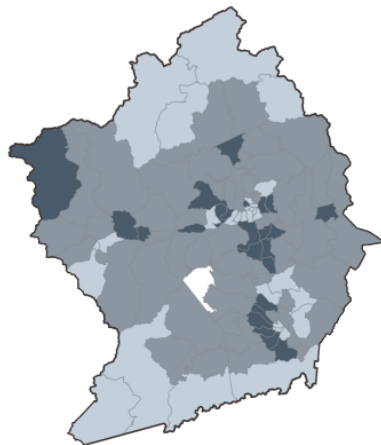
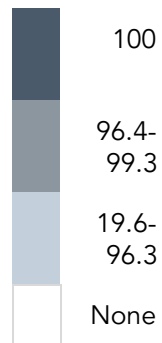
### Landslides\*

Percent of  
assets  
exposed



### Wildfire

Percent of  
assets  
exposed

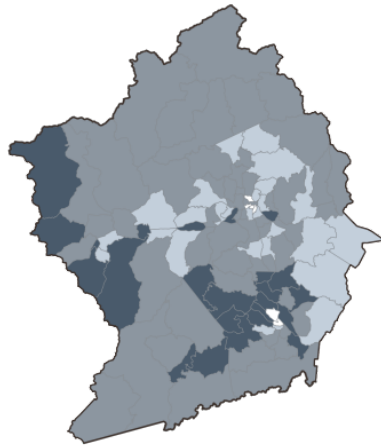
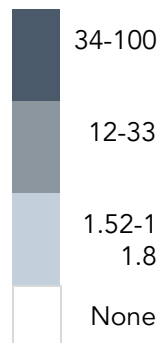


*\* Note that threat model data does not cover the entire region; asset totals are for the extent of the data available (Buncombe and Henderson counties).*

## Natural Property Exposure

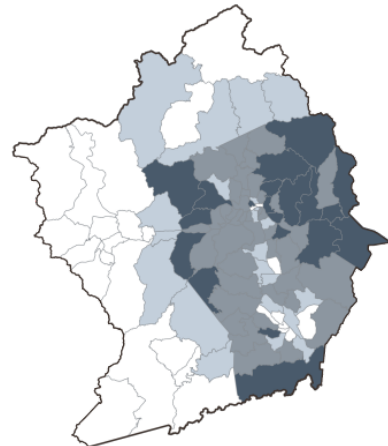
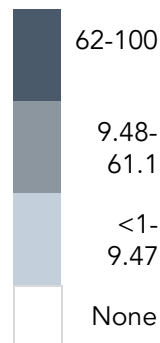
### Flooding

Percent of  
assets  
exposed



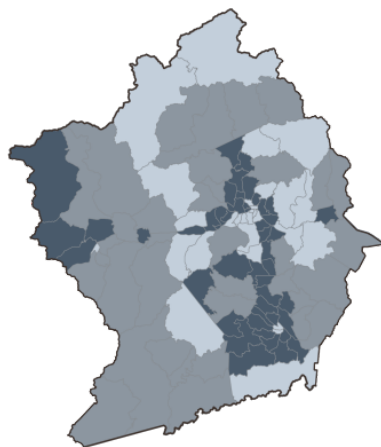
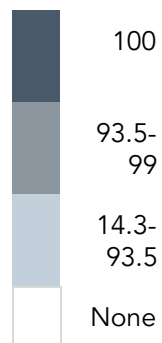
### Landslides\*

Percent of  
assets  
exposed



### Wildfire

Percent of  
assets  
exposed



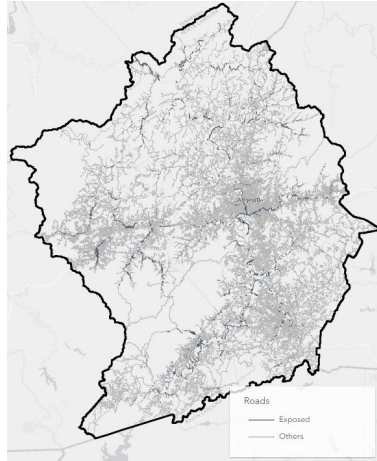
*\* Note that threat model data does not cover the entire region; asset totals are for the extent of the data available (Buncombe and Henderson counties).*



## Roads Exposure

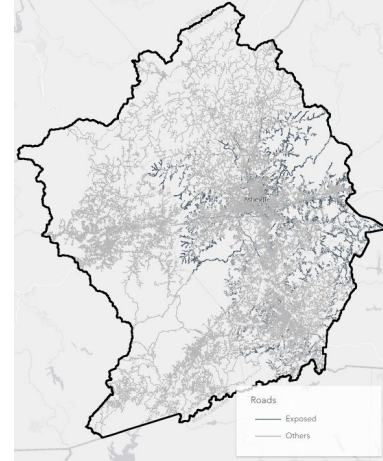
### Flooding

Exposed



### Landslides\*

Exposed



*\* Note that threat model data does not cover the entire region; asset totals are for the extent of the data available (Buncombe and Henderson counties).*

# Vulnerability and Risk

While exposure identifies assets that are in harm's way, the assessment of vulnerability and risk examines more detailed characteristics of exposed assets in order to understand how assets are more or less susceptible and likely to be impacted. For a more detailed methodological description of the assessment see Appendix A.

## Commercial Property and Flooding

For Phase II, commercial property and flooding was selected as the one asset-threat pair to be assessed for vulnerability and risk. Future work may include assessing additional asset-threat pairs.

Key findings from the vulnerability and risk assessment for commercial property and flooding include:

- Commercial property is vulnerable throughout the region.
- Regional impacts can be considered through two lenses 1) impact to major corridors, and 2) impact to smaller communities.
- Social vulnerability is an important consideration for all threats. For example, the commercial/flooding assessment shows that 8 of the 20 most vulnerable census tract areas also have among the highest percentages of households living below the poverty line in the region.
- Key services and resources that are provided by commercial assets may also be considered. For instance, which vulnerable properties provide food or critical supplies?
- Additional factors of vulnerability could be considered for commercial assets, in particular, road access and connectivity, and economic factors related to business interruption (i.e. jobs and sales volume).

The following two pages provide a regional scale profile for the vulnerability and risk assessment of commercial property and flooding along with the criteria used for the assessment.

# Commercial Property & Flooding

## Vulnerability & Risk Assessment

Impacts to commercial properties from flood inundation can range from property loss or damage to business interruption and loss of economic revenue. Commercial properties with the highest vulnerability and risk are those with structures in the floodway that had no base flood elevation requirements when they were constructed.

### EXPOSED:

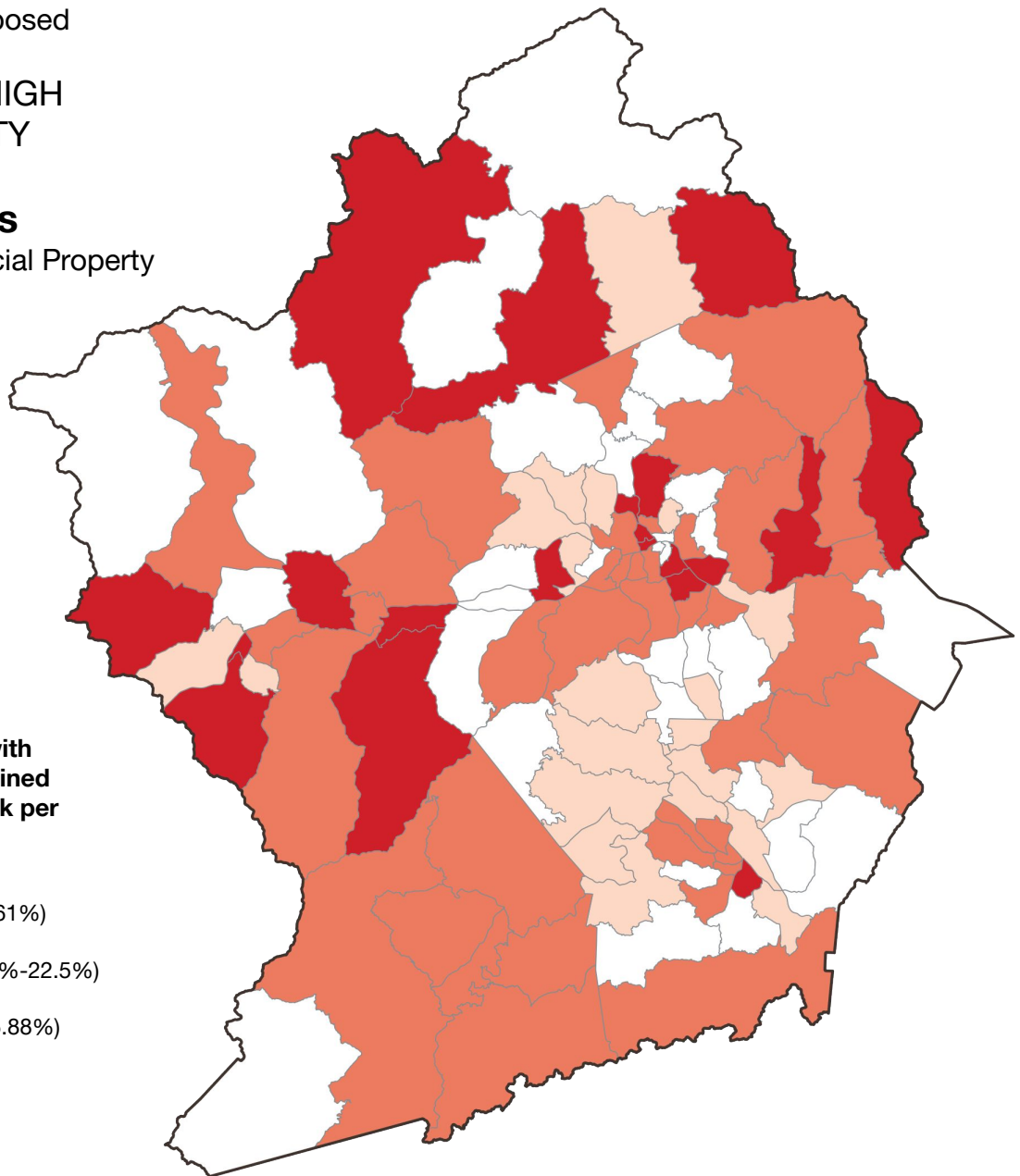
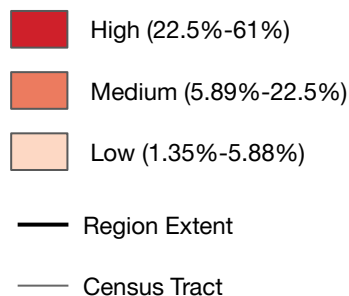
2,045 parcels exposed

### MEDIUM OR HIGH VULNERABILITY AND RISK:

**1,224 parcels**

23% of Commercial Property

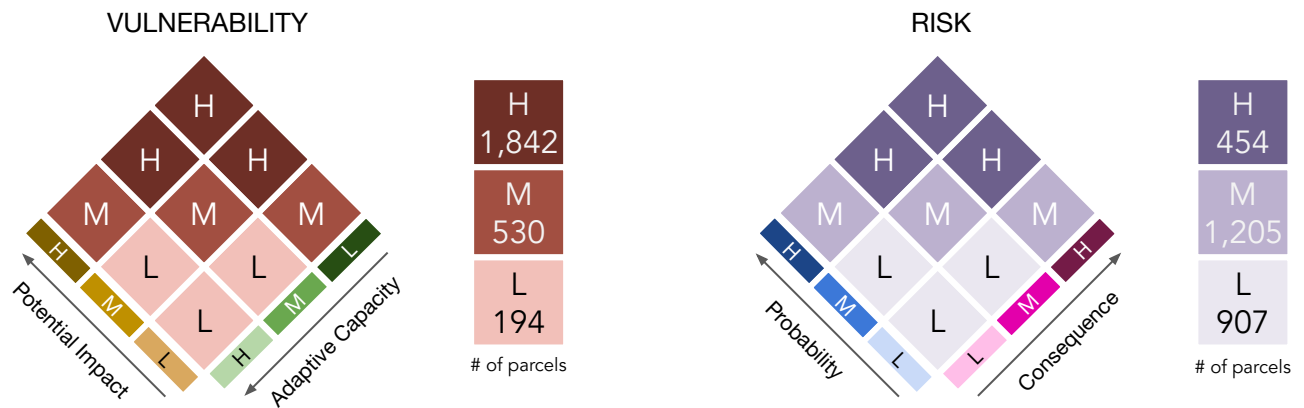
### Percent of assets with medium-high combined vulnerability and risk per census tract



These properties are found throughout most of the region. The areas shaded darkest red on the map show census tracts with the highest number of these types of properties. Note that some areas and corridors could be impacted more than others. For example, the Biltmore Village to Tunnel Rd corridor along the Swannanoa River and Downtown Waynesville make up about 26% of the region's total vulnerability and risk for commercial property.

# Commercial Property & Flooding

Potential Impact		Adaptive Capacity		Probability		Consequence	
High	Structure in inundation extent and historic or business-related (retail, restaurant, hotel)	Low	Structure in floodplain built before without a BFE requirement	High	In floodway inundation extent	High	Structure exposed and above median value
Med	Structure in inundation extent and warehouse or storage	Med	Structure in floodplain built from at BFE	Med	In 100-yr inundation extent	Med	Structure exposed and below median value
Low	No structure in inundation extent (land only)	High	Structure built out of floodplain or structure in floodplain built 1-3 ft above BFE	Low	In 500-yr inundation extent	Low	No structure exposed



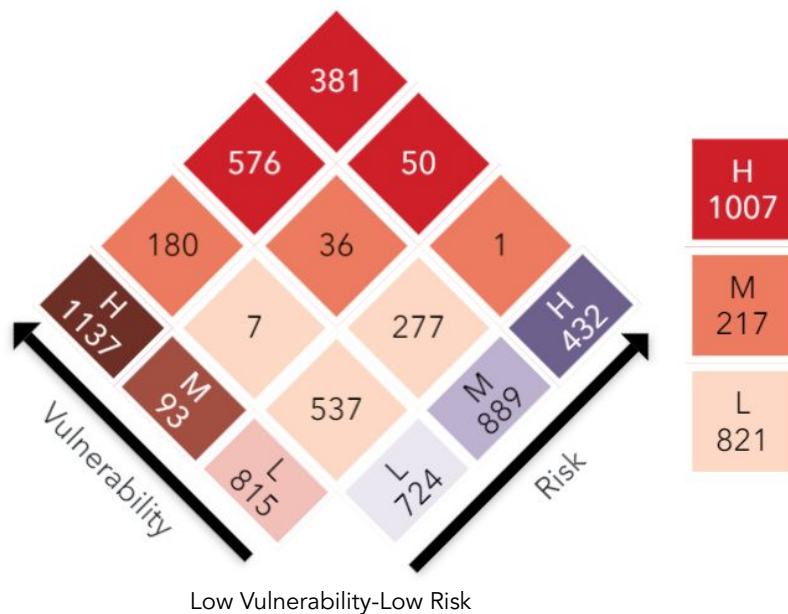
## COMBINED VULNERABILITY & RISK

High Vulnerability-High Risk

**EXPOSED:**  
2,045 parcels expo

**MEDIUM OR HIGH VULNERABILITY AND RISK:**

**1,224 parcels**  
23% of Commercial Property



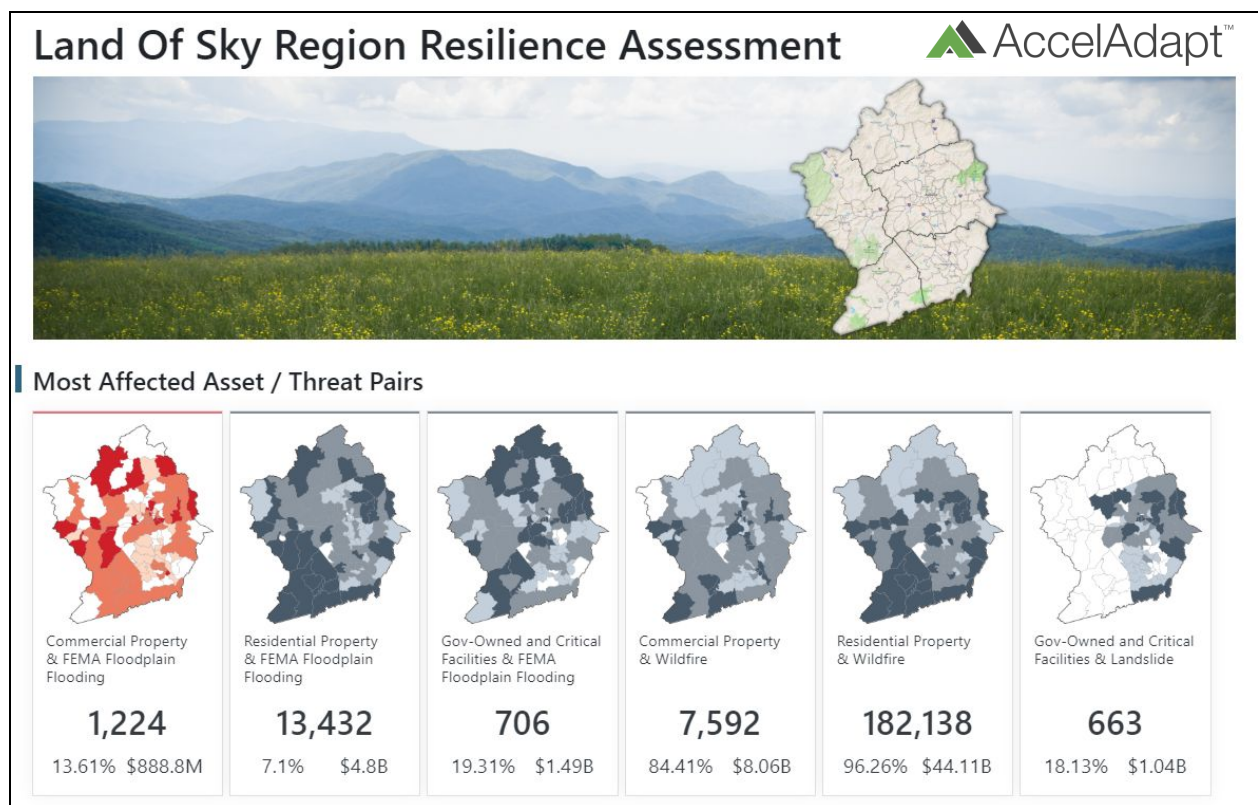
Adaptive capacity criteria are based on requirements for Base Flood Elevation (BFE) and flood-proofing for structures in the 100-yr FEMA floodplain, which have changed over the years.  
Median structure value for Commercial Property was \$225,850

# AccelAdapt

One of the primary tasks of Phase II was to provide all assessments in an interactive tool called AccelAdapt. AccelAdapt was developed by NEMAC+FernLeaf as a way to make resilience assessments interactive and transparent for decision making. Different scales of the assessment data and information is made available through the tool, including regional analytics, census tract or neighborhood area map summaries, and parcel-level data. In addition to the parcel-based assessments, socioeconomic metrics are also made available in order for social vulnerability to be considered across the region.

Using AccelAdapt, key issues and areas of interest can be explored with the exposure or vulnerability and risk information being available for each asset-threat pair. Land of Sky is now exploring how to make the assessments and AccelAdapt tool available to decision makers in the region.

*Note: Below is an image of the LOSRC Overview page in AccelAdapt:*





## Next Steps

In addition to coordinating with municipalities and making the Regional Resilience Assessment available to decision makers in the region, Land of Sky also plans to continue expanding on the assessments for the region. These expanded assessments could include property-based vulnerability and risk assessments for additional asset-threat pairs, road connectivity assessments, and assessments of economic factors.

### Property-based assessments

Of the 12 asset-threat pairs identified for the region, only one (commercial property and flooding) has been assessed through vulnerability and risk. Additional assessments could explore other threats in the region, such as for wildfire or landslides.

### Road connectivity assessments

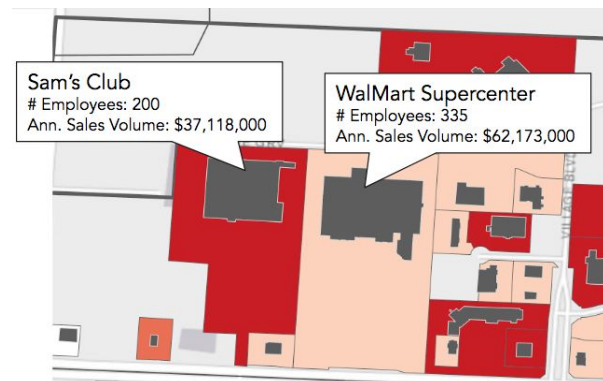
Connectivity assessments can determine potentially inaccessible roads due to flooding and landslides and identify areas or properties in the region that could become isolated and inaccessible to emergency response during flooding and landslide events.

### Potential economic impact assessments

This type of assessment identifies potential economic impacts associated with properties that are vulnerable to threats such as flooding and landslides. A couple of economic factors could include the impact to jobs and annual sales volume.



Example road connectivity assessment



Example economic impact factors of jobs/employees and annual sales volumes shown along with parcel-based vulnerability and risk

# References

1. U.S. Federal Government, 2014: U.S. Climate Resilience Toolkit. [[toolkit.climate.gov](http://toolkit.climate.gov)]
2. Hall, Nina Flagler, James Fox, and Dave Michelson. Economic Resilience Exposure Analysis: Phase I Report for the Land of Sky Regional Council. Asheville, NC: UNC Asheville's National Environmental Modeling and Analysis Center, June 2018.
3. North Carolina Floodplain Mapping Program. [<http://www.ncfloodmaps.com/>]
4. Wooten, Richard M., Anne C. Witt, Kenneth A. Gillon, Thomas J. Douglas, Stephen J. Fuemmeler, Jennifer B. Bauer, and Rebecca S. Latham. *Map of Known and Potential Debris Flow Pathways in Buncombe County, North Carolina: For Shallow Translational Slope Movements*. Geologic Hazards Map Series 4: Slope Movement Hazard Maps of Buncombe County, North Carolina, Sheet 3 of 3, Version August 24, 2009. North Carolina Department of Environment and Natural Resources, Division of Land Resources, North Carolina Geological Survey, 2009.  
[[https://ncdenr.s3.amazonaws.com/s3fs-public/Energy%20Mineral%20and%20Land%20Resources/Geological%20Survey/Assorted%20maps/Buncombe\\_DFP\\_Final\\_300ppi.pdf](https://ncdenr.s3.amazonaws.com/s3fs-public/Energy%20Mineral%20and%20Land%20Resources/Geological%20Survey/Assorted%20maps/Buncombe_DFP_Final_300ppi.pdf)]
5. Southern Group of State Foresters. *Southern Wildfire Risk Assessment Portal (SouthWRAP) User Manual*. Texas A&M Forest Service, February 2015.  
[[https://www.southernwildfirerisk.com/help/SouthWRAP\\_User\\_Manual.pdf](https://www.southernwildfirerisk.com/help/SouthWRAP_User_Manual.pdf)]

# Appendix A: Analysis Technical Documentation

## Process overview

The U.S. Climate Resilience Toolkit defines *exposure* as “the presence of people, assets, and ecosystems in places where they could be adversely affected by hazards.” For purposes of this assessment, “exposure” specifically means that an asset (e.g., a structure, parcel, or roadway) is spatially coincident with a specific hazard (e.g., flooding). For example, a warehouse located within the 500-year floodplain is considered to be “exposed.”

Conceptually, the hazards to which assets are exposed are affected by both climate and non-climate stressors (Figure 1). For purposes of this assessment, these hazards are presented using pre-existing hazard models, and discussion of how those hazards may change over time is presented through narrative and supporting information rather than modification of the hazard models using a variety of stressor scenarios.

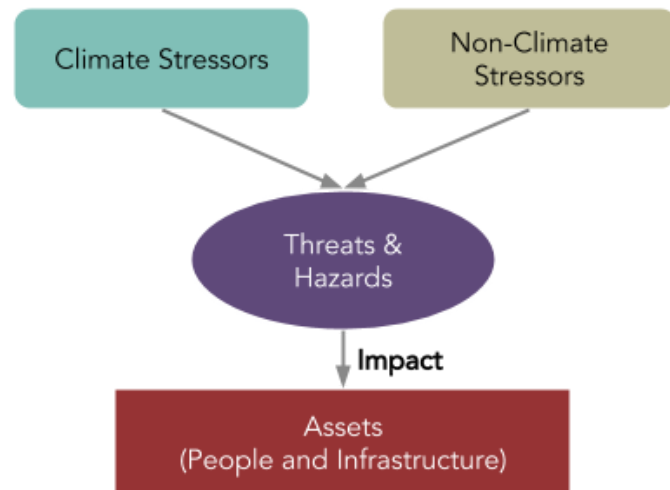
The assessment was conducted in three stages:

1. Asset data normalization and categorization;
2. Spatial relation of individual assets to each hazard layer; and
3. Aggregation of exposed assets to census tracts.

## Asset data normalization and categorization

As the data for asset types differs, it must first be normalized into a general shape by removing superfluous fields and ensuring that the spatial data is complete, and then categorized according to the asset’s use. For this assessment, parcel data for property-based assets were categorized according to the parcel use codes attached to each parcel record. Other asset types did not require additional categorization.

**Figure 1: Exposure concept diagram**



## Exposure analysis of individual assets to hazard layers

For each asset-threat pair, we performed a spatial intersection of the asset with the hazard. Refer to Table 2 for definitions of asset types described below.

- For assets of Property Parcels type, if any part of the hazard extent fell within the extent of a given parcel, it was marked as exposed. Only the intersection of parcels to the hazard data was considered; structures were not considered for properties in the exposure assessment.
- For assets of Linear Feature type, if any part of a line segment of the feature intersected with the hazard geography, that line segment was cut at the intersection and the piece within the hazard was marked as exposed.

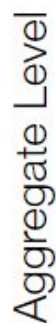
## Aggregation of exposure to census tracts

The U.S. Census Bureau defines census tracts ("tracts") as small, relatively permanent statistical subdivisions of a county or equivalent entity with a primary purpose of providing a stable set of geographic units for the presentation of statistical data.<sup>1</sup> A census tract generally has a population size between 1,200 and 8,000 people, with an optimum size of 4,000 people. In the assessment, tracts are used to aggregate localized analyses to the same scale as the socioeconomic variables published by the U.S. Census Bureau and Esri's Business Analyst Online (Figure 2). Using a common spatial unit for aggregation allows comparison across asset categories for a given hazard, and across hazards for a given asset.

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<sup>1</sup> U.S. Census Bureau. "[Geography: Geographic Terms and Concepts - Census Tract.](#)" Last modified 6 December 2012.

Parcel Level



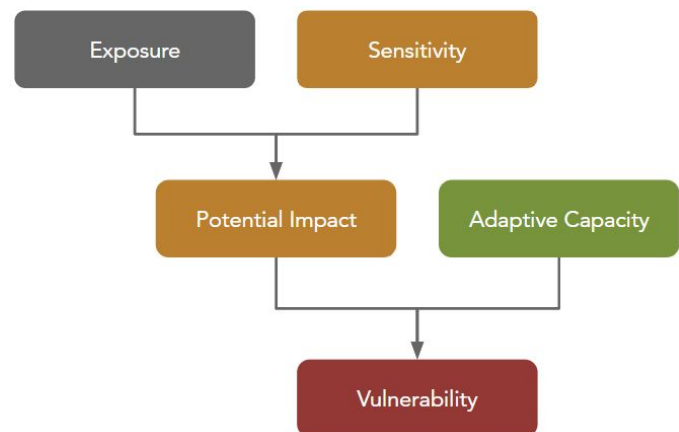


## Vulnerability and Risk Assessment

The vulnerability and risk assessment framework used multi-criteria decision analysis as well as spatial analysis in a data-driven pipeline.<sup>2</sup> This involved developing criteria, or rules, that were used to assign to assets specific ordinal classifications of *high*, *medium*, and *low* for each of the variables described below. The classifications were then combined using a matrix approach to determine levels of vulnerability, risk, and combined vulnerability and risk.<sup>3</sup>

### Vulnerability

Vulnerability describes the susceptibility of exposed assets based on the two core concepts described above: (1) potential impact—the degree to which an asset is affected; and (2) adaptive capacity—the ability the asset has to cope with a potential impact.



### Potential Impact

Potential impact is the degree to which an exposed asset (asset that is in harm's way) is potentially negatively affected by a climate-related threat. The level at which an exposed asset is negatively affected is also referred to as the asset's *sensitivity*. Assets that are not exposed have no potential impact; thus, they are not vulnerable, or at risk. Exposed assets were evaluated for levels of sensitivity, which were used in determining levels of potential impact.

Factors used to determine levels of potential impact were based on the asset's characteristics or on the level of impact due to service loss if the asset were to be affected.<sup>4</sup> For example, a property with a building structure in a flood hazard area has a higher potential impact than does a property that does not have a building in a flood hazard area.

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<sup>2</sup> Malczewski, Jacek, and Claus Rinner. *Multicriteria Decision Analysis in Geographic Information Science*. Springer-Verlag, 2015.

<sup>3</sup> EPA Office of Water, Climate Ready Estuaries. *Being Prepared for Climate Change: A Workbook for Developing Risk-Based Adaptation Plans*. U.S. Environmental Protection Agency, 2014.  
[\[https://www.epa.gov/sites/production/files/2014-09/documents/being\\_prepared\\_workbook\\_508.pdf\]](https://www.epa.gov/sites/production/files/2014-09/documents/being_prepared_workbook_508.pdf)

<sup>4</sup> Glick, P., B. A. Stein, and N.A. Edelson, editors. *Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment*. National Wildlife Federation, 2011.  
[\[http://www.habitat.noaa.gov/pdf/scanning\\_the\\_conservation\\_horizon.pdf\]](http://www.habitat.noaa.gov/pdf/scanning_the_conservation_horizon.pdf)

## Adaptive Capacity

Adaptive capacity considers how an asset is able to cope with a threat event or impact. An asset with adaptive capacity is able to withstand an impact with minimal disruption or loss. Measures of adaptive capacity can include physical elements, conditions, or designs in place that help an asset absorb an impact. Exposed assets were evaluated for indicators of adaptive capacity and classified accordingly.

For example, a commercial building that has flood-proofed its foundation and raised its ground floor above flood levels has more adaptive capacity than a commercial building that has not done so. As another example, a park with facilities designed to withstand flood waters without damaging its infrastructure has adaptive capacity.

Levels of potential impact and adaptive capacity are then combined to inform vulnerability. Assets with low potential impact and high adaptive capacity are the least vulnerable. Assets with high potential impact and low adaptive capacity are the most vulnerable. For example, a business-related structure in the flood hazard zone has a “high” level of potential impact and, if it was built before 1979, it is classified as having “low” adaptive capacity. Together, they result in a “high” vulnerability classification.

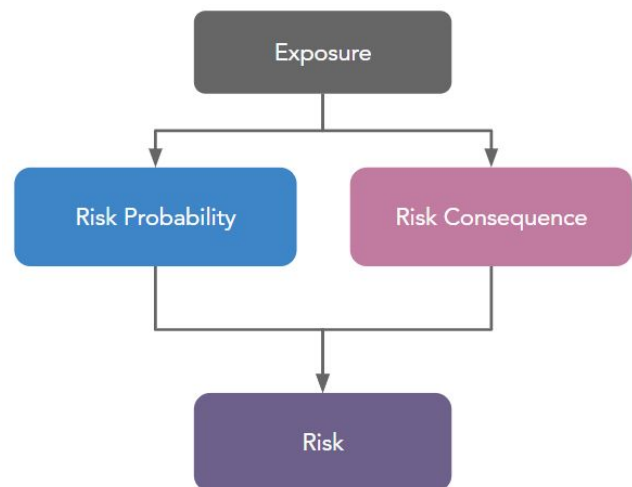


## Risk Scoping

Just as potential impact and adaptive capacity combine to determine vulnerability, risk probability and risk consequence combine to give us an assessment of risk scoping.

### Risk Probability

Probabilities were determined for each threat using annualized likelihoods of threat occurrence or relative levels based on known risk factors. For example, for Rainfall-Induced Flooding, the 10-year, 100-year, and 500-year flood hazard zones were used to evaluate different probabilities of flooding for each asset.

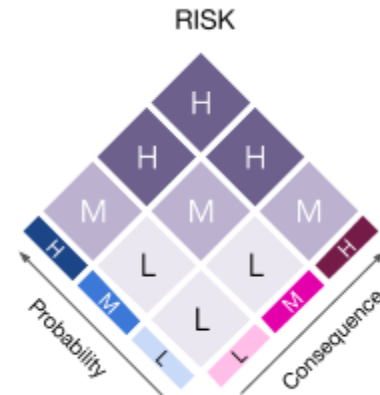


## Risk Consequence

Risk consequence refers to negative outcomes or critical thresholds that indicate varying levels of significance if a threat were to occur. For example, assets with affected structures or a higher monetary value may have a greater negative consequence than assets with no affected structures or that have a lower monetary value.

Levels of risk probability and risk consequence are then combined to inform risk scoping. For example, a parcel with an exposed high-value building in the 10-year flood hazard zone would have a high risk classification, while a parcel in the 100-year flood hazard zone without an exposed building would have a low risk classification.

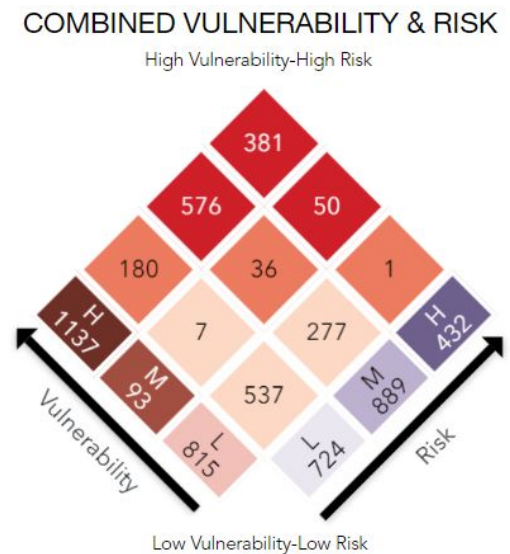
It is important to note that this step is referred to as risk scoping, as no loss estimates were quantified.



## Combined Vulnerability and Risk

Vulnerability considers how an asset might be impacted and its ability to cope if a given threat event were to occur, and risk considers the probability of the threat occurring and the general consequence of the threat (without considering factors that make it susceptible). Combining these concepts allows decision makers to evaluate which assets are most susceptible and most likely to be impacted, and also to consider options according to different levels of risk threshold.

The matrix shown here features the combination of vulnerability and risk for Commercial Property and Rainfall-Induced Flooding. High-vulnerability and high-risk parcels are in the top-most cell. Those that have low vulnerability and low risk are in the bottom-most cell.

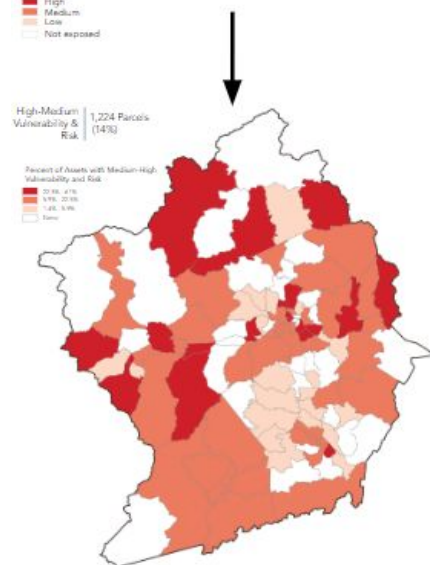


## Aggregation of Vulnerability and Risk

In order to focus on the most vulnerable and risk assets, the assets with either medium or high combined vulnerability and risk are mapped at the aggregate scale. In the matrix and parcel-level map to the right, these are the cells or parcel with with the two darkest shades of red.

For mapping purposes, two census tract-level maps are provided, one that shows the total number of assets (parcels) that are vulnerable and at risk and another that shows the percent of assets that are vulnerable and at risk. Due to varying sizes of census tracts in the region, the percent of assets map is used to provide a relative perspective of vulnerability within different areas in the region.

## Vulnerability & Risk



## Appendix B: Data sources

Table 1: Hazard data sources

Hazard	Source	Data format
Flooding	FEMA Floodplains, North Carolina Flood Risk Information System: <ul style="list-style-type: none"> <li>• Buncombe, 2017</li> <li>• Haywood, 2016</li> <li>• Henderson, 2019</li> <li>• Madison, 2011</li> <li>• Transylvania, 2017</li> </ul>	Vector features
Landslides	Debris Flow Pathways, NCDEQ: <ul style="list-style-type: none"> <li>• Buncombe, 2009</li> <li>• Henderson, 2011</li> </ul>	Vector features
Wildfire	WUI Wildfire Risk Index, Southern Group of State Foresters (2015)	Raster

Table 2: Asset and socioeconomic data sources

Asset Type	Source	Data format
Property parcels	County Parcel Data Sets (Accessed Spring, 2019)	Vector features
Roads	Open Street Map	Linear Features
Socioeconomic Metrics	U.S Census, American Community Survey (ACS)	Vector features
Social Vulnerability Index	CDC's Social Vulnerability Index	Vector features



# Appendix C: Asset classification

## Parcel-based asset categories

All properties are based on county property parcel data. Specific use types were determined used available class codes (some of which were used in rulesets for vulnerability assessment).

Asset Category	Specific type	Bunc. [Class]	Haywood [Bldg_Use_C]	Henderson [LAND_CLASS]	Madison [Class]	Transylvania [Improvemen]
Commercial	General	341, 400, 405, 442, 448, 466, 470, 480, 483, 601, 602	'CRS'	COMMERCIAL', 'COMM-CONDO', 'COMM-LI'	4	10, 10C, 25, 29, 35
	Industrial	440, 444, 446, 447, 700, 701, 710, 720, 721	IND', 'WHS', 'SWH', 'WHM', 'WHD'	'DISTRIBUTION WHSE', 'INDUSTRIAL', 'MINI WAREHOUSES'	5	40, 41, 42, 42F, 43, 44, 45, 46, 47, 48, 48D, 48M, 49, 51, 52, 54, 55, 92, 93
	Restaurants	420, 421, 422, 423, 424, 425, 426, 479	RWI', 'RFF'	FAST FOOD REST', 'RESTAURANTS'		21, 21C, 22, 22C, 33
	Office	460, 462, 464, 465, 610, 646	OFG', 'BNK', 'BDT'	BANKS', 'DRIVE-THRU BANKS', 'NON PROFIT ORGANIZAT'		17, 18, 23, 24, 30, 36
	Retail	430, 431, 432, 433, 434, 435, 441, 450, 454, 455, 456, 458, 471, 472, 473, 481, 490, 492, 494, 495, 530, 541, 542, 545, 558, 695	LAM', 'ARM', 'ASC', 'ADL', 'BBS', 'CWD', 'CWS', 'SRE', 'FHM', 'GRS', 'GML', 'GRS', 'SVS', 'SSM', 'SCN', 'SCC', 'SDS'	AUTO DEALERSHIP', 'CEMETARY', 'CONVENIENCE STORES', 'DISCOUNT SUPER CNTR', 'DRUG STORES', 'HOME IMPV CENTER', 'MULTI-USE CONV STORE', 'SUPERMARKET', 'STRIP SHOPPING CTR'		10D, 10H, 10P, 11, 11M, 12, 12A, 12D, 13, 13D, 13W, 14, 15, 16, 26, 27, 27D, 27M, 27S, 34, 38, 53, 57, 64, 76
	Hotel	414, 415, 418	MOT', 'B&B'	HOTEL', 'MOTEL'		37, 39
Residential	single_residence	100, 105, 173	D'	PERSONAL PROPERTY MH', 'REAL PROP MANF HOME', 'RES-SINGLE FAMILY',	2	01, 05, 07, 09

				'RES-LEASEHOLD'		
	multi_residence	120, 121, 180, 411, 634, 635	APT', 'DOR', 'CTT', 'DD'	APARTMENT', 'APT-CONDO', 'LOW INCOME APARTMENT', 'RES-CONDO', 'RES-DUPLEX', 'RES-MULTI RES', 'RES-TOWNHOUSE', 'RES-TRIPLEX'		04, 06, 60, 61, 62, 63
	group_home	631				69, 70, 75
	nursing_home	476, 633, 644	CHM'			74, 74A, 74C, 74R
	mobile_home	170, 416	DW', 'PM', 'SW', 'MD'	MANU HOME PARK', 'RES-MODULAR', 'RV-PARK'		01M, 02, 03
	public_housing					
Gov-Owned & Critical Facilities	emergency_services	662	FRS'	FIRE DEPARTMENT', 'VOLUNTEER FIRE DEPT'		90
	utility	800, 810, 817, 820, 822, 830, 831, 850, 852, 853	TEX'	CELLULAR TOWER', 'SOLAR FARM', 'UTILITIES'		91
	medical	468, 475, 640, 642, 645, 694	OFS', 'OFM', 'OFV'	MEDICAL'		19, 19V, 20, 73S
	medical_major	641	HOS'	HOSPITAL'		73, 85
	schools	478, 486, 612, 613, 614, 615, 616, 617	DAC', 'SCH'	EDUCATIONAL'		31, 68, 72, 72C, 83, 84
	transportation_facility	307, 437, 438, 624, 653, 841, 842, 844	PGR'	TRANSPORTATION'		28, 79, 81H, 81M
	post_office	654	POF'	POST OFFICE'		
	government_owned	365, 650, 651, 652, 670, 682	GOV', 'JAL'	GOVERNMENTAL'	6	80, 81, 94
	federal_owned					88
	state_owned	658				87

	county_owned					86
	municipal_owned					89
	religious	620, 621, 622, 623, 625, 628	CHR'	CHURCH', 'RELIGIOUS'	7	71, 71F
	community	477, 510, 543, 544, 554, 600, 618, 632	CHS', 'CMC', 'CCB', 'FRB', 'GYM', 'HTC'			34F, 34R, 67, 77, 78, 82B
	cultural	512, 515, 611, 630, 636, 680, 681, 836	LIB', 'RTV', 'THR'			32, 32A, 86L
Natural	park_greenway	306, 417, 500, 551, 552, 555, 930, 931, 933, 934		GOLF COURSES', 'PARKS', 'RECREATIONAL', 'CAMPS'		08, 65, 82
	agricultural/farms	320	2009 PUV parcel data	AGRICULTURE-HORTICUL'; 2009 PUV parcel data	3	50; 2009 PUV parcel data
	protected_natural	900, 942		CONSERVATION EASEMEN'	17	

## Validation of farms based on agricultural census

The table below shows the comparison between the 2017 agricultural census and the number of properties selected from the 2019 property parcels using class codes and 2009 PUV data from across the region. The results show comparable or expected percentages:

County	2017 Ag Census		Number of 2019 properties	
	Total # farms	Percent in Region	Total # properties	Percent in Region
Buncombe	1,073	37%	2,800	29%
Haywood	540	18%	1,740	18%
Henderson	455	16%	1,749	18%
Transylvania	215	7%	751	8%
Madison	639	22%	2,500	26%





Triangle Regional Resilience Partnership

# Resilience Assessment

EXECUTIVE SUMMARY

PREPARED FOR THE



**TRIANGLE J**  
COUNCIL OF GOVERNMENTS

OCTOBER 2018



# Executive Summary

Resilience is about planning and investing today for a better future.

The Triangle region of North Carolina, like other communities across the United States, faces increasingly severe impacts from weather- and climate-related threats—threats that are expected to become even more frequent and severe in the future. The region is simultaneously dealing with stressors unrelated to climate, such as rapid population growth, continued development, and shifts in economic and demographic trends.

To better prepare for and adapt to these changing realities, the Triangle Regional

Resilience Partnership (the TRRP)—in partnership with UNC Asheville’s National Environmental Modeling and Analysis Center (NEMAC) and the Triangle J Council of Governments—performed a quantified assessment to help regional decision makers understand which assets are most vulnerable to specific threats and provide guidance on potential solutions. This regional assessment provides an initial framework to inform more detailed local plans and investments.

## How is the Triangle Region Changing?

The region is experiencing certain trends, primarily:



Increasing extreme precipitation events that lead to more frequent local flooding



Increasing temperatures and temperature variability



Increasing frequency and duration of drought conditions



Robust population growth leading to an increasing demand for resources and services and increasing social vulnerability

The purpose of the assessment was to examine these and other trends to see how these changes impact our valued assets—such as human health, infrastructure, and agriculture.



## How Do These Changes Impact the Triangle Region?

The assessment explores how and where our assets—people, property, services, and infrastructure—are impacted by these changes. There is a trend toward increasing **vulnerability and risk** in these key areas:

### » Impacts of Flooding on Properties and Road Access

With an expectation of increased precipitation and continued development comes the reality of increased localized flooding.

A major or widespread flooding event in the region could result in more than 30,000 properties becoming partially or fully inaccessible to residents and emergency vehicles due to either inundated or damaged roads.

### » Impacts of Minor Flooding on All Assets

The threat of minor flooding—flooding events that cause stress to stormwater systems, regardless of the size—arises from extreme or heavy precipitation that could result in runoff and erosion and impacts to surface water quality.

### » Impacts of Water Shortage on Water Supply

Changes in the amount and intensity of rainfall can and will affect the quality and quantity of regional water supplies.

### » Impacts of Extreme Heat on Residents

Extreme heat can cause negative health impacts, which causes concern for the region's socially vulnerable populations.

### » Impacts of Wildfire on Residential Properties

Development in the region has led to many homes being located in the wildland-urban interface, raising their vulnerability and risk to wildfire.

Socially vulnerable populations in the Triangle region may be disproportionately affected by stressors and impacts.

## How Can We Use the Assessment?

The assessment should be considered a starting point—one that focuses on regional solutions and begins the process of building community preparedness. Local governments should use the assessment as a guide for more detailed local planning to promote a more equitable and resilient future. The assessment empowers the region and its people to integrate long-term data analysis into current decision-making processes so

that they can make decisions with confidence and take action to build a resilient, climate-ready place to live, work, and thrive.

Using results from the assessment, the TRRP partners developed a number of **options and strategies** to help guide the region as it responds to climate and non-climate stressors while providing an improved quality of life and supporting regional vitality and livability.

# The Triangle Regional Resilience Partnership

The TRRP is a cooperative partnership among the Town of Cary, the Town of Chapel Hill, the City of Durham, the City of Raleigh, Durham County, and Orange County. The Steering Committee is composed of the partners' Sustainability Managers, Sustainability Directors, and Resilience Officers. The Triangle J Council of Governments provides administrative assistance.

## Community Resilience

Resilience is the capacity of a community, business, or natural system to prevent, withstand, respond to, and recover from a disruption.

Many local governments are recognizing the need to build community resilience as they experience (1) rapid growth, and (2) more frequent and/or severe extreme weather events.

The goal of resilience is more than simply “bouncing back” after an event—the idea is to “bounce forward” to a place where the community will be better able to withstand a future event.

## The Resilience Assessment Process

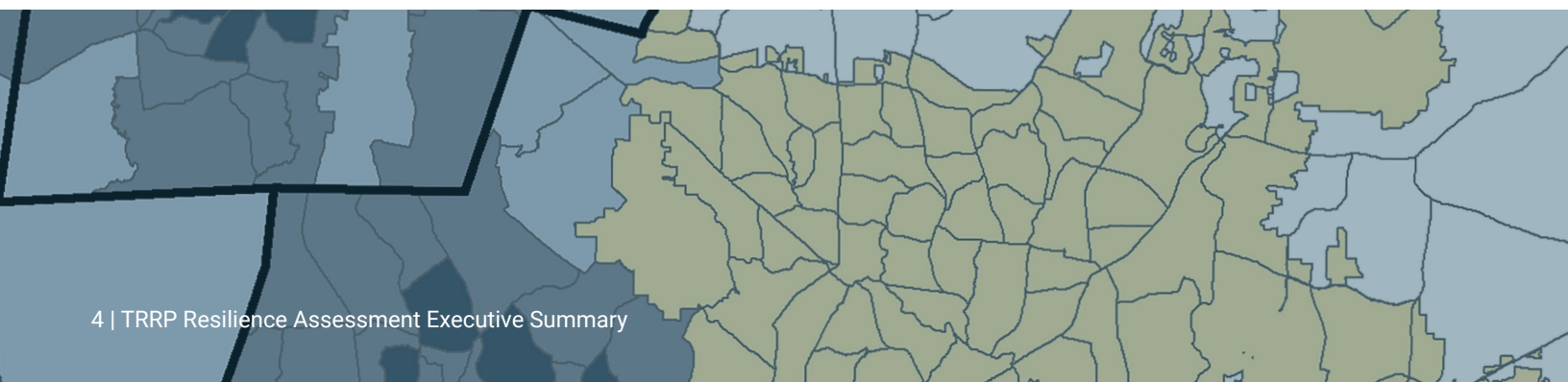
The Triangle Regional Resilience Assessment used a quantified process to identify and respond to both climate threats and non-climate stressors in the region. Using the “Steps to Resilience” framework from the U.S. Climate Resilience Toolkit<sup>1</sup> and guided by NEMAC, the TRRP partners determined key assets in each community, assessed the vulnerability and risks that these assets face, and developed potential strategies to address those vulnerabilities and risks to improve the region’s overall resilience.

GIS-based analyses were performed and mapped at the census tract level to assess regional-scale impacts. Not all areas within

a census tract will have uniform vulnerability, and localized impacts may vary within any given census tract.

Interactions between climate and non-climate stressors are complex, and the decisions being made are related to growth/sustainability and to climate. For example, the amount of precipitation that falls (or the lack thereof) is not a threat in and of itself. Extreme precipitation, however, is a climate stressor if enough of it falls in a short time frame and/or in combination with a high level of impervious surface—leading to the threat of flooding. Changing conditions can affect both climate and non-climate stressors, resulting in increased threats and hazards to key community assets.

<sup>1</sup> [toolkit.climate.gov](https://toolkit.climate.gov)



# The Triangle Region

Shared values and assets are vital to the way of life in this part of North Carolina and contribute to the regional culture of TRRP cities, towns, and counties. Key regional values and assets include:

- A strong, diversified economy;
- A highly educated populace, with excellent higher education institutions;
- Plentiful parks and open space;
- A regional culture of connectivity;
- Resurgent downtown spaces;
- Transit solutions to connect hubs and develop walkable neighborhoods;
- A sustainable environment;

- An abundant surface water supply (in normal conditions);
- A robust tree canopy; and
- Historic and cultural destinations that support quality of life (e.g., culture, entertainment, and dining).

Each community has its own set of values. The assessment does not attempt to reflect each community's values, but rather to show regional variability in order to facilitate regional coordination and collaboration to enhance resilience. Each partner needs to define its own acceptable risk level and make plans to address the risks that affect its community.

## » Water

The region boasts a plentiful supply of surface water, but may not have adequate water supply during periods of drought.

## » Transportation

The region is a transportation node for the Southeastern U.S., supporting regional as well as local mobility.

## » Energy

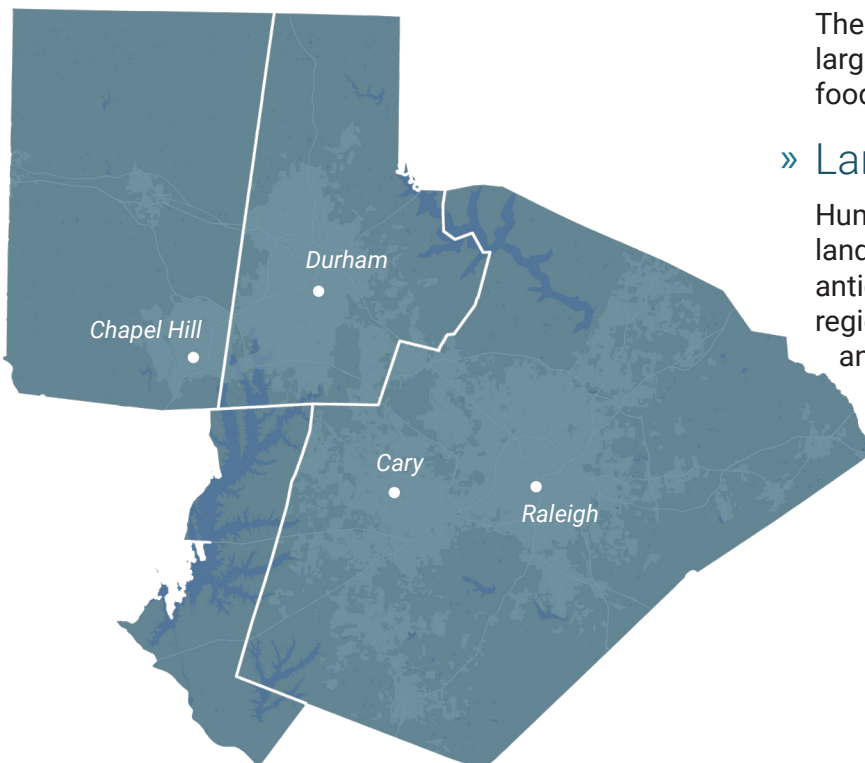
Increased growth and subsequent demand may stress local energy supplies, which would have an impact on the local economy and quality of life. Higher prices and/or a limited fuel supply would make a car-dominated and air-conditioning-dependent economy vulnerable.

## » Food

The region's proximity to the state's largest agricultural area is beneficial for food sustainability and resilience.

## » Land Use Patterns

Human changes to urban and rural landscapes that are not adaptive to anticipated risks could exacerbate regional impacts, such as from flooding and wildfire.



## Social Vulnerability

Socially vulnerable populations may experience more severe impacts on their health and access to services from extreme weather events.

## Climate Stressors

The assessment identifies several climate stressors, primarily:



Increasing extreme precipitation events that lead to more frequent local flooding



Increasing temperatures and temperature variability



Increased frequency and duration of drought conditions

## Non-Climate Stressors



Robust population growth leading to an increased demand for resources and services and increasing social vulnerability

The Triangle region has a reputation for a good quality of life, affordable housing, and excellent opportunity for high-paying jobs. This has led to robust population growth: from 1970 to 2016, the Triangle Region's population grew **over 250%**—compared to a national average of **less than 60%**—and growth is projected to continue at this rate.

The desire for newer houses in the suburbs resulted in sprawl, leading to:

- An increased demand for resources and services: water, energy, roads, schools, emergency services.
- Higher than normal average wages and median home prices do not translate across all sectors, leading to greater disparity and increased social vulnerability for some populations.

## Vulnerability and Risk

The assessment, based on the national standard risk framework, shows how the people, places, and assets of the Triangle region are affected by climate threats and non-climate stressors.

When considering the vulnerability and risk to people, the assessment focuses on socially

vulnerable populations. Impacts to property and infrastructure were considered when focusing on the transportation, water, natural areas, health, and public services sectors.

The results of the analysis show a concerning trend toward increased vulnerability and risk for some assets and threats in the Triangle region.

Results from the vulnerability and risk analysis performed as part of the assessment are found below and on the following pages. The analysis results are presented in “asset-threat pairs”—that is, examining the impact of one threat on one asset type—and are aggregated to and displayed at the census tract level. The asset-threat pairs included here are some that posed significant

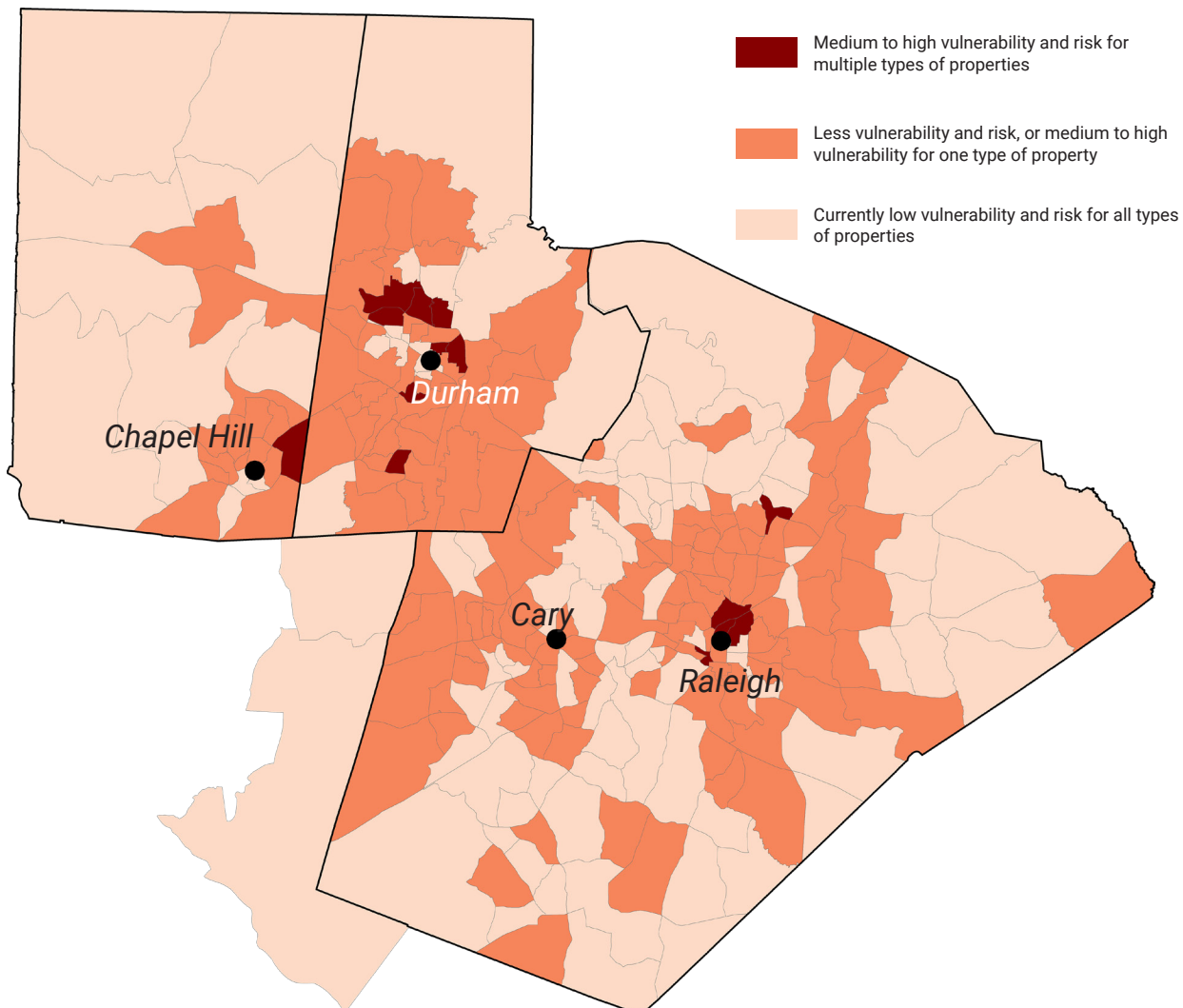
vulnerability and risk and were of high concern to the TRRP partners. They also show the range of regional issues and opportunities included in the assessment.

Please refer to the Technical Report for a full list of analyzed asset-threat pairs, the results of the analysis, and the vulnerability and risk rulesets and criteria used for all asset-threat pairs.

## Properties and Flooding

With an expectation of more frequent and intense precipitation events and continued population growth and urbanization comes the reality of increased localized flooding that can affect commercial, industrial, and residential properties.

The assessment shows that a large number of commercial, industrial, and residential properties in the region face significant vulnerability and risk due to flooding.

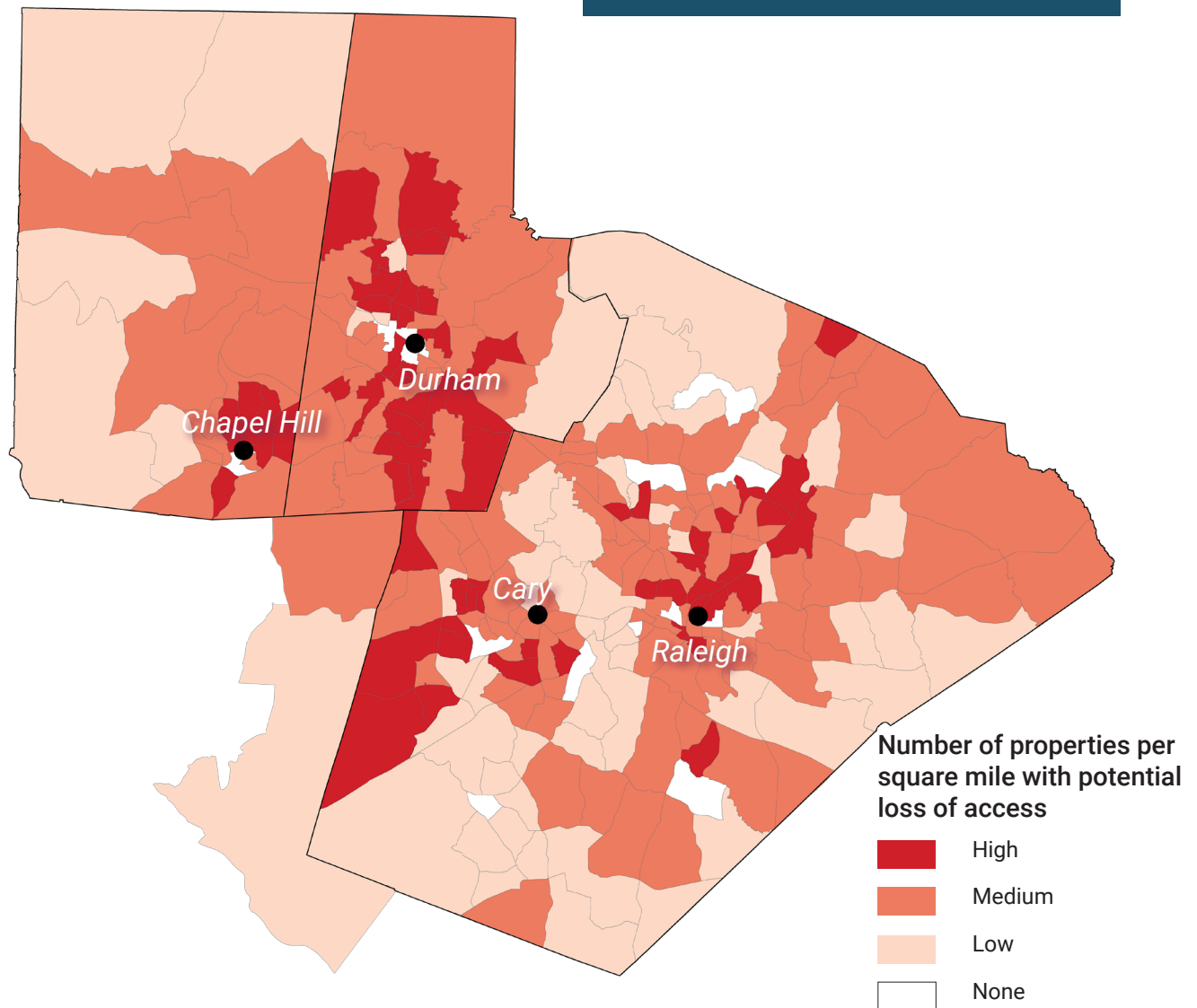




## Road Access and Flooding

Beyond day-to-day transportation needs, roads provide vitally important access for safety and emergency services. Many of these are in areas with a single access point. Red areas on the map have the highest estimated number of properties with the potential for loss of access during a flood event.

Depending on the circumstances, a flooding event in the region could result in more than 30,000 properties becoming inaccessible to residents and emergency vehicles due to either inundated or damaged roads.



## All Assets and Minor Flooding

Minor flooding events are usually less severe than major flooding, but can still cause significant impacts. Minor flooding is heavily influenced by the amount of developed land cover and impervious surfaces that contribute to runoff.

The problems related to minor flooding are regional because of the connectivity of shared watersheds in the region. Compare how east Raleigh and northeast Raleigh may be impacted differently due to amount of developed land cover and the size (area) of the watersheds upstream.

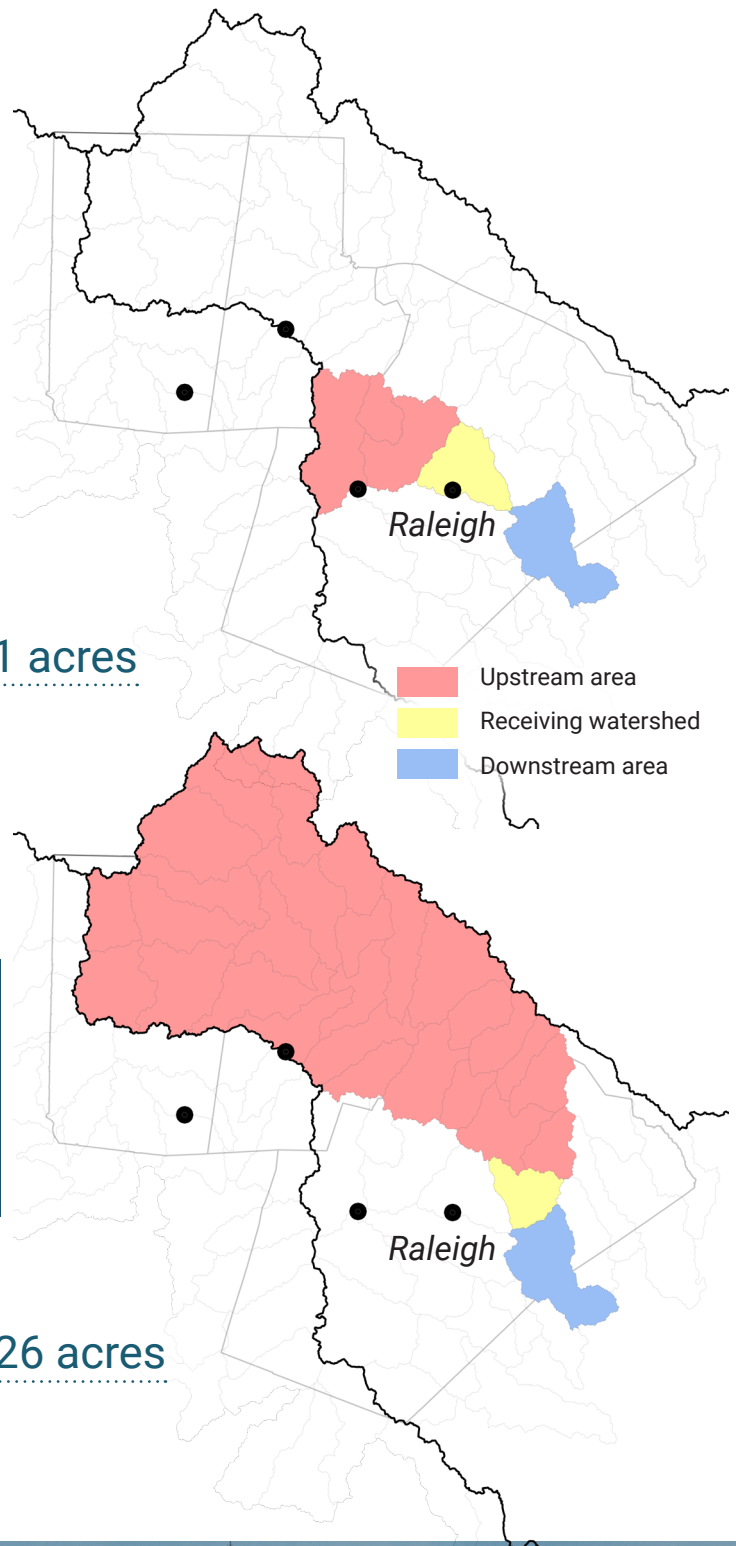
### NORTHEAST/CENTRAL RALEIGH

*Total Upstream Area* | **92,971 acres**  
*Total Upstream Developed Land Cover* | **35%**

The threat of minor flooding arises from extreme or heavy precipitation that results in runoff and erosion.

### EAST RALEIGH/KNIGHTDALE

*Total Upstream Area* | **479,926 acres**  
*Total Upstream Developed Land Cover* | **7%**



## Water Supply and Water Shortage

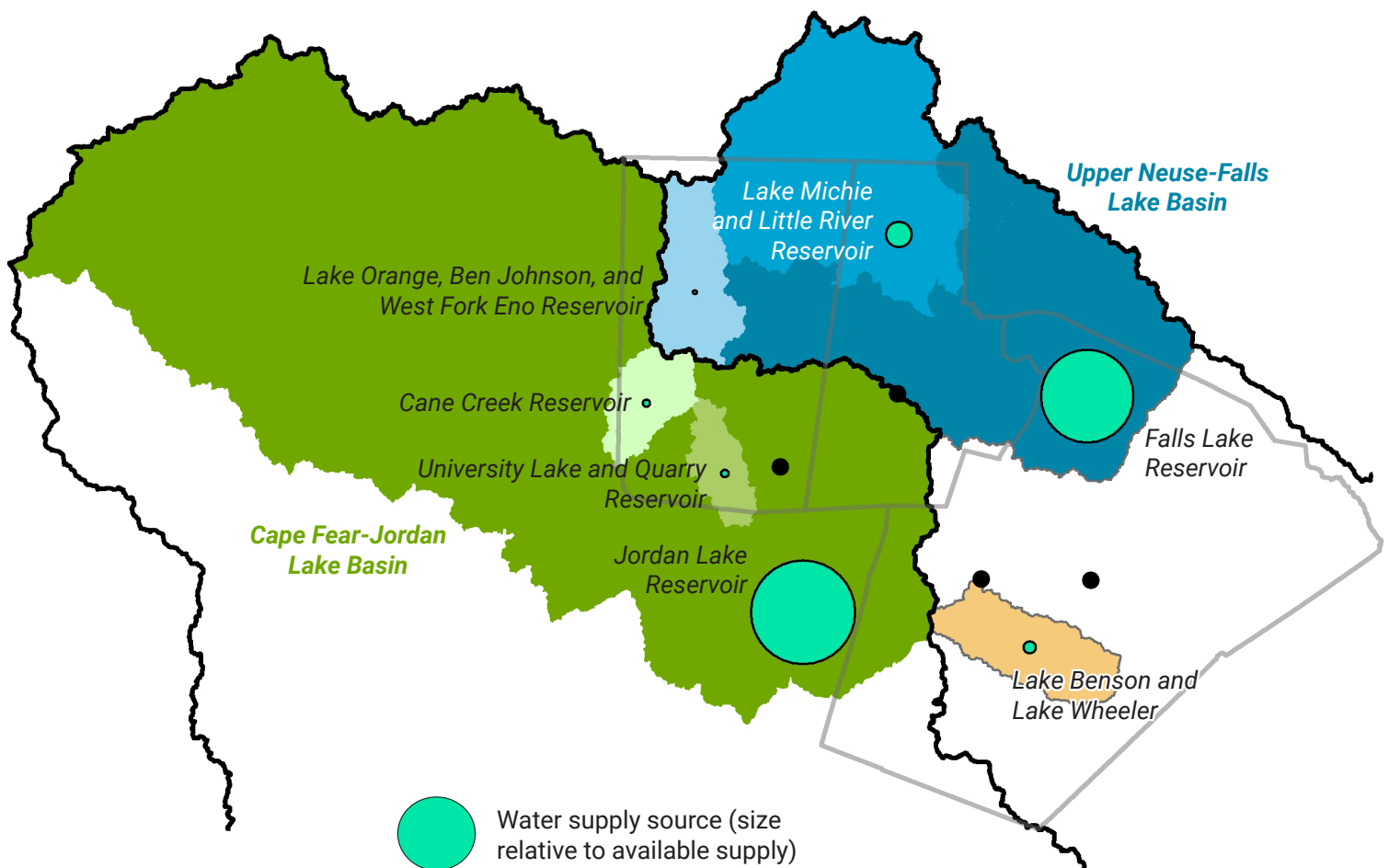
Non-climate factors—such as increased demand and aging infrastructure—compound climate-related issues, threatening the region’s supply of clean, safe water and reliable wastewater services.

As climate and non-climate stressors change, optimizing the use of supplies from different sources while meeting water-quality standards may present new challenges, even for veteran water managers.

The region has a strong history of partnership on water resource issues, such as the Jordan Lake Partnership and other continued efforts. The infrastructure investments and water

Changes in the frequency and severity of drought can and will affect the quality and quantity of regional water supplies.

sharing agreements established through these partnerships will help the region cope with water shortages; continuing the partnerships will help the region become adaptive to meeting water supply needs in the future.

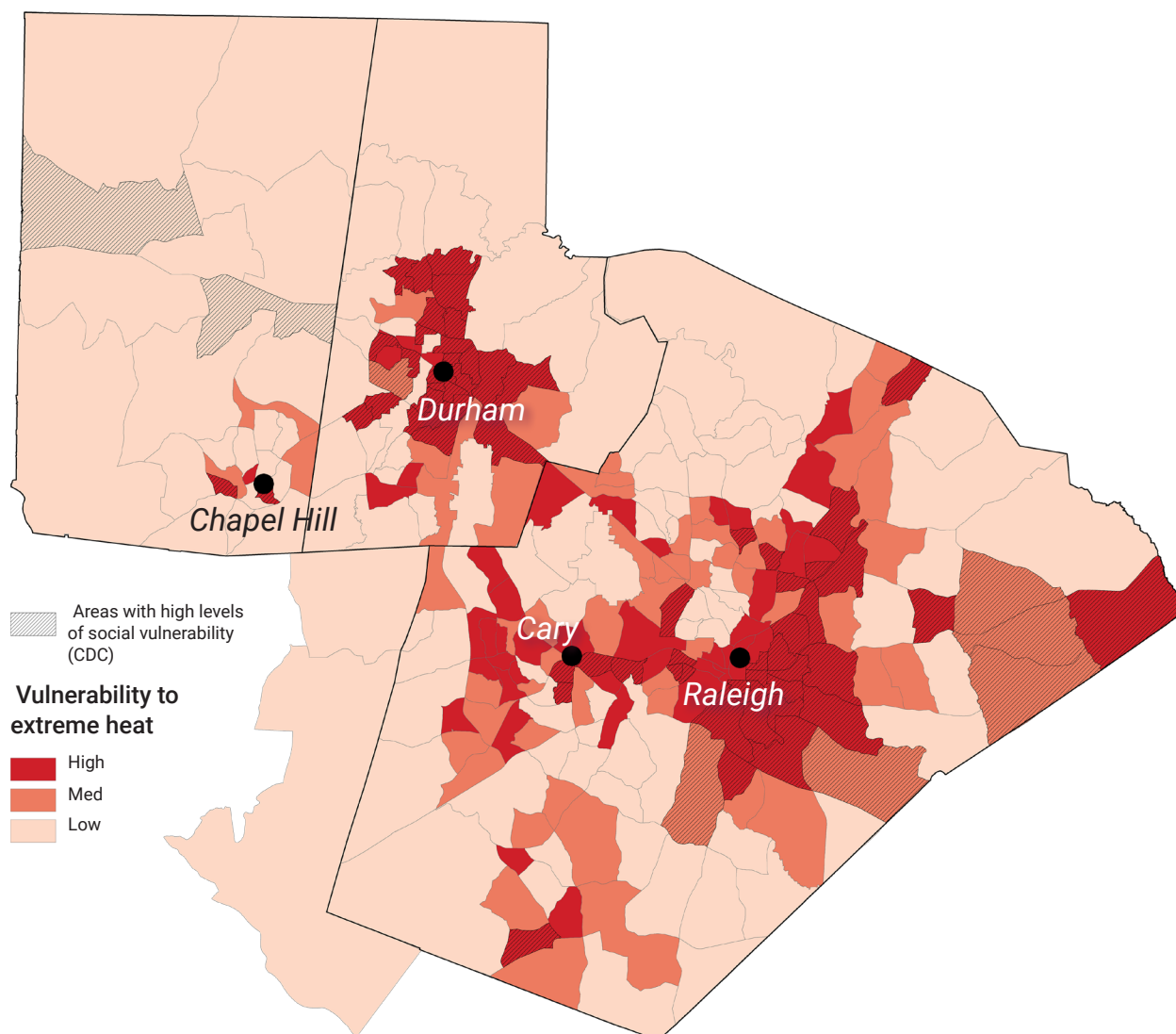


## Residents and Extreme Heat

Extreme heat can cause negative health impacts, which causes concern for the region's socially vulnerable populations.

The Triangle region has a history of extreme heat events, and their number is expected to increase. For example, from 2005 to 2012 the City of Raleigh experienced a higher than normal number of days over 92°F, particularly in 2010—with 48, the most on record.

The assessment considers socially vulnerable populations (using the CDC's Social Vulnerability Index, or SVI) who live in proximity to developed land cover. The SVI includes families living below the poverty line, households with disabilities and members who are age 65 and older, and households who have limited English language proficiency, among other metrics. Socially vulnerable populations in areas with a high percentage of developed land cover and low tree canopy are most vulnerable to negative health effects related to heat stress and due to the urban heat island effect.

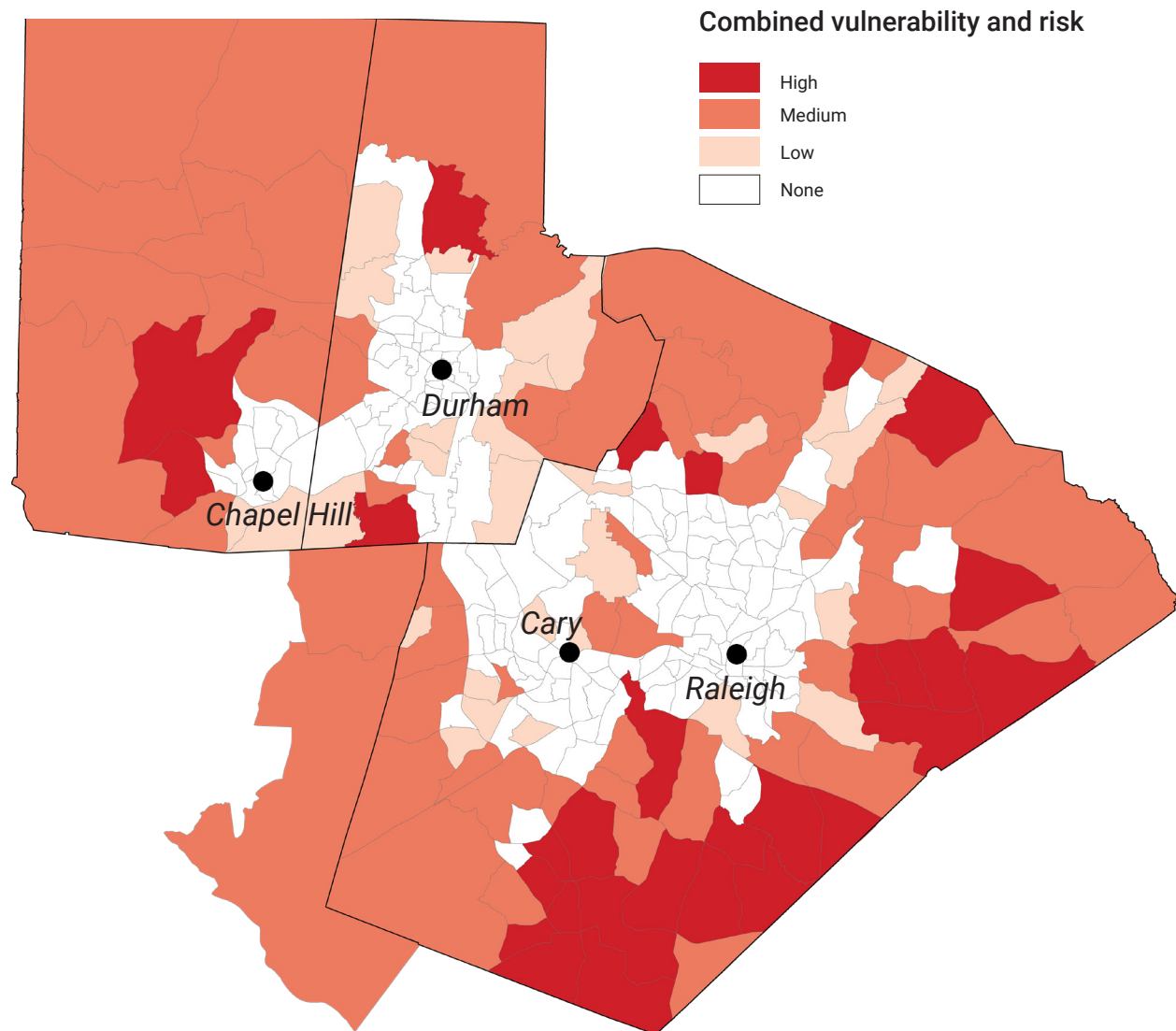




## Residential Properties and Wildfire

Increasing temperatures and drought conditions will contribute to increased wildfire frequency, intensity, and size. In the Triangle region, most of the properties with relatively high wildfire vulnerability and risk are residential.

Over 23,000 residential properties are located in the wildland-urban interface and are outside an eight-minute drive time from their local fire station.



This is not an exhaustive list of the asset-threat pairs analyzed in the assessment. To learn more about impacts to other key assets—such as transportation networks, energy supplies, and food infrastructure—please refer to the Technical Report.



# Strategies to Build Resilience

The assessment is a snapshot in time identifying regional assets that may face increasing vulnerability and risk. If we do nothing, we can expect a future that includes dealing with the consequences of that vulnerability and risk.

As a part of this effort, the partners developed options and strategies that may help guide the region as it responds to both climate threats and non-climate stressors, provide an improved quality of life, and support each community’s vitality and livability.

These strategies address the most vulnerable and at-risk assets and the key threats and stressors. Each strategy also addresses

vulnerability and risk by either (1) reducing exposure—removing assets from harm’s way, (2) increasing adaptive capacity—increasing the asset’s ability to cope with impacts, or (3) supporting response and recovery.

They are regional strategies and illustrate the best use of joint planning, action, and communication efforts.

The strategies were evaluated using criteria developed based on lessons learned from other jurisdictions, both here in the U.S. and across the globe, and on principles considered by the TRRP partners to be important to the Triangle region.

## EVALUATION CRITERIA

what	Ability to increase regional resilience	Provides co-benefits	Socially responsible	Ability to implement
why	To ensure that vulnerability and risks are addressed at a regional scale	To ensure that options and strategies address multiple problems	To promote fairness, equity, and social responsibility	To determine the feasibility for implementation

The resilience options and strategies will prepare the Triangle region for our changing realities.



The following potential strategies are organized into themes that represent topics of key concern for the region, based on the assessment. Some of these strategies also build on a broad set of efforts that are already underway.

## **PRIORITIZED OPTIONS AND STRATEGIES**

### » Building greater community capacity

- Develop a regional outreach and communication plan for all threats
- Create a communication plan for socially vulnerable populations
- Determine the use of distributed energy resources to provide backup power to critical facilities
- Transition public fleets to be less dependent on fossil fuels
- Establish regional coordination of fire station locations to reduce response time in key areas

### » Addressing flooding

- Establish regional evaluation of flooding potential
- Conduct regional mapping assessment of stormwater conveyances
- Implement a stream monitoring system that alerts emergency management about rising water levels
- Create and implement green stormwater infrastructure programs and fee credit programs for stormwater retention
- Create green infrastructure incentives and/or policies for redevelopment and new development
- Develop cross-boundary watershed solutions through comprehensive regional collaboration

### » Addressing extreme heat

- Establish regional “resilience centers” in partnership with faith-based and other community organizations
- Establish design standards to reduce heat absorption from roofs
- Increase the regional tree canopy coverage by implementing urban forestry programs

### » Addressing water shortage

- Utilize regional water supply planning for long-term demands
- Enhance capacity of regional water system interconnects

Going forward, the TRRP will continue to assess the impacts of climate and non-climate stressors, explore regional collaborative approaches to address these impacts, and identify and supplement local actions.

# Taking Action

How do we use the assessment to plan for action and build resilience?

The assessment identifies potential options and strategies that may be approached at the regional scale to enhance resilience and provides the basis to inform more detailed local plans and investments. These strategies represent a starting point for planning and implementing local actions to increase resilience.

The assessment itself can be used and integrated into each community's existing hazard mitigation, comprehensive, and emergency management plans to further current local actions.

Individual cities, towns, and counties can also use the assessment to generate and prioritize their own options and strategies to increase resilience at the local level, incorporating the input of all interested stakeholders.







TOWN of CARY



*Photo credits:*

*Cover photo sources, clockwise from top:*

*Town of Cary*

*Town of Chapel Hill*

*David Hunt, Orange County*

*City of Durham*

*Higgins Spooner, "Downtown Raleigh NC at night" (2018)*

*p. 9: Town of Chapel Hill*

*p. 13: Brandon Griggs (2016)*

*p. 15: Chris Liu-Beers (2014)*





# Building a Climate-Resilient Asheville

## PERSONAL ACTION GUIDE

Asheville has a history of climate-related impacts—major floods in 1916 and 2004, landslides, nuisance flooding, wildfires, and the record drought of 2007–2008, to name a few.

Asheville is also facing other stressors, like pressures from population growth, increasing demand for city services, economic changes, land use issues, and the desire to preserve a sense of place.

Over the past two years, city staff have been evaluating our vulnerability and risk to impacts from extreme weather events and are implementing projects to build resilience.

This guide provides strategies to help you become more resilient to extreme weather impacts.





## Central Asheville

Central Asheville is the region's primary employment hub and serves as the city's main commercial, dining, and entertainment center. Downtown Asheville is heavily developed, with a substantial amount of paved surfaces, making it more vulnerable to impacts from extreme heat. In addition to downtown Asheville and its surrounding residential neighborhoods, this area also includes Biltmore Village and the River Arts District, which are susceptible to flooding. Major institutional uses include Mission Hospital and A-B Tech.





## Flooding (major)

Buildings are most vulnerable when they're located in flood-prone areas and don't have an elevated first floor or floodproofing that helps them cope with flood waters.

Commercial and industrial property is especially at risk in the River Arts District (RAD) and in the area along Swannanoa River Road between Biltmore Village and Tunnel Road. Some residential properties in these areas are susceptible to flooding.

Key services are also vulnerable. In particular, food locations, including SNAP retailers, and bus routes could be impacted—which could result in service interruptions.



## Flooding (minor)

Properties are subject to minor flooding when they're in low-lying areas or when they're close to impervious surfaces that contribute to runoff.

Some areas in downtown—especially low-lying areas—may be impacted by nuisance flooding and runoff due to the high amount of impervious surfaces.



## Extreme Heat

Sensitive populations and households with members 65+ are vulnerable to extreme heat. Much of Central Asheville could be affected by the urban heat island effect—when developed areas are hotter than nearby rural areas—because of the large amount of paved surfaces and reflective buildings and the relatively low tree canopy cover.



## Landslides

Properties are most vulnerable when they're in the pathway of potential slope failures or landslides.

Residential, industrial, and commercial properties all have potential for slope instability and are at risk for landslides, especially along Beaucatcher Mountain and in the WECAN (West End/Clingman Avenue) and RAD neighborhoods.

Roads can also experience slope failures and landslides. Roads impacted by slope failures could result in temporary loss of road access, especially in the Beaucatcher Mountain area.





## North Asheville

North Asheville is characterized by its many historic residential neighborhoods tucked into the hillsides and accessible via the traditional commercial corridors of Merrimon Avenue and Broadway and Charlotte Streets. Other notable anchors include the campus of UNC Asheville, the Grove Park Inn, and the Country Club of Asheville. Some properties in the mountainous neighborhoods of North Asheville are at high risk for landslide, and properties along streams and other waterways are more vulnerable to flooding.





## Flooding (major)

Buildings are most vulnerable when they are located in flood-prone areas and do not have an elevated first floor or floodproofing that helps to cope with flood waters.

Residential property is particularly at risk in the Beaverdam, Linden-Murdock, and Beaver Lake neighborhoods and in the Reynolds Mountain/Woodfin area. Commercial and industrial property along US-19 in the Reynolds Mountain/Woodfin area is susceptible to major flooding.

Key services are also vulnerable, specifically food locations and SNAP retailers serving the Reynolds Mountain/Woodfin area and Hillcrest. Bus routes could be impacted and result in service interruptions, especially in the UNCA/Five Points and Beaverdam areas.

Roads inundated by flooding could result in temporary loss of road access, mostly in the Woodfin/Reynolds Mountain and Beaverdam areas.



## Landslides

Properties are most vulnerable when they are in the pathway of potential slope failures or landslides.

Commercial and industrial property in the Woodfin and Reynolds Mountain area could be impacted by landslides due to the presence of steep slopes along the US-19 corridor.

A few residential areas along Town Mountain, in the Beaverdam neighborhood, and in Reynolds Mountain are susceptible to landslides due to homes being on or adjacent to steep slopes.

Roads can also experience slope failures and landslides. Roads impacted by slope failures could result in temporary loss of road access, predominantly along Town Mountain, in Beaverdam, and in the Reynolds Mountain area.



## Extreme Heat

Sensitive populations and households with members 65+ are vulnerable to extreme heat. Several areas, including Hillcrest, Five Points, Montford, and Woodfin, could be impacted by the urban heat island effect—when developed areas are hotter than nearby rural areas—due to the amount of development and relatively low tree canopy cover.



## Flooding (minor)

Properties are subject to minor flooding when they're in low-lying areas or when they're close to impervious surfaces that contribute to runoff. Low-lying areas in Grove Park and along the Charlotte Street corridor might experience minor flooding and runoff due to the amount of impervious surfaces.



## Wildfire

Homes adjacent to or surrounded by fuels and vegetation are vulnerable to wildfire, especially in areas with steep slopes and where fire response may be more challenging. A few residential areas, mostly along Town Mountain and in Beaverdam, have a number of properties that are at risk for wildfire. These are also areas where the terrain is more challenging.





## East Asheville

East Asheville contains the busy Tunnel Road commercial corridor and neighborhoods that are more suburban in nature, with a lower population density than is found in other areas of the city. This area also includes a concentration of commercial development and recreational uses along Swannanoa River Road that are susceptible to flooding due to their proximity to the Swannanoa River, and properties on steep slopes that are vulnerable to landslides.







## Flooding (major)

Buildings are most vulnerable when they are located in flood-prone areas and do not have an elevated first floor or floodproofing that helps to cope with flood waters.

Residential property along the Swannanoa River in Swannanoa Hills and along Haw Creek is at risk for flooding, while commercial property along Swannanoa River Road and in the River Ridge area is susceptible.

Key services are also vulnerable. Food locations, including SNAP retailers, serving the River Ridge area may be impacted. Bus routes could also be affected and result in service interruptions, mainly in the Oakley, Haw Creek, and River Ridge/Beverly Hills areas.

Roads inundated by flooding could result in temporary loss of road access, mostly in Chunns Cove and along the Swannanoa River in the River Ridge/Beverly Hills areas.



## Landslides

Properties in the pathway of potential slope failures or landslides are most at risk.

Commercial and industrial property in the River Ridge/Beverly Hills and Haw Creek areas is vulnerable due to the presence of steep slopes.

Residential property in the Haw Creek, Chunns Cove, and Kenilworth areas may experience landslides due to homes being on or adjacent to steep slopes.

Roads are also impacted by slope failures and landslides. Roads affected by slope failures could result in temporary loss of road access, particularly in the Haw Creek, Chunns Cove, and Kenilworth areas.



## Extreme Heat

Sensitive populations and households with members 65+ are vulnerable to extreme heat. Several areas, including Oakley and River Ridge, could be impacted by the urban heat island effect—when developed areas are hotter than nearby rural areas—due to the amount of development and relatively low tree canopy cover.



## Flooding (minor)

Properties are subject to minor flooding when they are in low-lying areas or when they're close to impervious surfaces that contribute to runoff. Low-lying areas in Haw Creek and Beverly Hills may experience minor flooding and runoff due to the amount of impervious surfaces.



## Wildfire

Homes adjacent to or surrounded by fuels and vegetation are vulnerable to wildfire, especially in areas with steep slopes and where fire response may be more challenging. Some residential areas, such as Swannanoa Hills, Haw Creek, and Chunns Cove/Wolfe Cove, have a number of properties that are at risk for wildfire.



## South Asheville

South Asheville is a long narrow section of the city situated between the Biltmore Estate to the west and steep mountain slopes to the east. The Henderson Road commercial corridor forms the spine of South Asheville and is flanked by many densely populated neighborhoods. Wildfire is the greatest risk for neighborhoods on the mountainside, and properties along streams and other waterways are more vulnerable to flooding.



**LINAMAR**

Linamar North Carolina



## Flooding (major)

Buildings are most vulnerable when they're located in flood-prone areas and don't have an elevated first floor or floodproofing that helps them cope with flood waters.

Commercial, industrial, and residential property in Biltmore Village, in the Shiloh neighborhood, and along Sweeten Creek is susceptible to flooding.

Key services are also vulnerable. Food locations, including SNAP retailers, and bus routes could be impacted, resulting in service interruptions.

Roads inundated by flooding could result in temporary loss of road access, particularly in the Biltmore Village, Busbee, and Ballentree areas.



## Wildfire

Homes next to or surrounded by fuels and vegetation are vulnerable to wildfire, especially in areas with steep slopes and where fire response may be more challenging.

The Treetops, Ramble, and Ballentree neighborhoods have a high number of properties at risk for wildfire.



## Extreme Heat

Sensitive populations and households with members 65+ are vulnerable to extreme heat. Some areas, specifically Biltmore Village, Oakley, and neighborhoods in the district's southern end, may experience the urban heat island effect—when developed areas are hotter than nearby rural areas—because of the high amount of development and relatively low tree canopy cover.



## Flooding (minor)

Properties are subject to nuisance flooding when they're in low-lying areas or when they're close to impervious surfaces that contribute to runoff.

Areas along Hendersonville Road and in the Shiloh neighborhood—especially low-lying areas—may experience nuisance flooding and runoff due to the high amount of impervious surfaces.



## Landslides

Properties are most vulnerable when they're in the pathway of potential slope failures or landslides.

Residential, industrial, and commercial properties all have potential for slope instability and may be impacted by landslides, mostly around the Biltmore Village area and in the Ballentree and Treetops neighborhoods.

Roads are also affected by slope failures and landslides. Roads impacted by slope failures could result in temporary loss of road access, mainly in the Ballentree, Treetops, and Biltmore Village areas.





## West Asheville

West Asheville, located on the west side of the French Broad River, is centered on the Haywood Road corridor—one of the city's only pedestrian-friendly environments outside of downtown. Patton Avenue, the primary connection for I-26, also serves the varied communities of this area, which are a mix of traditional and suburban-style neighborhoods. West Asheville has the lowest vulnerability and risk to climate-related threats in the city, although minor flooding and extreme heat are concerns.





## Flooding (minor)

Properties are subject to minor flooding when they're in low-lying areas or when they're near impervious surfaces that contribute to runoff.

Low-lying areas along the Patton Avenue/Smoky Park Highway corridor (Wilshire Park, Deaverview, and Malvern Hills) and the East West Asheville neighborhood may experience minor flooding and runoff due to the amount of impervious surfaces.



## Extreme Heat

Sensitive populations and households with members 65+ are vulnerable to extreme heat.

Several areas, specifically Emma, Johnston, Deaverview, and Pisgah View, could be impacted by the urban heat island effect—when developed areas are hotter than nearby rural areas—due to the amount of development and relatively low tree canopy cover.



## Flooding (major)

Buildings are most vulnerable when they are located in flood-prone areas and do not have an elevated first floor or floodproofing that helps to cope with flood waters.

Residential property is particularly at risk along Smith Mill Creek near Wilshire Park and along Moore Creek in Enka/Candler. Commercial property is susceptible along Smith Mill Creek on Patton Avenue; also along Hominy Creek and Pole Creek in Enka/Candler.

Key services are also vulnerable. Food locations, including SNAP retailers, and bus routes could be impacted, resulting in service interruptions.

Roads inundated by flooding could result in temporary loss of road access, mainly in the Enka/Candler area.



## Landslides

Properties are most vulnerable when they are in the pathway of potential slope failures or landslides. Commercial property is at risk for landslides due to the presence of steep slopes along the Patton Avenue corridor. A few residential areas, such as East West Asheville, could experience landslides due to homes being on or adjacent to steep slopes.

Roads are also impacted by slope failures and landslides. Roads affected by slope failures could result in temporary loss of road access, mostly in the East West Asheville neighborhood and in Enka/Candler.



## Wildfire

Homes adjacent to or surrounded by fuels and vegetation are vulnerable to wildfire, especially in areas with steep slopes and where fire response may be more challenging. A few residential areas, such as in Enka/Candler and around Bingham Heights, have a number of properties at risk for wildfire.





# STRATEGIES

## ALL THREATS

**Be informed**

PERSONAL • \$ •

Know what disasters and hazards could affect you, your home, or your business.

Download, install, and use the ReadyNC app or consult the website. Also check online apps like Map Asheville to learn about your exposure to hazards.

**Make a plan and build a kit**

PERSONAL • \$ •

Make an emergency plan today.

- Families may not be together if a disaster strikes. Know how you'll contact one another and reconnect if separated. Establish a family meeting place that's familiar, easy to find, and safe.
- Businesses and their staff face a variety of hazards. A preparedness or business continuation plan can help you and your co-workers get ready.

After an emergency, you may need to survive on your own for several days. Being prepared means having your own food, water, and other supplies to last for at least 72 hours.

Putting together a kit means that you'll be ready if a disaster strikes. You can find and download checklists of needed items at Ready.gov and ReadyNC.org. Most of the items are inexpensive, easy to find, and any one of them could save your life.

**Sign up for hazard alerts**

PERSONAL • \$ •

Register for Community Connect and AVL Alert.

Community Connect is a free, secure, and easy-to-use platform that allows you to share critical information about your household to aid first responders and emergency response personnel when responding to your residence.

AVL Alert is the city's emergency notification system, providing geographically targeted alerts via text, email, phone, or the app.

**Post emergency contact information**

PERSONAL • \$ •

Post emergency contact information in your home or workplace.

Posting it on a refrigerator is a great idea—you can buy inexpensive magnets for this online, or make your own with supplies from a craft or dollar store.

**When making your emergency plan, remember that buses might not be running, roads may be closed or impassable, and you might not be able to reach a grocery store.**  
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## Create shade

PERSONAL/FINANCIAL • \$-\$\$\$ •

Consider ways to create shade in and around your home or workplace.

- Strategic use of blinds, curtains, and other window treatments can help keep you cool...and save energy.
- Planting trees provides shade and also increases the tree canopy—in an urban setting, this can help reduce the temperature of the entire neighborhood.
- Install awnings and/or canopies above windows to help shade interior spaces.
- For new construction, use best architectural practices—include porches and overhangs and locate buildings to take advantage of natural shade.

## Cool the air

PERSONAL/FINANCIAL • \$-\$\$\$ •

Air conditioning is great in a heat wave—but not everyone has it, and those who do probably think twice about the cost of running it non-stop. Look at other ways to help cool the air in your home.

- Manage your windows for heat: keep your blinds or curtains closed during the day. If the night or early morning is cool (and you have window screens), open windows, but close them as the day gets hotter.
- Circulating fans—ceiling fans, table fans, and floor fans—create a wind chill effect that will make you more comfortable, even if the room is also cooled by natural ventilation or air conditioning.
- Consider installing an attic fan, increasing building envelope efficiency, and adding distributed heating and cooling systems.

## Be a good neighbor

PERSONAL • \$ •

Check in on family members and vulnerable neighbors twice a day, especially if they're aged 65+. Older adults don't adjust as well as young people to sudden changes in temperature.

## Check the back seat

PERSONAL • \$ •

Never leave children or pets in a parked car. Even when it feels cool outside, cars can heat up to dangerous temperatures very quickly.

Leaving a window open is not enough—temperatures inside the car can rise almost 20°F within the first 10 minutes, even with a window cracked open.

## Recognize the signs of heat-related illness

PERSONAL • \$ •

Learn the symptoms and what to do if you or a loved one shows signs of having a heat-related illness.

Explore heat-related illness on the CDC website—and consider printing and posting their heat-related illnesses infographic.

## Know where you can go to get cool

PERSONAL • \$ •

Stay in an air-conditioned place as much as you can.

If your home doesn't have air conditioning, go to the mall or public library—even a few hours spent in air conditioning can help your body stay cooler when you go back into the heat.



## Be informed, make a plan, build a kit, and sign up for hazard alerts

PERSONAL • \$ • 🕒

The time to prepare for a flood is before a flood happens—develop a flood plan for your home or business now.

Know the types of flood risk in your area and learn and practice evacuation routes, shelter plans, and flash flood response. Gather supplies in case you have to leave immediately, or if services are cut off. Keep important documents in a waterproof container and create password-protected digital copies.

Look up your address in the FEMA Flood Map Service Center and use interactive tools to learn more about your risk. You don't have to live near a river, creek, or stream to be a victim of flood damage—channeled rainwater can cause water to flood your home, putting you at risk.

## Purchase flood insurance

FINANCIAL • \$\$-\$\$\$ • 🕒

Flood insurance provides financial protection for the cost of repairs or replacement of property due to flood damage.

### **Standard insurance policies don't cover flooding.**

Flood insurance is available for homeowners, renters, and business owners through the National Flood Insurance Program.

## Floodproofing (emergency)

PROPERTY • \$-\$\$ • 🕒

Sometimes, it makes sense to protect your home or building with temporary measures put in place between a flood warning and impact.

You can use sandbags, temporary flood barriers, and flood wrapping systems for emergency floodproofing.

## Floodproofing (permanent)

PROPERTY • \$\$-\$\$\$ • 🕒

Wet and dry floodproofing are the two main types of permanent floodproofing.

*Permanent floodproofing may need to be certified by a registered professional engineer or architect. Floodproofing that isn't in compliance with federal regulations won't reduce the property's flood insurance premium.*

- To waterproof a basement, consider treating exterior walls with a moisture barrier material. A basement's circuitry can also be elevated above the flood risk—elevate the main electric panel, all outlets, switches, wiring, and heating units at least one foot above the projected flood elevation.
- Install a sewer backwater valve. Sewage backflow occurs when stormwater backs up into a building because of a sewer line blockage or storm drain overflow. A backwater valve is a relatively inexpensive retrofit that can prevent sewer line failure by blocking reverse flow from entering your building through wastewater pipes.





## Did you know?

### WET FLOODPROOFING

allows floodwaters to enter a building while minimizing flood damage and protecting critical systems and contents.

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### DRY FLOODPROOFING

makes a building watertight to floods of limited duration (a few hours) and depth (typically less than two to three feet).

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## Remove or secure toxic materials

PROPERTY • \$ • 

Make sure that any toxic materials in your home or building are stored safely in floodproofed areas.

Anchor fuel tanks. Unanchored fuel tanks can be easily moved by floodwaters, posing serious threats to you, your property, public safety, and the environment.

## Elevate critical equipment and important personal property

PROPERTY • \$\$ • 

Your heating and/or cooling system, furnace, water heater, and electric panel can all be elevated above projected flood elevation.

If you're storing personal property in a basement or other floodprone area, consider moving it to higher ground or using pallets to elevate it above projected flood levels.

## Elevate your home or building

PROPERTY • \$\$\$ • 

An option for minimizing the impact of a future flood is to raise an entire building up and, hopefully, out of harm's way. The process is known as elevation. The upfront costs can represent a sizeable investment, but the dividends can meet or exceed those costs from just one flooding event.

When a house is properly elevated, the living area will be above all but the most severe floods. Several elevation techniques are available. In general, they involve (1) lifting the house and building a new, or extending the existing, foundation below it, or (2)

leaving the house in place and either building an elevated floor within the house or adding a new upper story.

If you're protecting your home by elevating it, you should include a minimum of one foot of "freeboard" in your flood protection elevation, even if you're not required to do so. Freeboard—a factor of safety usually expressed in feet above flood level—is recommended because of uncertainties having to do with expected flood elevations.



# FLOODING (MINOR)

## Reduce runoff and redirect stormwater

PROPERTY • \$-\$\$\$ • 

- To reduce runoff, disconnect your downspouts and reroute rooftop drainage pipes into rain barrels, cisterns, or permeable areas. You can store stormwater and/or allow it to infiltrate into the soil, but make sure that you don't discharge stormwater flows onto adjacent properties.
- To help with runoff issues, improve lot grading so that stormwater drains away from the building. You can also install a J-drain system—a modular composite drainage and collection system designed to replace a conventional sand- or gravel-covered pipe drain around building foundations and retaining walls.
- Replace impermeable surfaces such as concrete with permeable pavers and gravel. This can be expensive, but it's worth considering—especially if you're already replacing deteriorated asphalt or concrete.
- Remove or redirect stormwater by diverting or intercepting runoff:
  - Build a berm or dry well. A berm is a small hill covered with grass or other plants that will divert runoff around what you want to protect.

A dry well is a hole in the ground that remains dry most of the time; however, when water is flowing, it can be routed to the well by a swale or roof downspout.

- Use a swale or a French drain. A swale is a shallow ditch with gently sloping sides; a French drain is a gravel-filled trench that may have a perforated pipe at the bottom.
- Make sure you that you don't discharge the stormwater onto adjacent properties.
- In buildings that are prone to flooding, consider installing and using a sump pump to remove accumulated water. Sump pumps send water away from a house or building to any place where it's no longer problematic—such as a municipal storm drain or a dry well. They're usually hardwired into a home's electrical system, and may have a battery backup in case of power loss.
- Homeowners can participate in RiverLink's WaterRICH program, designed to assist homeowners in understanding rainwater management. The program offers hands-on workshops that teach site analysis and introduce design tools to use right in your own backyard.





## Install “green” infrastructure and store rainwater

PROPERTY • \$\$–\$\$\$ • 

Different types of green infrastructure and rainwater storage can be installed to help manage and control stormwater:

- Rain barrels capture water from a roof and hold it for later use—such as watering lawns, gardens, or indoor plants. Collecting roof runoff in rain barrels reduces the amount of water that flows from your property. It’s a great way to conserve water and it’s free water for use in your landscape.
- Rain gardens allow rainwater to run off from roofs, driveways, walkways, parking lots, and compacted lawn areas so that it can be absorbed into the ground.
- Bioswales are vegetated, mulched, or xeriscaped (not needing supplemental water) channels that slow, filter, and retain stormwater as they move it from one place to another. Since they’re linear, they’re particularly well suited for installation along streets and parking lots.
- Underground water storage tanks and cisterns provide emergency water supplies and can be used for landscape watering.

## Clear stormwater drains

PROPERTY • \$ • 

- Clean your gutters and downspouts twice a year to ensure a well-flowing drainage system. Direct flows from downspouts away from your foundation, but make sure that it doesn’t discharge the flows onto adjacent properties.

- Don’t pile yard waste like fallen leaves where it could wash into city drains—keep it in a waste bin or other container.
- Use a rake or broom to remove leaves and debris that may collect on the tops of storm drains.
- Get involved in neighborhood clean-up programs. Asheville GreenWorks coordinates roadside, river, and environmental clean-ups in the area.

## Maintain natural vegetation

PROPERTY • \$–\$\$ • 

Preserving existing trees and vegetative cover and planting additional trees on your property can help reduce stormwater impacts.

Trees and vegetative cover improve stream quality by decreasing the amount of stormwater runoff and pollutants that reach our local waters, and reduce and slow stormwater by intercepting precipitation in their leaves and branches.

## Protect stream buffers

PROPERTY • \$–\$\$ • 

If there’s a stream on your property, protect its buffers.

Riparian or stream buffers—vegetated areas adjacent to a stream that help shade and partially protect it—improve water quality by filtering sediment and pollutants from soil runoff and providing shade to keep water cool. They also combat erosion by stabilizing banks and regulating stream flow, and offer habitats to many plant and wildlife species.



# LANDSLIDES

## Be informed, make a plan, build a kit, and sign up for hazard alerts

PERSONAL • \$ • 

The best way to prepare for landslides is to stay informed about changes in and around your home or workplace that could signal that a landslide is likely to occur. Learn more about this from *The Landslide Handbook*, a free publication from the U.S. Geological Survey.

Learn whether debris flows have occurred in your area by contacting the North Carolina Geological Survey. Slopes where debris flows have occurred in the past are likely to experience them in the future.

Prepare for landslides by following proper land-use procedures—avoid building near steep slopes, close to mountain edges, near drainage ways, or along natural erosion valleys.

Contact your local authorities to learn about any emergency response and evacuation plans for your area, and develop your own emergency plans for your family and business.

## Be aware of surface water runoff and keep ditches and culverts clear

PROPERTY • \$ • 

Be aware of and manage surface water on your property.


Before a heavy rainfall event, clean out ditches and culverts so that stormwater will flow through them freely.

## Recognize the signs of slope instability

PROPERTY • \$ • 

Watch the patterns of stormwater drainage on slopes near your home and for any signs of land movement. Note especially the places where runoff water converges, increasing flow over soil-covered slopes.

Watch the hillsides around your home for any signs of land movement, such as small landslides or debris flows or progressively tilting trees.



Properties are most vulnerable when they're in the pathway of potential slope failures or landslides.





## Maintain natural vegetation to prevent erosion

PROPERTY • \$-\$\$ • 🕒

Erosion can sometimes lead to slope failures and drainage problems.

You can take action to prevent erosion before bigger slope-failure problems occur. For example, straw or wood chips effectively hold the soil in place and, as an added bonus, increase the organic content of the soil.

Planting or encouraging natural growth of vegetation—especially mature trees and vegetation—can be an effective means of slope stabilization.

Burned slopes in areas prone to debris flow can become especially hazardous. When saturated by rainfall, the likelihood and intensity of debris flows on these slopes increases.

## Stabilize slopes

PROPERTY • \$\$-\$\$\$ • 🕒

A geotechnical engineer, civil engineer, or engineering geologist can properly evaluate the hazard potential of a site, built or unbuilt, and provide recommendations related to landslides hazards and slope stabilization.

**LANDSLIDES CAN  
OCCUR QUICKLY—OFTEN  
WITH LITTLE NOTICE—  
WHEREVER THERE'S A  
SLOPE**

.....



*Photo courtesy of North Carolina Department of Transportation*





# WILDFIRE

## Be informed, make a plan, build a kit, and sign up for hazard alerts

PERSONAL • \$ • 

Wildfires can ruin homes and cause injuries or death to people and animals. Wildfires can happen anywhere, anytime. Risk increases in periods of little rain and high winds.

To prepare for a wildfire, sign up for Community Connect, AVL Alert, and/or other hazard alert services—see the resource guide on the inside back cover for more information. Develop an evacuation plan and find several ways to leave the area; drive the evacuation routes and find shelter locations. Have a plan for pets and livestock.

Gather emergency supplies, including N95 respirator masks that filter out particles in the air you breathe. Keep in mind each person's specific needs, including an updated asthma action plan and medication, if needed.

Designate a room that can be closed off from outside air; close all doors and windows. Set up a portable air cleaner to keep indoor pollution levels low when smoky conditions exist.

Keep important documents in a fireproof, safe place and create password-protected digital copies.

Find an outdoor water source with a hose that can reach any area of your property.

Pay attention to air quality alerts.

## Purchase/review insurance coverage

FINANCIAL • \$\$-\$\$\$ • 

Purchase or review existing insurance coverage to make sure it is enough to replace your property.

Create or update a home inventory to help settle claims faster.

## Use fire-resistant building materials

PROPERTY • \$-\$\$ • 

Use fire-resistant building materials to build, renovate, or make repairs to your home or building.

Class A fire-rated roofing products offer the best protection; examples include composite shingles, metal, and concrete and clay tiles. Use fire-resistant siding such as brick, fiber-cement, plaster, or stucco and dual-pane tempered glass windows.

## Consider neighborhood strategies

PERSONAL • \$-\$\$\$ • 

Talk with your neighbors and friends about becoming a FireWise Community.

The National Fire Protection Association's Firewise USA® program teaches people how to adapt to living with wildfire and encourages neighbors to work together and take action now to prevent losses.





## Manage vegetation and fuels

PROPERTY • \$ • 🕒

Research points to embers and small flames as the main way that the majority of homes ignite in wildfires, so managing fuels on your property can be crucial in determining whether or not your house or building will survive a wildfire.

Prepare your building to withstand ember attacks and minimize the likelihood of flames or surface fire touching the structure.

- In the immediate zone around the building (0–5 feet):
  - Clear leaves, pine needles, and other debris from gutters, eaves, porches, and decks
  - Install ⅛-inch metal mesh screening on eave and attic vents
  - Repair or replace damaged or loose window screens and any broken windows
  - Remove items from under your deck or porch
  - Move any flammable materials—including mulch, flammable plants, leaves and needles, and firewood piles—away from wall exteriors
- In the intermediate zone (5–30 feet):
  - Clear vegetation from under large stationary propane tanks
  - Create fuel breaks with driveways, patios, and walkways
  - Keep lawns and grasses mowed to a height of four inches
  - Keep tree canopies at least 10 feet away from structures
- In the extended zone (30–100 feet out to 200 feet):
  - Dispose of heavy accumulations of ground litter/debris

- Remove dead plant and tree material
- Remove small conifers growing between mature trees
- Remove vegetation adjacent to storage sheds or other outbuildings

In most cases, manual debris removal and vegetation management is probably the most effective method. For some landowners, other management techniques—such as using livestock grazing or mechanical treatment—may be more suitable.

### What is fuel for wildfire?

Fuel for wildfire can include everything from trees to grass—including underbrush, dead or fallen branches, dry leaves, and dry grassy fields. A lot of available fuel makes a fire burn more intensely and spread faster.



# CITY-LED STRATEGIES

Since 2016, the City of Asheville's Office of Sustainability has been working with UNC Asheville's National Environmental Modeling and Analysis Center (NEMAC) to determine how Asheville can become more resilient to environmental changes. A Climate Resilience Assessment was completed and published in April 2018 and was adopted as part of the city's Comprehensive Plan in June 2018.

Below are some of the identified resilience strategies that the city is presently implementing:

- **Hazard mitigation and emergency response planning.** The City of Asheville is a participating member of the *Buncombe Madison Regional Hazard Mitigation Plan*, which was prepared in coordination with FEMA Region IV and the North Carolina Department of Emergency Management. City departments also address potential threats and hazards by working through the four phases of emergency response—mitigation, preparedness, response, and recovery. In addition, the city has implemented a rapid emergency notification service to alert citizens of hazard events.
- **City-led initiatives for further analysis.** A few examples of city-supported initiatives include:
  - A tree canopy and gap analysis, through the Asheville Tree Commission and Public Works, which seeks to better protect and preserve Asheville's trees.
  - The Energy Innovation Task Force, which is working to research and recommend energy efficiency and demand-side management programs.
- **The Flood Damage Reduction Task Force,** appointed by the Asheville City Council in 2006, is made up of members from city staff, the development community, and private property owners. The task force's mission is to establish a regional approach and long-range plan for flood damage reduction, floodplain protection, and watershed management.
- **Development ordinances and design standards.** The city has ordinances for floodplain and steep slope development. The city's floodplain ordinance, a part of the Unified Development Ordinance, was last updated in 2010 to exceed FEMA standards, which helped the city achieve a 10 percent discount on flood insurance premiums for property owners in special flood hazard areas. For steep slope areas, the city has special requirements for removal of vegetation. The city also has proactive fire programs and building codes that follow the North Carolina Building Code for fire protection.
- **Partnerships and programs to further water conservation.** The City of Asheville participates and partners with organizations, such as the Mills River Partnership and others, to preserve and protect watersheds.
- **Plan and respond to protect homes and critical access points on steep slopes.** With the resources available, city departments work to maintain safety and access on city-maintained roads that can be susceptible to landslides or slope failures.

*Photo credits:*

*Cover: City of Asheville; neighborhood photos pp. 2–11: City of Asheville; p. 12: Kyle Glenn; pp. 13, City of Asheville; pp. 14–15: Leif Skoogfors, FEMA; pp. 16–17: City of Asheville; pp. 18–19: Jason Kean, USGS; pp. 20–21: National Wildfire Coordinating Group; p. 22: City of Asheville*

Resilience is about planning, preparing, and investing today for a better future.

## Resources

- [The City of Asheville, North Carolina](#)
- [Living Asheville: A Comprehensive Plan for Our Future](#)
- [Asheville Office of Sustainability](#)
- [Planning for Climate Resilience | City of Asheville, North Carolina](#)

### All threats

- [ReadyNC.org](#)
- [Ready.gov](#)
- [AVL Alert](#)
- [Community Connect](#)
- [Map Asheville](#)

### Extreme heat

- [Ready.gov | Extreme Heat](#)
- [CDC | Warning Signs and Symptoms of Heat-Related Illness](#)
- [National Integrated Heat Health Information System](#)
- [Energy.gov](#)

### Flooding

- [Ready.gov | Floods](#)
- [FEMA | How to Prepare for a Flood](#)
- [FEMA | Flood Map Service Center](#)
- [North Carolina | Flood Risk Information Center](#)
- [FEMA | The National Flood Insurance Program](#)
- [FEMA | Homeowners Guide to Retrofitting](#)
- [FEMA | Floodproofing Non-Residential Buildings](#)
- [RiverLink | WaterRICH](#)
- [EPA | Green Infrastructure](#)
- [Center for Watershed Protection | Trees and Stormwater Runoff](#)
- [American Tree Farm System | Three Ways to Protect Your Rivers and Streams](#)
- [Asheville Greenworks | Rivers & Roads](#)

### Landslides

































- [Ready.gov | Landslides & Debris Flow](#)
- [USGS | The Landslide Handbook](#)
- [Appalachian Landslide Consultants | How to Avoid Landslide Hazards](#)
- [Appalachian Landslide Consultants | Landslide Maps of Western North Carolina](#)
- [NCDEQ | Landslides](#)
- [North Carolina Geological Survey](#)
- [City of Asheville Emergency Preparedness](#)

### Wildfire

- [Ready.gov | Wildfire](#)
- [National Fire Protection Association | Firewise USA®](#)
- [Wildland Fire in the Southeast | Wildfire Safety and Property Protection](#)
- [National Fire Protection Association | Preparing Homes for Wildfire](#)
- [Forests and Rangelands | Community Guide to Preparing and Implementing a Community Wildfire Protection Plan](#)

To access the hyperlinks for resources listed above, use the interactive version of this guide, available at [bit.ly/avlstrategies](https://bit.ly/avlstrategies).

# Strategies Quick Reference

	FOCUS	COST	TIME RANGE
<b>ALL THREATS</b>			
Be informed	Personal	\$	
Make a plan and build a kit	Personal	\$	
Sign up for hazard alerts	Personal	\$	
Post emergency contact information	Personal	\$	
<b>EXTREME HEAT</b>			
Create shade	Personal/Financial	\$–\$\$	
Cool the air	Personal/Financial	\$–\$\$\$	
Be a good neighbor	Personal	\$	
Check the back seat	Personal	\$	
Recognize the signs of heat-related illness	Personal	\$	
Know where you can go to get cool	Personal	\$	
<b>FLOODING</b>			
<b>Major flooding</b>			
Be informed, make a plan, build a kit, and sign up for hazard alerts	Personal	\$	
Purchase flood insurance	Financial	\$\$–\$\$\$	
Floodproofing (emergency)	Property	\$–\$\$	
Floodproofing (permanent)	Property	\$\$–\$\$\$	
Remove or secure toxic materials	Property	\$	
Elevate critical equipment and important personal property	Property	\$\$	
Elevate your home or building	Property	\$\$\$	
<b>Minor flooding</b>			
Reduce runoff and redirect stormwater	Property	\$–\$\$\$	
Install “green” infrastructure and store rainwater	Property	\$\$–\$\$\$	
Clear stormwater drains	Property	\$	
Maintain natural vegetation	Property	\$–\$\$	
Protect stream buffers	Property	\$–\$\$	
<b>LANDSLIDES</b>			
Be informed, make a plan, build a kit, and sign up for hazard alerts	Personal	\$	
Be aware of surface water runoff and keep ditches and culverts clear	Property	\$	
Recognize the signs of slope instability	Property	\$	
Maintain natural vegetation to prevent erosion	Property	\$–\$\$	
Stabilize slopes as needed	Property	\$\$–\$\$\$	
<b>WILDFIRE</b>			
Be informed, make a plan, build a kit, and sign up for hazard alerts	Personal	\$	
Purchase/review insurance coverage	Financial	\$\$–\$\$\$	
Use fire-resistant building materials	Property	\$–\$\$\$	
Consider neighborhood strategies	Property	\$	
Manage vegetation and fuels	Property	\$–\$\$	

\$ LOW EXPENSE    \$\$ MODERATE EXPENSE    \$\$\$ HIGH EXPENSE



LOW TIME COMMITMENT



MODERATE TIME COMMITMENT

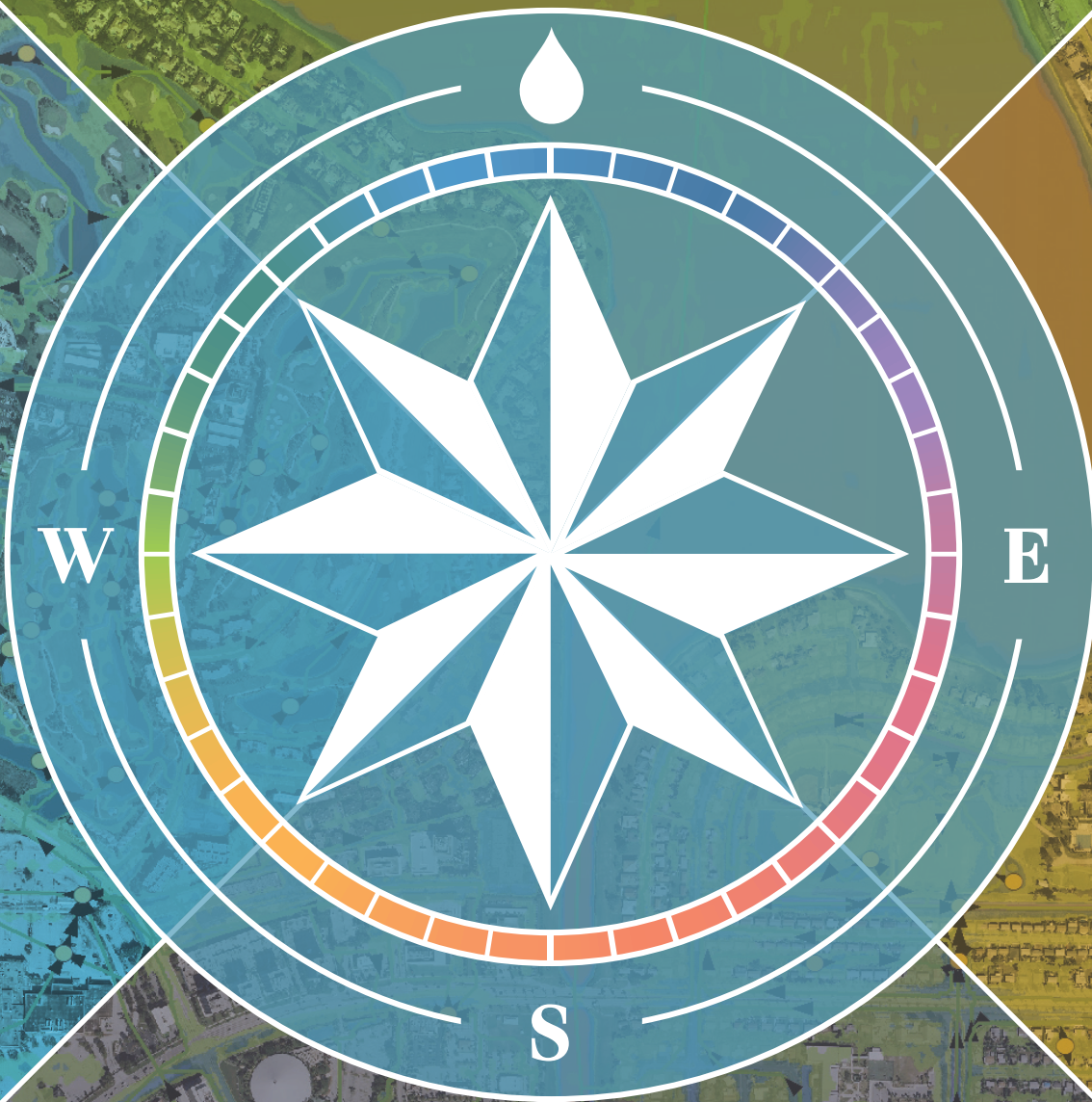


HIGH TIME COMMITMENT





WEST PALM BEACH



## STORMWATER MASTER PLAN | VOL. 3

THE CITY'S GUIDE TO STORMWATER FOR THE NEXT 30 YEARS

STORMWATER MAP ATLAS | MAY 2017

DRAFT B





WEST PALM BEACH

## Technical Memorandum #9

### Stormwater Master Plan

**Collective Water Team**

*Analysis of Potential Futures (Phase 1 Hydrologic Baseline)*

---

**Subject:** Sea Level Rise and Climate Change Vulnerability  
**Date:** May 10, 2017  
**To:** City Staff Technical Team  
**From:** Stephanie Dunham (*Collective Water Resources*)  
Anna Leitschuh (*Collective Water Resources*)  
Elizabeth Perez (*Collective Water Resources*)  
**Copy to:** Project File  
Stormwater Master Plan

*This memorandum fulfills the requirements of Scope Item 6.2 of the Scope of Work for the Stormwater Master Plan. These analyses should also assist with fulfilling the requirements of a vulnerability analysis for staff usage as part of various initiatives and certifications.*

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**Technical Memorandum #9**

***Analysis of Potential Futures (Phase 1 Hydrologic Baseline)***

*Page 1*

## Introduction

On May 26, 2015, Mayor Jeri Muoio City signed the Mayor’s Climate Action Pledge. This Pledge, in addition to many actions by the City, is part of the City’s ongoing work to reduce the impacts of climate change and sea level rise. The City is an active member of the Southeast Florida Climate Compact (The Compact), which led the development of the Mayor’s Climate Action Pledge. The Compact is an active scientific and policy consortium that is leading much of the work to reduce potential future impacts of climate change and sea level rise.

This analysis was developed based on the scientific foundation laid by The Compact. Many of the baseline assumptions used throughout this analysis were pulled from the recommended scientific baseline of The Compact. However, Collective Water’s approach is very much customized for the City and uses the data and tools created during the creation of the 2016 Stormwater Master Plan (SWMP). In many ways, this is the final analysis of the SWMP and creates the ultimate set of futuristic baselines for the City. The City considers this a critical analysis in the development of a 30-year SWMP.

At the outset of the analyses, it was important to:

- Provide a sound hydrologic baseline for the City to analyze multi-stressor scenarios (“getting the water right” from the outset) now and in the future.
- Provide analyses based on best available data and at a reasonable resolution for planning efforts. This Phase 1 Analysis will focus on impacts to infrastructure and physical systems of interest to the City’s Utility Department. Future phases may focus on other stressors that are of interest to other City Departments and/or stakeholders throughout central Palm Beach County.
- Determine data deficiencies for future phases and explore partnerships to participate in cost-sharing and analyses as the City moves forward. This is a particularly important objective given the complexity of potential climatological and hydrologic impacts.

Additionally, since the City scoped the SWMP as a 30-year plan, this analysis will investigate potential conditions in 2046. It is notable that this analysis used several key datasets that are discussed in other Technical Memorandums in Volume 2 of the SWMP. Without the foundational work on these datasets and models, a detailed sea level rise/climate change analysis is not possible for a City of West Palm Beach’s complexity.

Generally, the following issues will be investigated:

1. Water resources and supply (since the City is an integrated stormwater and water supply system, both issues must be investigated together). This integrated system was

investigated primarily through a hydrologic analysis and subsequent post-processing in GIS.

2. Water quality (particularly changes in salinity as sea level rise occurs in the Lake Worth Lagoon and then impacts the City's inland manmade and natural systems). The City must also be concerned with significant water budgets shifts in the future for both Grassy Waters Preserve and Clear Lake/Lake Mangonia. This analysis was completed primarily through interpretation of raster images produced from the primary analysis. Future efforts could investigate detailed water budgets over the next 30 years in these surface waterbodies.
3. Utilities infrastructure (stormwater, wastewater, and potable water). Similar to item #1, this primarily consisted of a post-processing exercise using the hydrologic analysis completed as part of item #1 and analyzing impacted areas.
4. City Roads and Evacuation Routes – Similar to items #1 and #3, roads were investigated as part of a post-processing exercise.
5. Built environment – Best available information was used to develop a series of statistics to project impacts on the built environment for the 2046 Baseline. This analysis could be expanded once the 2017 Palm Beach County LIDAR is made available since it is likely that the City will have improved data on the built environment at that time.

## Methodology

Generally, this analysis investigated added risk to City infrastructure due to various sea level rise scenarios. Modified sea level scenarios and groundwater elevation scenarios were simulated in the existing ICPR model created for the SWMP to identify impacts to the City. The unified sea level projections published by Southeast Florida Regional Climate Change Compact in October 2015 combined with the historic, measured rise in local sea levels were utilized to establish sea level rise projections for the City of West Palm Beach over the next 30 years. Local projections of mean sea level and mean higher-high water (MHHW) through 2046 based on three projection rates as well as the measured historic rate of rise were estimated.

Additionally, the response of the water table from sea level rise was determined based on best available data provided by SFWMD and interpretation of the City's groundwater model (JLA Geosciences, 2014). While not ideal for an analysis of this resolution, these data sources provided some generalized information about the behavior of groundwater near the coast. In the future, it is recommended that the City work with other interested stakeholders (particularly Palm Beach County) to secure funding and assistance in building a SEAWAT model. This model should be built at a resolution that could be used for detailed resiliency studies. The sensitivity



of the City's ICPR (stormwater) model to groundwater conditions was also explored to examine the response of the system as groundwater conditions change.

The existing sea level in the 2016 SWMP ICPR model is 0.988 feet, NAVD88. Two sea level rise scenarios for the MHHW were established to evaluate the impact to City infrastructure in 30 years:

- Scenario 1 (A and B) for 2046 = 1.60 feet, NAVD 88;
- Scenario 2 (A and B) for 2046 = 2.12 feet, NAVD 88;

Each scenario was run with and without a change in water table to examine response. The estimated range in water table response to sea level rise for each scenario is summarized as follows:

- Scenario 1A: increase sea level by 0.61-feet with no change to water table elevations.
- Scenario 1B: increase sea level by 0.61-feet and increase water table elevations by 0.14-feet for basins adjacent to the Lake Worth Lagoon (to 2 miles inland);
- Scenario 2A: increase sea level by 1.13-feet with no change to water table elevations.
- Scenario 2B: increase sea level by 1.13-feet and increase water table elevations by 0.75-feet for basins adjacent to the Lake Worth Lagoon to 2 miles inland;

According to literature reviewed (see the end of this memorandum for a complete listing), direct impacts of sea level rise for coastal communities in Palm Beach County will include inundation of land along or directly connected to coastal waters - as well as increased flooding for interior areas that are served by stormwater management systems and/or regional canal systems. Sea level rise will also likely impact the discharge capacity of gravity-based stormwater management systems and canals with outfalls to tidally influenced waterbodies.

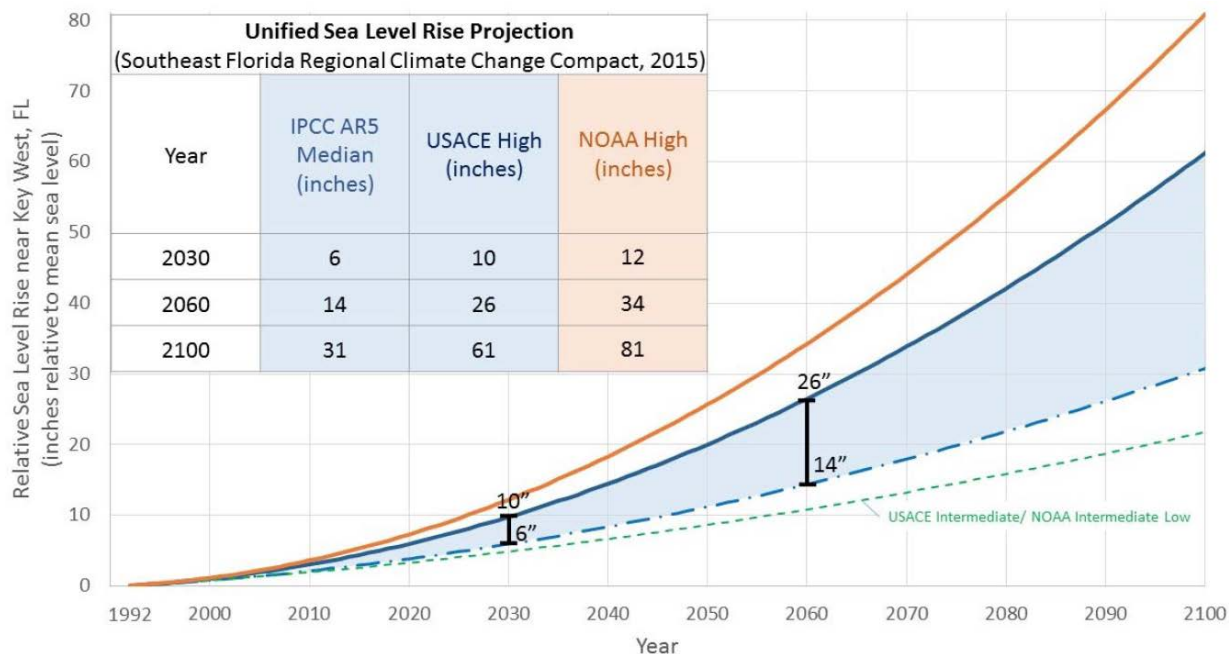
In addition, sea level rise will likely increase water table elevations along the coast. The USGS modeling for Miami-Dade County indicates the impacts of sea level rise on water table elevation decreases as distance from the coastline decreases with no impact to water table elevations at a distance of five to ten miles from the coastline. As the water table rises closer to the surface, the capacity of the soil to store stormwater from infiltration reduces; thereby, generating more surface water runoff. Other impacts may include reductions in the effectiveness of stormwater facilities such as exfiltration trenches.

The unified sea level projections published by Southeast Florida Regional Climate Change Compact (SEFRCCC) in October 2015 combined with the historic, measured rise in local sea levels and established tidal datums were utilized to evaluate potential impacts to critical facilities, City roads and evacuation routes, stormwater infrastructure, City lift stations, City buildings, and water supply (primarily Clear Lake/Lake Mangonia and the Water Treatment Plant).

The following sections present the application of the unified sea level projections to define sea levels and water table scenarios for inputs into the existing ICPR model. It is important to note that the analysis was conducted for the portion of the City that extends from the Lake Worth Lagoon to Military Trail. This was the portion of the City that was modeled in detail as part of the SWMP (see Technical Memorandum 4 and associated attachments in Volume 2 of the SWMP).

## Sea Level Rise Projections

In October 2015, the SEFRCCC Sea Level Rise Working Group released an updated report of unified regional projections for the period from 1992 through 2100 based on projections and scientific literature released since 2011. **SEFRCCC’s unified sea level rise projections are offered to the local planning community to ensure that all major infrastructure projects have the same basis for design and constructions relative to future sea levels.** The unified projections include three global mean curves that were regionally adapted to account for observed acceleration in South Florida, specifically the Key West, Florida National Oceanic and Atmospheric Administration (NOAA) tidal gauge 8724580. As illustrated by **Figure 1**, the three curves consist of an adjusted “NOAA High” curve, U.S. Army Corps of Engineers (USACE) “High” curve (same as the “NOAA Intermediate-High”), and the median of the Intergovernmental Panel on Climate Change Fifth Assessment Report Representative Concentration Pathway 8.5 scenario (i.e. “IPCC AR5 Median” curve). The “USACE Intermediate”, which is equivalent to the “NOAA Intermediate-Low” curve, was also included in the figure to reflect the projection based on a significant reduction in greenhouse gas emissions, which is not likely given the current emission trends. The “USACE Intermediate/ NOAA Intermediate-Low” curve is not part of SEFRCCC’s recommendations.

**Figure 1: SEFRCCC Unified Sea Level Rise Projection (SEFRCCC Sea Level Rise Work Group, 2015)**

These projections represent the range in uncertainty, primarily associated with the rate and magnitude of ice sheet loss. These projections start at 1992 since 1992 is the middle year of the latest NOAA National Tidal Datum Epoch (1983 through 2001). National Tidal Datum Epochs are 19-year periods adopted by the National Ocean Service and are used to define mean values of tidal datums, such as mean sea level (MSL). Additionally, the unified projections are referenced to the Key West gauge (NOAA Station ID 8724580) and are relative to MSL.

For this analysis, the “IPCC AR5 Median” and the “USACE High” were used to estimate the rise in sea level for 2046. These two projections were chosen because they will identify areas that are most susceptible to sea level rise (Scenario 1: IPCC AR5) and areas where critical infrastructure could possibly be susceptible to sea level rise (Scenario 2: USACE High).

The “IPCC AR5 Median” curve represents global mean sea level rise as a result of the most extreme of four anthropogenic-based greenhouse gas emission scenarios (i.e., RCP 8.5) presented in the IPCC Fifth Assessment report released in 2013. Sea level rise includes contributions from thermal expansion, glaciers, ice sheet, and anthropogenic land water storage. The following equation is used to define the curve between 1992 and 2100:

$$E(t) = [0.0022t + (4.684499 \times 10^{-5})t^2] * 39.37$$

Where:

- $E(t)$  = the estimated change in regional MSL between 1992 and year  $t$  (inches);

- 0.0022 = the rate of regionally-corrected, historic MSL rise (meter/year) for the Key West, FL gauge;
- $t$  = years since 1992 (e.g. for 2016,  $t = 24$  years);
- $4.684499 \times 10^{-5}$  = represents the acceleration of sea level change for the “IPCC AR5 Median” curve (meter/year); and
- 39.37 = conversion factor from meters to inches.

The “USACE High” curve is computed from the modified National Research Council’s (NRC’s) Curve III considering projected ocean warming, recent ice sheet loss, and the local rate of vertical land movement (subsidence or uplift). The following equation was used to fit the curve between 1992 and 2100:

$$E(t) = [0.0022t + 0.000113t^2] * 39.37$$

Where:

- $E(t)$  = the estimated change in regional MSL between 1992 and year  $t$  (inches);
- 0.0022 = the rate of regionally-corrected, historic MSL rise (meter/year) for the Key West, FL gauge;
- $t$  = years since 1992 (e.g. for 2016,  $t = 24$  years);
- 0.000113 = the acceleration of sea level change for the “USACE High” curve (meter/year); and
- 39.37 = conversion factor from meters to inches.

These equations from SEFRCCC’s unified sea level rise projections are based, in part, on the historical sea rise measured at NOAA’s Key West tidal gauge, Station 8724580. NOAA has published regional, historical sea level change rates for three gauges within southeast Florida: Miami Beach (also referred to as Virginia Key), Vaca Key, and Key West (NOAA, 2013). While additional tidal gauges exist in the area and even closer to the City, they do not have a long enough period of record (i.e., 40 or more years) to establish a regional rate of mean sea level rise. Therefore, the Miami Beach gage was used for the City’s analysis due primarily to the long period of record. Regional sea level rise rates reflect variations due to a combination of regional vertical land movement, regional oceanographic change, and global mean sea level change.

**Specifically, the rate of 0.00239-meters-per-year (or 0.00784 feet-per-year) rate established by NOAA for Miami Beach was used to define the City’s curves rather than Key West’s 0.0022-meters-per-year rate (NOAA, 2013).** Therefore, the equations for the two projection curves to be used for the City are as follows:

“IPCC AR5 Median” curve relative SLR near Miami Beach:

$$E(t) = [0.00239t + (4.684499 \times 10^{-5})t^2] * 39.37$$



“USACE High” curve relative SLR near Miami Beach:

$$E(t) = [0.00239t + 0.000113t^2] * 39.37$$

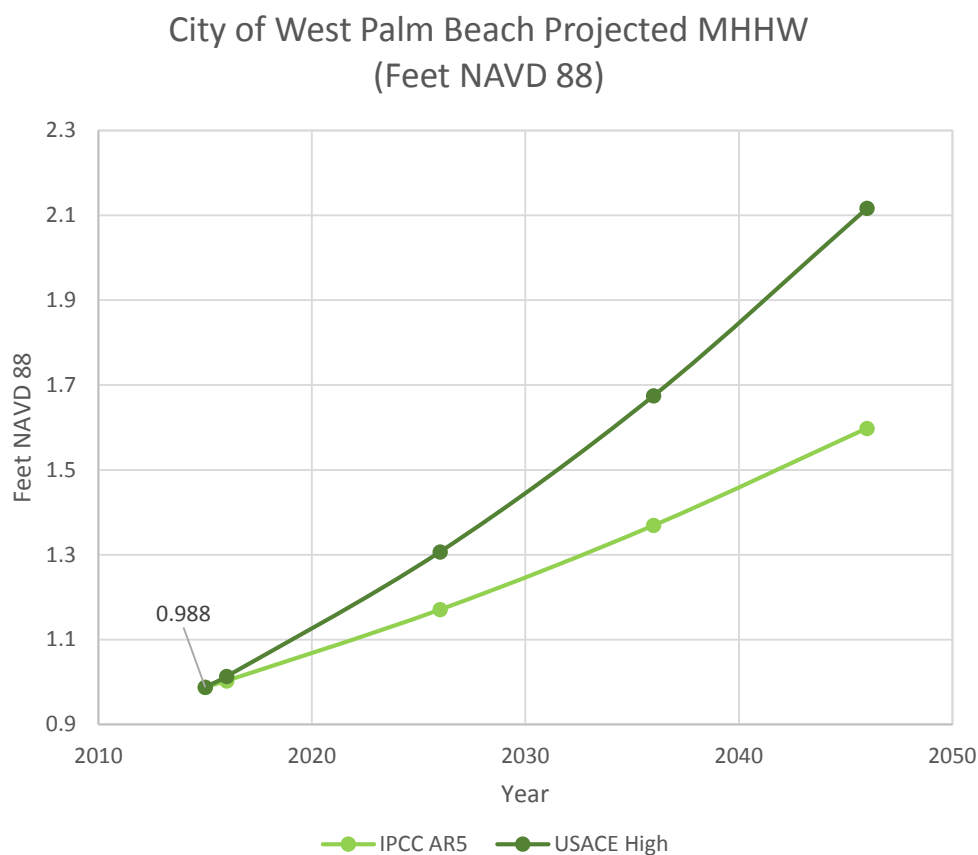
Where:

- $E(t)$  = the estimated change in MSL between 1992 and year  $t$  (inches) and
- $t$  = years since 1992 (e.g. for 2016,  $t = 24$  years).

The 2016 SWMP team utilized local gauges (Lake Worth Lagoon, NOAA gauge 8722670) and projections to arrive at a sea level for 2015 of 0.988 feet NAVD88 for the ICPR model. Therefore, these equations were utilized for relative rises from 2015 to 2046 rather than from 1992. This was done by finding the difference between the rise from 1992 to 2015 and from 1992 to 2046 for each equation. This relative rise was added to the 0.988 feet NAVD 88 for the sea level projections for each equation.

**Table 1: Projected MHHW, by year, for the City of West Palm Beach Relative to 2015 Conditions in NAVD88.**

	SLR Relative to 1992 - Feet		SLR Relative to 2015 - Feet		Sea Level - Feet NAVD 88	
Year	IPCC AR5 Scenario 1	USACE High Scenario 2	IPCC AR5 Scenario 1	USACE High Scenario 2	IPCC AR5 Scenario 1	USACE High Scenario 2
1992	0	0	-	-	-	-
2015	0.26	0.38	0	0	0.988	0.988
2016	0.28	0.40	0.02	0.03	1.00	1.01
2026	0.44	0.70	0.18	0.32	1.17	1.31
2036	0.64	1.06	0.38	0.69	1.37	1.67
2046	0.87	1.50	0.61	1.13	<b>1.60</b>	<b>2.12</b>

**Figure 2: Projected MHHW for two SLR scenarios, NAVD88 (feet)**

## Water Table Projections

The water table response to groundwater was determined based on the best available data provided by South Florida Water Management District. SFWMD had previously run the South Florida Water Management Model (SFWMM) under various sea level rise scenarios for other analyses. These model results were utilized to determine a response to groundwater due to the rise modeled in Scenario 1b and Scenario 2b in ICPR. It is notable that although the SFWMM is a regional model, it was determined through conversations with SFWMD that it represents best available information for this effort and Palm Beach County at this time.

The SFWMM is a regional scale model that spans 7600 square miles from Lake Okeechobee in the North to the Florida Bay in the South. The model simulates precipitation, evapotranspiration, and the interaction between surface and groundwater on a 2 mile by 2 mile grid. The model runs on a daily timestep using input data from 1965 to 2000. The only changes made to the baseline

conditions for the sea level rise model runs were an immediate increase in sea level rise on day 1 of the simulation. The amount of sea level rise varied between model runs.

The output from the SFWMM is a depth to groundwater for each 2 mile by 2 mile cell for each day in the simulation period. This output was used to create a relationship between sea level rise and groundwater rise for each cell in the SFWMM. The daily depth to groundwater outputs from each sea level rise scenario were compared to the output generated with baseline conditions (no rise in sea level) for each day in each cell. These daily values were averaged for wet season months (May through October) for each 2 mile by 2 mile grid cell. This analysis produced the (wet season) average difference in groundwater levels between no sea level rise and 1 foot, 2 feet, and 3 feet of sea level rise for each cell. There was a rise in cells overlapping the Lake Worth Lagoon and extending 2 miles inland (Column: 40) but no notable rise in cells west of column 40.

**Figure 3: South Florida Water Management Model Grid cells at West Palm Beach, FL.**



Because of the scale and resolution of the SFWMM, the results cannot be used to develop a relationship for change in groundwater rise with distance from the Lake Worth Lagoon. Given that this model was the best available data, it was decided that one value for rise would be established and applied to the basins that overlap from the Lagoon westward to column 40. Future phases could focus on establishing a groundwater model with appropriate scale to establish more information about the interrelationships between sea level rise and groundwater response in Palm Beach County.

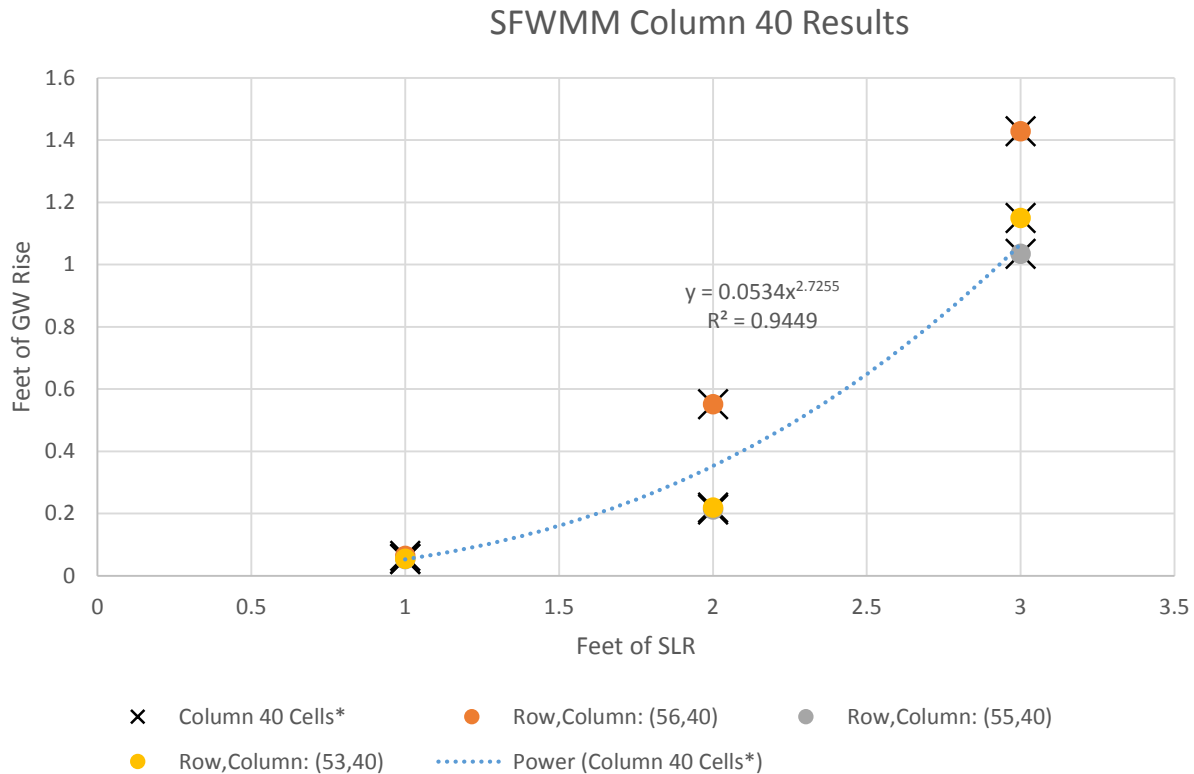
To estimate the rate of groundwater rise to sea level rise in column 40, the results from all rise scenarios from all cells in column 40 in West Palm Beach were analyzed. A relationship between rise in sea level to rise in groundwater was established with a power function. This relationship was used to interpolate a rise in groundwater given the estimated sea level rise from the IPCC AR5 and the USACE High.

**Table 2: Projected rise in MHHW and resulting rise in groundwater, for Scenario 1 and Scenario 2, for the City of West Palm Beach Relative to 2015 Conditions in NAVD88.**

Sea Level Rise Scenario	Equation:	$GWR = 0.0534(SLR)^{2.7255}$
	Feet of Sea Level Rise (SLR)	Feet of Groundwater Rise (GWR)
<b>Scenario 1b (IPCC AR5)</b>	0.61	0.14
<b>Scenario 2b (USACE High)</b>	1.13	0.75



**Figure 4: Relationship between groundwater and sea level rise used to project groundwater rise for Scenario 1b and 2b.**



\*Row/Column 54,40 not included as the results were outliers when compared with other results from cells in column 40.

### Model Modifications in ICPR3

The planning horizon recommended for existing and immediate improvements to the City's stormwater management system is 30 years. Because of the uncertainty about how climate will change in the future, a range of sea level rise scenarios was necessary to examine possible conditions. Actual sea level change will not follow a curvilinear path as defined by the aforementioned projection curves nor track to a single projection condition. Therefore, two scenarios were developed representing the 30-year planning horizon and two projection curves from the SEFRCCC's unified projections. Additionally, analyzing proposed stormwater management alternatives with and without a rise in the water tables defined how sensitive each alternative is to changes in the water table.

In developing specific projections for the City, SEFRCCC Sea Level Rise Working Group's recommendations on which projection curves to apply were considered:

- The low curve (i.e. IPCC AR5 RCP8.5) should be applied for low risk projects with an approximate design life of 10 years, could easily be adapted or replaced, or would have limited impact if failure occurred.
- The high curve (i.e. NOAA High) should be applied when evaluating critical infrastructure, such as projects that cannot be easily adapted, have a 50+ year design life, will be implemented after 2060, or if failure would have catastrophic impacts;
- The projection zone between the low curve and the middle curve (i.e. USACE High) should be used for most projects with a planning horizon or design life on the order of 30 years to 50 years.

For the City's drainage analysis, the low curve of the projection zone (IPCC AR5 RCP8.5) was recommended for the 30-year planning horizon for easily adaptable and replaceable infrastructure and infrastructure that will likely be replaced approximately every decade. Additionally, this scenario is applicable for identifying elements of the City's stormwater system that are susceptible to the least amount of sea level rise.

The USACE High curve projections for the 30-year planning horizon is being used to formulate potential stormwater strategies for all but the most critical infrastructure and evaluate their effectiveness in alleviating flooding problems at present as well as in the future.

Lastly, the NOAA High curve projection was not selected as this is intended for longer term planning, which is not within the scope of this 2016 SWMP.

**Based on the sea level and water table projections presented in the previous sections, two scenarios were analyzed for 30-year planning horizon:**

- **IPCC AR5 RCP8.5-based projection for 2046;**
- **USACE High-based projection for 2046.**

The existing ICPR3 model, created for the 2016 SWMP for West Palm Beach, was used to model these various sea level rise and groundwater rise scenarios. As stated previously, the existing sea level in the 2016 SWMP ICPR model is 0.988 feet, NAVD88. Two sea level rise scenarios for the MHHW were established to evaluate the impact to City infrastructure in 30 years:

- Scenario 1 (A and B) for 2046 = 1.60 feet, NAVD 88;
- Scenario 2 (A and B) for 2046 = 2.12 feet, NAVD 88;

To evaluate sensitivity to groundwater changes, each scenario was run with and without a change in water table, which results in four separate scenarios. As stated in the groundwater projections section of this memorandum, the estimated water table response was based on the amount of sea level rise.

Various parameters were edited in the ICPR3 model to represent these scenarios. Projected MHHW was utilized to establish the tidal boundary conditions within the Lake Worth Lagoon adjacent to the City. More specifically **Table 3** presents the tidal elevations simulated for the two future conditions scenarios along with the associated change in MHHW from current conditions.

**Table 3: Future Scenario Tidal Elevations and Difference from Current Conditions**

Scenario	Curve	Year	Tidal Elevation (feet, NGVD29)	Difference (feet) Projected - Current
1 (A and B)	IPCC AR5 RCP8.5	2046	1.60	0.61
2 (A and B)	USACE High	2046	2.12	1.13

To run these scenarios in the 2016 ICPR model, boundary nodes in Lake Worth Lagoon were changed to represent high sea level under 2046 conditions. The following constant time-stage nodes, which are in the Lake Worth Lagoon, were changed from 0.988 feet NAVD88 to 1.60 feet NAVD88 for Scenario 1 and to 2.12 feet NAVD88 for Scenario 2:

- Node NB1607
- Node NH1606
- Node NL1605
- Node NP1604

Other boundary nodes are in canals above control structures and thus would not experience direct effect from sea level rise. Structures would likely be operated differently under higher sea level conditions to mitigate salt water intrusion into groundwater and other issues. This likely change was not assessed and modeled for this effort. Rather, this effort was meant to assess what will be affected if infrastructure is *not* operated differently.

The change in depth to water table due to these two sea level conditions, and associated loss in soil storage capacity was represented in the ICPR model for scenarios 1B and 2B. The estimated response of the water table to these future sea level conditions was determined using the water table response to sea level rise based on the results from the SFWMM presented in the previous section. The estimated range in water table response within the City for each scenario is summarized as follows:

- **Scenario 1A:** Water table will not increase.
- **Scenario 1B:** Water table will increase 0.14-feet at cells adjacent to Lake Worth Lagoon and 2 miles inland.

- **Scenario 2A:** Water table will not increase.
- **Scenario 2B:** Water table will increase between 0.75-feet at cells adjacent to Lake Worth Lagoon and 2 miles inland.

To represent a change in water table elevation in the model, the cut off depth was decreased by the amount of water table change for each scenario. This parameter, cutoff depth, represents the depth to groundwater. Only the basins that overlapped with the cells in column: 40 from the SFWMM were adjusted. The cutoff depth for the IPCC AR5 sea level rise scenario, or Scenario 1b, was reduced by 0.14 feet and the cutoff depth was reduced by 0.75 feet for the USACE High sea level rise scenario, Scenario 2b.

It is possible that under the significant sea level rise, such as Scenario 2B, the associated rise in water table may cause the water table to be at or above the soil surface in low lying areas of the City. Where the reduction resulted in a negative cutoff depth (an above ground groundwater level) the cutoff depth was adjusted to zero (groundwater is at the ground level, no storage capacity). The ICPR3 model was run with these groundwater changes in addition to the corresponding sea level rise changes.

***Results and findings from these analyses are provided in Volume 1 of the SWMP. Volume 3 also contains a special series of Sustainability Maps that further explore the findings of these analyses.***



## References and Literature Reviewed

- Bjerklie, D.M., Mullaney, J.R., Stone, J.R., Skinner, B.J., and Ramlow, M.A. (2012) *Preliminary investigation of the effects of sea-level rise on groundwater levels in New Haven, Connecticut: U.S. Geological Survey Open-File Report 2012–1025*. Reston, Virginia.
- Christensen, J.H., K. Krishna Kumar, E. Aldrian, S.-I. An, I.F.A. Cavalcanti, M. de Castro, W. Dong, P. Goswami, A. Hall, J.K. Kanyanga, A. Kitoh, J. Kossin, N.-C. Lau, J. Renwick, D.B. Stephenson, S.-P. Xie and T. Zhou, 2013: Climate Phenomena and their Relevance for Future Regional Climate Change. In: *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W.T. Pfeffer, D. Stammer and A.S. Unnikrishnan. (2013) *Sea Level Rise Change*. In: *Climate Change 2013: The Physical Science Basis* (eds Stocker, T.F. et al.). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- Clark, P.U., J.A. Church, J.M. Gregory, A.J. Payne. (2015) *Recent Progress in Understanding and Projecting Regional Global Mean Sea Level Change*. Current Climate Change Reports, Volume 1, Issue 4. 224-246.
- Ezer, T., Atkinson, L.P., Corlett, W.B., and Blanco, J.L. (2013) *Gulf Stream's Induced Sea Level Rise and Variability Along the U.S. Mid-Atlantic Coast*. Journal of Geophysical Research: Oceans. 118. 685-697.
- Federal Emergency Management Agency. (2015, July). *Federal Insurance and Mitigation Administration Policy: Standards for Flood Risk Analysis and Mapping*. Washington, D.C.
- Federal Emergency Management Agency. (2014, August). *Flood Insurance Study: Palm Beach County, Florida, and Incorporated Areas*. Washington, D.C.
- Flato, G., J. Marotzke, B. Abiodun, P. Braconnot, S.C. Chou, W. Collins, P. Cox, F. Driouech, S. Emori, V. Eyring, C. Forest, P. Gleckler, E. Guilyardi, C. Jakob, V. Kattsov, C. Reason and M. Rummukainen. (2013) *Evaluation of Climate Models*. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

- Goddard, P.B., Yin, J., Griffies, S.M., Zhang, S. (2015) *An Extreme Event of Sea-Level Rise Along the Northeast Coast of North America in 2009-2010*. Nature Communications, 6:6346 doi:10.1038/ncomms7346.
- Hughes, J.D., and White, J.T. (2014) *Hydrologic Conditions in Urban Miami-Dade County, Florida, and the Effect of Groundwater Pumpage and Increased Sea Level on Canal Leakage and Regional Groundwater Flow: U.S. Geological Survey Scientific Investigations Report 2014–5162*. Reston, Virginia.
- Kirtman, B., S.B. Power, J.A. Adedoyin, G.J. Boer, R. Bojariu, I. Camilloni, F.J. Doblas-Reyes, A.M. Fiore, M. Kimoto, G.A. Meehl, M. Prather, A. Sarr, C. Schar, R. Sutton, G.J. van Oldenborgh, G. Vecchi and H.J. Wang. (2013) *Near-term Climate Change: Projections and Predictability. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Knuston, T. R., J. J. Sirutis, G. A. Vecchi, S. Garner, M. Zhao, H. Kim, M. Bender, R. Tuleya, I. M. Held, G. Villarini. (2013) *Dynamical Downscaling Projections of Twenty-First-Century Atlantic Hurricane Activity: CMIP3 and CMIP5 Model-Based Scenarios*. Journal of Climate. American Meteorological Society. Volume 26, 6951-6617.
- Maloney, M. and B.L. Preston. (2014) *A geospatial dataset for U.S. hurricane storm surge and sea-level rise vulnerability: Development and case study applications. Climate Risk Management*. Volume 2, 26-41.
- Masterson, J.P. and Garabedian, S.P. (2007) *Effects of Sea-Level Rise on Ground Water Flow in a Coastal Aquifer System*. Ground Water, Volume 45, Number 2. March-April.
- Maurer, E. P., L. Brekke, T. Pruitt, and P. B. Duffy. (2007) *Fine-resolution climate projections enhance regional climate change impact studies*, EOS Transactions. American Geophysical Union, Volume 88, Number 47, 504–504.
- Neumann, J.E., K. Emanuel, S. Ravela, L. Ludwig, P. Kirshen, K. Bosma, J. Martinich. (2014) Joint effects of storm surge and sea level rise on US Coasts: new economic estimates of impacts, adaptation, and benefits of mitigation policy. Climate Change. Volume 129, 337-349.
- Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. (2012) *Global Sea Level Rise Scenarios for the US National Climate Assessment*. NOAA Tech Memo OAR CPO-1. Silver Springs, Maryland.

- Obeyskera, J., J. Park, M. Irizarry-Ortiz, P. Trimble, J. Barnes, J. VanArman, W. Said, E. Gadzinski. (2011) *Past and Projected Trends in Climate and Sea Level for South Florida*. South Florida Water Management District. West Palm Beach, Florida.
- Obeyskera, J. (2011) *Climate Change and Water Management in South Florida*. Presentation at Sea Level Rise Adaptation in the Florida Keys, May 10-12.
- Sallenger, A.H., Doran, K.S., and Howd, P.A. (2012) *Hotspot of Accelerated Sea-Level Rise on the Atlantic Coast of North America*. Nature Climate Change. Volume 2, Number 12, 884-888. Doi:10.1038/nclimate1597.
- South Florida Water Management District. (2005, November). Documentation of the South Florida Water Management Model Version 5.5. Retrieved from [https://www.sfwmd.gov/sites/default/files/documents/sfwmm\\_final\\_121605.pdf](https://www.sfwmd.gov/sites/default/files/documents/sfwmm_final_121605.pdf)
- Southeast Florida Regional Climate Change Compact Sea Level Rise Work Group. (2015) *Unified Sea Level Rise Projection for Southeast Florida*. Florida.
- Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.). (2013) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.
- Tebaldi, C., Strauss, B. H., & Zervas, C. E. (2012). Modelling sea level rise impacts on storm surges along US coasts. *Environmental Research Letters*, 7(1), 014032
- Teegavarapu, R.S.V., A. Goly, J. Obeyskera. (2013) *Influences of Atlantic Multidecadal Oscillation Phases on Regional Precipitation Extremes*. Journal of Hydrology, 495, 74-93.
- Trimble, P., J. Obeyskera, L. Cadavid, E. Santee. (2005) *Application of Climate Outlooks for Water Management in South Florida*. Climate Variations, Climate Change, and Water Resources Engineering: pp. 65-85.
- USACE. (2015) North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk. U.S. Army Corps of Engineers.
- Wdowinski, S., Bray, R. L., Kirtman, B. P., Wu, Z. (2014) *Recurrence Flooding in Miami Beach as an Indicator of Accelerating Rates of Sea Level Rise along the US Atlantic Coast*, Abstract OS33C-1089 presented at 2014 Fall Meeting, American Geophysical Union. San Francisco, California, 15-19.




















## 3. SCHEDULE

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### 3. Schedule


ID	Task Name	Duration	Start	Finish	Qtr 4	2020 Qtr 1	Qtr 2	Qtr 3	Qtr 4	2021 Qtr 1	Qtr 2
1	Contract Negotiations/Approval	15 days	Mon 2/3/20	Fri 2/21/20							
2	Kickoff Meeting with Working Group	1 day	Mon 2/24/20	Mon 2/24/20							
3	Outreach Plan	91 days	Tue 2/25/20	Tue 6/30/20							
4	<b>STEP 1: EXPLORE CLIMATE THREATS</b>	<b>91 days</b>	<b>Tue 2/25/20</b>	<b>Tue 6/30/20</b>							
5	Identifying Climate Threats and Impacts	75 days	Tue 2/25/20	Mon 6/8/20							
6	Reviewing Climate Science for Scenario Projections	75 days	Tue 2/25/20	Mon 6/8/20							
7	Working Group Climate Threats Exercises	1 day	Tue 6/9/20	Tue 6/9/20							
8	Summary Repot, Geodatabase, and Inventory	10 days	Wed 6/10/20	Tue 6/23/20							
9	Step 1 Deliverables Approved by Working Group	5 days	Wed 6/24/20	Tue 6/30/20							
10	<b>Step 1 Deliverables Submitted to FDEP</b>	<b>0 days</b>	<b>Tue 6/30/20</b>	<b>Tue 6/30/20</b>							
11	<b>STEP 2: ASSEMBLE DATA ON COMMUNITY SYSTEMS</b>	<b>91 days</b>	<b>Tue 2/25/20</b>	<b>Tue 6/30/20</b>							
12	Review, Mine, and Refine Community Asset Data	75 days	Tue 2/25/20	Mon 6/8/20							
13	Community Captain Meetings with Individual Communities	5 days	Tue 6/2/20	Mon 6/8/20							
14	Working Group Presentation	1 day	Tue 6/9/20	Tue 6/9/20							
15	Summary Repot, Geodatabase, and Inventory	10 days	Wed 6/10/20	Tue 6/23/20							
16	Step 2 Deliverables Approved by Working Group	5 days	Wed 6/24/20	Tue 6/30/20							
17	<b>Step 2 Deliverables Submitted to FDEP</b>	<b>0 days</b>	<b>Tue 6/30/20</b>	<b>Tue 6/30/20</b>							

Project: 20200112_schedule_v1 Date: Mon 1/13/20	Task		Inactive Summary		External Tasks	
	Split		Manual Task		External Milestone	
	Milestone		Duration-only		Deadline	
	Summary		Manual Summary Rollup		Progress	
	Project Summary		Manual Summary		Manual Progress	
	Inactive Task		Start-only			
	Inactive Milestone		Finish-only			

ID	Task Name	Duration	Start	Finish	<div> <div>Qtr 4</div> <div>2020</div> <div>Qtr 1</div> <div>Qtr 2</div> <div>Qtr 3</div> <div>Qtr 4</div> <div>2021</div> <div>Qtr 1</div> <div>Qtr 2</div> </div>							
18	<b>STEP 3: ASSESS VULNERABILITIES AND RISKS</b>	81 days	Wed 6/24/20	Wed 10/14/20								
19	Exposure, Vulnerability, and Risk Assessment	60 days	Wed 6/24/20	Tue 9/15/20								
20	Community Captain Meetings with Individual Communities	5 days	Wed 9/9/20	Tue 9/15/20								
21	Working Group Presentation	1 day	Wed 9/16/20	Wed 9/16/20								
22	Summary Repot, Geodatabase, and Inventory	15 days	Thu 9/17/20	Wed 10/7/20								
23	Public Outreach Materials of Step 3 Results	15 days	Thu 9/17/20	Wed 10/7/20								
24	Step 3 Deliverables Approved by Working Group	5 days	Thu 10/8/20	Wed 10/14/20								
25	<b>STEP 4: INVESTIGATE POTENTIAL ADAPTATION STRATEGIES</b>	80 days	Thu 10/8/20	Wed 1/27/21								
26	Adaptation Strategies Identification	30 days	Thu 10/8/20	Wed 11/18/20								
27	Adaptation Prioritization	30 days	Thu 11/19/20	Wed 12/30/20								
28	Adaptation Prioritization Workshops	10 days	Thu 11/19/20	Wed 12/2/20								
29	Update Adaptation Prioritization Including Engagement	20 days	Thu 12/3/20	Wed 12/30/20								
30	Summary Repot	15 days	Thu 12/31/20	Wed 1/20/21								
31	Step 4 Deliverables Approved by Working Group	5 days	Thu 1/21/21	Wed 1/27/21								
32	<b>STEP 5: FINAL REPORT AND INTERACTIVE MAP/TOOL</b>	50 days	Thu 1/21/21	Wed 3/31/21								
33	Draft Summary Repot and Geodatabase	15 days	Thu 1/21/21	Wed 2/10/21								
34	Working Group and Community Meetings	5 days	Thu 2/11/21	Wed 2/17/21								




















Project: 20200112\_schedule\_v1  
Date: Mon 1/13/20

Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			

ID	Task Name	Duration	Start	Finish	2020					2021		
					Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	
35	Public Outreach Meetings	10 days	Thu 2/18/21	Wed 3/3/21								3/31
36	Final Summary Report and Geodatabase	15 days	Thu 3/4/21	Wed 3/24/21								
37	Transfer Output to GIS Enterprise	1 day	Wed 3/24/21	Wed 3/24/21								
38	Step 5 Deliverables Approved by Working Group	5 days	Thu 3/25/21	Wed 3/31/21								
39	Step 3, 4, and 5 Deliverables Submitted to FDEP	0 days	Wed 3/31/21	Wed 3/31/21								

**Note: Schedule details can be refined during negotiations. The Collective Team also suspects that we may be able to provide final deliverables ahead of the March 31, 2021 deadline since we have worked within tighter deadlines on other similar projects.**

Project: 20200112\_schedule\_v1  
Date: Mon 1/13/20

Task		Inactive Summary		External Tasks	
Split		Manual Task		External Milestone	
Milestone		Duration-only		Deadline	
Summary		Manual Summary Rollup		Progress	
Project Summary		Manual Summary		Manual Progress	
Inactive Task		Start-only			
Inactive Milestone		Finish-only			

## 4. REFERENCES

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**EXHIBIT "D"**

**RFP 20-203 Multi-Jurisdictional Climate Change Vulnerability Assessment**  
**REFERENCES**

Fill out and submit the below list of references, per the RFP requirements, for providing similar Climate Change Vulnerability Assessment (CCVA) services. Provide the name, addresses, and telephone numbers of three organizations, governmental or private, for whom you now are, or have **within the past three (3) years** provided services. This form may be copied.

**REFERENCE #1**

Company or Organization Name: City of West Palm Beach  
Address: 401 Clematis Street, West Palm Beach, FL 33401  
Phone: (561 ) 358-1445 Fax: ( ) Not available email: predford@wpb.org  
Contact Person: Penni Redford Title: Resilience/Climate Change Manager  
Date Services Began: 2012 Date Services Completed: Ongoing  
Description of services: Collective and NEMAC+Fernleaf have been working on various phases  
of studies related to resiliency since 2012.

**REFERENCE #2**

Company or Organization Name: City of Charleston, South Carolina  
Address: 80 Broad Street, Charleston, South Carolina 29401-0304  
Phone: (843 ) 619-6118 Not available email: wilbertm@charleston-sc.gov  
Fax: ( )  
Contact Person: Mark Wilbert Title: Chief Resilience Officer  
Date Services Began: 03/2019 Date Services Completed: Ongoing  
Description of services: Multi-Hazard Vulnerability Assessment (see detailed project description  
in Section 2 of this proposal) and Resiliency Plan. Both Collective and NEMAC+Fernleaf  
are working on this project.

**REFERENCE #3**

**REFERENCE FOR NEMAC+FERNLEAF**

Company or Organization Name: National Oceanic and Atmospheric Administration  
Address: 1401 Constitution Avenue NW, Room 5128, Washington, DC 20230  
Phone: (301 ) 734-1207 Not available: email david.herring@noaa.gov  
Fax: ( )

Contact Person: David Herring Title: Communication, Education, & Engagement Manager

Date Services Began: 03/2019 Date Services Completed: 01/2020

Description of services: Preparation of the US Climate Resilience Toolkit (see detailed description in Section 2 of this proposal).

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## 5. COST PROPOSAL

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# 5. Cost Proposal

RFP #20-203

Lake Worth Beach: Multi-Jurisdictional Climate Change Vulnerability Assessment

Because of likely efficiencies with Steps 1-2 due to the local nature of the team, we have redistributed cost slightly for Steps 3-5. Shifts in threats and strategies may also warrant some slight shifts. We believe that many of these subtelties can easily be resolved during negotiations.

Step No.	Step Name	Total
1	Explore Climate Threats	\$ 28,780.00
2	Assemble Data on Community Assets	\$ 25,280.00
3	Assess Vulnerabilities and Risks	\$ 165,480.00
4	Investigate Potential Adaptation Strategies	\$ 94,490.00
5	Prepare Final Report and Interactive Map	\$ 50,290.00
Total (all Steps)		\$ 364,320.00



## 6. LICENSES



## 6. Licenses & Insurance

# *State of Florida Department of State*

I certify from the records of this office that COLLECTIVE WATER RESOURCES LLC is a limited liability company organized under the laws of the State of Florida, filed on June 12, 2012.

The document number of this limited liability company is L12000077694.

I further certify that said limited liability company has paid all fees due this office through December 31, 2020, that its most recent annual report was filed on January 2, 2020, and that its status is active.

*Given under my hand and the  
Great Seal of the State of Florida  
at Tallahassee, the Capital, this  
the Second day of January, 2020*



*Ronald R. R.*  
Secretary of State

Tracking Number: 6357603772CC

To authenticate this certificate, visit the following site, enter this number, and then follow the instructions displayed.

<https://services.sunbiz.org/Filings/CertificateOfStatus/CertificateAuthentication>

**Palm Beach County  
Office of Small Business Assistance**

Certifies That

**Collective Water Resources, LLC.**

VENDOR # VS0000004343

*is a Small/Woman Business Enterprise as prescribed by Section 2-80.21– 2-80.35 of the Palm Beach County Code for a three year period from July 11, 2017 to July 10, 2020*

The following Services and/or Products are covered under this certification:

**Civil Engineering  
Environmental Engineering  
Mapping and Geographical Information Systems (GIS Services, Digitized, Cartography)**

Palm Beach County Board of County Commissioners

Paulette Burdick, Mayor  
Melissa McKinlay, Vice Mayor  
Hal Valeche  
Dave Kerner  
Steven L. Abrams  
Mary Lou Berger  
Mack Bernard

County Administrator  
Verdenia C. Baker

  
Allen Gray, Manager  
July 11, 2017



*State of Florida*

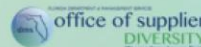
**Woman Business Certification**

**Collective Water Resources, LLC**

Is certified under the provisions of  
287 and 295.187, Florida Statutes, for a period from:

08/09/2018 to 08/09/2020

  
Erin Rock, Secretary  
Florida Department of Management Services



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**\*\*LOCATED AT\*\***

**8461 LAKE WORTH RD  
 LAKE WORTH, FL 33467**

TYPE OF BUSINESS	OWNER	CERTIFICATION #	RECEIPT #/DATE PAID	AMT PAID	BILL #
54-0064 ENGINEER	PEREZ ELIZABETH	61023	B19.549680 - 07/03/19	\$33.00	B40171696

This document is valid only when received by the Tax Collector's Office.

B2 - 1894

COLLECTIVE WATER RESOURCES LLC  
 COLLECTIVE WATER RESOURCES LLC  
 8461 LAKE WORTH RD STE 231  
 LAKE WORTH, FL 33467

**STATE OF FLORIDA  
 PALM BEACH COUNTY  
 2019/2020 LOCAL BUSINESS TAX RECEIPT**

**LBTR Number: 2017100908  
 EXPIRES: SEPTEMBER 30, 2020**

This receipt grants the privilege of engaging in or managing any business profession or occupation within its jurisdiction and MUST be conspicuously displayed at the place of business and in such a manner as to be open to the view of the public.





Ron DeSantis, Governor



STATE OF FLORIDA

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**PEREZ, ELIZABETH MARIA**

3158 N. GREENLEAF CIRCLE  
BOYNTON BEACH FL 33426

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**DUNHAM, STEPHANIE Y.**

2686 NW 41ST ST  
BOCA RATON FL 33434

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**MCBRYAN, EMILY**

8461 COLLECTIVE WATER RESOURCES  
LAKE WORTH ROAD  
SUITE 231  
LAKE WORTH FL 33467

**LICENSE NUMBER: PE60774**

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**LEITSCHUH, ANNA MARIE**

875 NW 13TH ST  
APT. 405  
BOCA RATON FL 33486

**LICENSE NUMBER: PE84415**

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# *State of Florida*

## *Department of State*

I certify from the records of this office that BRIZAGA, INC. is a corporation organized under the laws of the State of Florida, filed on May 15, 2017, effective May 15, 2017.

The document number of this corporation is P17000043548.

I further certify that said corporation has paid all fees due this office through December 31, 2019, that its most recent annual report/uniform business report was filed on April 4, 2019, and that its status is active.

I further certify that said corporation has not filed Articles of Dissolution.

*Given under my hand and the  
Great Seal of the State of Florida  
at Tallahassee, the Capital, this  
the Fifteenth day of July, 2019*



*Ronald R. Lee*  
Secretary of State

Tracking Number: 1948533389CU

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Ron DeSantis, Governor

Halsey Beshears, Secretary



**STATE OF FLORIDA  
DEPARTMENT OF BUSINESS AND PROFESSIONAL REGULATION**

**BOARD OF PROFESSIONAL ENGINEERS**

THE ENGINEERING BUSINESS HEREIN IS AUTHORIZED UNDER THE  
PROVISIONS OF CHAPTER 471, FLORIDA STATUTES

**BRIZAGA, INC.**

100 SE 3RD AVENUE  
STE 1000  
FORT LAUDERDALE FL 33394

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**ANTINELLI, MICHAEL ALLEN**

100 SE 3RD AVENUE  
STE 1000  
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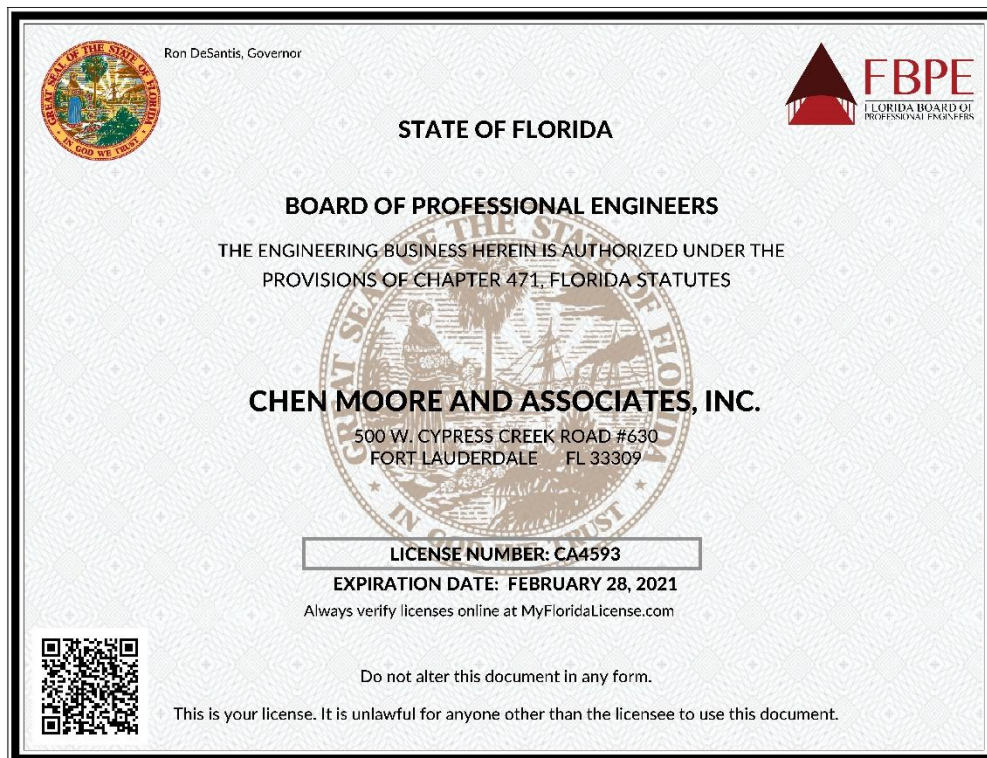
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## Chen Moore & Associates





Ron DeSantis, Governor

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**WHITFIELD, BRENT M.**

133 DUKE DRIVE  
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**ACORD**<sup>TM</sup>**CERTIFICATE OF LIABILITY INSURANCE**

DATE (MM/DD/YYYY)

8/26/2019

THIS CERTIFICATE IS ISSUED AS A MATTER OF INFORMATION ONLY AND CONFERS NO RIGHTS UPON THE CERTIFICATE HOLDER. THIS CERTIFICATE DOES NOT AFFIRMATIVELY OR NEGATIVELY AMEND, EXTEND OR ALTER THE COVERAGE AFFORDED BY THE POLICIES BELOW. THIS CERTIFICATE OF INSURANCE DOES NOT CONSTITUTE A CONTRACT BETWEEN THE ISSUING INSURER(S), AUTHORIZED REPRESENTATIVE OR PRODUCER, AND THE CERTIFICATE HOLDER.

**IMPORTANT:** If the certificate holder is an **ADDITIONAL INSURED**, the policy(ies) must have **ADDITIONAL INSURED** provisions or be endorsed. If **SUBROGATION IS WAIVED**, subject to the terms and conditions of the policy, certain policies may require an endorsement. A statement on this certificate does not confer any rights to the certificate holder in lieu of such endorsement(s).

<b>PRODUCER</b> <b>USI Insurance Services, LLC</b> <b>2502 N Rocky Point Drive</b> <b>Suite 400</b> <b>Tampa, FL 33607</b>		<b>CONTACT NAME:</b> <b>PHONE (A/C, No, Ext): 813 321-7500</b> <b>FAX (A/C, No): 813 321-7525</b> <b>E-MAIL ADDRESS:</b>	
		<b>INSURER(S) AFFORDING COVERAGE</b>	<b>NAIC #</b>
		<b>INSURER A : Phoenix Insurance Company</b>	<b>25623</b>
		<b>INSURER B : Travelers Indemnity Company</b>	<b>25658</b>
		<b>INSURER C : Travelers Casualty and Surety Company</b>	<b>19038</b>
		<b>INSURER D : AXIS Insurance Company</b>	<b>37273</b>
		<b>INSURER E :</b>	
		<b>INSURER F :</b>	

**COVERAGES** **CERTIFICATE NUMBER:** **REVISION NUMBER:**

THIS IS TO CERTIFY THAT THE POLICIES OF INSURANCE LISTED BELOW HAVE BEEN ISSUED TO THE INSURED NAMED ABOVE FOR THE POLICY PERIOD INDICATED. NOTWITHSTANDING ANY REQUIREMENT, TERM OR CONDITION OF ANY CONTRACT OR OTHER DOCUMENT WITH RESPECT TO WHICH THIS CERTIFICATE MAY BE ISSUED OR MAY PERTAIN, THE INSURANCE AFFORDED BY THE POLICIES DESCRIBED HEREIN IS SUBJECT TO ALL THE TERMS, EXCLUSIONS AND CONDITIONS OF SUCH POLICIES. LIMITS SHOWN MAY HAVE BEEN REDUCED BY PAID CLAIMS.

INSR LTR	TYPE OF INSURANCE	ADDL INSR	SUBR WVD	POLICY NUMBER	POLICY EFF (MM/DD/YYYY)	POLICY EXP (MM/DD/YYYY)	LIMITS
<b>A</b>	<input checked="" type="checkbox"/> <b>COMMERCIAL GENERAL LIABILITY</b> <input type="checkbox"/> CLAIMS-MADE <input checked="" type="checkbox"/> OCCUR  GEN'L AGGREGATE LIMIT APPLIES PER: <input type="checkbox"/> POLICY <input type="checkbox"/> PRO-JECT <input type="checkbox"/> LOC OTHER:	<b>x</b>	<b>x</b>	<b>6601E450858</b>	<b>02/05/2019</b>	<b>02/05/2020</b>	EACH OCCURRENCE <b>\$2,000,000</b> DAMAGE TO RENTED PREMISES (Ea occurrence) <b>\$1,000,000</b> MED EXP (Any one person) <b>\$10,000</b> PERSONAL & ADV INJURY <b>\$2,000,000</b> GENERAL AGGREGATE <b>\$4,000,000</b> PRODUCTS - COMP/OP AGG <b>\$4,000,000</b> \$
<b>A</b>	<b>AUTOMOBILE LIABILITY</b> <input type="checkbox"/> ANY AUTO OWNED AUTOS ONLY <input checked="" type="checkbox"/> HIRED AUTOS ONLY <input type="checkbox"/> SCHEDULED AUTOS NON-OWNED AUTOS ONLY	<b>x</b>	<b>x</b>	<b>6601E450858</b>	<b>02/05/2019</b>	<b>02/05/2020</b>	COMBINED SINGLE LIMIT (Ea accident) <b>\$2,000,000</b> BODILY INJURY (Per person) \$ BODILY INJURY (Per accident) \$ PROPERTY DAMAGE (Per accident) \$ \$
<b>B</b>	<input checked="" type="checkbox"/> <b>UMBRELLA LIAB</b> <input type="checkbox"/> EXCESS LIAB <input checked="" type="checkbox"/> RETENTION <b>\$10000</b>	<b>x</b>		<b>CUP8K397499</b>	<b>02/05/2019</b>	<b>02/05/2020</b>	EACH OCCURRENCE <b>\$1,000,000</b> AGGREGATE <b>\$1,000,000</b> \$
<b>C</b>	<b>WORKERS COMPENSATION AND EMPLOYERS' LIABILITY</b> ANY PROPRIETOR/PARTNER/EXECUTIVE/OFFICER/MEMBER EXCLUDED? <b>N</b> (Mandatory in NH) If yes, describe under DESCRIPTION OF OPERATIONS below		<b>x</b>	<b>UB0K318377</b>	<b>02/05/2019</b>	<b>02/05/2020</b>	<input checked="" type="checkbox"/> PER STATUTE <input type="checkbox"/> OTH-ER E.L. EACH ACCIDENT <b>\$1,000,000</b> E.L. DISEASE - EA EMPLOYEE <b>\$1,000,000</b> E.L. DISEASE - POLICY LIMIT <b>\$1,000,000</b>
<b>D</b>	<b>Professional Liability</b>			<b>AE002859012018</b>	<b>09/21/2019</b>	<b>09/21/2020</b>	<b>\$2,000,000 per claim</b> <b>\$2,000,000 annl aggr.</b>

DESCRIPTION OF OPERATIONS / LOCATIONS / VEHICLES (ACORD 101, Additional Remarks Schedule, may be attached if more space is required)

**Professional Liability coverage is written on a claims-made basis.**

**CERTIFICATE HOLDER****CANCELLATION**

**For Proposal Purposes**

SHOULD ANY OF THE ABOVE DESCRIBED POLICIES BE CANCELLED BEFORE THE EXPIRATION DATE THEREOF, NOTICE WILL BE DELIVERED IN ACCORDANCE WITH THE POLICY PROVISIONS.

AUTHORIZED REPRESENTATIVE



## 7. APPENDIX (FORMS)

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**EXHIBIT "B"**

**RFP 20-203 Multi-Jurisdictional Climate Change Vulnerability Assessment**  
**CITY'S CAMPAIGN CONTRIBUTION STATEMENT**

This RFP is subject to Section 2-101 of the City of Lake Worth Beach Code of Ordinances regarding campaign contributions which provides:

**Sec. 2-101. - Additional and supplemental disclosures requirements.**

- (a) Any elected official of the City of Lake Worth Beach, who is a current sitting member of the city commission and has accepted an election campaign contribution in an amount that is more than one hundred dollars (\$100.00) from an individual or business entity having an interest in a matter before the city commission in which the city commission will take action, must publically disclose, both verbally and in writing, such contribution prior to any discussion or vote on the matter. The written disclosure must be submitted to the city clerk.
- (b) Any applicant coming before the city commission for an award of a contract with the city and who has made an election campaign contribution in an amount that is more than one hundred dollars (\$100.00) to any elected official of the city commission, who is a current sitting member of the commission, **must disclose such election campaign contribution, verbally and in writing, during the application or bidding process and before the award of the contract.**

**Respondent to complete:** Check which statement applies, fill in the requested information, if applicable, and sign below.

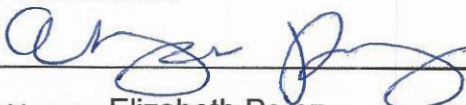
☒ Neither the undersigned business nor any of its owners or officers contributed more than \$100.00 to the campaign of a sitting City Commission member. [If you checked this statement, you are done and may sign below.]

☐ The undersigned business or one or more of its owners or officers contributed more than \$100.00 to the campaign of a sitting City Commission member. All such contributions are listed below and on the attached sheet of paper (if more room is needed). [If you checked this statement, please fill in the information requested below and sign below.]

- 1. \_\_\_\_\_ contributed a total of \$\_\_\_\_\_ to the campaign of City Commission member \_\_\_\_\_.
- 2. \_\_\_\_\_ contributed a total of \$\_\_\_\_\_ to the campaign of City Commission member \_\_\_\_\_.
- 3. \_\_\_\_\_ contributed a total of \$\_\_\_\_\_ to the campaign of City Commission member \_\_\_\_\_.
- 4. \_\_\_\_\_ contributed a total of \$\_\_\_\_\_ to the campaign of City Commission member \_\_\_\_\_.

**Signature:**

I hereby certify that the above statements are true and correct to the best of my knowledge and I understand that a false or inaccurate statement may result in the rejection of this bid/proposal/submittal or the immediate termination of any resulting agreement with the City of Lake Worth Beach.

By:  \_\_\_\_\_

Print Name: Elizabeth Perez

Print Title: President

Print Name of Business: Collective Water Resources, LLC.

**Commissioner/Mayor to complete:** Check which statement applies, fill in the requested information, if applicable, and sign below.

[ ] Neither the above referenced business nor any of its owners or officers contributed more than \$100.00 to my campaign. [If you checked this statement, you are done and may sign below.]

[ ] The above referenced business or one or more of its owners or officers contributed more than \$100.00 to my campaign. All such contributions are listed below and on the attached sheet of paper (if more room is needed). [If you checked this statement, please fill in the information requested below and sign below.]

_____	contributed a total of \$ _____	to my campaign.
_____	contributed a total of \$ _____	to my campaign.
_____	contributed a total of \$ _____	to my campaign.
_____	contributed a total of \$ _____	to my campaign.

**Signature:**

I hereby certify that the above statements are true and correct to the best of my knowledge and I understand that a false or inaccurate statement may result in the rejection of this bid/proposal/submittal or the immediate termination of any resulting agreement with the City of Lake Worth Beach.

By: \_\_\_\_\_

Print Name: \_\_\_\_\_

**For City Clerk's Use Only.**

**THIS SECTION SHALL BE COMPLETED ONLY IF THERE IS A CAMPAIGN CONTRIBUTION LISTED ABOVE BY THE VENDOR OR COMMISSION MEMBER.**

Applicable campaign contributions were disclosed in writing above, and prior to the award of the contract, the following statements were verbally made at the City Commission Meeting on the \_\_\_\_\_ day of \_\_\_\_\_, 201\_\_\_\_.

Check all that apply.

\_\_\_\_\_ Commissioner/Mayor \_\_\_\_\_ verbally disclosed the campaign contribution(s) set forth above.

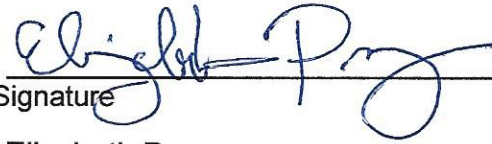
\_\_\_\_\_ Vendor, \_\_\_\_\_, verbally disclosed the campaign contribution(s) set forth above.

**EXHIBIT "C"**

**RFP 20-203 Multi-Jurisdictional Climate Change Vulnerability Assessment**  
**RESPONDENT INFORMATION FORM**

Company Name: Collective Water Resources, LLC.

Authorized  
Signature:

  
Signature

Elizabeth Perez

Print Name

Title:

President

Physical  
Address:

8461 Lake Worth Road, Suite 231

Street

Lake Worth

FL

33467

City

State

Zip Code

Telephone:

(561)713-1320

Fax:

Email Address: lperez@collectivewater.com

Website (if applicable): www.collectivewater.com

Federal Identification Number: 45-5472666

This is a requirement of every Respondent.



**EXHIBIT "E"**

**RFP 20-203 Multi-Jurisdictional Climate Change Vulnerability Assessment  
CONFIRMATION OF DRUG-FREE WORKPLACE FORM**

In accordance with Section 287.087, Florida Statutes, whenever two or more proposals are equal with respect to price, quality, and service which are received by any political subdivision for the procurement of commodities or contractual services, a proposal received from a business that certifies that it has implemented a drug-free workplace program shall be given preference in the award process. In order to have a drug-free workplace program, a business shall:

- (1) Publish a statement notifying employees that the unlawful manufacture, distribution, dispensing, possession, or use of a controlled substance is prohibited in the workplace and specifying the actions that will be taken against employees for violations of such prohibition.
- (2) Inform employees about the dangers of drug abuse in the workplace, the business's policy of maintaining a drug-free workplace, any available drug counseling, rehabilitation, and employee assistance programs, and the penalties that may be imposed upon employees for drug abuse violations.
- (3) Give each employee engaged in providing the commodities or contractual services that are under proposal a copy of the statement specified in subsection (1).
- (4) In the statement specified in subsection (1), notify the employees that, as a condition of working on the commodities or contractual services that are under proposal, the employee will abide by the terms of the statement and will notify the employer of any conviction of, or plea of guilty or nolo contendere to, any violation of chapter 893 or of any controlled substance law of the United States or any state, for a violation occurring in the workplace no later than 5 days after such conviction.
- (5) Impose a sanction on, or require the satisfactory participation in a drug abuse assistance or rehabilitation program if such is available in the employee's community by, any employee who is so convicted.
- (6) Make a good faith effort to continue to maintain a drug-free workplace through implementation of this section.

As the person authorized to sign this statement on behalf of Collective Water Resources, LLC., I certify that Collective Water Resources, LLC. complies fully with the above requirements.

  
Authorized Representative's Signature

January 14, 2020  
Date

Elizabeth Perez  
Print Name

President  
Position




**EXHIBIT "F"**

**RFP 20-203 Multi-Jurisdictional Climate Change Vulnerability Assessment**  
**SCRUTINIZED COMPANIES CERTIFICATION FORM**

By execution below, I, Elizabeth Perez, President, on behalf of Collective Water Resources, LLC.  
(hereinafter, the "Contractor"), hereby swear or affirm to the following certifications:

The following certifications apply to all procurements:

1. The Contractor has reviewed section 215.4725, Florida Statutes, section 215.473, Florida Statutes and section 287.135, Florida Statutes, and understands the same.
2. The Contractor is not on the Scrutinized Companies that Boycott Israel List nor is the Contractor engaged in a boycott of Israel.
3. If awarded a contract, the Contractor agrees to require these certifications for applicable subcontracts entered into for the performance of work/services under this procurement.
4. If awarded a contract, the Contractor agrees that the certifications in this section shall be effective and relied upon by the City for the entire term of the contract, including any and all renewals.  
If the contract awarded hereunder is for one million dollars or more, the following additional certifications apply:
  1. The Contractor is not on the Scrutinized Companies with Activities in Sudan List.
  2. The Contractor is not on the Scrutinized Companies with Activities in the Iran Petroleum Energy Sector List.
  3. The Contractor is not engaged in business operations in Cuba or Syria.
  5. If awarded a contract, the Contractor agrees to require these certifications for applicable subcontracts entered into for the performance of work/services under this procurement.
  6. If awarded a contract, the Contractor agrees that the certifications in this section shall be effective and relied upon by the City for the entire term of the contract, including any and all renewals.

By:   
Name: Elizabeth Perez  
Title: President  
Date: January 14, 2020

STATE OF FLORIDA

COUNTY OF Palm Beach

The foregoing instrument was sworn to (or affirmed) and subscribed before this 14th day of January, 2020, by Elizabeth Perez, who is the President of Collective Water Resources, LLC, who is personally known to me or who has produced \_\_\_\_\_ as identification.



Brianna Fearon  
Commission # GG172035  
Expires: January 2, 2022  
Bonded thru Aaron Notary

NOTARY PUBLIC

Printed Name of Notary Brianna Fearon  
My Commission expires: January 2, 2022