Regional Resilience Trust Funds

An Exploratory Analysis for the New York Metropolitan Region

A Report by Jesse M. Keenan
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Abstract

This paper explores the legal and financial viability of a series of state trust funds designed to provide financial products to support interventions advanced in the name of climate change adaptation and resilience in the New York Metropolitan Region. The subject financial model, known as a Regional Resilience Trust Fund (RRTF), would be governed by a Regional Resilience Commission (RRC) made up of political appointees from the states of New York, New Jersey and Connecticut who would serve as stewards of each state's respective trust fund. This paper evaluates the proposition that the RRTF could be feasibly capitalized by a surcharge on certain regulated insurance lines (Proposition A). Second, based on the assumed validity of the First Proposition, the paper evaluates the proposition that the RRTF could sustainably support a range of financial products, including grants, low-cost loans, non-recourse loans and market-rate loans that could accommodate 100% of the states' unmet resilience needs, as defined by existing disaster resilience plans (Proposition B). The findings of this research support an affirmation of the legal and financial feasibility of the RRTF pursuant to Proposition A. Consistent with Proposition B, this paper provides evidence in support of a sustainable portfolio strategy for products supporting a range of potential projects, from short-term community resilience planning to long-term infrastructure finance. With the exception of Connecticut, the modeled assumptions of the RRTF could not support an affirmation of the proposition that a RRTF could fulfill 100% of the unmet resilience needs of the states. However, the findings do support an alternative proposition that the RRTF may be able to accommodate a significant portion of unmet resilience needs. This paper provides a broader strategic understanding of how products and portfolios can be designed to operate in the uncertainties associated with climate change.

Keywords

Climate Change, Finance, Resilience, Adaptation, Insurance, Trust Funds

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I. Introduction

The New York Metropolitan Region ("NYMR") faces an uncertain future in light of the impacts of climate change (Horton, et al., 2015, 2016). These wide ranging impacts from extreme heat (Knowlton, et al., 2007; Rosenthal, Kinney & Metzger, 2014) to sea level rise (Hallegatte, 2013; Kemp, et al., 2017) challenge the conventional utility of single jurisdiction resources and strategies (Vella, et al., 2016). As such, some policy makers and scholars have called for a regional approach to resilience planning and development that benefits from an aggregation of greater political and economic capital than could otherwise be mustered by individual jurisdictions in isolation (Lebel, et al., 2006; Jacobs, et al., 2016; Peng, et al., 2017). In particular, existing funding mechanisms for resilience and adaptation are highly irregular and are largely reliant on philanthropic and federal post-disaster sources (Adeniyi., Perera & Collins, 2016). Those sources of financing that do exist are often programmatically too rigid to address a variety of processes and co-benefits necessary for effective and comprehensive adaptation planning and administration (LePore, 2016).

In response to these constraints, the Regional Plan Association proposed the development of a regional governance organization for the NYMR, known as the Regional Resilience Commission ("RRC"). The RRC would serve as regional entity to facilitate the pooling of resources and to coordinate multijurisdictional climate change planning. This paper explores the legal and financial viability of a series of state trust funds designed to provide financial products to support interventions advanced in the name of climate change adaptation and resilience. The subject financial model, known as a Regional Resilience Trust Fund ("RRTF"), would be governed by the RRC, which itself would be made up of political appointees from the states of New York, New Jersey and Connecticut (the "States"), who would serve as stewards of each State's respective RRTF. The broader intent of the RRTF is to both catalyze and define public and private sector investments in resilience and adaptation.

The central research question of this paper is whether the RRTF could serve as a viable model for financing local and regional projects planned and designed in the advancement of resilience and adaptation. Specifically, this paper evaluates the proposition that the RRTFs could be feasibly capitalized by a surcharge on certain regulated insurance lines as originally proposed under the Bloomberg administration in New York City (City of New York, 2013) ("Proposition A"). Second, based on the assumed validity of the First Proposition, the paper evaluates the proposition that the RRTF could sustainably support a range of financial products, including grants, low-cost loans, non-recourse loans and market-rate loans that could accommodate 100% of the States' unmet resilience needs, as defined by current resilience planning ("Proposition B"). Propositions A and B are evaluated through a mixed methods research design grounded in initial semi-structured interviews and focus groups that helped shape the underlying research question and subsequent propositions, which are evaluated further through structured interviews, legal and programmatic textual reviews, and portfolio simulation analysis. The relevance of this research is defined by the unchartered waters for designing and evaluating resilience and adaptation financing models in the U.S.. Should Propositions A and B be affirmed, it would represent a potentially significant step forward in a broader discourse as to the viability of advancing innovation in the financing of climate resilience and adaptation.

II. Resilience and Adaptation Finance

Financing relating to climate change planning and interventions falls into one of several categories that are defined more by the beneficiary of the resources than they are by the process of underwriting or delivering such resources. First, adaptation trust funds have been utilized to advance adaptation mainstreaming within conventional international development channels as a mechanism for developed countries to offset the impacts of climate change on developing countries (Müller, 2009). The most prominent mechanism is the Adaptation Fund developed pursuant to the 2001 Kyoto Protocol (Adaptation Fund, 2017). For instance, Africa contributes less than 4% to global greenhouse gases, but annual adaptation costs are expected to reach 1.5% to 3% of annual gross domestic product (GDP) by 2030 (Reddy, Zhanje & Taylor, 2011). These funds primarily operate within existing government programs and are highly institutionalized and capital intensive in their modes of delivery (Hortsmann, 2011). Largely for this reason, the Adaptation Fund has been challenged for its ability to efficiently and equitably reach vulnerable populations (Persson & Remling, 2014; Stadelmann, 2014). In addition, as funds like the Green Climate Fund mobilize on a global scale, there are also renewed debates as to the appropriate allocations for investing in mitigation versus adaptation (Fridahl & Linnér, 2016).

A second category of adaptation trust funds relates to conservation biology and ecology. The most notable of these domestic funds is the Climate Adaptation Fund managed by The Wildlife Conservation Society (Wildlife Conservation Society, 2017a). Despite its limited size, this fund has a broad scope where the evaluation of incoming projects is based on a set of open criteria that speak to measured outcomes and not necessarily regimented processes for obtaining those outcomes (Long, 2014; Wildlife Conservation Society, 2017b). However, most of these adaptation funds are more or less grant programs, wherein the utilization of debt and equity instruments has been a controversial and unsettled debate largely relegated to a limited number of private and public sector actors, such as sovereign wealth funds (Atteridge, 2009; Stadelmann, Michaelowa, & Roberts, 2013; Fenton, et al., 2014; Pauw, et al., 2016).

A third category of trust funds most relevant to evaluating the feasibility of the RRTF model relates to the financing of resilience and risk mitigation measures. This category has perhaps been the most ripe for dual public and private sector engagement given the emerging methodological capacity to measure avoided costs (Vajjhala, 2016). In a domestic context, conventional cost-benefit analyses have consistently shown that the benefits of risk mitigation outweigh the costs on average "by about four times the costs in terms of avoided and reduced losses" (Mechler, 2016, p. 2123; *see generally*, Multihazard Mitigation Council, 2005). However, avoided cost evaluations are often based on cost benefit analyses ("CBA") that are methodologically limited in their capacity to accommodate qualitative data that cannot easily or reliably be reduced to a monetary value (Liu, et al., 2016). CBA's are also limited in their ability to utilize quantitative data from which there is a limited probabilistic basis to draw correlative inferences between mitigation and avoided losses or undefined benefits associated with an indeterminate definition of general system resilience (Knight-Lenihan, 2016).

Therefore, while a CBA may work well in terms of risk mitigation within a well-defined parameters of a closed system (e.g., flood mitigation), it arguably under accounts

for costs and benefits associated with the resilience of complex and open systems, such as communities and cities (Mechler, et al., 2014; André, et al., 2016). As such, many have called for CBA-driven underwriting to be augmented by a variety of decision support tools including costs-effectiveness analysis ("CEA"), multi-criteria analysis ("MCA"), real options approaches (ROA"), and robust decision making ("RDM"), which does not focus on economic optimization but instead looks across a wide array of uncertain futures for the most robust, effective and socially and environmentally optimal outcomes (Watkiss, et al., 2015; Ellen, et al., 2016). While probabilistic risk may lend itself to economic analysis within the context of risk mitigation (i.e., avoided losses), resilience investments are much more challenging to evaluate. Given the deep uncertainty or lack of probabilities associated with many impacts of climate change, resilience and adaptation frameworks that focus solely on avoided costs are limited in their expected value functions.

While the aforementioned resilience and risk mitigation perspective have focused on the internal risk management and the implications of avoided costs, there is another sub-category of resilience financing that looks to the value-add benefits that are both internal and external to the underlying investment. This perspective builds off a body of work in strategic adaptation that looks at the costs and benefits of a range of strategies including: (i) no regrets; (ii) reversible/flexible; (iii) cheap safety margins; (iv) reduced decision horizon; and, (v) and co-benefits synergies (Hallegatte, 2009; Keenan, 2015). These strategies have expanded the limitations of conventional risk mitigation models wherein benefits only accrue in the event of an extreme event (Tanner, et al., 2016). This value-add perspective is consistent with empirical research in climate adaptation that suggests, in at least one case, that nearly 80% of observed activities and investments were motivated by secondary factors (Berrang-Ford, Ford & Paterson, 2011). Therefore, one could infer that adaptation is often motivated not only by climate change but also by the opportunity to capture co-benefits defined by secondary considerations. A version of this value-add perspective was popularized by the resilience "dividend" advanced by the Rockefeller Foundation (Brown, 2012; Rodin, 2014).

Constructive examples of funds or pools of funds within either risk mitigation and/or value-add driven resilience frameworks are relatively scarce. From an international perspective, the most notable example is the Global Resilience Partnership financed by the Rockefeller Foundation, USAID and Sweden. In addition, there are a very limited number of domestic prototypes for pooling funds. Examples include the State of Washington's Floodplains by Design (Floodplains by Design, 2016) and natureVest's D.C. Green Infrastructure Fund (natureVest, 2016). There are also a few notable federally driven programs for resilience oriented retrofitting, including the Property-Assessed Clean Energy (PACE) financing and Water Infrastructure Finance and Innovation Program at the Environmental Protection Agency (EPA)(White House, 2016). Overall, according to the U.S. Climate Resilience Toolkit, there are just thirteen (n=13) funds or grant programs available to support resilience and adaptation in the U.S. in both the public and private sectors (USCRT, 2016). Despite the lack of financing resources and conduits, the need for resilience finance programs is more relevant than ever considering the pending Federal Emergency Management Agency (FEMA) rule for imposing a disaster deductible on states (FEMA, 2017). Unfortunately, none of the existing programs represent a portfolio approach based on a dedicated revenue source, and only a handful of programs have leveraged

finance products. As such, there are no free-standing funds or programs that represent analog models that can directly speak to the modeled parameters of the RRTF.

III. Research Design and Methodology

The research design for this paper is based on a mixed methods approach developed over the course of approximately twenty-four (24) months (Creswell, 2013). Initial scoping on the broader theme of resilience and adaptation finance occurred over the course of eighteen (18) months by researchers operating under the Climate Change Working Group of the Fourth Regional Plan promulgated by the Regional Plan Association. The central research question and the general parameters of the RRC and the RRTF were developed through a combination of semi-structured interviews (Galletta, 2013), focus groups (Eliasson, 2000), and textual reviews of academic literature (Hart, 1998), gray literature (Gray, 2013), finance programs and applicable laws and regulations (Goldsmith & Vermeule, 2002). The total number of formal semi-structured interviews was twenty-five (n=25). Transcripts of each interview were subsequently produced and shared with interviewees to ensure the accuracy of statements.

In evaluating Propositions A and B, two distinct methodologies were utilized. For Proposition A, legal research was conducted to evaluate the legality of an insurance surcharge that would be hypothetically imposed by each State's legislature, as well as the lawful incorporation of the investment vehicle as a public benefit corporation. Thereafter, research was conducted to evaluate prior surcharges, as well as the total capitalization necessary to meet documented unmet financial needs relative to existing climate change planning. Finally, existing state trust funds were evaluated to identify critical elements for investment management, asset management, auditing requirements, fiscal oversight and governance. Research was not conducted to evaluate the socio-political preferences that would speak to the viability of passing the laws necessary to authorize the formation and capitalization of the RRTF. In evaluating Proposition B, a quantitative portfolio analysis was utilized to simulate the operational parameters of the RRTF with and without bond leverage (Liesiö, Mild, & Salo, 2008; Liesiö & Salo, 2012). The preliminary results of the portfolio modeling were shared with selected interviewees in order to calibrate, validate and further qualify the results. This underlying methodology will be explained in more detail in the subsequent section dedicated to portfolio modeling.

IV. Governance: Regional Resilience Commission

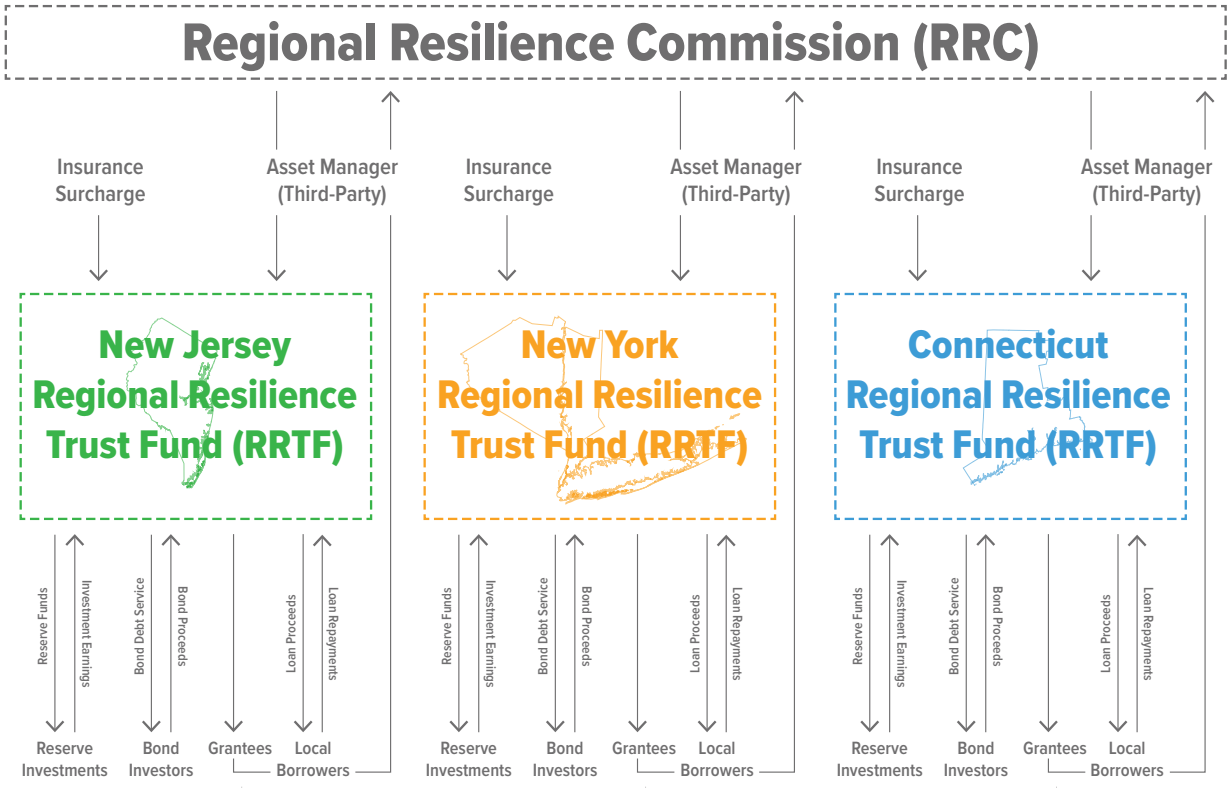
A normative exploration of the potential governance mechanisms of the RRTF model is central to understanding the broader utility of the evaluated Propositions. While the details of the normative development of the RRC are beyond the purview of this paper, it is useful to briefly frame the underlying prospective organizational structure of the entity. The RRC would be a single administrative unit chartered by the legislatures of New York, New Jersey and Connecticut. Pursuant to the interstate compact clause of the U.S. Constitution (Art. I, Sec. 10), compacts between states require the consent of Congress. While the case of *Virginia v. Tennessee*, 148 U.S. 503 (1893) qualified this consent requirement to matters where states would increase their power though a compact, the congressional consent of the Port Authority of New York and New Jersey (1921) likely provides a strong precedent for the necessity of congressional approval in light of the intent

of the each state's RRTF to have the authority, if necessary, to issue revenue bonds based on the insurance surcharges. However, because the RRC would not be issuing the bonds, it is debatable whether congressional consent would be required.

As a technicality, the governance of the RRTF could be shared through a Memorandum of Understanding between a third-party asset or portfolio manager and the RRC. While it is also conceptually possible that a RRTF could operate independent from the RRC, the RRC offers an opportunity to independently define the public benefits associated with resilience and adaptation investments. For instance, the governance of the RRC could be made up up of four (4) gubernatorial appointees from each of the States for a total of twelve (12) members of the board of directors (the "Board of Directors"). Each appointee would have a staggered term of four years. At any given time, each State must have at least one (1) appointee who serves as a designated representative who is otherwise qualified as a scientist whose expertise relates, in part, to climate change. In addition to a professional staff of public finance professional, actuarists, scientists, ecologists and engineers, the RRC board of directors is supported by an gubernatorial appointed advisory board made up of an equal number of representatives from each of the following categories: (i) community advocacy organizations; (ii) environmental advocacy organizations; (iii) municipal and county officials; and, (iv) private sector commercial enterprise (collectively, the "Advisory Board").

Even though each state administers and manages its own RRTF, the RRC is

Figure 1: Hypothetical Relationship between Regional Resilience Trust Funds and Regional Resilience Commission



charged with independently underwriting and approving all grants and loans (collectively, the "Product(s)"), including those Products that are expended entirely within any one of the States, as represented in Figure 1. Figure 1 represents just one of multiple potential options for structuring the governance of the RRC. States would be obligated to allocate an equal fixed minimum percentage of each state's RRTF annual portfolio allocations for Products to be designated for projects that are regional in nature, as defined by those projects whose impacts extend beyond any single State. The investment criteria of the RRC would prioritize the allocation of Products for those projects that have the potential to promote regional resilience and/or adaptation. For example, with the approval of the Advisory Board, the Board of Directors would have to have at least six (6) votes to approve any given Product. Without the approval of the Advisory Board, the Board of Directors would require nine (9) votes to approve any given project. The intent of the RRC is to help guide and incentivize a regional effort to plan and mainstream resilience and adaptation within public and private investments. In so doing, the RRC has the opportunity to set benchmarks for planning, design, operations and performance that inure to a broad array of projects that may or may not benefit from the RRC's Products.

V. Trust Fund

a. Organization

The States each have a history of extending surcharges for the purposes of capitalizing trust funds or public benefit corporations. In New York, these surcharges capitalize funds whose legislative intent is to protect consumers in the event of an insolvency. These funds include the Life Insurance Guaranty Fund (NY INS § 7501, et seq.) and Property and Casualty Security Funds (NY INS § 7601, et seq.). New Jersey has a similar fund known as the Surplus Lines Guaranty Fund, but the fund has not utilized its statutory authority to impose a surcharge since 1993 (NJ Rev Stat § 17:22-6.73). New York and New Jersey (for workers compensation only) operate under a pre-assessment model wherein a surcharge is only assessed when the net asset value of the fund dips below a certain amount. For property and casualty lines, Connecticut and New Jersey have a similar fund organized as an association that is financed by direct assessments to member insurance companies based on their proportional market share of lines of coverage, which are subject to actual instances of insolvency each year (C.G.S. § 38a-866)[1]. One critical issue identified in the course of this research related to the equity and practicality of imposing a surcharge on an entire State versus imposing the surcharge on select counties that fall within the NYMR for each of the States. At issue is the extent to which coastal NYMR counties cross-subsidize landlocked non-NYMR counties who are arguably less vulnerable to the effects of sea level rise and storm surge. In addition, while the States do not have a history of utilizing surcharges for the external financing of investments deemed to be in the broader public benefit, other states such as Kentucky (K.R.S. § 136.392) (e.g., law enforcement) and Mississippi (M.S.C. § 83-34-37)(e.g., reinsurance / general fund) have had more liberal applications of the surcharge.

The organizational structure of each of the RRTFs would be based on the respective laws of incorporation in each of the States. In New York, the RRTF would be a Public Benefit Corporation authorized under the state constitution (NY Const.. art. X, § 5; NY BCL

[1]Connecticut H.B. 5518 (2016) proposed a surcharge on net direct premium for fund operating budgets for local firefighting services. The bill has since been tabled.

§1702(e)). As this legal entity is not considered a state agency and would have its own fiscal obligations separate from the state (Wein v. State, 39 N.Y.2d 136 (1976)), it may or may not require direct state oversight provided by the New York Public Authorities Control Board (NY PBA § 50, et seq.). However, interviewees noted that such direct oversight may add additional compliance costs to operations that may not be necessary in light of the gubernatorial appointees to the RRC, which could theoretically possess a controlling percentage of the RRTF's shares. New Jersey has a similar entity known as a Benefit Corporation, but with the added requirement for the transparency of the measurement and reporting of the public benefits (NJ Rev Stat § 14A:18-1(2013), as well as requirements for evaluating the effects of any such investments or actions across a wide array of considerations from the global environment to a domestic workforce (NJ Rev Stat § 14A:18-6 (2013).

Finally, Connecticut has a similar Benefit Corporation, but with the additional requirement that the benefits be derived pursuant to a "third-party standard" (C.G.S. § 33-1351(15)). While New Jersey has a similar third-party requirement, Connecticut requires a more formal standard development process to govern the determination of public benefit (Id.). Given the lack of standards development in resilience and adaptation, these requirements may present a potential barrier, as internal underwriting and stewardship requirements promulgated by the RRC may or may not qualify as a third-party standard. In addition, absent a win-win, no-regrets co-benefits strategy, resilience and adaptation investments represent a potential existential challenge to the notion of recognized public benefits because many or most of the benefits may not arise until a point in time where their utility is recognized contemporaneous with the occurrence of climate change or an extreme event. This is particularly relevant given the lack of empirical evidence for demonstrating the existence of true win-win, no-regrets strategies (Preston, Mustelin, & Maloney, 2015).

b. Capitalization

The question as to what is the optimal size—in terms of capitalization—required to adequately capture unmet resilience and adaptation needs is central to the development of the RRTF model. In particular, the answer to this question is critical to establishing a rational legislative intent likely required to justify a surcharge on particular lines of insurance. This paper makes the assumption that the size of each State's RRTF would be benchmarked to an amount approximately equal to the unmet financial needs identified in each of the State's Community Development Block Grant—Disaster Recovery ("CDBG-DR") amended Action Plans ("Action Plans"). Table 1 shows the range of unmet needs based on existing assessments derived following Hurricane Sandy. The CDBG-DR numbers are not an ideal proxy for unmet needs because they include recovery, mitigation and resilience expenditures. As such, the categories identified in Table 1 do not necessarily reflect the underwriting criteria and/or funding priorities of the RRC. While these estimates are not necessarily a precise proxy for the total amount of unmet resilience needs for each local jurisdiction within the NYMR, they represent the only consistent approximation based on the existing capacity of the relevant jurisdictions to engage in climate change and disaster risk mitigation planning. An additional logic for using these numbers as an initial capitalization benchmark is that there is a potential downside politically and economically to overcapitalizing the fund if there are not a sufficient number of projects that would qualify as advancing resilience and/or adaptation. This "absorptive capacity" problem has been observed to be a

constraint for adaptation funds across the globe (Müller, 2009). To that end, while interviewees highlighted the opportunity to issue bonds based on the potential revenue from insurance surcharge, an initial survey of potential projects in the NYMR suggested that this bonding capacity might not need to be utilized until a later phase of resilience planning can develop the appropriate projects.

Table 1: Estimates of State Unmet Resilience Needs

New Jersey Unmet / CDBG-DR	
Flood Hazard	$4,955,329,131
Energy	$5,607,534,587
Water/ Wastewater	$2,639,620,426
Transportation	$3,708,313,761
Community Facilities	$236,548,191
Debris Removal and Dredging	$225,406,264
Total	$17,372,752,360
Source: New Jersey Department of Community Affairs (2016)	
New York City Unmet / CDBG-DR	
Housing	$2,381,944,000
Business	$2,309,000,000
Infrastructure	$2,409,070,000
Other City Services	$571,467,000
Coastal Resiliency	$1,952,463,000
Total	$9,623,944,000
Source: City of New York (2016)	
Connecticut Unmet / CDBG-DR	
Infrastructure	$151,600,000
Housing	$259,407,500
Economic Revitalization	$10,797,888
Mitigation	$27,758,056
Planning	$25,000,000
Total	$474,563,444
Source: Connecticut Department of Housing (2016).	

Based on the assumption relating to unmet needs, the question remains as to what is the optimal insurance surcharge for each State. This question should be contextualized with the variable term to which a surcharge does or does not sunset (i.e., expire) based on prevailing legislative preferences. NYC's Special Initiative for Recovery and Resiliency (SIRR) originally proposed a hypothetical 1.5% surcharge (City of New York, 2013). As the SIRR report noted, "[t]his surcharge would translate to just over a dollar a month for a homeowners' insurance policy with a $1,000 annual premium" (Id., p. 405). Based on a sample of insurance premiums for the mean household value in the NYMR, this cost burden would be closer to $2 per month. Table 2 provides a sensitivity analysis for a projected annual revenue generated from a range of surcharges for each state based on recent historical rates of growth for property and casualty lines found in Appendix Table 2. Based on this information, it would take a number of years to reach a capitalization roughly equal to the present value unmet needs of the States.

Table 2: Sensitivity Analysis for Projected Revenue from State Insurance Surcharges

Surcharge Revenue (Low, 0.5%)											($ in thousands)	
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	10 Yr Total	Proj. CAGR
New York	$72,255	$75,771	$79,458	$83,324	$87,379	$91,631	$96,090	$100,766	$105,669	$110,811	$903,154	4.87%
New Jersey	$31,190	$32,918	$34,519	$36,199	$37,961	$39,808	$41,745	$43,776	$45,907	$48,140	$392,363	4.87%
Connecticut	$15,594	$16,353	$17,149	$17,984	$18,859	$19,776	$20,739	$21,748	$22,806	$23,916	$194,924	4.87%
Surcharge Revenue (Medium, 1.0%)											**($ in thousands)**	
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	10 Yr Total	Proj. CAGR
New York	$144,510	$151,542	$158,916	$166,649	$174,758	$183,262	$192,180	$201,532	$211,338	$221,622	$1,806,309	4.87%
New Jersey	$62,780	$65,835	$69,039	$72,398	$75,921	$79,616	$83,490	$87,553	$91,813	$96,281	$784,726	4.87%
Connecticut	$31,189	$32,707	$34,298	$35,967	$37,717	$39,553	$41,477	$43,496	$45,612	$47,832	$389,847	4.87%
Surcharge Revenue (High, 1.5%)											**($ in thousands)**	
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	10 Yr Total	Proj. CAGR
New York	$216,764	$227,312	$238,374	$249,973	$262,137	$274,893	$288,270	$302,298	$317,008	$332,434	$2,709,463	4.87%
New Jersey	$94,170	$98,753	$103,558	$108,597	$113,882	$119,424	$125,235	$131,329	$137,720	$144,421	$1,177,089	4.87%
Connecticut	$46,783	$49,060	$51,447	$53,951	$56,576	$59,329	$62,216	$65,243	$68,418	$71,748	$584,771	4.87%

Source: Adapted from data from, Insurance Information Institute (2007-2015).
*2018 Figures based on 2015 property and casualty insurance premium projection based on a 9 year historical average adjusted for inflation.

For instance, assuming a 1.5% surcharge, an unlevered RRTF operating over the course of ten years would only accommodate 21.9% of New York's and 7.8% of New Jersey's unmet needs adjusted for inflation over the same period. However, it would cover 96.3% of Connecticut's unmet needs. Pursuant to Table 3, the surcharge necessary to meet the unmet needs within one decade are equal to 5.33% in New York, 14.67% in New Jersey, and 1.16% in Connecticut. Under this scenario, a New Jersey homeowner could see a cost burden of a little under $20 a month. Given the relatively large surcharges or lengthy surcharge sunset periods for New York and New Jersey, leverage from revenue bonds offers an alternative scenario. By contrast, Connecticut could arguable proceed with no bond leverage. Of course, insurance surcharges are just one of many different options for funding an RRTF (e.g., impact fees, financial transaction taxes, etc...). With this in mind, future analysis of alternative sources of capitalization would need to consider the extent to which such sources would be considered stable and consistent enough to float revenue bonds.

Table 4 represents possible revenue streams with bond leverage based on three different surcharge rates. These gross figures do not represent the operations and returns of the RRTF, which will be discussed in the following section. As such, assuming a 1.5% surcharge, a levered (1x) RRTF operating over the course of 20 years would accommodate 25.9% of New York's, 9.6% of New Jersey's and 116.3% of Connecticut's unmet needs adjusted for inflation over the same period. Therefore, with the exception of Connecticut, leverage only marginal fills

Table 3: Revenue Scenarios to Fulfill CDBG-DR Unmet Needs with 10-Year Sunset

Surcharge Rate		Unmet Needs (CDBG-DR)	($ in thousands)
New York	**5.33%**	New York	$9,623,944
New Jersey	**14.67%**	New Jersey	$11,765,218
Connecticut	**1.16%**	Connecticut	$474,563

Surcharge Revenue **($ in thousands)**

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	10 Yr Total
New York	$769,942	$807,408	$846,697	$887,899	$931,105	$976,414	$1,023,927	$1,073,753	$1,126,003	$1,180,796	$9,623,944
New Jersey	$928,537	$976,425	$1,026,784	$1,079,740	$1,135,427	$1,193,986	$1,255,565	$1,320,320	$1,388,414	$1,460,021	$11,765,218
Connecticut	$36,757	$38,800	$40,957	$43,234	$45,637	$48,174	$50,852	$53,679	$56,663	$59,813	$474,563

Source: Connecticut Department of Housing (2015); New Jersey Department of Community Affairs (2016); City of New York (2016).

*2018 Figures based on 2015 property and casualty insurance premium projection based on a 9 year historical average adjusted for inflation.

**New Jersey's CDBG-DR unmet needs do not include energy projects (n= $5,607,534,587), as they would prospectively fall under the mandate of the New Jersey Energy Resilience Bank.

Table 4: Sensitivity Analysis for Projected Capitalized with Bond Leverage by State

Surcharge Revenue (Low, 0.5%) **($ in thousands)**

	2017 Bond Revenue (PV)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$1,361,917	$69,309	$69,719	$70,131	$70,537	$70,954	$71,373	$71,795	$72,211	$72,638	$73,067	$68,712	$68,687	$68,671	$68,656	$68,640	$62,153	$61,757	$61,362	$60,970	$60,572
New Jersey	$618,053	$29,895	$29,857	$29,819	$29,777	$29,739	$29,701	$29,663	$29,622	$29,584	$29,546	$29,508	$29,467	$29,429	$29,392	$29,354	$34,167	$34,451	$34,738	$35,027	$35,315
Connecticut	$301,404	$14,995	$15,120	$15,245	$15,371	$15,499	$15,628	$15,758	$15,888	$16,020	$16,153	$14,660	$14,639	$14,620	$14,602	$14,583	$14,563	$14,544	$14,525	$14,507	$14,486

Surcharge Revenue (Medium, 1.0%) **($ in thousands)**

	2017 Bond Revenue (PV)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$2,723,834	$138,618	$139,438	$140,262	$141,075	$141,908	$142,747	$143,591	$144,423	$145,276	$146,135	$137,423	$137,374	$137,343	$137,312	$137,280	$124,307	$123,513	$122,725	$121,941	$121,144
New Jersey	$1,236,107	$59,791	$59,714	$59,638	$59,554	$59,478	$59,403	$59,327	$59,327	$59,168	$59,092	$59,017	$58,934	$58,859	$58,784	$58,709	$68,333	$68,902	$69,476	$70,055	$70,630
Connecticut	$602,809	$29,989	$30,239	$30,491	$30,741	$30,998	$31,256	$31,516	$31,775	$32,040	$32,306	$29,319	$29,278	$29,241	$29,203	$29,166	$29,125	$29,088	$29,051	$29,014	$28,973

Surcharge Revenue (High, 1.5%) **($ in thousands)**

	2017 Bond Revenue (PV)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$4,085,751	$207,928	$209,156	$210,393	$211,612	$212,862	$214,120	$215,386	$216,634	$217,915	$219,202	$206,135	$206,061	$206,014	$205,967	$205,920	$186,460	$185,270	$184,087	$182,911	$181,717
New Jersey	$1,854,160	$89,686	$89,572	$89,457	$89,331	$89,218	$89,104	$88,990	$88,865	$88,752	$88,638	$88,525	$88,401	$88,288	$88,175	$88,063	$102,500	$103,353	$104,214	$105,082	$105,946
Connecticut	$904,213	$44,984	$45,359	$45,736	$46,112	$46,496	$46,883	$47,274	$47,663	$48,059	$48,460	$43,979	$43,917	$43,861	$43,805	$43,749	$43,688	$43,632	$43,576	$43,521	$43,459

Source: Adapted from data from, Insurance Information Institute. (2007-2015); State of New York (2016); Moodys (2016).

*2018 Figures based on 2015 property and casualty insurance premium projection based on a 9 year historical average adjusted for inflation

**Based on hypothetical 1x bond leverage.

the gaps over 20 years—assuming no other investments are made to substantively reduce unmet needs and that the needs themselves would otherwise hold constant. In present value terms, a bond issuance based on a 1.5% surcharge in 2017 would account for 42.4% of New York's, 15.76% of New Jersey's and 190.5% of Connecticut's current unmet needs. Again, CDBG-DR unmet needs may not be representative of the true unmet needs for adaptation to climate change. These numbers may be overestimated based on recovery in certain areas (e.g., housing) and underestimated in other areas (e.g., aging infrastructure). An additional challenge that will be discussed in the portfolio modeling section of this paper is the ability to translate this revenue into products that support projects that may or not be in a pipeline sufficient to rollover the investment capital of each State's RRTF.

Again, the absorptive capacity of the system to supply eligible projects suggests that leverage may not be immediately desirable. In theory, the amount of unmet needs will grow over time. However, the estimated rates of growth above and beyond various rates of capital and project inflation are unknown. The time function for capitalization is based on the previously cited prevailing legislative preference to either sunset a surcharge or only utilize it to maintain either a minimum floor net asset valuation (NAV) or a minimum level of liquidity for the fund. In the alternative, the legislature could maintain a lower surcharge rate that does not sunset. Under this scenario, the utilization of leverage through revenue bonds could offer the opportunity to amplify a lower surcharge over a longer period of time.

c. Operations and Underwriting

As previously noted, the RRTF would prospectively have a separate asset manager for each State and the RRC would serve as the conduit for identifying, evaluating and underwriting projects and Products. Although the asset manager would have the ultimate fiduciary obligation to ratify projects referred from the RRC, the asset manager would not have the authority to independently originate Products. However, the asset manager would retain the authority to develop new Products; to alter and approve amended terms of existing projects; and, to refrain or discontinue certain types of Products that undermine the sustainability and stability of the RRTF portfolio. For instance, interviewees suggested that a certain fixed percentage of grants is desirable to advance resilience and adaptation planning efforts in a pre-design phase. For instance, as will be discussed in the next section, allocations in favor of grants and non-resource loans may vary year-to-year depending on the broader performance of the portfolio defined in terms of reinvestment roll-over, default rates, interest rates, deployment lag and various other portfolio considerations.

Beyond the conventions of portfolio and asset management, there rests a more fundamental question as to how one defines and underwrites investments that advance resilience and adaptation. In particular, resilience knowledge can be divided into categorical variations that include ecological, socioecological, engineering, urban, disaster, and community variants (Brand & Jax, 2007; Matyas & Pelling, 2015; Meerow, Newell & Stults, 2016). To this end, across scales of time and space, as well as actor or object orientation, resilience may be simultaneously viewed as a positive, negative and/or neutral intervention (Carpenter, et al., 2001; Klein, Nicholls, & Thomalla, 2003; Olsson, et al., 2015). Resilience is not an objective good and the benefits of resilience investments may be subjectively evaluated and unevenly distributed. Despite the proliferation of resilience policies in the Obama Administration (Keenan, 2016),

a lack of operationalizable guidelines and metrics has thwarted the development of both public administration (Larkin, et al., 2015) and private sector finance (White House, 2016). As resilience was originally a descriptive and not a normative concept (Holling, 1973; Gunderson, 2000), there have been numerous lines of research advanced by scholars and practitioners in disaster risk reduction who have attempted to use indicators as proxies for measuring the post-disaster resilience of specific communities and jurisdictions (Cutter, 2016). However, much of the empirical research that has attempted to validate these indicators has either come up short or has identified somewhat self-evident indicators for explaining recovery, such as housing income and tenure (Burton, 2015).

By contrast, within closed and engineered systems (i.e., infrastructure), resilience is relatively well defined and forms the basis for many practices in process, systems and civil engineering (Gilbert, 2010; Menoni, et al., 2012; Ayyub, 2014). However, what unites finance with various other applications of resilience, including engineering resilience, is the struggle to accommodate either deep uncertainty or ignorance as to the nature or depth of either probabilistic or non-probabilistic events—particularly low probability, high impact events (Hallegatte, et al., 2012). While the occurrence of many physical phenomenon of climate change are probabilistic, many more impacts are not. This presents a short-term biasing in everything from insurance to the pricing of the future values associated with risk mitigation investments. As previously referenced, the uncertainty associated with value-add aspects of resilience and/or adaptation are equally as challenging in methodological terms.

There are two perspectives on how to underwrite and deliver resilience and adaptation investments. One perspective is based on a top-down model that mainstreams these concepts into existing matters of public administration and service provision (e.g., The Adaptation Fund). This top-down model uses existing metrics modified to account for the marginal costs and returns for mitigating hazards, reducing exposure and reducing vulnerability. Conventional methods such as CBA, CEA and ROA are more appropriate given the existing known parameters of performance, risk and uncertainty. The other model is based on a loose framework generated from bottom-up local actors who are engaged in scalable prototypes and experiments (e.g., Wildlife Conservation Society). The evaluation of these projects are often based on MCA and RDM methods that can capture the qualitative innovation that has little to no historical precedent to support a probabilistic assessment. Both of these delivery models are generally based on a specific type of resilience known as 'disaster resilience' (Davidson, et al., 2016).

There are two perspectives on disaster resilience. The basic definition suggests that multi-hazard resilience is "reactively [oriented] through resistance, relief and recovery approaches" (Id., p. 27). More advanced and integrated definitions of disaster resilience expand reactionary performance characteristics to precautionary capacities developed through interdisciplinary perspectives that cut across environmental, community and infrastructural perspectives (Zhou, et al., 2010). One opportunity to develop performance benchmarks is to build off of the analytical standards developed by the U.S. Commerce Department at the National Institute of Standards and Technology (NIST). The NIST Community Planning Guides (NIST Guides) have set a benchmark for expanding disaster resilience within both the community and infrastructure domains (NIST, 2015a, 2015b). The analyses found in these standards could be organized by infrastructure systems and could

provide a basis for additional weighting within a MCA model. One weakness in the NIST Guides is that they do not contain metrics for environmental resilience. Recent interviews with EPA researchers confirmed that resilience metrics are woefully underdeveloped. By example, in FEMA's broad interagency review of resilience metrics, they could identify only one environmental resilience metric (FEMA, 2016).

Interviewees highlighted a number of keys aspects for focusing resilience sufficiently enough to evaluate the performance of any given prospective project. First, a prospective project should be specific and precise with regard to who or what will be the beneficiaries of the project, as well as what set of risks or hazards are addressed by the project. In addition, the project should be just as transparent about what the project will not address. By extension, the project should identify conflicts or opportunity costs with other actors or objects that are directly or indirectly engaged or impacted by the project. Interviews consistently reinforced the necessity to understand the trade-offs and path dependencies associated with resilience and/or adaptation. For instance, how will this resilience investment (e.g., risk mitigation) limit my options (e.g., ROA) to adapt in the future?

Second, the range of potential hazards should be extended beyond the conventions of flooding and heat to also include human-caused and technological hazards. This represents an opportunity to capture a variety of co-benefits within other domains such as national security, public safety or public health. Third, the project level performance should be based on specific resilience and not general resilience. Specific resilience is focused on a specific object or a specific system or organization with clear and articulated performance measures, boundaries and metrics (Nelson, 2011). General resilience focuses on the resilience of a broader system that is often open, unbounded and difficult to measure or observe (Carpenter, et al., 2012). While this perspective may bias material investments over social investments, one is obligated to clearly articulate the costs and benefit to a degrees the narrows the parity between cost burden and beneficiaries. In addition, the broader assumption is that the specific resilience of particular projects will collectively work to advance general resilience.

Appendix Table 3 contains a checklist that attempts to capture a range of unweighted criteria for assessing the nature of any given project's resilience or adaptive capacity ("Checklist"). Whether one utilizes an approach such as a scorecard or an index, the process often distills to a matter of weighting for each criteria. As such, each State will likely have a different weighting depending on not only its unmet needs, but also its local preferences. The Checklist builds off of the work of the National Security Council and the author for distilling disaster resilience within the parameters of capabilities identified with the framework of the National Preparedness Goals developed pursuant to Presidential Homeland Security Directive 8 (HSPD-8)(U.S. Department of Homeland Security, 2011). This Checklist and the respective capabilities or capacities represent merely a starting point. Additional capacities may include a range of performance criteria relating to the environment, for instance, including water storage, water filtration, toxics remediation or radiant cooling. Based on data from the interviews, the intent should be to use these as inclusive and not exclusive evaluation criteria. It can be argued that the most successful project evaluation process will be one that looks at specific resilience within a top-down mainstreaming that is reinforced by bottom-up local experimentation based on novel and innovative capacities.

d. Products

Given the diversity of potential eligible projects, delivery models and underwriting methodologies, it can be argued that that the RRTF's Products must be flexible enough to accommodate changing financial and fiscal circumstances. However, an infinity array of flexible Product terms is not possible for effective and sustainable portfolio management. This paper assumes several Product types that form the basis for portfolio modeling in the following section. These Products include grants, which are estimated to account for a minimum of 10% of a portfolio's allocation. These grants can be utilized to advance everything from project level climate change planning to education and training. The portfolio could also include soft loans that are non-recourse and bear a 0% interest rate or are indexed to inflation or the weighted cost of capital. Soft loans have a similar intent to grants but are able to accommodate specific requirement relating to federal income tax to which some borrowers may be sensitive. The next class of loans are fixed and variable rate mid-cap, below-market loans with terms ranging from 5 to 25 years. These concession loans are intended to serve a variety of purposes, including gap financing or permanent financing where traditional infrastructure products cannot efficiently scale-down. The final class of loans relates to fixed and index-adjusted variable rate loans with 5 and 10 year terms. This class of loans is primarily intended to help gap finance larger infrastructure projects or finance critical risk mitigation interventions that are difficult to finance with conventional products. A portfolio allocation optimization analysis in the following section will highlight optimal allocations based on a survey of existing loan rates and terms. The immediately following section offers some example projects that might benefit from one of the foregoing Products.

Project 1: Small Grant

Borrower: State of New York, Department of Environmental Conservation
Amount: $500,000
Type: Planning Study

This project would utilize a small grant of $500,000 for a planning study of the coastline of New York. The state agency could leverage the grant with federal funding through the U.S. Department of Housing and Urban Development Sustainable Communities Regional Planning Grant. The grant would be disbursed in the first year of operation and would require a 20% funding matching from the state. The study would take upwards of three years and would include: (i) a coastal area typology study; (ii) an inventory of potential adaptation strategies for existing green infrastructure; (iii) adaptive management processes for science informed decision making in local jurisdictions; (iv) case studies of existing resilience and adaptation projects; and, (v) education and outreach materials for engaging coastal communities in the face of extreme events and climate change.

Project 2: Large Grant

Borrower: New Jersey Sports and Exposition Authority
Amount: $15,000,000
Type: Brownfield Remediation

This project would utilize a large grant of $15,000,000 to offset eligible projects costs for remediating toxic chemicals from land in the Meadowlands that is highly vulnerable to flooding and inundation with sea level rise. In partnership with local jurisdictions and property owners, the authority would leverage funds from the U.S. Environmental Protections Agency's Brownfield Grant Program and the New Jersey Hazardous Discharge Site Remediation Fund. The term of the project would be 10 years and the grant would be based on allowable expenses in the first 5 years. In addition to cleanup activities, the grant would help support adjacent site assessments, ecological adaptation strategies for local habits, and community planning and training.

Project 3: Large Grant

Borrower: Norwalk Department of Public Works / Stamford Office of Operations / Fairfield County, Connecticut
Amount: $1,000,000
Type: Green Infrastructure Design and Maintenance Training

This project would develop programs to train municipal and county public works personnel to design and maintain green infrastructure that serves a dual hazard mitigation purpose. The project team is based on a collaboration with academic institutions, including the University of Connecticut, Yale University, Rutgers University, and the State University of New York, Stony Brook. Project funding could be leveraged from several federal sources, including the U.S. Department of Housing and Urban Development's Green Infrastructure and the Sustainable Communities Initiative and the US EPA's Clean Water Act Section 319 grant program. With a project term of 3 years, the grant would require a 10 % funding match and would be disbursed in the first year.

Project 4: Concession Loan

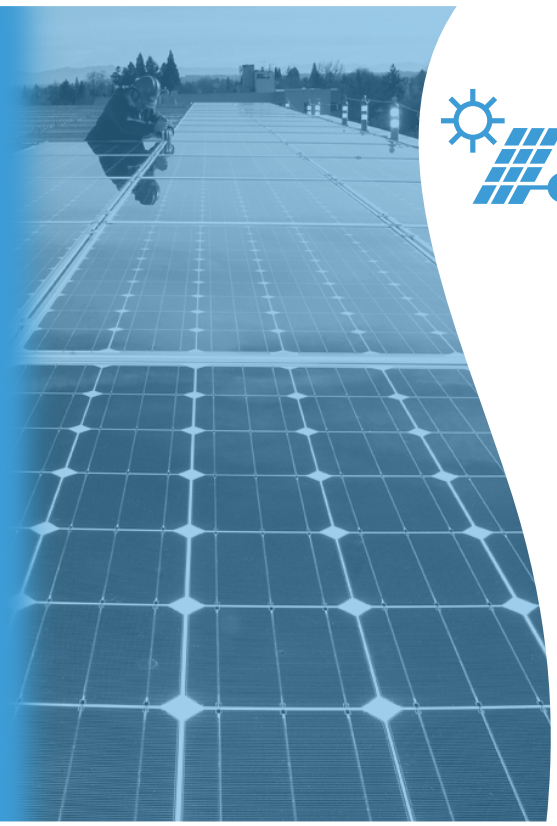
Borrower: Local Town, New Jersey
Amount: $30,000,000
Type: Managed Housing Relocation Finance Program

This project is based on a program to help finance the relocation of low-to-moderate income households whose properties are in highly vulnerable geographies subject to the risk of subsidence, storm surge and relative sea level rise. The program would help finance the disposition of existing properties and the acquisition of in-land properties that were previously foreclosed ("REO Asset(s)"). Local governments and REO Asset managers would contribute capital allocations to a holding company that would be capitalized in part by the RRTF. This would allow for a lowerassessment on the fair market value of foreclosed homes and would allow risk to be shifted off the balance sheet of banks based on a fixed pre-negotiated return. Highly vulnerable disposed properties would be cleared, cleaned and deeded to a land conservation. The program's initial term would be limited to 20 years and the concession loan would be disbursed based quarterly in an amount equal to the sum of mortgages provided to cover the acquired homes. The mortgages would be held by the holding company in a REMIC trust whose A tranches are held by the RRTF and whose B pieces are held by the holding company. The net result is that relocated households have a lower barrier to entry to in-land housing markets and neighborhoods with previously foreclosed properties get an injection of social and financial capital.

Project 5: Concession Loan

Borrower: GRID Alternatives (non-profit)
Amount: $5,000,000
Type: Photovoltaic (PV) Installation in Public and Senior Housing

This projects supports the assessment, design and installation of PV systems on public and senior housing facilities. The project serves the co-benefits of climate mitigation, as well as the benefits of increasing the passive survivability of facilities supporting highly vulnerable populations. With climate change, extreme heat and power disruptions represent critical hazards for impacting human health. With an aging society, passive survivability is a potentially important part of community resilience. In conjuncture with existing energy efficiency subsidies, this concession loan provides the capital necessary to bring the levelized cost of energy to within the means of financially strapped housing operators. The loan terms would be 15 years with 3.5% interest rate, which would otherwise serve as an effective hedge on increased energy costs. However, in the event of a power outage, the value of lives potentially saved defies monetization.



Project 6: Prime Rate Loan

Borrower: Nassau County Department of Public Works
Amount: $100,000,000
Type: Gap Loan for Bay Park Water Reclamation Facility

This project would provide the gap financing necessary to help the borrower accommodate an $830 million renovation to the plant designed to mitigate and manage the risks associated with storm surge, increased deluge events, and relative sea level rise. In particular the loan would support the funding of: (i) the upgrading of power and back-up systems; (ii) the elevating of chemical tanks and electrical controls; (iii) the installing of new pumping systems; and, (iv) the development of dual-purpose public spaces that promote the physical resiliency and environmental sustainability of the adjacent neighborhood. This loan helps finance the increased marginal costs associated with resilience and adaptation measures and operations of the facility.

Project 7: Prime Rate Loan

Borrower: Lower Manhattan Property Cooperative (non-profit)
Amount: $350,000,000
Type: Infrastructure Finance for Multi-Purpose Flood Protection

This project would provide supplemental efforts to the ongoing city led effort to fortify Lower Manhattan. The borrower is a public-private non-profit cooperative corporation whose members are property owners, building owners, large tenants, Con Edison and the New York City Economic Development Corporation. The members of the association would contribute additional working capital and resources to the association whose mission is to develop block and district level infrastructure improvements that complement the Lower Manhattan Coastal Resiliency Project. As aging commercial office buildings are replaced, this source of funding helps finance coordinated lot and block improvements that synchronize with the district level waterfront improvements. Eligible improvements would be limited to those interventions in energy distribution, water management and public space that inure to the resilience of public and private operations in the district.

Project 8: Prime Rate Loan

Borrower: New Jersey Transit
Amount: $100,000,000
Type: NJ TransitGrid

This project builds off existing U.S. Department of Transportation and state financial commitments to enhance the energy resilience of NJ Transit operations in the NYMR. The project would provide additional financing for developing an innovative micro-grid that accommodate a variety of extreme events from heat to flooding. With an increasing stressed and aging transit system, the project seeks to increase reliability and reduce down time through the intelligent management of distributed and renewable energy sources. This includes the development of more energy efficiency local generation capacity to support the system. Aside from the core infrastructure improvements, the financing could support consumer communications for re-routing when service is altered, as well as contingent operations planning and operations redundancy for extreme events.

VI. Portfolio Modeling

a. Portfolio Model Setup and Results

Based on the range of unleveraged capitalization potentially available from the State insurance surcharges identified in the preceding sections, the research design dictated that a secondary step is to develop an optimal allocation of aforereferenced product types. To optimize a portfolio allocation, interest rates and terms for comparable products were researched for each of the States, as well as across the country. Interest rate spreads were developed for each product and were modeled relative to recent and anticipated trends in various interest rate structures. Debt product interest rates were then compared with rates and terms of recent (i.e., 18 months) bond issuances to provide greater sensitivity for how each State's RRTF may be underwritten by the market. For instance, while various New York revenue and general obligation bonds are relatively stable, the bond market in New Jersey has been comparatively volatile with long-term pension and infrastructure liabilities underscoring a broader financing capacity.

An initial step in the portfolio engineering was to model a fixed percentage of grants in order to ascertain what percentage allocation—relative to assumed parameters of the products—would provide a sustainable portfolio with a 10 year sunset on the surcharge. The result for grant allocations was rounded up to 10%. Thereafter, based on a sample of returns and terms of each product type, mean and standard deviations were normally distributed using a Monte Carlo method to calculated randomized rates of return (Glasserman, 2013). This method is based on an iterative sample rate (n=1,000) to calculate the distribution. Pairs of products, not including grants and non-recourse soft loans, were then simulated and correlated for a 2-loan portfolio using Sharp regression (Sharpe, 1994; Goetzmann, et al., 2007). The regression simulates different weights of the pair to isolate an optimal weight strength, which is graphically represented in Appendix Figure 1 as the highest Sharpe ratio (Greenwood, Seasholes & Biery, 2015). The Sharpe ratio is understood to equal the required return minus the risk free return over volatility (Dowd, 2000). Again, the transient portfolio of loans is subject to 1,000 sample Monte Carlo simulation. The overall results of this Sharpe analysis provided the basis for the optimal allocations identified in Table 5, which are based on a constructed weighting of each transient portfolio of pairs over the entire product offering. However, it should be noted that each run of the portfolio model would dictate a slightly different output than what is represented in Table 5. Therefore, Table 5 is merely an approximation based on a limited number of model simulation runs.

Table 5: Optimal Portfolio Weighting and Product Allocations

Products	Term (Yr)	Return Type	Financial Return	σ Financial Return	Volatility	Loan Weights	Total Weight	Financial Return MC
Grants		Rg	X	X	X	X	10.00%	X
Soft Loans		Rs	X	X	X	X		X
Concession Loans	5	Rc	2.18%	0.0041	0.1892	2.96%	90.00%	2.17%
	10		3.37%	0.0108	0.3203	5.04%		3.41%
	15		2.75%	0.0123	0.4460	1.53%		2.78%
	20		3.63%	0.0114	0.3138	5.84%		3.64%
	25		3.55%	0.0050	0.1410	28.55%		3.64%
Market Loans (Fixed)	5	Rx	5.00%	0.0150	0.3000	12.39%		5.04%
	10		7.00%	0.0250	0.3571	14.08%		6.85%
Market Loans (CPI Indexed)	5	Rxi	6.77%	0.0280	0.4131	9.60%		6.64%
	10		8.77%	0.0380	0.4329	20.00%		8.83%
Weighted Portfolio Return 5.46%		Years to Revolve 8.15						
Loan Portfolio Volatility 0.1102								

Using the portfolio weights (i.e., product allocations) in Table 5, cash flows for each instrument are weighted and adjusted for projected inflation (CPI-U) over a period of 20 years. For each loan, it is assumed that there is a rollover of the investment capital without any reinvestment risk. This represents a significant methodological limitation for evaluating the performance of any RRTF because of the long lead time for the planning, designing and permitting of infrastructure projects. Therefore, the ability of any given RRTF to rollover investments via larger infrastructure debt products is dependent on the extent to which the RRC and local jurisdictions can develop a pipeline of resilience infrastructure interventions. The answer to this outstanding concern could have significant impact on rates, terms and volatility of the portfolio. However, under the fixed assumptions presented in Table 5, the portfolio could potentially achieve a weighted portfolio return of 5.46% and could be entirely self-sustained in 8.15 years. Therefore, if the surcharge were to sunset in 10 years, the RRTF could continue to operate independently without any additional surcharge revenue. If a RRTF is not able to deploy capital consistently and timely enough to meet the weighted return, then lower returns would mean a longer revolving period that may extend beyond the current estimates. As such, a 10 year sunset may be insufficient to achieve independent operations. In addition, a 10% allocation to grants is merely a modeled assumption. A portfolio could operate with a higher percentage allocation for grants. However, the greater the percentage of grants, the longer it takes for the portfolio to be independently sustainable in its operations relative to its reliance on an insurance surcharge.

b. Bond Leverage Analysis

Although the existing metric for unmet needs is somewhat problematic, the unlevered revenue from the surcharges and the initial operations of the unlevered portfolio suggested that the revenue would be insufficient for New York and New Jersey. As such, the third step of the research design was to model the RRTFs with (1x) and without (0x) leverage. The estimates for leverage and coupon rates were based on a survey of recent issuances (e.g., 18 months) over various bond types in each of the States as reported by Moodys and the States themselves. This survey provided a blended rate (mean) and standard deviation for the bond market assumptions for each of the RRTFs. Again, each of these assumptions varies depending on the underlying relative performance of each State's bond market. Appendix Table 4 provides gross revenue and Appendix Table 5 provides net revenue from a balanced portfolio after payments to the bold holders. A balanced portfolio is inclusive of both reserve investment returns and portfolio returns. Appendix Table 6 and 7 extend the analysis of a balanced portfolio without and without leverage over the course of 20 years and discount the cash flow to 5%. This discount rate is an approximation on the levered weighted average cost of capital, plus investment and reinvestment risk. Based on the data memorialized in the tables, leverage in a 1.5% surcharge scenario with no sunset would yield an additional $1.8 billion over 20 years for New York; $999 million for New Jersey; and, $455 million for Connecticut.

Table 6 highlights some additional sensitivity for surcharges in terms of what would be allocated to loans and grants. Based on a 1.5% surcharge and a straight-line allocation, approximately $20 million in New York, $9 million in New Jersey and $4 million in Connecticut could be allocated for grants every year. Over all, pursuant to Table 7, the impact of leverage is more pronounced as the surcharge rate increases. However, under the existing assumptions for leverage and bond and

Table 6: Sensitivity Analysis for Projected Bond Revenue Allocations		
($ in thousands)	Cash flow invested as grants	10%
	Cash flow invested as loans	90%
Surcharge Revenue (Low, 0.5%)	**Loans**	**Grants**
New York	$1,225,725	$136,192
New Jersey	$556,248	$61,805
Connecticut	$271,264	$30,140
Surcharge Revenue (Medium, 1.0%)	**Loans**	**Grants**
New York	$2,451,451	$272,383
New Jersey	$1,112,496	$123,611
Connecticut	$542,528	$60,281
Surcharge Revenue (High, 1.5%)	**Loans**	**Grants**
New York	$3,677,176	$408,575
New Jersey	$1,668,744	$185,416
Connecticut	$813,792	$90,421

Table 7: Sensitivity Analysis for Net Impact of Bond Leverage		
($ in thousands)		
Surcharge Revenue (Low, 0.5%)	**1x Leverage**	**0x Leverage**
New York	$1,977,440	$1,359,332
New Jersey	$923,722	$590,543
Connecticut	$445,079	$293,378
Surcharge Revenue (Medium, 1.0%)	**1x Leverage**	**0x Leverage**
New York	$3,954,879	$2,718,664
New Jersey	$1,847,443	$1,181,086
Connecticut	$890,158	$586,757
Surcharge Revenue (High, 1.5%)	**1x Leverage**	**0x Leverage**
New York	$5,932,319	$4,077,996
New Jersey	$2,771,165	$1,771,629
Connecticut	$1,335,237	$880,135
*Discounted to 5% over 20 years.		

product rates and terms, the total capitalization of the RRTFs would not be able to address the State's unmet needs. If the unmet needs hold constant and are adjusted for inflation over twenty years, under a 1.5% surcharge scenario with 1x leverage, New York and New Jersey would only be able to accommodate 37.6% and 14.3% of their respective unmet needs.

VII. Conclusions

The findings of this paper support an affirmation of the feasibility for the development and operation of an RRTF model pursuant to Proposition A. These findings include references to historical precedents for insurance surcharges; an existing legal and organizational capacity for public benefit funds; and, a portfolio model that could operate independently within a hypothetical and likely politically convenient 10 year sunset of an insurance surcharge. However, significant challenges remain for not only sourcing eligible resilience and adaptation projects but also developing metrics to underwrite and define resilience and adaptation. While this paper offers some constructive evaluation perspectives and methodologies relating to risk mitigation and disaster resilience, other areas such as environmental resilience are much less developed. In addition, while the existing portfolio models are useful for deriving optimal allocations based on potentially impactful products, there is a major unknown in the ability of local actors to plan, design and permit projects in a timely manner to take advantage of the RRTF's opportunity to rollover investment capital. This rollover risk represents a significant uncertainty in the operations of a RRTF. If a RRTF is not able to deploy funds at a higher return rate than the baseline reserve return rate (e.g., federal bonds), then a RRTF may be indefinitely reliant on a surcharge beyond a sunset term. This may or may not be a handicap, as a large capital reserves could be useful for promoting resilience efforts following the probabilistic occurrence of an extreme event. However, the uncertainties associated with extreme events provides little guidance for portfolio management of an RRTF.

Pursuant to Proposition B, the findings of this paper suggest that under the current assumptions (e.g., 1.5% surcharge, 1x leverage) the RRTFs could not accommodate 100% of the unmet resilience needs in New York and New Jersey. However, under these assumptions, Connecticut could very well accommodate well beyond its current documented resilience needs. The baseline data for unmet resilience needs is based on CDBG-DR reporting that is somewhat problematic as it conflates recovery

and resilience and does not clearly articulate future resilience needs that may arise by virtue of either increased exposure or increased risk—or, both. Existing unmet needs are unlikely to be entirely accommodated through increased leverage. With increased leverage comes increased risk, and bond rates and terms would reflect this dynamic. Future research needs to evaluate not only more precise metrics for unmet and future needs, but also the risks and opportunities associated with increasing premiums and/or decreasing market share by virtue of the manifestation of hazards that result in a lack of insurability.

The RRC and the RRTFs reflect an opportunity for process innovation that offers the potential to not only manage risks, but also to capture opportunities associated with climate change. Whether it is co-benefits between public health and infrastructure or workforce training and environmental conservation, the broader adaptation of society is dependent on resources allocations in both the public and private sector. The RRTF model offers a novel approach for not only funding resilience and adaptation interventions, but also for the identification and evaluation of such interventions. Because of the open and competitive nature of project selection under the RRC, a broad array of potential projects may seek to advance resilience and adaptation analysis that sets a new benchmark for professional practices. At the same time, this paper highlights the reality of the necessity and the opportunity to finance the marginal costs of resilience within conventional projects. The necessity rests in the practical acknowledgment that free-standing resilience and adaptation projects are limited in number and are challenging to design, finance and permit in a sufficient volume to justify the scale of capital aggregated by an RRTF.

While the current framing of resilience practices are primarily oriented towards disasters and risk mitigation, there is much room for advancement in community resilience, economic adaptation and adaptive environmental management. To this end, the RRTF model is simply a conduit that financially incentivizes more resolute analytical processes that are inclusive of a broader array of considerations from social equity to environmental justice. Without such an incentive, it can be argued that the only other motivation for the pooling of collective resources will be based on the shame and indignity of a post-disaster response. In this light, this paper provides a partial affirmation that the RRTF model represents a potential innovation that dictates that not all commons are predisposed to tragedy.

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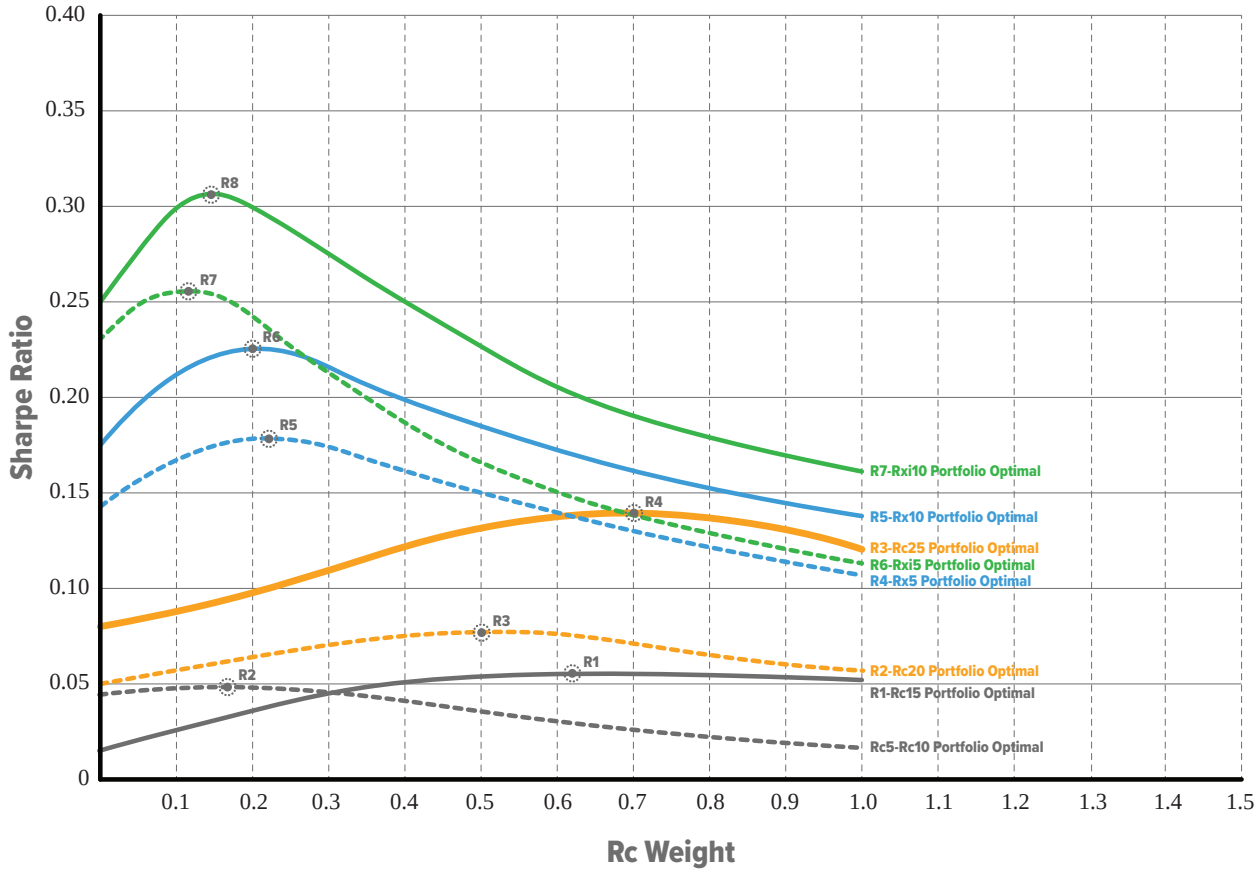
X. Appendix

Appendix Figure 1: Sharpe Ratio Portfolio Optimization



Appendix Table 1: List of Interviewees	
Name	**Affiliation**
Chen, Chen	University of Notre Dame
Civitenga, Peter	AIR Worldwide
Clark, Anthony	Conneticut Green Bank
Davies, Craig	University of Cambridge
Firth, John	Acclimatise
Gimont, Stan	U.S. Department of Housing and Urban Development
Grunwaldt, Alfred	Inter-American Development Bank
Kaniewski, Daniel	AIR Worldwide
Kao, Andrew	AIR Worldwide
Koh, Jay L.	Siguler, Guff & Company
Laven, Chuck	Forsyth Street
Levaggi, Marcia	Adaptation Fund
Lindberg, Mark	Margaret Cargill Foundation
Liu, Tony	Siguler, Guff & Company
McFadden, Marion	Enterprise Community Partners
Medlock, Samantha	U.S. Office of Management and Budget
Murdock, Sarah	The Natural Conservancy
Ollikainen, Mikko	Adaptation Fund
Poliquin, Brent	AIR Worldwide
Roy, Arghya Sinha	Asia Development Bank
Seville, Aleka	Twenty Four Seven Consulting
Shafer, Julie	Bank of the West
Starkman, Kendall	Twenty Four Seven Consulting
Swann, Stacy	Climate Finance Advisors
Vajjhala, Shalini	Re:Focus Parnters
Wilson, Steven R.	Inter-American Development Bank

Appendix Table 2: Property & Casualty Insurance Premiums Written by State, 2006 -2015

New York

	2006	2008	2009	2010	2011	2012	2013	2014	2015
Homeowners Multiple Peril	$3,627,091	$4,096,975	$4,238,743	$4,357,145	$4,519,844	$4,725,048	$4,925,004	$5,110,113	$5,220,744
Commercial Multiple Peril	$3,180,652	$3,131,076	$3,096,679	$3,035,189	$3,119,458	$3,310,734	$3,562,364	$3,711,941	$3,706,915
Farmowners Multiple Peril	$33,066	$34,822	$33,935	$34,902	$35,788	$36,787	$38,249	$39,591	$41,296
Fire	$806,746	$797,810	$767,144	$736,578	$746,028	$759,213	$812,122	$849,193	$820,460
Allied Lines	$468,609	$470,253	$447,712	$432,166	$459,309	$501,327	$567,790	$593,643	$653,181
Inland Marine	$913,226	$987,741	$978,460	$985,589	$1,048,911	$1,150,991	$1,288,601	$1,400,482	$1,510,929
Ocean Marine	$599,118	$513,898	$450,468	$440,482	$454,701	$447,849	$446,304	$452,773	$406,485
Boiler and Machinery	$82,534	$87,213	$90,297	$87,413	$89,064	$99,538	$103,017	$106,112	$117,613
Earthquake	$37,786	$32,772	$29,825	$34,479	$35,965	$40,883	$44,211	$50,597	$53,503
Private Crop									$28
Total, Nominal	$9,748,828	$10,152,560	$10,133,263	$10,143,943	$10,509,068	$11,072,370	$11,787,662	$12,314,445	$12,531,154
Total (2015 Dollars)*	$11,461,498	$11,176,478	$11,195,065	$11,026,007	$11,073,348	$11,430,351	$11,993,099	$12,329,062	$12,531,154
Growth Rate, Nominal		4.14%	-0.19%	0.11%	3.60%	5.36%	6.46%	4.47%	1.76%

New Jersey

	2006	2008	2009	2010	2011	2012	2013	2014	2015
Homeowners Multiple Peril	$1,696,424	$1,877,038	$1,957,270	$2,007,475	$2,093,434	$2,230,734	$2,391,724	$2,479,828	$2,556,089
Commercial Multiple Peril	$1,314,336	$1,256,621	$1,204,386	$1,172,881	$1,201,258	$1,284,139	$1,379,336	$1,434,577	$1,424,250
Farmowners Multiple Peril	$2,739	$2,882	$2,855	$2,846	$2,322	$2,392	$2,375	$2,544	$2,622
Fire	$324,053	$320,259	$333,534	$335,752	$349,831	$377,147	$407,562	$387,830	$372,581
Allied Lines	$216,633	$218,352	$219,554	$220,117	$229,828	$256,475	$304,375	$343,522	$334,645
Inland Marine	$410,067	$417,190	$378,611	$385,998	$400,398	$435,714	$471,649	$507,068	$550,979
Ocean Marine	$117,068	$129,710	$125,855	$120,655	$121,728	$131,395	$138,011	$133,880	$135,249
Boiler and Machinery	$35,347	$38,194	$38,842	$36,938	$40,125	$41,077	$45,331	$44,717	$47,948
Earthquake	$15,731	$12,062	$12,147	$12,770	$13,969	$15,209	$16,687	$19,339	$19,597
Private Crop									$27
Total, Nominal	$4,132,398	$4,272,308	$4,273,054	$4,295,432	$4,452,893	$4,774,282	$5,157,050	$5,353,305	$5,443,987
Total (2015 Dollars)*	$4,858,376	$4,703,184	$4,720,801	$4,668,940	$4,691,989	$4,928,639	$5,246,928	$5,359,659	$5,443,987
Growth Rate, Nominal		3.39%	0.02%	0.52%	3.67%	7.22%	8.02%	3.81%	1.69%

Connecticut

	2006	2008	2009	2010	2011	2012	2013	2014	2015
Homeowners Multiple Peril	$913,479	$1,037,569	$1,065,532	$1,107,784	$1,146,334	$1,221,067	$1,308,798	$1,379,750	$1,408,185
Commercial Multiple Peril	$581,031	$548,684	$519,668	$512,310	$532,001	$578,155	$612,146	$635,253	$638,210
Farmowners Multiple Peril	$3,021	$3,557	$3,795	$4,068	$4,300	$4,680	$5,051	$5,493	$5,894
Fire	$103,629	$112,028	$121,308	$120,031	$131,540	$132,374	$139,986	$142,656	$130,236
Allied Lines	$98,349	$91,637	$89,901	$92,696	$102,863	$109,365	$120,763	$124,768	$111,834
Inland Marine	$209,174	$218,427	$213,434	$193,758	$216,538	$243,015	$249,951	$254,596	$293,180
Ocean Marine	$52,335	$54,115	$48,112	$50,844	$50,301	$49,374	$51,652	$52,181	$87,409
Boiler and Machinery	$14,584	$14,570	$15,477	$15,115	$16,173	$17,700	$19,370	$18,559	$21,316
Earthquake	$5,867	$5,152	$5,140	$5,526	$6,900	$7,089	$6,720	$8,428	$8,277
Private Crop									
Total, Nominal	$1,981,469	$2,085,739	$2,082,367	$2,102,132	$2,206,950	$2,362,819	$2,514,437	$2,621,684	$2,704,541
Total (2015 Dollars)*	$2,329,573	$2,296,092	$2,300,565	$2,284,922	$2,325,451	$2,439,211	$2,558,259	$2,624,796	$2,704,541
Growth Rate, Nominal		5.26%	-0.16%	0.95%	4.99%	7.06%	6.42%	4.27%	3.16%

*Adjusted for inflation using the annual Consumer Price Index for All Urban Consumers (CPI-U); complete data is not available for 2007.

Appendix Table 3: RRTF Resilience Underwriting Check-List

Abstract Information

Borrower/ Grantee:
Agency:
Product Type:
Borrower:
Guarantor:
Project Term:
Finance Term:
Community Partnerships:
Government Partnerships:
Jurisdictions:

Project Type

	Buildings (new)		Buildings (retrofit)
	Buy-out		Climate Change Planning
	Communications		Community Planning
	Ecological Conservation/Restoration		Energy
	Green Infrastructure		Hazard Mitigation Planning
	Intelligence Capacity		Infrastructure
	Reference Standards		Research & Development
	Resilience Planning		Resilience Personnel
	Social Network Development		Social Service Delivery
	Vulnerability Assessment		Training Course

Review Questionnaire

Proprietary Information				
Is the submission publicly available? If yes, explain:	Yes		No	
Was this submission developed with public input? If yes, explain:	Yes		No	
Is the submission compliant with existing codes and standards? If yes, explain:	Yes		No	
Does the submission help advance a new reference standard? If yes, explain:	Yes		No	
Is the submission sponsored by a public authority? If yes, explain:	Yes		No	
Has the submission been reviewed by a public authority? If yes, explain:	Yes		No	
Is the submission specific to extreme events? If yes, explain:	Yes		No	
Does the submission offer potentially generalizable findings/practices? If yes, explain:	Yes		No	
Does the submission offer potentially scalable findings/practices? If yes, explain:	Yes		No	
Does the submission address private sector benefits? If yes, explain:	Yes		No	
Does the submission address public sector benefits? If yes, explain:	Yes		No	
Has the submission been informed by on-the-ground practice or experience? If yes, explain:	Yes		No	

Has the submission been endorsed by resilience or advocacy organizations? If yes, explain:	Yes		No	
Can the outcomes of this submission be measured with existing capacities? If yes, explain:	Yes		No	

Categorization

Geographic Scope (state, county, municipal, district, block, lot)

Region								
Population:		Urban		Suburban		Exurban		Rural
Geography:		Coastal		Riverine		Interior(Non-Riverine)		Mountainous

Hazards and Impacts					
Natural					
	Algal Bloom		Animal Disease		Avalanche
	Collateral Hazards		Drought		Earthquake: Shaking
	Earthquake: Ground Deform.		Extreme Temperatures		Flood
	Glacial Melt		Hurricane/Typhoon		Invasive Species
	Landslide		Pandemic (Human)		Permafrost Melt
	Rapid Sea Level Rise		Salt Water Intrusion		Sea Level Rise (Mean Proj.)
	Severe Convection/ Winds		Sinkholes/Subsidence		Space Weather
	Storm Surge		Tornado		Tsunami
	Vector Borne Disease		Volcanic Eruption		Wildfire
	Winter/Ice Storm				
Technological					
	Air Traffic Suspension		Bridge Failure		Communications Failure
	Dam Failure		Fuel Shortage		Hazmat Release (Radiological)
	Hazmat Release (Chemical)		Mine Accident		Pipeline Failure/ Explosion
	Road Failure		Track Failure		Transportation Accident
	Underground Fire		Urban Conflagration		Utility Interruption
	Water Contamination				
Human-Caused					
	Active Shooter(s)		Aircraft as Weapon		Arson
	Biological Attack		Chemical Attack		Civilian Disturbance
	Cyber Attack		Drone as Weapon		Explosive Devices
	Fisheries Depletion		Food/Water Contamination		Mass Migration
	Metal Theft		Nuclear/ Radiological Attack		

Sector					
Public					
	Defense		Disaster Management		Education
	Emergency Services		Energy: Coal & Natural Gas		Energy: Hydroelectric & Dams
	Energy: Nuclear		Financial		Highway Transportation
	Mass Transportation		Monetary System		Public Health
	Social Services		Solid Waste		Water & Wastewater
	Water		Telecommunications		Other:
Private					
	Agriculture		Chemical		Construction
	Critical Manufacturing		Education		Defense Industrial Base
	Energy: Nuclear		Energy: Coal & Natural Gas		Energy: Green
	Financial Services		Food Distribution		Healthcare
	Information Technology		Logistics		Mining

Sector cont'd					
Private cont'd					
	Pharmaceuticals		Real Estate		Recycling
	Solid Waste		Scientific/Tech R&D		Water & Wastewater
	Telecommunications		Transportation		Other:
Non-Profit					
	Aging & Elderly		Community Advocacy		Community Recovery
	Cultural Affinity		Environmental Stewardship		Food Bank
	Industry Association		Mental Health & Substance Abuse		Philanthropy
	Political Advocacy		Professional Association		Religious
	Social Assistance		Urban Planning		Other:

Strategy *(select all that apply)*			
Social Resilience			
	Access / Functional Needs Assessments		Community Impact Assessments
	Community Network Capacity		Community Planning
	Communications Models		Cultural Preservation
	Economic Development		Long-term Housing & Community Development
	Post-Recovery Shelter & Housing		Public Health
Technical & Design Resilience			
	Building Codes & Standards		Engineering Techniques & Analysis
	Risk Standards & Thresholds		Sustainable Systems
	Urban Design		Zoning & Land Use Planning
Material Resilience			
	Composite Innovation in Materials		Low-Technology Solutions
	Materials Performance Standards		Nano-Materials
	Thermal Dynamic Materials		
Infrastructure Resilience			
	External Intelligence Systems		Facility Guidance & Training
	Impact Assessments		Innovation in Risk Management
	Internal Intelligence Systems		Operations & Scenario Planning
	System Redundancy		
Organizational Resilience			
	Business Continuity Planning		Critical Systems Design
	Data Backup & Security		External Intelligence Systems
	Internal Intelligence Systems		Remote Workforce
	Workforce Training		
Ecosystems Resilience			
	Agriculture		Fisheries
	Water		Wildlife

Climate Change	
	Climate Change Mitigation
	Climate Change Adaptation

Planning Phases			
	Determine Options, Goals & Objectives		Plan Development
	Plan Implementation, Testing & Maintenance		Plan Preparation
	Planning Team and Stakholder Identification		Understand Context, Risks & Impacts

Primary Actor

	Advocacy Organizations		Private Sector Enterprise
	State & Local Government		Other

Capacity Building

	Access Control & Identity Verification		Accounting & Auditing Systems
	Actor & Stakeholder Identification		Agency Benefit-Cost Analysis
	Agricultural Extension System		Chief Resilience Officer / Staff
	Civil Court System Services		Claims Adjusting
	Climate & Weather Services		Community Advocacy Mobilization
	Critical Transportation Services		Cross-Jurisdictional Professional Capacity
	Cultural Resource Preservation		Cybersecurity
	Displaced Persons Registry		Economic Recovery Strategies
	Emergency Financial/Funding Capacity		Emergency Healthcare Delivery
	Emergency Procurement System		Employment Training
	Environmental Response/Health Services		Fatality Management Services
	Fire Management and Suppression		Forensics and Attribution
	Government Affairs Services		Intelligence and Information Sharing
	Interdiction and Disruption		Legal Planning
	Logistics and Supply Chain Management		Long-term Housing Planning
	Long-term Vulnerability Reduction		Marketing & Public Communications
	Mass Care Services		Mass Search and Rescue Operations
	Mental Health Counseling		Mutual Assurance Agreements
	Natural Resource Preservation		On-scene Security, Protection, & Law Enforce-
	Operational Communications		Operational Coordination
	Operational Planning		Physical Protective Measures
	Potable Water Distribution Services		Primary Healthcare Delivery
	Private Sector Cost-Benefit Analysis		Property and Engineering Inspections
	Public Health, Healthcare, & EMS		Public Information and Warning
	Redundant Infrastructure Systems		Risk and Disaster Resilience Assessment
	Risk Management Expertise		Risk Management for Protection Programs and Activity
	Screening, Search, & Detection		Short-term Shelter Providers
	Situational Assessment		Social Network Development, Resourcing & Maint.
	Social Service Delivery		Strategic Building Materials Supplies
	Strategic Food Supplies		Strategic Medical Supplies
	Strategic Planning		Supply Chain Integrity and Security
	Supply Chain Management		Threats and Hazard Identification
	Volunteer System Mobilization		

Appendix Table 4: Gross Revenue from Balanced Portfolio from Bond Issue

Surcharge Revenue (Low, 0.5%) **($ in thousands)**

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438	$169,438
New Jersey	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893	$76,893
Connecticut	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498	$37,498

Surcharge Revenue (Medium, 1.0%) **($ in thousands)**

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875	$338,875
New Jersey	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785	$153,785
Connecticut	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996	$74,996

Surcharge Revenue (High, 1.5%) **($ in thousands)**

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313	$508,313
New Jersey	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678	$230,678
Connecticut	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494	$112,494

*Gross revenue before bond payments.

Appendix Table 5: Net Revenue on Balanced Portfolio from Bond Issue

Surcharge Revenue (Low, 0.5%) **($ in thousands)**

	Net Revolving Amount*	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$1,033,105	$97,183	$93,667	$89,980	$86,113	$82,059	$77,807	$73,348	$68,672	$63,768	$58,626	$53,234	$47,580	$41,650	$35,432	$28,911	$22,072	$14,901	$7,381	-$504	-$8,774
New Jersey	$514,475	$45,503	$43,975	$42,373	$40,694	$38,932	$37,085	$35,148	$33,116	$30,986	$28,752	$26,410	$23,953	$21,377	$18,676	$15,843	$12,872	$9,757	$6,490	$3,064	-$529
Connecticut	$241,553	$21,904	$21,145	$20,349	$19,515	$18,639	$17,722	$16,759	$15,750	$14,692	$13,582	$12,418	$11,198	$9,918	$8,576	$7,169	$5,693	$4,145	$2,522	$820	-$965

Surcharge Revenue (Medium, 1.0%) **($ in thousands)**

	Net Revolving Amount*	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$2,066,209	$194,366	$187,334	$179,959	$172,226	$164,117	$155,613	$146,695	$137,344	$127,537	$117,253	$106,468	$95,159	$83,300	$70,863	$57,821	$44,145	$29,803	$14,763	-$1,009	-$17,548
New Jersey	$1,028,951	$91,005	$87,950	$84,747	$81,387	$77,864	$74,170	$70,296	$66,233	$61,972	$57,505	$52,819	$47,906	$42,754	$37,351	$31,685	$25,744	$19,513	$12,979	$6,127	-$1,058
Connecticut	$483,105	$43,807	$42,290	$40,698	$39,029	$37,279	$35,443	$33,519	$31,500	$29,384	$27,164	$24,837	$22,396	$19,836	$17,152	$14,338	$11,386	$8,290	$5,044	$1,641	-$1,929

Surcharge Revenue (High, 1.5%) **($ in thousands)**

	Net Revolving Amount*	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$3,099,314	$291,549	$281,000	$269,939	$258,339	$246,176	$233,420	$220,043	$206,015	$191,305	$175,879	$159,703	$142,739	$124,949	$106,295	$86,732	$66,217	$44,704	$22,144	-$1,513	-$26,322
New Jersey	$1,543,426	$136,508	$131,925	$127,120	$122,081	$116,796	$111,255	$105,443	$99,349	$92,959	$86,257	$79,229	$71,860	$64,131	$56,027	$47,528	$38,616	$29,270	$19,469	$9,191	-$1,587
Connecticut	$724,658	$65,711	$63,434	$61,047	$58,544	$55,918	$53,165	$50,278	$47,251	$44,076	$40,747	$37,255	$33,594	$29,755	$25,728	$21,506	$17,079	$12,436	$7,567	$2,461	-$2,894

*After Bond Payments.

Appendix Table 6: Net Investments with 1x Leverage

Surcharge Revenue (Low, 0.5%) **($ in thousands)**

	Net Investment in PV	2017 Bond Revenue	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$1,977,440	$1,225,725	$92,555	$84,959	$77,728	$70,836	$64,286	$58,053	$52,120	$46,467	$41,095	$35,982	$31,117	$26,483	$22,079	$17,888	$13,901	$10,106	$6,498	$3,066	-$199	-$3,305
New Jersey	$923,722	$556,248	$43,336	$39,887	$36,604	$33,474	$30,500	$27,670	$24,976	$22,408	$19,969	$17,647	$15,437	$13,333	$11,332	$9,429	$7,618	$5,894	$4,254	$2,695	$1,212	-$199
Connecticut	$445,079	$271,264	$20,861	$19,179	$17,578	$16,053	$14,603	$13,222	$11,909	$10,658	$9,468	$8,336	$7,259	$6,233	$5,258	$4,330	$3,447	$2,607	$1,808	$1,047	$324	-$363

Surcharge Revenue (Medium, 1.0%) **($ in thousands)**

	Net Investment in PV	2017 Bond Revenue	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$3,954,879	$2,451,451	$185,110	$169,917	$155,456	$141,672	$128,573	$116,105	$104,240	$92,935	$82,189	$71,964	$62,233	$52,967	$44,158	$35,776	$27,802	$20,212	$12,996	$6,131	-$399	-$6,609
New Jersey	$1,847,443	$1,112,496	$86,672	$79,773	$73,207	$66,948	$61,000	$55,339	$49,951	$44,817	$39,937	$35,293	$30,874	$26,665	$22,664	$18,857	$15,235	$11,787	$8,509	$5,390	$2,424	-$398
Connecticut	$890,158	$542,528	$41,721	$38,358	$35,157	$32,105	$29,205	$26,445	$23,818	$21,315	$18,936	$16,672	$14,518	$12,466	$10,515	$8,660	$6,894	$5,213	$3,615	$2,095	$649	-$727

Surcharge Revenue (High, 1.5%) **($ in thousands)**

	Net Investment in PV	2017 Bond Revenue	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$5,932,319	$3,677,176	$277,665	$254,876	$233,184	$212,508	$192,859	$174,158	$156,360	$139,402	$123,284	$107,946	$93,350	$79,450	$66,237	$53,664	$41,703	$30,319	$19,494	$9,197	-$598	-$9,914
New Jersey	$2,771,165	$1,668,744	$130,007	$119,660	$109,811	$100,423	$91,501	$83,009	$74,927	$67,225	$59,906	$52,940	$46,311	$39,998	$33,997	$28,286	$22,853	$17,681	$12,763	$8,085	$3,635	-$598
Connecticut	$1,335,237	$813,792	$62,582	$57,537	$52,735	$48,158	$43,808	$39,667	$35,727	$31,973	$28,404	$25,008	$21,777	$18,699	$15,773	$12,989	$10,341	$7,820	$5,423	$3,142	$973	-$1,090

*Discount Rate 5%.

Appendix Table 7: Net Investments with 0x Leverage

Surcharge Revenue (Low, 0.5%) **($ in thousands)**

	Net Investment in PV	2017 Bond Revenue	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$1,359,332	$ -	$68,814	$68,726	$68,639	$68,542	$68,455	$68,367	$68,280	$68,184	$68,097	$68,010	$67,924	$67,828	$67,741	$67,655	$67,569	$67,474	$67,388	$67,302	$67,216	$67,121
New Jersey	$590,543	$ -	$29,895	$29,857	$29,819	$29,777	$29,739	$29,701	$29,663	$29,622	$29,584	$29,546	$29,508	$29,467	$29,429	$29,392	$29,354	$29,313	$29,276	$29,238	$29,201	$29,160
Connecticut	$293,378	$ -	$14,852	$14,833	$14,814	$14,793	$14,774	$14,755	$14,737	$14,716	$14,697	$14,678	$14,660	$14,639	$14,620	$14,602	$14,583	$14,563	$14,544	$14,525	$14,507	$14,486

Surcharge Revenue (Medium, 1.0%) **($ in thousands)**

	Net Investment in PV	2017 Bond Revenue	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$2,718,664	$ -	$137,628	$137,453	$137,277	$137,084	$136,909	$136,735	$136,560	$136,368	$136,194	$136,021	$135,847	$135,656	$135,483	$135,310	$135,138	$134,947	$134,775	$134,603	$134,432	$134,242
New Jersey	$1,181,086	$ -	$59,791	$59,714	$59,638	$59,554	$59,478	$59,403	$59,327	$59,243	$59,168	$59,092	$59,017	$58,934	$58,859	$58,784	$58,709	$58,626	$58,551	$58,477	$58,402	$58,320
Connecticut	$586,757	$ -	$29,704	$29,666	$29,628	$29,586	$29,548	$29,511	$29,473	$29,432	$29,394	$29,357	$29,319	$29,278	$29,241	$29,203	$29,166	$29,125	$29,088	$29,051	$29,014	$28,973

Surcharge Revenue (High, 1.5%) **($ in thousands)**

	Net Investment in PV	2017 Bond Revenue	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
New York	$4,077,996	$ -	$206,442	$206,179	$205,916	$205,626	$205,364	$205,102	$204,841	$204,552	$204,291	$204,031	$203,771	$203,484	$203,224	$202,965	$202,706	$202,421	$202,163	$201,905	$201,648	$201,364
New Jersey	$1,771,629	$ -	$89,686	$89,572	$89,457	$89,331	$89,217	$89,104	$88,990	$88,865	$88,752	$88,638	$88,525	$88,401	$88,288	$88,175	$88,063	$87,939	$87,827	$87,715	$87,603	$87,480
Connecticut	$880,135	$ -	$44,555	$44,499	$44,442	$44,379	$44,323	$44,266	$44,210	$44,148	$44,091	$44,035	$43,979	$43,917	$43,861	$43,805	$43,749	$43,688	$43,632	$43,576	$43,521	$43,459

*Discount Rate 5%.

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