Appendix A12

Tier 1 Other Social Effects/Environmental Justice Analysis

New York – New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study

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1 Introduction

1.1. Purpose

The New York – New Jersey Harbor and Tributaries (NYNJHAT) study is investigating a set of Coastal Storm Risk Management (CSRM) alternatives to reduce the risk of flooding and improve the resilience and sustainability of communities in the study area. Severe coastal storms including Hurricane Sandy in 2012 have had devastating impacts on the region. Projected climate change and sea level rise indicate greater vulnerability of the region to future coastal storm damage and flooding. The NYNJHAT study will evaluate the alternative plans for managing coastal storm risk and reducing storm damages for flood risk areas. The evaluation will provide a recommendation for the alternative that will be most beneficial in terms of the four accounts of public benefit.

Much of the study area geography, topography, and proximity to tidally influenced areas is vulnerable to flooding from coastal storms. Flooding has direct impacts on communities and residents, posing a risk of injury or death and damaging public and private assets. Flooding often causes secondary impacts via infrastructure that is disrupted or damaged such as school closures, transportation shutdowns, power and utility outages, degraded housing conditions, and more. Lane et al (2013) review health impacts of flooding and note the mediating effect of infrastructure on the extent of flood impacts on people. Flooding and flood risk has financial impacts on communities and residents as well, such as the costs associated with evacuation, property damage, and cost of flood insurance as well as impacts to tax base and of business interruption. Research on Hurricane Sandy and natural disasters, more broadly, note that various factors affect how challenging a flood event will be for communities and residents, and show study results indicating they can be unevenly skewed based on race and income (Government Accountability Office 2021, SAMHSA 2017, Herreros-Cantis et al. 2020, Stony Brook University 2017).

The OSE assessment considered stakeholder priorities as stated to project planners. These included consideration of exposure from contaminants that are mobilized during flooding events and a request for an environmental justice analysis. There was also concern about access to recreational land, which is likely an example of the “everyday effects” that will be explored below. Access to transportation also emerged as a community concern, but since the study area has a high reliance on public transportation, transportation can be based on policies that are unrelated to flood infrastructure. Stakeholders expressed concern about the effects of the potential project on displacement and gentrification in some areas. Finally, although these issues arose through conversations with stakeholders, additional public engagement may well emphasize separate issues in later tiers of analysis.

In 1983, the Water Resources Council established the Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, which created four accounts to evaluate the effects of alternative plans (USACE 2011):

- The national economic development (NED) account evaluates changes in the economic value of the national output of goods and services.

- The environmental quality (EQ) account evaluates non-monetary effects on significant natural and cultural resources.
- The regional economic development (RED) account evaluates changes in the distribution of regional economic activity.
- The other social effects (OSE) account evaluates project impacts from perspectives relevant to the planning process, but which are not included in the other three accounts.

This assessment is broadly scoped with the intention to capture broad themes and extreme outcomes. Further analysis of the project's other social effects will be carried out during future phases of design, along with additional engagement of local communities to ensure that effects are addressed either through design refinement or mitigation. More localized analyses may be warranted in the future. Public comments that are received following the release of this report will help to identify community-level concerns and potential outcomes that need to be looked at more closely in the next phase of the project.

This Appendix describes the methodology for the Other Social Effects (OSE) analysis of the NYNJHAT study alternatives for the feasibility report and Tier 1 Environmental Impact Statement (EIS). Development of the methodology was strongly informed by the guidance developed by the USACE Institute of Water Resources including Dunning:

- *Handbook on Applying "Other Social Effects" Factors in Corps of Engineers Water Resources Planning* (Dunning and Durden 2009);
- *Applying Other Social Effects in Alternatives Analysis* (Durden, Weiss, Prakash, and Amarakoon 2013);
- *Other Social Effects: A Primer* (Durden and Wegner-Johnson 2013).

The alternative measures will affect resident and community well-being directly, by reducing risk to injury or mortality, and indirectly by affecting factors that contribute to well-being such as the economy, infrastructure quality, community identity and cohesion, and public spaces. Although for this analysis these impacts cannot easily be monetized for inclusion in a benefit cost analysis, they are systematically assessed so that they can be considered in tandem with other information in guiding plan selection.

This analysis includes consideration of environmental justice (EJ). This is compliant with Title VI of the Civil Rights Act, 42 U.S.C., Sec. 2000 et seq which states that "No person in the United States shall, on the ground of race, color or national origin be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." Executive Order (EO) 12898 (1994) "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" further requires that "…each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies and activities on minority populations and low-income populations…." [Subsection 1-101] (USACE 2011). The analysis seeks to fulfill these mandates in its EJ analysis.

1.2. Description of the Study Area

The study area encompasses the New York Metropolitan Area including New York City and the six largest cities in New Jersey, as well as areas adjacent to the Hudson River up to Troy, NY. Figure 1.1 shows the study area, which is broken into nine regions.

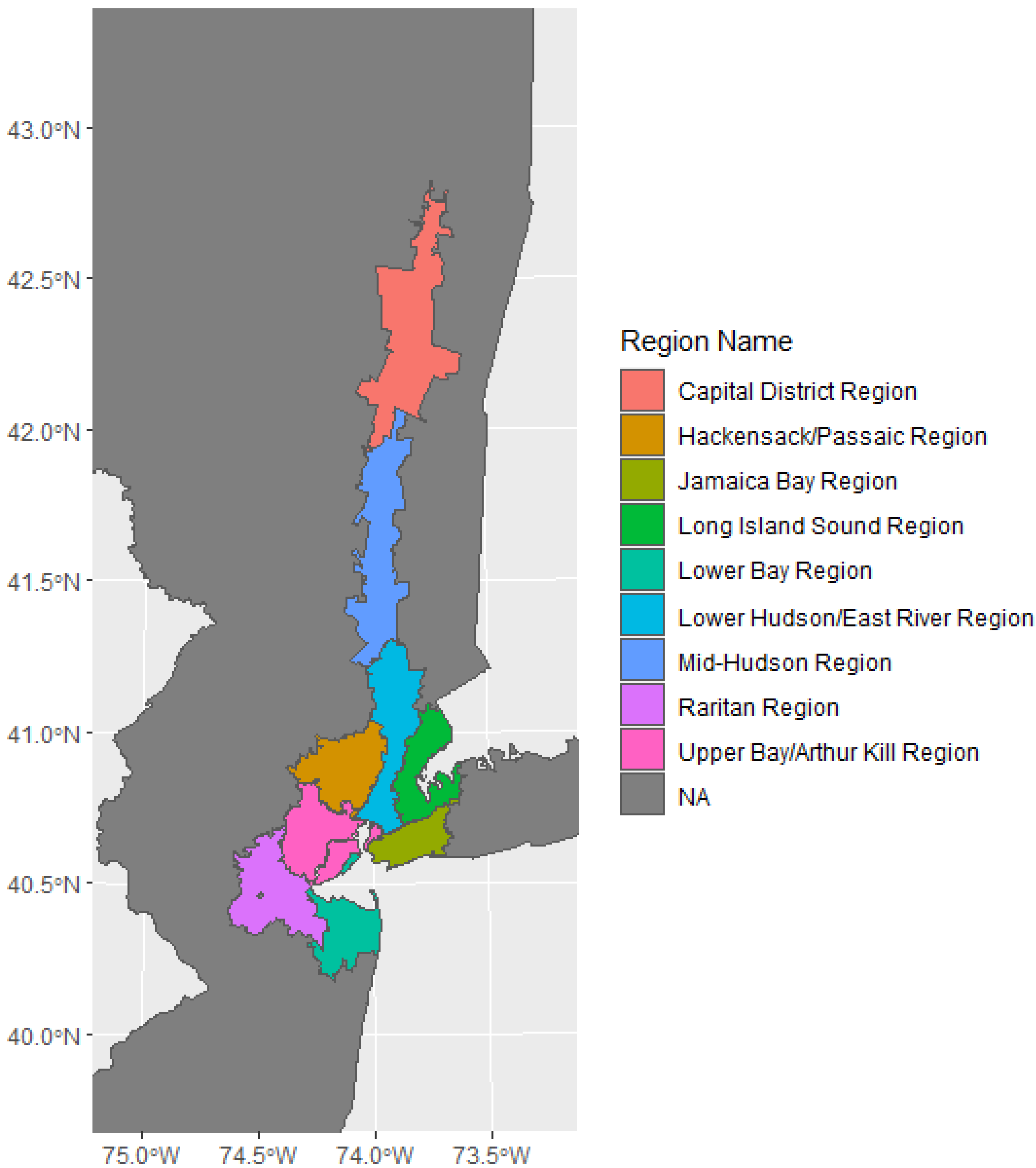


Figure 1.1. NYNJHAT Study Regions

The study area was identified as high risk for coastal storms by the North Atlantic Coastal Comprehensive Study (USACE 2015). Coastal storms have severely impacted portions of the study area, including Hurricane Irene (2011), Hurricane Sandy (2012), and Hurricane Ida (2021), and coastal flooding is projected to increase over the next 100 years under the USACE intermediate sea level rise scenario. The study area covers more than 2,150 square miles and comprises parts of 25 counties in New Jersey and New York that experience tidal flooding during storms.

The events of Hurricane Sandy provide insight into the experience of the study area with severe coastal storms. The study area is coastal and/or tidally influenced and therefore exposed to storm surge, wave attack, high tides, and sea level risk. The water depth due to Sandy was 6-10 feet in many coastal areas in common with this study and over 10 feet in some locations, with waves reported to be 12 feet high (City of New York 2013). Hurricane Sandy caused devastation in the study area, damaging property and disrupting millions of lives. As a result of the storm, 48 people lost their lives in New York and 12 people lost their lives in New Jersey. The flooding damaged facilities and interrupted services that are crucial to the well-being of communities in the study area and caused extensive and long-lasting physical and economic damage in the worst hit areas (City of New York 2013).

1.2.1. Existing Conditions - Demographic Characteristics of Study Area Residents

Table 1.1 provides broad demographic characteristics for the study area in terms of gender, age, race, ethnicity, disability status, education, employment, and household characteristics. Due to its immense size the study area has been broken up into nine regions. The text below will explore the demographic data in detail by region. Data for the following section including Table 1.1. is from the U.S. Census Bureau American Community Survey Data 2016-2020 5-Year Estimates (U.S. Census Bureau 2020a; U.S. Census Bureau 2020b; U.S. Census Bureau 2020c; U.S. Census Bureau 2020d; U.S. Census Bureau 2020e; U.S. Census Bureau 2020f).

Table 1.1 Demographics of the Population in the Study Area

	Total	Capital District Region	Hackensack/ Passaic Region	Jamaica Bay Region	Long Island Sound Region	Lower Bay Region	Lower Hudson/ East River Region	Mid-Hudson Region	Raritan Region	Upper Bay/ Arthur Kill Region
Population	16020609 (100)	259195 (100)	1996763 (100)	2889036 (100)	2996602 (100)	576208 (100)	4159324 (100)	263255 (100)	872853 (100)	2007373 (100)
Gender										
Male	7724466 (48.2)	128350 (49.5)	973388 (48.7)	1373124 (47.5)	1438296 (48)	280357 (48.7)	1996800 (48)	130780 (49.7)	429125 (49.2)	974246 (48.5)
Female	8296143 (51.8)	130845 (50.5)	1023375 (51.3)	1515912 (52.5)	1558306 (52)	295851 (51.3)	2162524 (52)	132475 (50.3)	443728 (50.8)	1033127 (51.5)
Age										
18 or younger	3406773 (21.3)	49243 (19)	445024 (22.3)	659629 (22.8)	666131 (22.2)	122883 (21.3)	761280 (18.3)	51080 (19.4)	196487 (22.5)	455016 (22.7)
65 or older	2419836 (15.1)	42932 (16.6)	300763 (15.1)	461511 (16)	467646 (15.6)	99404 (17.3)	596326 (14.3)	43096 (16.4)	123620 (14.2)	284538 (14.2)
Mean	40.1 (--)	39.85 (--)	40.51 (--)	40.36 (--)	40.19 (--)	41.74 (--)	39.25 (--)	40.72 (--)	40.56 (--)	40.25 (--)
Race										
White	7753744 (48.4)	188212 (72.6)	1134258 (56.8)	1011581 (35)	1130422 (37.7)	471277 (81.8)	2107273 (50.7)	182881 (69.5)	483661 (55.4)	1044179 (52)
Black	3265960 (20.4)	38054 (14.7)	286544 (14.4)	980457 (33.9)	585408 (19.5)	26395 (4.6)	731440 (17.6)	37512 (14.2)	114579 (13.1)	465571 (23.2)
American Indian or Alaskan Native	60750 (0.4)	672 (0.3)	6099 (0.3)	10617 (0.4)	15258 (0.5)	698 (0.1)	17864 (0.4)	877 (0.3)	2495 (0.3)	6170 (0.3)
Asian	2068130 (12.9)	11470 (4.4)	225923 (11.3)	467591 (16.2)	504807 (16.8)	42637 (7.4)	435642 (10.5)	7357 (2.8)	170680 (19.6)	202023 (10.1)
Hawaiian Native or other Pacific Islander	7878 (0.05)	72 (0)	837 (0)	1376 (0)	1773 (0.1)	129 (0)	2314 (0.1)	207 (0.1)	210 (0)	960 (0)
Other	1963472 (12.2)	5215 (2)	213673 (10.7)	284499 (9.8)	591411 (19.7)	14416 (2.5)	593033 (14.3)	18298 (7)	61580 (7.1)	181347 (9)
Two or more races	900675 (5.6)	15500 (6)	129429 (6.5)	132915 (4.6)	167523 (5.6)	20656 (3.6)	271758 (6.5)	16123 (6.1)	39648 (4.5)	107123 (5.3)
Ethnicity										
Hispanic	4494635 (28.1)	20648 (8)	695780 (34.8)	520409 (18)	1126941 (37.6)	68227 (11.8)	1327859 (31.9)	48055 (18.3)	196281 (22.5)	490435 (24.4)
Non-hispanic	11525974 (71.9)	238547 (92)	1300983 (65.2)	2368627 (82)	1869661 (62.4)	507981 (88.2)	2831465 (68.1)	215200 (81.7)	676572 (77.5)	1516938 (75.6)
Disability Status										
Disabled	1653499 (10.3)	35912 (13.9)	186085 (9.3)	296782 (10.3)	349131 (11.7)	58113 (10.1)	422187 (10.2)	32549 (12.4)	75793 (8.7)	196947 (9.8)
Disabled, under 18	117865 (0.7)	2748 (1.1)	12742 (0.6)	18184 (0.6)	29824 (1)	3418 (0.6)	26545 (0.6)	2568 (1)	6838 (0.8)	14998 (0.7)
Disabled, 18 to 64	770423 (4.8)	19193 (7.4)	84944 (4.3)	126733 (4.4)	167045 (5.6)	26281 (4.6)	200964 (4.8)	16390 (6.2)	33315 (3.8)	95558 (4.8)
Disabled, 65 or older	765211 (4.8)	13971 (5.4)	88399 (4.4)	151865 (5.3)	152262 (5.1)	28414 (4.9)	194678 (4.7)	13591 (5.2)	35640 (4.1)	86391 (4.3)
Education (Population 25 or older)										
Less than 9th grade	871991 (7.8)	6566 (3.7)	102661 (7.5)	173693 (8.7)	216922 (10.5)	12624 (3.1)	231567 (7.6)	6941 (3.8)	30237 (5.1)	90780 (6.5)
9th to 12th grade, no diploma	799380 (7.1)	13010 (7.3)	80298 (5.8)	160247 (8)	190629 (9.2)	19019 (4.7)	205131 (6.8)	11970 (6.6)	28277 (4.8)	90799 (6.5)
High school graduate or equivalency	2712581 (24.2)	48886 (27.4)	381162 (27.7)	557912 (28)	521845 (25.2)	105764 (26)	546564 (18)	49802 (27.4)	138646 (23.4)	362000 (26)
Some college, no degree	1591220 (14.2)	29685 (16.7)	207301 (15.1)	306995 (15.4)	296722 (14.3)	67373 (16.5)	357335 (11.8)	32737 (18)	82910 (14)	210162 (15.1)
Associate's degree	722796 (6.4)	20284 (11.4)	80067 (5.8)	147489 (7.4)	155607 (7.5)	29867 (7.3)	153433 (5.1)	17722 (9.8)	38489 (6.5)	79838 (5.7)
Bachelor's degree	2618406 (23.3)	32909 (18.5)	327657 (23.8)	393401 (19.7)	401038 (19.3)	103429 (25.4)	844545 (27.8)	33136 (18.2)	160083 (27.1)	322208 (23.1)
Graduate or professional degree	1914584 (17.0)	26817 (15.1)	196557 (14.3)	253119 (12.7)	292060 (14.1)	69335 (17)	696758 (23)	29364 (16.2)	112776 (19.1)	237798 (17.1)
Employment (Population 16 or older)										
In labor force	8394177 (64.7)	134452 (62.2)	1059462 (66.2)	1419055 (61.7)	1486055 (61.8)	301482 (64.3)	2335619 (67.2)	140166 (64.1)	465927 (66.7)	1051959 (65.7)
In labor force, employed	7868132 (60.6)	127011 (58.7)	997145 (62.3)	1325323 (57.7)	1383120 (57.5)	287012 (61.2)	2190525 (63)	132125 (60.5)	438850 (62.8)	987021 (61.7)
In labor force, unemployed	526045 (4.1)	7441 (3.4)	62317 (3.9)	93732 (4.1)	102935 (4.3)	14470 (3.1)	145094 (4.2)	8041 (3.7)	27077 (3.9)	64938 (4.1)
U-6 Unemployment Rate	-- (6.3)	-- (5.5)	-- (5.9)	-- (6.6)	-- (6.9)	-- (4.8)	-- (6.2)	-- (5.7)	-- (5.8)	-- (6.2)
Commuting	7656362 (--)	123325 (--)	974525 (--)	1283701 (--)	1337384 (--)	280965 (--)	2137012 (--)	129066 (--)	428913 (--)	961471 (--)
Car, truck, or van -- drove alone	3038658 (39.7)	87562 (71)	599398 (61.5)	433328 (33.8)	453823 (33.9)	189651 (67.5)	394058 (18.4)	92012 (71.3)	297224 (69.3)	491602 (51.1)
Car, truck, or van -- carpooled	466620 (6.1)	11075 (9)	86792 (8.9)	72990 (5.7)	85261 (6.4)	21761 (7.7)	73958 (3.5)	10912 (8.5)	38601 (9)	65270 (6.8)
Public transportation (excluding taxicab)	2847672 (37.2)	6820 (5.5)	171132 (17.6)	601283 (46.8)	606797 (45.4)	40489 (14.4)	1113496 (52.1)	7402 (5.7)	38731 (9)	261522 (27.2)
Walked	532539 (7.0)	7633 (6.2)	37705 (3.9)	78216 (6.1)	86809 (6.5)	4386 (1.6)	259183 (12.1)	5936 (4.6)	9300 (2.2)	43371 (4.5)
Other means	210062 (2.7)	1994 (1.6)	19368 (2)	26873 (2.1)	25019 (1.9)	4727 (1.7)	88336 (4.1)	2881 (2.2)	10136 (2.4)	30728 (3.2)
Worked from home	560811 (7.3)	8241 (6.7)	60130 (6.2)	71011 (5.5)	79675 (6)	19951 (7.1)	207981 (9.7)	9923 (7.7)	34921 (8.1)	68978 (7.2)
Mean travel time (minutes)	37.86 (--)	21.91 (--)	32.04 (--)	45.44 (--)	41.62 (--)	38.7 (--)	36.06 (--)	30.28 (--)	34.17 (--)	36.86 (--)

	Total	Capital District Region	Hackensack/ Passaic Region	Jamaica Bay Region	Long Island Sound Region	Lower Bay Region	Lower Hudson/ East River Region	Mid-Hudson Region	Raritan Region	Upper Bay/ Arthur Kill Region
Industry										
Agriculture, forestry, fishing and hunting, and mining	10906 (0.1)	756 (0.6)	1036 (0.1)	1095 (0.1)	2054 (0.1)	523 (0.2)	2260 (0.1)	889 (0.7)	865 (0.2)	1428 (0.1)
Construction	427258 (5.4)	7308 (5.8)	59693 (6)	78330 (5.9)	89610 (6.5)	21383 (7.5)	83345 (3.8)	7791 (5.9)	23943 (5.5)	55855 (5.7)
Manufacturing	388127 (4.9)	8197 (6.5)	89320 (9)	41172 (3.1)	47686 (3.4)	13898 (4.8)	83985 (3.8)	7710 (5.8)	38870 (8.9)	57289 (5.8)
Wholesale trade	196314 (2.5)	2184 (1.7)	34836 (3.5)	28807 (2.2)	30591 (2.2)	7510 (2.6)	47913 (2.2)	2896 (2.2)	16356 (3.7)	25221 (2.6)
Retail trade	745345 (9.5)	13189 (10.4)	106600 (10.7)	127096 (9.6)	134604 (9.7)	29917 (10.4)	178155 (8.1)	15248 (11.5)	44809 (10.2)	95727 (9.7)
Transportation and warehousing, and utilities	526590 (6.7)	5127 (4)	70322 (7.1)	117519 (8.9)	93738 (6.8)	18052 (6.3)	99139 (4.5)	7670 (5.8)	33309 (7.6)	81714 (8.3)
Information	264610 (3.4)	2298 (1.8)	27094 (2.7)	32290 (2.4)	31805 (2.3)	8337 (2.9)	114097 (5.2)	2482 (1.9)	12968 (3)	33239 (3.4)
Finance and insurance, and real estate and rental and leasing	724176 (9.2)	7468 (5.9)	78002 (7.8)	96519 (7.3)	114832 (8.3)	32131 (11.2)	262635 (12)	7452 (5.6)	39772 (9.1)	85365 (8.6)
Professional, scientific, and management, and administrative and waste management services	1104233 (14.0)	13213 (10.4)	131188 (13.2)	136924 (10.3)	163292 (11.8)	38469 (13.4)	393350 (18)	13459 (10.2)	70257 (16)	144081 (14.6)
Educational services, and health care and social assistance	2055878 (26.1)	35767 (28.2)	238308 (23.9)	422951 (31.9)	386484 (27.9)	71608 (24.9)	523901 (23.9)	37786 (28.6)	96738 (22)	242335 (24.6)
Arts, entertainment, and recreation, and accommodation and food services	714790 (9.1)	12589 (9.9)	74294 (7.5)	110701 (8.4)	151128 (10.9)	20033 (7)	230300 (10.5)	12141 (9.2)	28330 (6.5)	75274 (7.6)
Other services, except public administration	386676 (4.9)	5909 (4.7)	49288 (4.9)	67360 (5.1)	84756 (6.1)	10763 (3.8)	100005 (4.6)	7066 (5.3)	17033 (3.9)	44496 (4.5)
Public administration	314895 (4.0)	12679 (10)	36180 (3.6)	63523 (4.8)	51760 (3.7)	13856 (4.8)	70325 (3.2)	6921 (5.2)	15426 (3.5)	44225 (4.5)
Military	8334 (0.1)	327 (0.3)	984 (0.1)	1036 (0.1)	780 (0.1)	532 (0.2)	1115 (0.1)	2614 (2)	174 (0)	772 (0.1)
Households	5973052 (100)	108162 (100)	712874 (100)	992396 (100)	1072028 (100)	215052 (100)	1746948 (100)	98617 (100)	299369 (100)	727606 (100)
Household composition										
Married Couple	2510829 (42.0)	37601 (34.8)	341924 (48)	440767 (44.4)	443947 (41.4)	120305 (55.9)	576965 (33)	44857 (45.5)	167703 (56)	336760 (46.3)
Cohabitating Couple	345104 (5.8)	10078 (9.3)	42358 (5.9)	42459 (4.3)	54329 (5.1)	10555 (4.9)	118478 (6.8)	7775 (7.9)	15679 (5.2)	43393 (6)
Male householder, no spouse/partner	1120257 (18.8)	24314 (22.5)	118598 (16.6)	167993 (16.9)	192151 (17.9)	30903 (14.4)	403703 (23.1)	17224 (17.5)	43008 (14.4)	122363 (16.8)
Female householder, no spouse/partner	1996862 (33.4)	36169 (33.4)	209994 (29.5)	341177 (34.4)	381601 (35.6)	53289 (24.8)	647802 (37.1)	28761 (29.2)	72979 (24.4)	225090 (30.9)
Households with one or more people under 18 years	1819538 (30.5)	27707 (25.6)	241606 (33.9)	330315 (33.3)	352055 (32.8)	68294 (31.8)	415882 (23.8)	27831 (28.2)	108863 (36.4)	246985 (33.9)
Household income										
Less than $10,000	414824 (6.9)	7238 (6.7)	40388 (5.7)	70402 (7.1)	87184 (8.1)	7246 (3.4)	138633 (7.9)	4893 (5)	11726 (3.9)	47114 (6.5)
$10,000 to $14,999	278379 (4.7)	5828 (5.4)	26595 (3.7)	51535 (5.2)	59396 (5.5)	6186 (2.9)	90246 (5.2)	4181 (4.2)	7303 (2.4)	27109 (3.7)
$15,000 to $24,999	278379 (4.7)	5828 (5.4)	26595 (3.7)	51535 (5.2)	59396 (5.5)	6186 (2.9)	90246 (5.2)	4181 (4.2)	7303 (2.4)	27109 (3.7)
$25,000 to $34,999	430286 (7.2)	11086 (10.2)	52505 (7.4)	79326 (8)	88288 (8.2)	11476 (5.3)	111801 (6.4)	7974 (8.1)	16512 (5.5)	51318 (7.1)
$35,000 to $49,999	575499 (9.7)	14033 (13)	69583 (9.8)	108115 (10.9)	115654 (10.8)	16383 (7.6)	150622 (8.6)	11009 (11.2)	25106 (8.4)	64994 (8.9)
$50,000 to $74,999	850868 (14.2)	18585 (17.2)	105432 (14.8)	151434 (15.3)	162738 (15.2)	30589 (14.2)	221789 (12.7)	14832 (15)	41836 (14)	103633 (14.2)
$75,000 to $99,999	680364 (11.4)	12639 (11.7)	85070 (11.9)	121450 (12.2)	121363 (11.3)	25401 (11.8)	180440 (10.3)	11586 (11.7)	37892 (12.7)	84523 (11.6)
$100,000 to $149,999	933700 (15.7)	15168 (14)	116869 (16.4)	156976 (15.8)	154871 (14.4)	40420 (18.8)	255606 (14.6)	18110 (18.4)	57843 (19.3)	117837 (16.2)
$150,000 to $199,999	525856 (8.8)	7150 (6.6)	66875 (9.4)	79798 (8)	74763 (7)	26380 (12.3)	155356 (8.9)	9197 (9.3)	34380 (11.5)	71957 (9.9)
$200,000 or more	815323 (13.7)	5616 (5.2)	94435 (13.2)	90909 (9.2)	108771 (10.1)	39298 (18.3)	308407 (17.7)	10167 (10.3)	50541 (16.9)	107179 (14.7)
Mean household income (dollars)	92647 (--)	76815.1 (--)	108697.25 (--)	93002.87 (--)	97669.24 (--)	132428.74 (--)	131722.16 (--)	101497.62 (--)	124832.91 (--)	116229.08 (--)
Gini Coefficient (income equality)	0.41 (--)	0.42 (--)	0.4 (--)	0.42 (--)	0.43 (--)	0.35 (--)	0.42 (--)	0.39 (--)	0.35 (--)	0.4 (--)
People in households below the poverty level	2311126 (14.4)	40632.217 (15.7)	245581.09 (12.3)	435498.261 (15.1)	501039.011 (16.7)	39277.309 (6.8)	695103.232 (16.7)	29420.272 (11.2)	80142.979 (9.2)	244431.465 (12.2)

Capital District Region

This region is located at the northern extent of the study area in New York state and is bisected north to south by the upper reaches of the Hudson River. This region is home to 259,195 people, which is the smallest region population in the HATS study area. The mean age is 39.8 years old, with 19% that are 18 or younger and 16.6% that are 65 or older. 72.6% of residents identify as White, 14.7% as Black, with the remainder identifying as other minority races. 31% of the 70 census tracts in the region meet the criteria for designation as a disadvantaged community. Eleven census tracts have 20-40% of residents with less than a high school education. All the tracts have less than 30% of people who are linguistically isolated. Compared to other regions, the Capital District has a higher percent of its population that lives with a disability (13.9% of all people in the region and 11 census tracts that have 19-38% of the population living with a disability).

Mid-Hudson Region

This region is also located in New York state, south of the capital region. There are 263,355 residents of the study area in this region, which is comparatively small for regions in the HATS study area. The mean age is 39.25 years old, with 19.4% that are 18 or younger and 16% that are 65 or older. 69.5% of residents identify as White, 14.2% as Black, with the remainder identifying as other minority races. 23% of the 60 census tracts in the region meet the criteria for designation as a disadvantaged community. Very few census tracts have 20-40% of residents with less than a high school education. None of the tracts have more than 30% of people who are linguistically isolated. 12.4% of the population lives with a disability.

Lower Hudson/East River Region

This region has 4,159,324 residents, which is substantially higher than the two regions to the north. A greater portion of the study area overlaps with the region and the population density is high. The age distribution similar to the northern regions (mean is 39.25, 18.3% 18 or under, 14.3% 65 or older). 50.7% of residents identify as White, 17.6% as Black, 14.3 as other race, and 10.5% as Asian. 57% of 464 census tracts in the region meet the criteria for a disadvantaged community. The number of tracts with a notable proportion of the population with low educational attainment is higher in this region than those to the north. 10.2% of people live with a disability, which is similar to other regions of the study area. There are more census tracts that have an elevated number of people that are linguistically isolated (56 have 30-60% of its population that is linguistically isolated). 34 census tracts have an elevated proportion of the population living with a disability (19-38% and 38-57%).

Upper Bay/Arthur Kill Region

This region is located in New Jersey, across the lower Hudson River estuary from New York. This region has 2,007,373 residents in the study area. It has the second highest percentage of its population that is 18 or younger (22.7%). 14.2% are 65 or older. 52% of residents identify as White, 23.2% as Black, 10.1% as Asian, and 9% identify as other race. 57% of the 415 census tracts in the region meet the criteria for designation as a disadvantaged community. 131 census tracts have elevated numbers of the population with low educational attainment (20% - 40% and 40% - 60%) and 34 census tracts have 30%-60% of their population who are linguistically isolated. 9.8% of residents live with a disability, with no tracts that are specifically elevated.

Lower Bay Region

This region is the southernmost in the study area and is located in coastal New Jersey. 576,208 people reside in the study area of the region. The mean age is the highest in the study area (41.74) but not notably so. 81.8% of the population identifies as White, 7.6% as Asian, and 4.6% as Black. 6% of the 108 census tracts in the region meet the criteria for designation as a disadvantaged community, which is very low compared to many of the study regions. 7.8% have less than a high school diploma, which is comparatively low for the study area, however there are specific tracts where 20-40% of the population have completed high school. Tracts do not have an elevated number of people that are linguistically isolated (none with over 30% of people). 10.1% live with a disability and one census tract has 19-38% living with a disability.

Hackensack/Passaic Region

This region is located in New Jersey, across the lower Hudson River estuary from New York including Manhattan. The population is 1,996,763. The mean age is 40.51 (22.3% are 18 or younger; 15.1% are 65 or older). 56.8% of residents identify as White, 14.4% as Black, 11.3% as Asian, 10.7% identify as other. 59% of the 398 census tracts in the region meet the criteria for designation as a disadvantaged community. 9.3% of the population lives with a disability. Few census tracts have an elevated portion of people living with a disability, though one census tract has 95% of its population living with a disability. There are 35 census tracts that have 30-60% of the population that is linguistically isolated. 13.3% of the population have less than a high school diploma, with 92 tracts having 20-40% of the population with low educational attainment and 10 tracts with 40-60% in that same category.

Raritan

This region is located in New Jersey and is the most western of the regions. The population is 872,853. 22.5% are 18 or younger and 14.2% are 65 or older (mean age is 40.56). 55.4% of residents identify as White, 19.6% as Asian, 13.1% as Black, 7.1% as other. 47% of the 157 census tracts in the region meet the criteria for designation as a disadvantaged community. 9.9% of the population has less than a high school diploma. There are some tracts that have a higher proportion of the population than the region; 18 tracts have 20-40% of the population, three that are 40-60% and one greater than 60%. 8.7% of the population lives with a disability, which is the lowest in the study area. This region has eight tracts with 30-60% of the residents being linguistically isolated.

Long Island Sound Region

Long Island Sound Region is to the east of the Lower Hudson/ East River Region and includes the northeastern portion of New York City. The coastline is touched by the sound. 70% of the 685 census tracts in the region meet the criteria for designation as a disadvantaged community, which is very high compared to many of the other regions and is the second highest after Jamaica Bay Region. 2,996,602 people reside in the study area of the regions. The mean age is 40.19, with the percent 18 or younger and 65 or older similar to other regions. The racial distribution has the largest spread in the study area: 37.7% of residents identify as White, 19.7% as Other, 19.5% as Black, and 16.8% as Asian. 11.7% of the population lives with a disability, and a few tracts have a high concentration of people that live with a disability. This region has a comparatively high number of tracts (303) where the population has elevated low educational attainment (20% of population or greater); 19.7% of the population in the study area do not have a high school diploma. This region has 11 tracts with greater than 60% of the residents being linguistically isolated.

Jamaica Bay Region

Jamaica Bay Region includes some of southeast New York City and the western portion of Long Island. It has a large amount of coastline, exposed to the Atlantic Ocean. 79% of the 810 census tracts in the region meet the criteria for designation as a disadvantaged community, which is the highest in the study area. 2,889,036 people live in the study area of the region. It is the only study area region for which the proportion of people who identify as Black (33.9%) and White (35%) are almost even. 16.2% identify as Asian and 9.8% identify as Other. 16.7% of the population does not have a high school diploma, which is higher than all by one region. Low attainment is concentrated in some census tracts and the number of total tracts with low educational attainment is high compared to the study area. The same is true for the number of tracts that have a high proportion of linguistic isolation. The proportion of people living with a disability is 9.3%. While there are few overall tracts that have a high percent of the population that lives with a disability, one has 57-76% of its population living with a disability and another with 76-95% of its population.

Throughout the study area, the three largest demographics are, respectively, white (non-Hispanic), Black, and Asian (U.S. Census Bureau 2020). These demographic characteristics show some differences, proportionally, between the various regions of the study area, as seen in Figure 1.2.

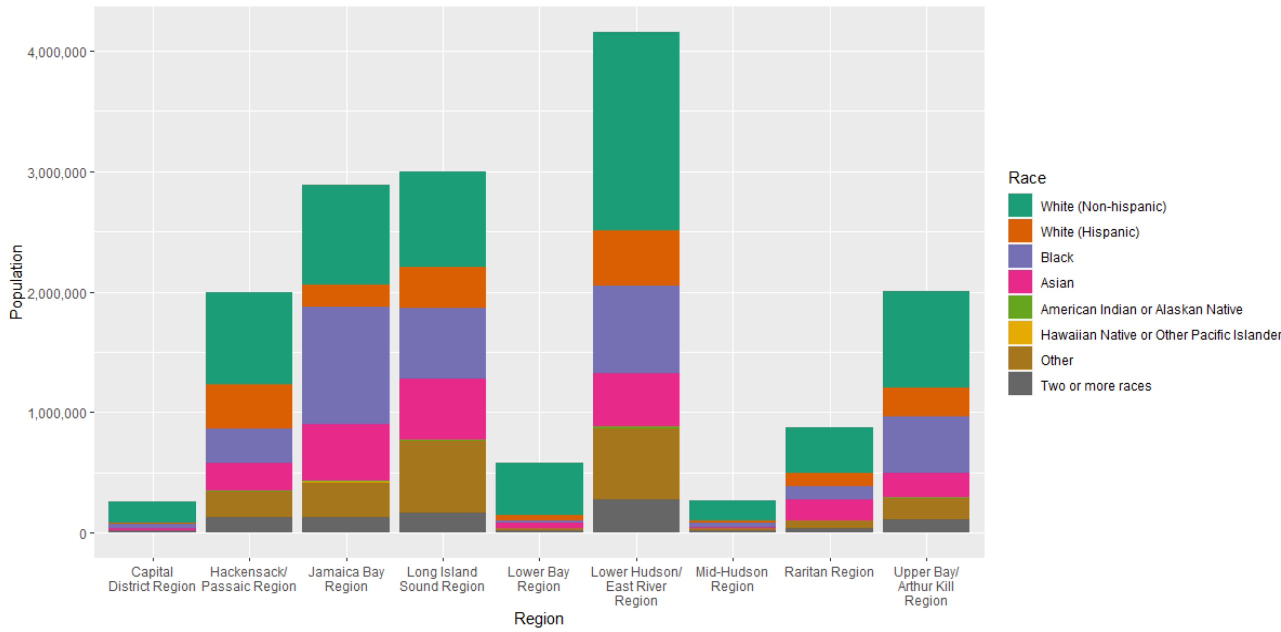


Figure 1.2 Population by Race in Each Study Region

The Figure 1.3 below shows educational attainment according to study region, normalized by the population.

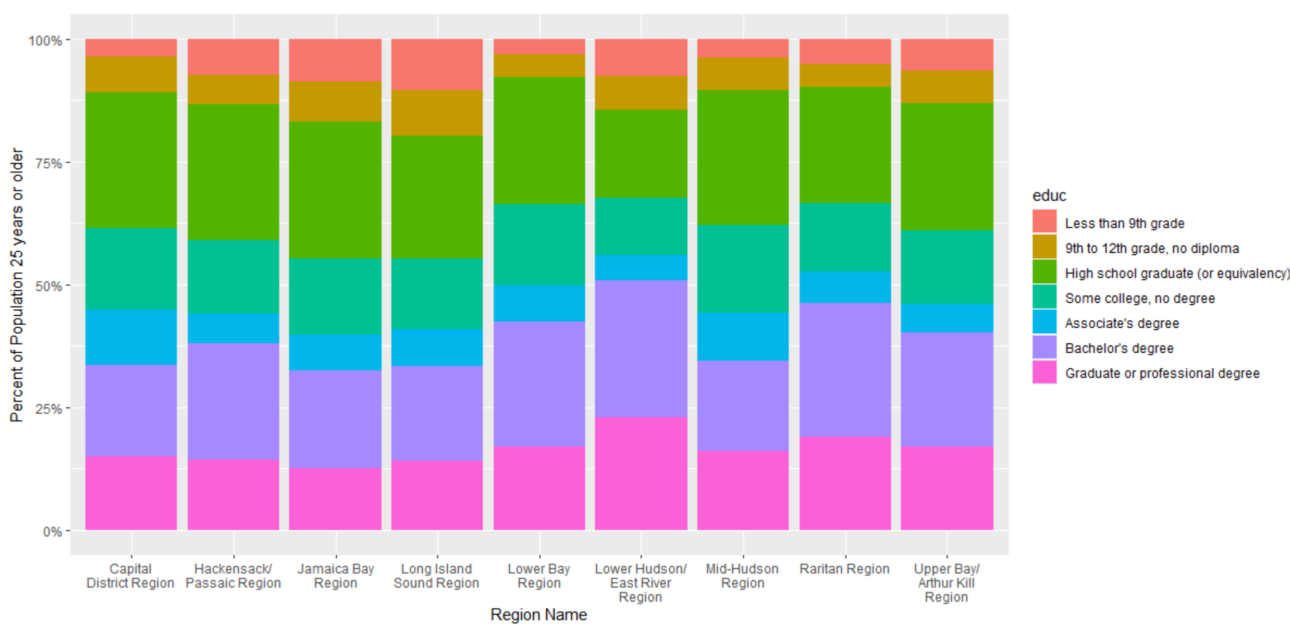


Figure 1.3 Educational Attainment by Study Region

1.2.2. Social Vulnerability in the Study area

Growing calls to action with respect to incorporating equity within government investment (White House 2021) justify a focus of this Appendix on potential disproportionate impact of coastal storm flooding on residents with characteristics indicative of elevated vulnerability. Vulnerability refers to three elements: exposure to hazards, sensitivity to hazards, and adaptive capacity, all of which are influenced by community and individual socio-economic characteristics. Elevated vulnerability can compound the direct and secondary consequences of a hazard. Although the terminology and exact definitions of social vulnerability, disadvantaged persons, and similar designations vary, the underlying premise is that characteristics of a person or group can affect how individuals experience and recover from adverse events. Targeting resources to achieve greater equity requires that decision makers are aware of and act on the specific circumstances of communities. Table 1.2 from Dunning and Durden (2011) summarizes common vulnerability characteristics and shows the connection to how they can impact hazard outcomes.

Table 1.2 Social vulnerability factors and their implications during and after floods (Table recreated from Dunning and Durden 2011)

Vulnerability factor	During event	Recovery (Resiliency)
Low income/poverty level	Lack of resources may complicate evacuation	Lack of resources may hinder ability to recover
Elderly/very young	Greater difficulties in evacuation, more health and safety issues, potential for higher loss of life	May lack resources, willingness, ability to rebound
Disabled	Greater difficulties in evacuation, more health and safety issues, potential for higher loss of life	Lack of facilities and medical personnel in aftermath may make it difficult to return
Female-headed households	Lack of resources and special needs may complicate evacuation	Lack of resources may hinder ability to recover
Minorities	Lack of influence to protect interests; lack of connections to centers of power or influence	Lack of influence to protect interests; lack of connections to centers of power or influence
Occupants of mobile homes/renters	Occupy more vulnerable housing	Potential displacement with higher rents
Unhoused	Difficult to locate and provide information to; difficult to estimate numbers	Difficult to locate and provide information to; difficult to estimate numbers

Similar to the idea of social vulnerability is the designation of communities as ‘disadvantaged’. The designation is intended to help inform decision making about investment. Within this assessment, census tracts are flagged as disadvantaged communities (DAC) if they meet either or both:

- Greater than or equal to 23.59% of the population is below the federal poverty level
- Greater than or equal to 51.1% of the population identify as minority.

This is further described in the section “Social Vulnerability, Resilience, and Environmental Justice”

2 Description of Alternatives

Although detailed descriptions of the alternatives can be found elsewhere in the NYNJHAT Study, this section provides brief overviews of each alternative, including estimates for the risk-reduced areas of each.

Alternative 1 is not evaluated in this OSE analysis; it is the future without the project (FWOP), meaning that it constitutes the baseline for comparison for the other alternatives. When alternatives receive a score of 0 in the analysis, it means they have the same anticipated outcome as the future without the project; this is what defines the current flood zone that the other alternatives seek to mitigate. However, this does not mean there will be no efforts to improve resilience or reduce coastal flood risks in the study area if the NYNHAT project does not proceed. Such efforts might be undertaken in the future but are not incorporated into the analysis at this time.

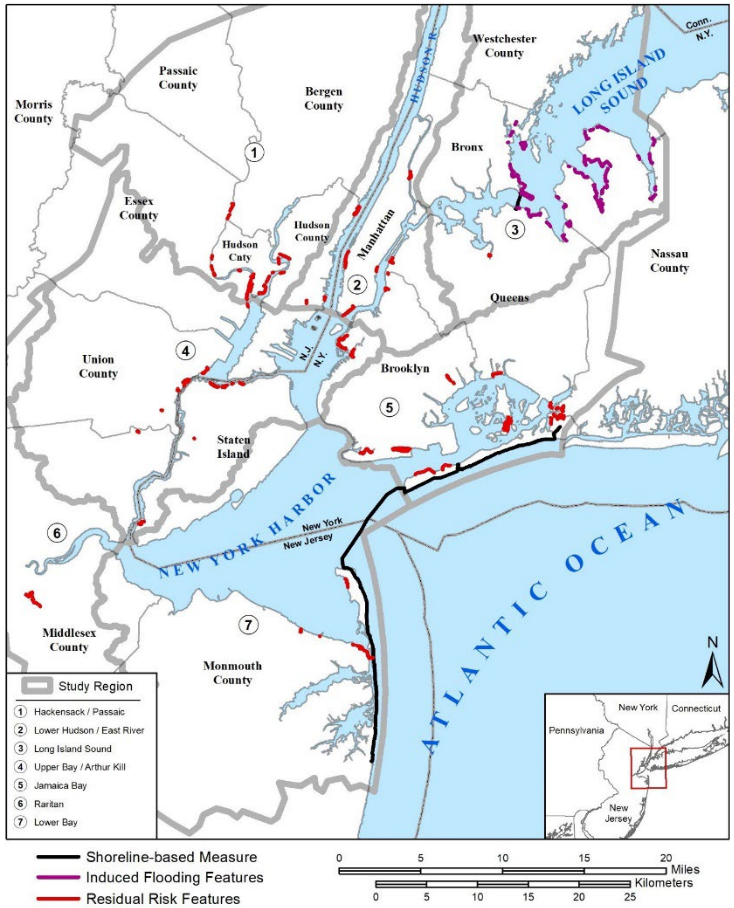


Figure 2.1 Alternative 2 Measures

For Alternative 2, the geography of the study area presents an opportunity to broadly address coastal storm surge and wave attack for the vast majority of the flood zones using offshore measures. Alternative 2 capitalizes on this opportunity, and is predominantly off-shore, in-water structures (storm surge barriers) as a levee, berm and surge gate/barrier system that connects Sandy Hook, New Jersey to Breezy Point of Rockaway peninsula and similar surge barrier enclosure along the East River just west of the Throgs Neck. For the scenario of the 1% flood (100-year return period) with 95% confidence level plus the intermediate relative sea level change at year 2095, Alternative 2 would reduce coastal storm flooding for 96% of the area.

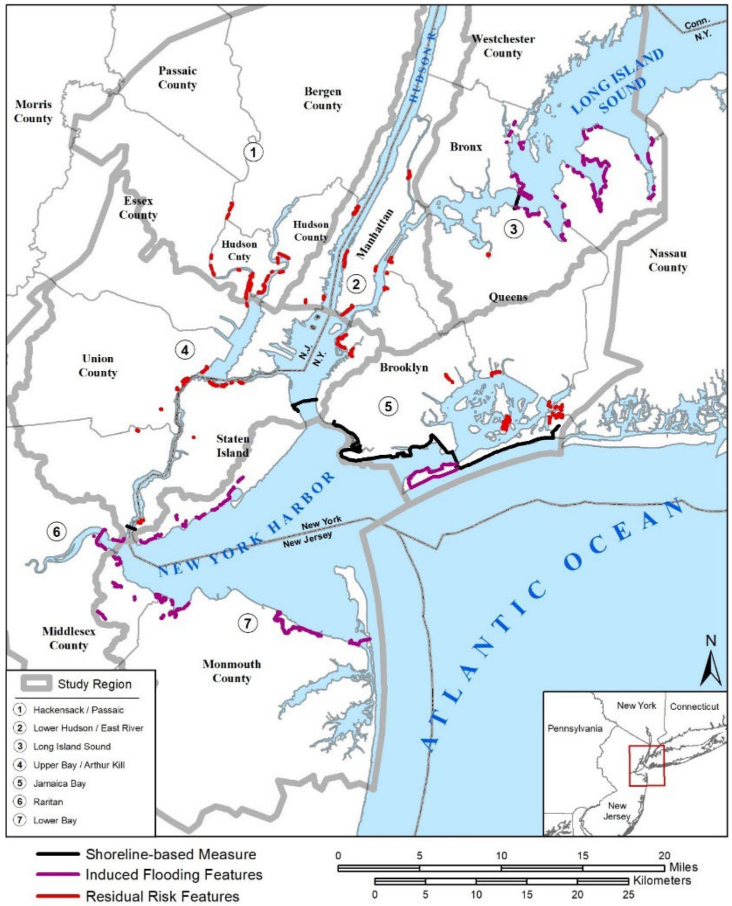


Figure 2.2 Alternative 3A Measures

Alternative 3A consists primarily of offshore storm surge barriers and shoreline-based measures and addresses storm surge for large and small rivers in two main areas on the coast: 1) Upper Bay, Newark Bay, Hudson River, East River, Harlem River, Passaic River, Hackensack River, Kill Van Kull and Arthur Kill (and numerous other creeks) and 2) Jamaica Bay, southern Brooklyn, Sheepshead Bay, southern Queens including Rockaway Peninsula (and numerous other creeks). The structures have induced flooding feature components to address flooding outside of the areas with the proposed structures under Alternative 3A. According to estimates for the 1% flood with 95% confidence level plus the intermediate relative sea level change at year 2095, the measures in Alternative 3A would reduce coastal storm flooding for 86.6% of the area expected to flood.

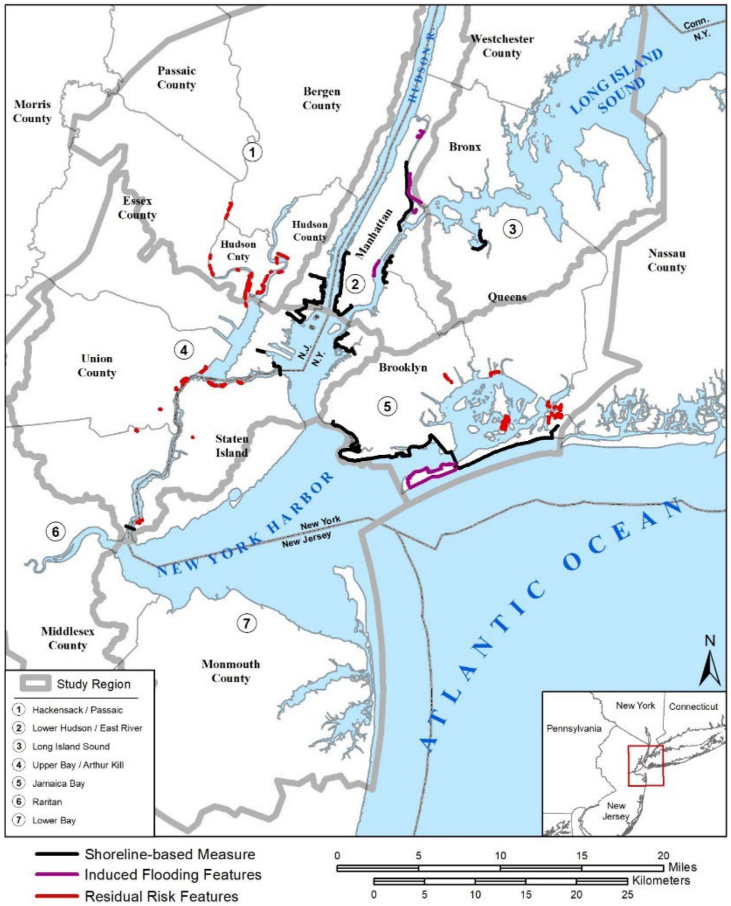


Figure 2.3 Alternative 3B Measures

Alternative 3B will have multiple storm surge barriers with three primary structural components on the individual creeks of Gowanus, Newtown and Flushing located in Brooklyn and Queens, and three primary structural shoreline-based measures in Jersey City, the lower west side of Manhattan, and East Harlem. The two primary structural components involving multiple storm surge barriers are: 1) a combination of storm surge barriers and surge gate structures in the southern Brooklyn to the mouth of Jamaica Bay and then to Rockaway Peninsula, Lower Brooklyn (the same component as in Alternative 3A above and Alternative 4 below), and 2) two storm surge barriers on the mouth of the Arthur Kill and Kill Van Kull tidal straits combined with shoreline-based measure to address coastal storm surge for the geographic areas of Newark Bay, Passaic River, Hackensack River, Kill Van Kull and Arthur Kill (and numerous other creeks). According to estimates for the 1% flood with 95% confidence level plus the intermediate relative sea level change at year 2095, the measures in Alternative 3B would reduce coastal storm flooding for 62.75% of the area expected to flood.

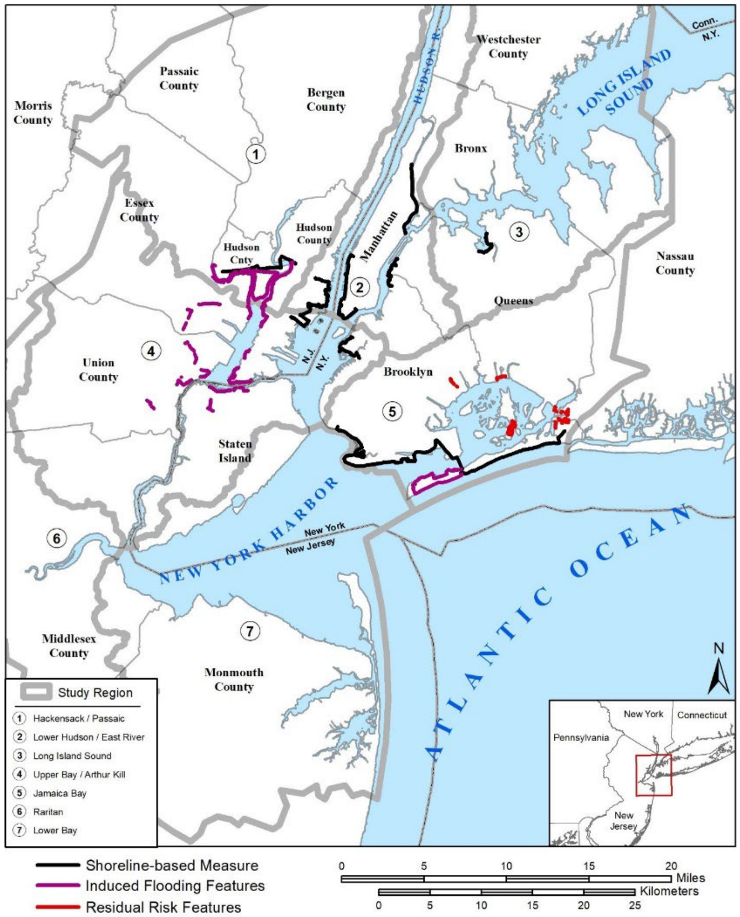


Figure 2.4 Alternative 4 Measures

Alternative 4 has one primary structure involving several storm surge barriers and then four components of storm surge barriers on various local rivers and creeks. The storm surge barriers involve a combination of shoreline-based measures along with surge gate structures that extend from southern Brooklyn to the mouth of Jamaica Bay and then to the Rockaway Peninsula, the same as Alternatives 3A and 3B above. The estimates for the 1% flood with 95% confidence level plus the intermediate relative sea level change at year 2095 indicate that the measures in Alternative 4 would reduce coastal storm flooding for 45.57% of the area expected to flood.

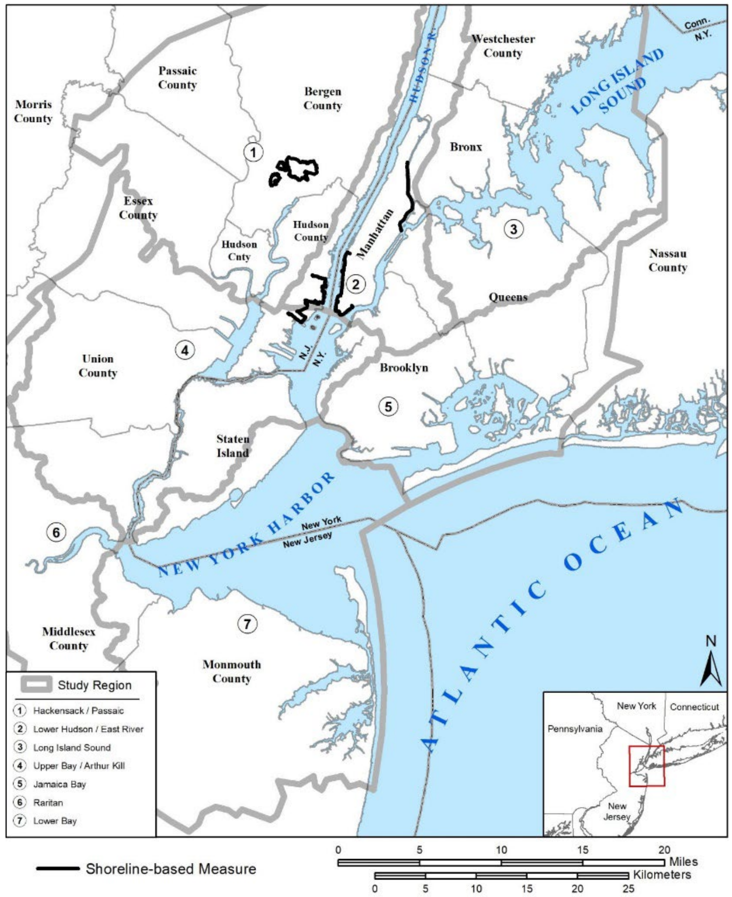


Figure 2.5 Alternative 5 Measures

In contrast with the other Alternatives, Alternative 5 does not have any large in-water features. Having only shoreline-based features is cost prohibitive for flood reduction measures for many areas addressed in the other alternatives with their in-water features. The four primary structural SBMs are located in the Hackensack Meadowlands, Jersey City, the lower west side of Manhattan, and East Harlem. The estimates for the 1% flood with 95% confidence level plus the intermediate relative sea level change at year 2095 indicate that the measures in Alternative 5 would reduce coastal storm flooding for 3.24% of the area expected to flood.

3 Measuring Other Social Effects of Flood Infrastructure

USACE projects seek to improve the lives of people in the United States. While this is often parsed into weighing the benefits against the costs of potential projects, such a formulation risks missing elements of well-being that are more difficult to measure and quantify. In accounting for Other Social Effects

(OSE), USACE considers the Humans Needs Theory of essential life components that people need to both survive and thrive (Dunning and Durden 2007). These include the seven factors that comprise the metrics for OSE analysis. Comparing OSE of a project's alternatives will provide a fuller understanding of both positive and negative impacts on peoples' lives and can help motivate the selection of one alternative over another to promote the highest well-being of affected communities.

The USACE IWR publication "Applying Other Social Effects in Alternatives Analysis" (IWR 2013) provides guidance for Districts to develop their own study-specific method for capturing and assessing the impacts of their respective projects. For each social factor, the OSE assessment team should identify appropriate metrics that indicate the ways in which alternatives can have a positive or negative impact. Durden and Wegner-Johnson (2013) provides sample metrics for the assessment team to select from and anticipates that the team will refine the set to suit their specific needs (see Table 3-1 in that publication).

The metrics serve to quantify how alternatives are expected to perform with respect to different aspects of community and individual well-being. The assessment team must select metrics that can be characterized for the study area and for which judgment can be reasonably made about whether the information is indicative of negative or positive impact. Metrics can be formulated as quantifiable data (e.g., number of people or distance to area of interest). This analysis provides a screening-level assessment (i.e., does not include any primary social data collection such as interviews) and is driven largely by geospatial data (demographic profile of communities, location of infrastructure with respect to areas at risk) and expert judgment.

The assessment will measure both positive and negative impacts of the alternatives. In general, positive impacts are related to losses that will be avoided due to risk reduction measures. These positive impacts materialize only when (and if) flooding conditions occur, which are many fewer days of the year than non-flood conditions. Some measures can also deliver benefits during non-flood conditions, such as flood barriers that provide elevated promenades for public enjoyment.

However, this OSE analysis also examines "everyday effects," meaning the impacts that the flood barriers will have for the local community on days when there are no floods. The flood measure alternative features each change the landscape, with varying consequences for social effects, e.g., public space accessibility, viewsheds, and important community buildings that existed prior to flood measure construction. These impacts to the status quo tend to be negative or negatively perceived when experienced on non-flood days, at least initially (Rasmussen et al. 2021).

The OSE assessment framework for the NYNJHAT study was formulated based on the IWR guidance (IWR 2013) and tailored to the study area's local context using the expressed interests of the non-federal sponsors and NAN planners. The OSE assessment team engaged with subject matter experts from NJ Department of Environmental Protection, NY Department of Environmental Conservation, New York City Mayor's Office of Climate and Environmental Justice, and New York City Health Department. This tailoring required examining the factors and metrics of OSE provided by IWR and seeking measurable criteria to assess them. The criteria need to provide useful information to the assessment (e.g., help to distinguish alternatives) and be practical to use. As the OSE assessment team sought to fulfill each metric for each factor, some metrics were deemed to be unusable or redundant. For example, the IWR factor “Social Vulnerability and Resilience” had three suggested metrics: “Residents of the Study Area”, “Socially Vulnerable Groups”, and “Housing Cost Burden.” However, total number of residents with reduced flood risk (by alternative), was better placed under the factor Physical and Mental Health and Safety and thus was removed from Social Vulnerability and Resilience. Similarly, the metric “Housing Cost Burden” was incorporated into “Socially Vulnerable Groups” because the methodology used to measure social vulnerability already incorporated housing. Thus, in Table 3.1, which shows the final criteria, the second column usually shows a single metric for each factor, with the exception of Physical and Mental Health and Safety, which retains two metrics.

The exercise to suggest criteria to fulfill the IWR framework produced many ideas, and it was not always certain that these criteria would provide meaningful information about the other social effects of the alternatives. Although the social effects of some criteria are self-evident (e.g. access to healthcare, in the factor of Health and Safety), a subset of criteria require justifications for inclusion in the OSE framework. These justifications, in terms of the relationship of these criteria to resident and community well-being, are included in the descriptions of the criteria in the next section. Some suggested criteria were ultimately omitted because the OSE assessment team could not establish a reasonable relationship to well-being, such as the two criteria considered to measure gentrification. Other suggested criteria were omitted because data were not available to consistently characterize the flood zone. The sections describing the factors and their criteria, below, each include a table listing the omitted criteria and the reason(s) they were omitted.

Table 3.1 displays the final metrics selected for inclusion in the framework.

Table 3.1 OSE Matrix formulated for NYNJHAT

Factors	Metrics	Criteria
Physical and Mental Health and Safety	Safety	Residents of Risk-Reduced Areas
		Access to Healthcare
		Population with Physical Vulnerabilities in Risk-Reduced Areas
	Health	Point Sources of Contamination in Risk-Reduced Areas
Economic Vitality	Business Climate	Business Buildings in Risk-Reduced Areas
Social Connectedness	Community Facilities	Community Buildings in Risk-Reduced Areas
Identity	Identity	Community Monuments in Risk-Reduced Areas
		Aesthetics of Barrier
Social Vulnerability and Resilience	Socially Vulnerable Groups	Intersection of Barrier with Environmental Justice Communities
		Environmental Justice Communities in Risk-Reduced Areas
		Socially Vulnerable Groups in Risk-Reduced Areas
		Life Expectancy for Residents in Risk-Reduced Areas
Participation	Public Participation	Reflection of Community Priorities
Leisure and Recreation	Recreational Activities	Change in Outdoor Recreation/Leisure/Nature Space

3.1. Sources of Data

Many of the criteria in Table 3.1 required geospatial analysis of the alternative measures and risk reduced areas to score. The basis for the geospatial analysis to score criteria related to reduced risk is the change in the spatial extent of the 100-year flood plain for each project alternative compared to that of the future without project condition. A risk-reduced area was calculated for each project alternative as any area which would no longer be inundated during the 100-year flood as a result of project measures. Because this calculation was based on flooding extent rather than depth, the risk reduced area for each alternative does not include any areas which remain inundated but would experience a reduction in flood depth under the 100-year flood.

The analysis was performed at the census tract scale. Because flood extents do not conform to political boundaries, an overlap analysis was used to calculate the percent area of each census tract which falls within the FWOP floodplain extent and risk reduced area for each project alternative to allow for proportional allocation of tract-level data for each tract based on the area at risk. The analysis was coded using R (R Core Team 2022) and the RStudio Integrated Development Environment (RStudio Team 2022). This analysis also relied heavily on the following R packages: Tidyverse (Wickham et al. 2019), for data manipulation, calculations, and visualizations, Simple Features or sf (Pebesma 2018) for importing and manipulating spatial datasets, and Tidycensus (Walker and Herman 2022) for downloading U.S. Census boundary and attribute data.

The purpose of the geospatial analysis was to assess the social effects of each alternative based on who or what is located in the original flood plain and risk reduced area for each alternative rather than simply comparing flood extents under each alternative. This approach acknowledges the fact that reducing the extent of potential flooding only results in a reduction of risk if it occurs in an area where there are people or properties susceptible to adverse impacts as a result of that flooding. The geospatial analysis was used to assess and score the following criteria from Table 3.1, above: 1) residents of risk-reduced areas, 2) access to healthcare, 3) population with physical vulnerabilities in risk-reduced areas, 4) point sources of contamination in risk-reduced areas, 5) business buildings in risk reduced areas, 6) community buildings in risk-reduced areas, 7) intersection of barriers with environmental justice communities, 8) environmental justice communities in risk-reduced areas, 9) socially vulnerable groups in risk-reduced areas, and 10) life expectancy of residents in risk reduced areas. More information about the specific data and methods used to calculate scores for each of these criteria is included below.

3.2. Preserving Physical and Mental Health and Safety

These factors address basic needs for safety and health by insulating individuals and groups from flood risk. Such insulation is meant to reduce risk to people's physical well-being which in turn improves outcomes for mental well-being by reducing anxiety about safety and disruption. This section comprises two themes: safety and health. *Safety* relates to outcomes experienced during a flood event, and physical and mental *health* refers to the long-term consequences of the flood barrier's construction, some of which extend into everyday effects. Safety measures should provide a separation from floodwater, either by separation or escape. Health measures ensure that the broader environment before, during, and after the flooding is conducive to long-term health.

3.2.1. Safety

Residents of Risk-Reduced Areas

To evaluate the reduction in the number of people that would be negatively affected by flooding, the resident population of risk-reduced areas was estimated for each alternative compared to the resident population within the Future Without Project (FWOP) flood zone. Even if the residents are not present at the time of the flood, their access to shelter may be compromised, and the shelter itself may be damaged or destroyed. Thus, resident status in the flood zone is a criterion that relates flood impacts to well-being. Possible scores for each alternative range from 0 (no residents in the risk-reduced area) to 3 (the resident population of the risk-reduced area equal that of the FWOP floodplain). Population data for each census tract in the study area was downloaded from the U.S. Census Bureau's American Community Survey 2016-2020 5-year estimates (U.S. Census Bureau 2020d) using the Tidycensus R package (Walker and Herman 2022).

Access to Healthcare

This criterion presumes that health care facilities provide a service to the broader population, and thus the benefits are not limited to people within the flood risk area. The analysis used the New Jersey and New York statewide databases from HAZUS (FEMA Flood Map Service Center 2019) to identify the locations of hospitals within the study region. Scores range from 0 (no hospitals in the risk-reduced area) to 3 (the risk-reduced area encompasses all hospitals in the FWOP floodplain).

Population with Physical Vulnerabilities

It was assumed that populations with physical vulnerabilities would have more difficulty evacuating to avoid flooding. Therefore, alternatives should be compared based on their impacts to known populations with physical vulnerabilities. To score this criterion, the number of people with physical disabilities living in the risk-reduced areas was calculated for each alternative. Scores were between 0 (risk-reduced areas do not include any people with physical disabilities) and 3 (risk-reduced areas cover all areas in the flood zone with populations of people with physical disabilities). Disability data for each census tract in the study area was downloaded from the U.S. Census Bureau's American Community Survey 2016-2020 5-year estimates (U.S. Census Bureau 2020a) using the Tidycensus R package (Walker and Herman 2022).

3.2.2. Health

Point Sources of Contamination in Risk-Reduced Areas

During flooding, dangerous chemicals or bacteria that are normally contained by designated facilities or sites can become mobilized. This type of disaster is increasingly being recognized, in which the impacts of a natural disaster cascade into other disasters, like access to critical infrastructure (Hendricks and Van Zandt 2020). Exposure to contaminants can present significant health issues in the near and longer term. In this assessment, proximity of residents to potentially hazardous sites, often called Locally Unwanted Land Uses (LULUs), is considered to increase their risk of exposure if a flood occurs.

The analysis used the New Jersey and New York statewide databases from HAZUS (FEMA Flood Map Service Center 2019) to identify the locations of point-sources of contamination within the study region. Point-sources of contamination from the HAZUS databases included hazmat facilities, natural gas facilities, oil facilities, and wastewater facilities. Alternatives were scored between 0 (no point sources of contamination in the risk-reduced area) to 3 (all contamination sources in the flood zone are encompassed in the risk-reduced area).

Criteria not Included in Health and Safety

Table 3.2 Criteria not included in Health and Safety

Rejected Criteria	**Details**	**Reason for exclusion**
Population most vulnerable to electricity outages	Relevant to buildings with elevators, people reliant on home-care medical equipment	No reliable way to measure at the Tier 1 level of analysis
Total number of people in the risk-reduced areas	In addition to residents of flood zone, people who work, learn, or recreate in those areas	No reliable way to measure at the Tier 1 level of analysis. Depends on time of day and whether evacuation orders are issued, and when.
Evacuation zones	Evacuation zones in the risk-reduced areas as a proxy for areas with most difficulty traveling	Data were not available for entire project area
Inundation of distribution points for emergency supplies	Access to emergency supplies assists with recovery	Distribution points are highly dynamic. If some are inundated, others will open. No reliable way to measure impact from any one event due to this complexity.
Home damage	Experiencing home damage is bad for mental health.	This is already factored into the Safety criterion “Residents of Risk-Reduced Areas”, which measures flood

		inundation intersecting with residences.
Mental health improvements due to perceptions of increased safety	Could the presence of a barrier improve mental health for residents in risk-reduced areas?	There was no methodology to establish which residents might be affected, nor how to measure the effect.
People who experience social isolation	Could this vulnerability further exacerbate the impacts of flooding?	No, this data is not available spatially.
Access to transportation for evacuation	Car ownership is indicative of mobility for many parts of the country, but the relationship is not as clear for urban areas.	Car ownership data is available, but the urban area of Manhattan and its environs have many non-car options for mobility. Unclear whether this metric is relevant to the study area.
Uninsured Population	Are uninsured people more vulnerable to flooding, in terms of health and safety?	No reliable way to measure this for the study area.

3.3. Economic Vitality

This factor refers to the local economy's ability to provide a good standard of living for residents into the future. This might include aspects such as employment opportunities, income, poverty rates, unemployment trends, educational opportunities, and access to essential consumer goods. However, the process of generating economic vitality criteria showed that many of these criteria were measured within other factors, such as social vulnerability, which incorporated low-income populations and employment rates. Additionally, some metrics are not expected to change according to alternative (such as access to essential consumer goods). Others did not have available data. Thus, economic vitality was measured based on the single criteria below.

Reduced Flood Risk to Businesses

The flood measures will reduce risks to businesses in the flood zone, and this should improve the long-term economic vitality for the neighborhood. Reduced risk for businesses is measured by the number of commercially and industrially zoned buildings in the risk-reduced areas of the alternatives. It is scored linearly from 0 (no commercial or industrial areas in the risk-reduced area) to 3 (all commercial and industrial areas in the flood zone are within the risk-reduced area). Commercial and industrial building counts were gathered from the HAZUS New Jersey and New York statewide databases (FEMA Flood Map Service Center 2019).

Criteria Not Included in Economic Vitality

Table 3.3 Criteria not included in Economic Vitality

Rejected Criteria	**Details**	**Reason for exclusion**
Intersection of barrier with commercial districts	Coarse estimate of disruptions in business districts due to the barriers.	Date not available for entire study area
Tourism	Better situated in the NED analysis	Not applicable; better situated in the NED analysis than in OSE
Changes in business rent after implementation of barrier	This could change the commercial landscape in neighborhoods	No predictive power to estimate change in business rent. Additionally, some people might benefit from changes.

3.4. Social Connectedness

Social connectedness refers to the stability and predictability of the social networks that provide meaning and structure to life. Civic infrastructure can provide individuals with opportunities to foster and maintain connections.

Community Buildings in Risk-Reduced Area

The flood measures will reduce risks to community buildings in the flood zone, and this should improve social cohesion, especially after a flooding event. Reduced risk for community buildings is measured by the number of religious, governance, and education buildings in risk-reduced areas of the alternatives. This criterion is scored from 0 (no community buildings in the risk-reduced area) to 3 (all community buildings in the flood zone are within the risk-reduced area). Community building counts were gathered from the HAZUS New Jersey and New York statewide databases (FEMA Flood Map Service Center 2019).

Criteria Not included in Social Connectedness

Table 3.4 Criteria not included in Social Connectedness

Rejected Criteria	Details	Reason for exclusion
Intersection of barrier with community buildings	Whether flood measure will require demolishing community buildings	Data were not available to reliably measure at the Tier 1 level of analysis.
Residents of risk-reduced areas	Displacement by flooding disrupts peoples' ability to participate in social networks.	This criterion was measured earlier in Health and Safety
Other types of community buildings (e.g., community centers)	Religious, governance, and education buildings are not sufficient to capture community engagement spaces	Data were not available to reliably measure at the Tier 1 level of analysis.
Housing vacancies	Housing vacancies could indicate that displaced residents could find housing within their existing community	Unclear whether housing vacancies have a relationship to social connectness

3.5. Identity

Identify refers to a person's sense of self as well as their "cultural security" within their community (IWR 2009) which, if violated, can reduce well-being. This factor considers what might indicate a community with strong identity, which could indicate a lack of vulnerability. In contrast with the Social Connectedness factor, the Identity factor is demarcated as conferring passive experiences, where a person gains an identity via shared connections to recognizable features of their communities. These criteria required considerable efforts to score and justify.

Community Monuments in Risk-Reduced Areas

Community monuments often appear on town emblems or seals, such as the USACE castle logo. Monuments represent a "memory with purpose," meaning the beliefs and ideas about the past that give a society a lens to understand both its past, present, and by implication, its future (Anderson 1983; Bodnar 1992; Kammen 1993; Rothman 1994; Barber 2004). This can occur on different scales, where local monuments can provide a broader living narrative that gives shape to a city and its inhabitants (Evans and Lees 2021). Monuments are designed to create an emotional tie to a past, which might well be imagined (Reich 2020; Doss 2010). As such, the protection of such monuments through flood risk reduction measures can constitute a social benefit for the surrounding community. Such benefits are only evident during periods of storm surge, but the knowledge that risk reductions are benefiting important community monuments may sway stakeholders to support one alternative over another.

To develop scores for the community monuments, the analysis summed counts of properties in the National Register of Historic Places, Historic districts (which are groups of historic properties, features, and landscapes in the National Register), National Register-eligible properties, National Register-eligible districts, National Historic Landmarks, and municipal designations of individual landmarks and landmark districts. It is possible there was some overlap for these counts, but further analysis would be needed to identify and remove them. The counts used are shown in the results.

Aesthetics of Barrier

Flood protection projects have encountered opposition due to impacts on aesthetics (Fordham 1999; Clarke et al. 2018), and views in New York have demonstrable value: a residence's view over the park or river is worth 10-15% more in rent or purchase price to its inhabitants (Biggs 2019). The Metropolitan NY-NJ Working Group for the NYNJHAT study has referenced the high walls in some alternatives as "controversial as to…how much view and access to the waterfront would be lost" (USACE 2019) and community members have called the plans for such measures "unsightly" (Barnard 2020). As such, impacts to aesthetics could have a large role in determining community support for the project.

Under National policy, aesthetic resources can be protected along with other natural resources. (USACE 2000). USACE (1988) stresses implementation during the planning process, though it includes considerations for evaluating alternatives. Of the three measures that USACE (1988) suggests, two measures consider initial conditions and surrounding conditions. This emphasis on existing visual resources supports USACE (2000) in its assertion that the impact of aesthetic changes depends on the surrounding environment, for example "a concrete channel without aesthetic treatment may not be visually objectionable in a heavy industrial area." However, when comparing residential areas, such a precedent could enable less aesthetic consideration in neighborhoods that already experience a lack of aesthetic value, which contrasts to this project's goals of environmental justice and equity. Therefore, the analysis focuses on the remaining measure of USACE (1988): degree of structure or project visibility.

This analysis was not able to differentiate the alternatives by the number of people viewing the flood measures, as suggested in USACE (1988), because the region is densely populated and the people within it are highly mobile, both on the ground and vertically in tall buildings. This analysis also did not consider possible aesthetic mitigations that may be applied.

To evaluate the degree of structure of project visibility, the project team considered:

a) Type of feature
b) Length of feature
c) Proximity to shore

First the project team subjectively ranked the types of features in terms of aesthetics, from least aesthetically offensive to most offensive: deployable flood barrier (most of the time not deployed), elevated promenade, buried seawall dune, levee, tide gate, storm surge barrier, seawall, and floodwall. The project engineers reviewed these assumptions and approved the ordering. The analysis also assumes that shorter length is preferred for any constructed measure when considering aesthetics, and proximity to shore is more disruptive to views. Figure 3.1 plots the lengths of features of the different alternatives, ordered loosely by aesthetic preference (from least preferred to most preferred, colored red to green respectively),

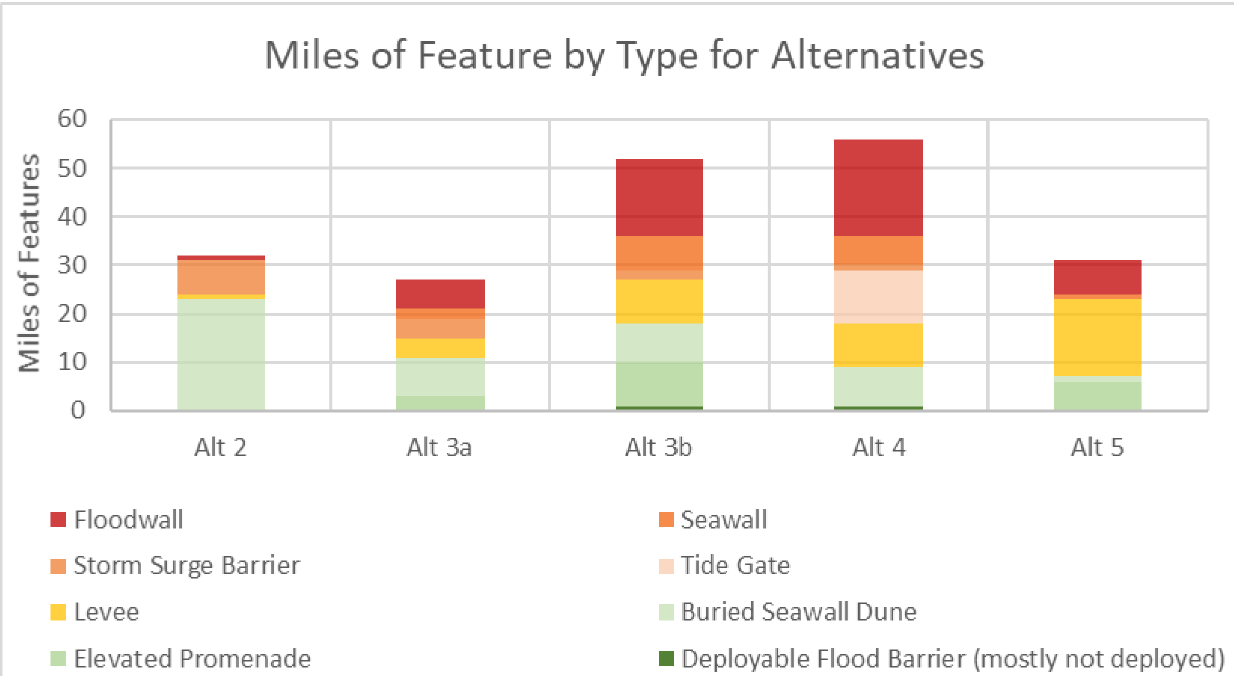


Figure 3.1 Miles of feature by type for alternatives

Figure 3.2 shows the lengths of features of the different alternatives, again ordered by aesthetic preference. The lengths of the features are displayed in both text and as the size of the bubble. The blue text indicates that the features are located offshore rather than on the shoreline. Alternatives with less overall length and less disruptive feature types or offshore will receive higher scores, shown at the bottom.

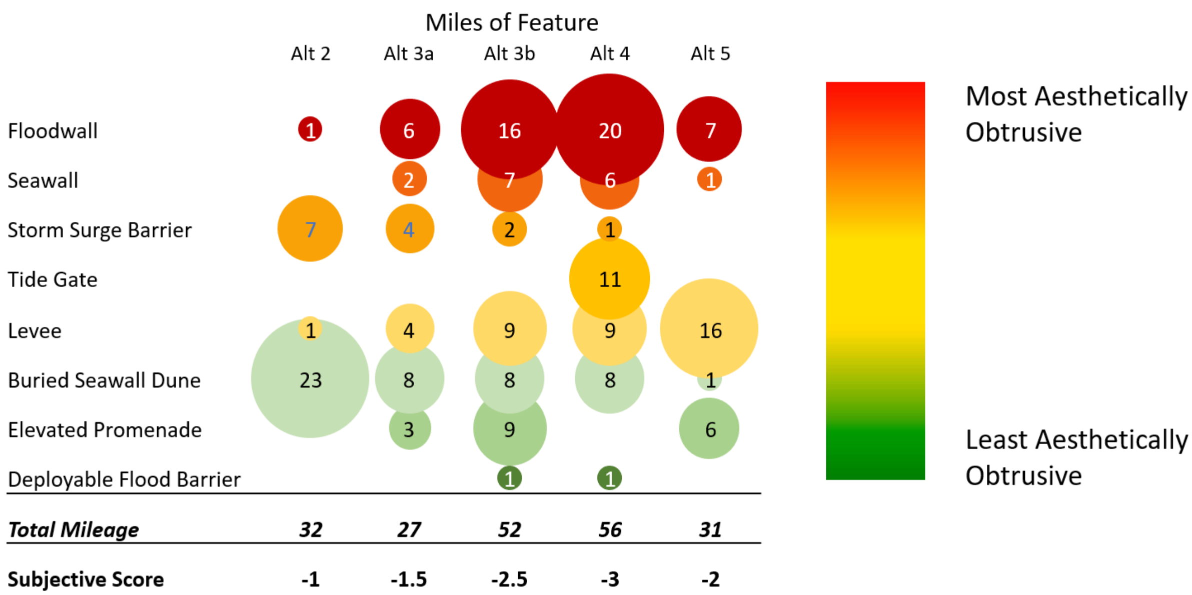


Figure 3.2 Miles of feature by type

After reviewing this table, Alternative 4 receives the lowest score for aesthetics (-3), and Alternative 2 the best score (-1). The three others fall between them, Alternative 3B receives -2.5, Alternative 5 receives -2, Alternative 3A receives -1.5.

This alternative ranking has many limitations: the study was not able to consider the public perceptions of the barriers as the plan is still developing final versions, nor were visual assessments able to make use of simulated visualizations of alternatives from multiple angles. It is also assumed that even the most favorable visible features (elevated promenade and buried seawalls) are still a net negative, rather than a positive that might cancel out other negatives. This evaluation is meant to approximately estimate viewshed impacts based on fairly simplistic information and assumptions.

3.6. Social Vulnerability, Resilience, and Environmental Justice

Social vulnerability is the susceptibility of social groups to primary and secondary impacts of adverse events, such as death, injury, loss, or livelihood disruption (FEMA n.d.). Resilience refers to a community's ability to respond to and recover from a disruptive event, to return to or improve the pre-disaster norm. The concepts of vulnerability and resilience are often related to each other in natural disaster risk research because social vulnerability is associated with lack of resilience. For this factor, the OSE assessment team examined a variety of community resident characteristics that can indicate elevated vulnerability and potentially lower resilience. That is, the team worked to identify geographic locations in the study area where flooding might have undue effects on residents or might be disproportionately impacted by the flood risk reduction measures.

Environmental justice (EJ) communities are those that have historically borne the brunt of harms from development that benefits the broader population due to lack of equity of environmental protections. EJ communities are defined by their proximity to locally unwanted land uses (LULUs)—e.g., landfills, industrial factories, or highways—that tend to "negatively impact the health of a community's environment, along with the physical and mental health of its citizens" (Arriens et al. n.d.). EJ communities are disproportionately affected or 'overburdened' with negative consequences of human development and activity as compared to other groups of people (racial, ethnic, or socioeconomic) (NYDEC, 2003). The Department of Energy defines EJ as ensuring that "no population bears a disproportionate share of negative environmental consequences resulting from industrial, municipal, and commercial operations or from the execution of federal, state, and local laws; regulations; and policies."

The introduction of this Appendix lists the federal mandates related to EJ and more related policies are specified in the Final Interim Implementation Guidance of Environmental Justice and the Justice40 Initiative (Dept. of the Army 2022). The Guidance emphasizes moving beyond "doing no harm" to help improve access to benefits provided by Civil Works projects. Within this OSE assessment, flood loss avoidance is considered the primary benefit, where flooding is an additional burden to EJ communities, which are already overburdened. This fits in the framing of cumulative impacts, which has been conceived of for EJ to describe how some communities are burdened with a wide variety of stressors that are essentially more than the sum of their parts.

Most designation criteria for identifying EJ communities include components of community identity that indicate disadvantage and likely a lack of political empowerment. This recognizes that historic processes of injustice have led to present-day disparities among different demographic groups (Keeler et al., 2020). The Draft Climate and Economic Justice tool, currently under development by the White House Council on Environmental Quality (The White House, 2022), preliminarily labels a community as disadvantaged in categories like climate or clean energy only if the community meets three criteria: it must have a high exposure to an environmental hazard (as defined by a threshold, unique to each hazard), be below the 65th percentile for low income households, and exceed the 80th percentile of population not enrolled in higher education.

New York and New Jersey both approach EJ from the point of social vulnerability (Table 3.5); New York City states that socially vulnerable communities are "more vulnerable to potential environmental injustices due to factors including history of systemic racism and inequitable resource distribution" (NYC Mayor's Office, 2021).

Table 3.5 State policy definitions for Environmental Justice Community delineation

Jurisdiction	Law	Low Income	Minority	English Proficiency
New York Department of Environmental Conservation	Potential Environmental Justice Area defined by New York Commissioner Policy 29	>= 23.59% is below the federal poverty level	>= 51.1% identify as minority in urban community or 33.8% in rural community	
New Jersey	Overburdened Communities defined by New Jersey Environmental Justice Law, N.J.S.A. 13:1D-157, (Law)	>= 35% at or below twice the federal poverty	>= 40% identify as minority	>= 40% of the households have limited English proficiency

To delineate Environmental Justice communities for this study, the Environmental Protection Agency Environment Justice Screen tool is used to characterize pollution burden (see methodology below). Census tracts that meet the New York State criteria for Potential Environmental Justice Areas (Table 3.5) are also identified so that the co-occurrence of pollution burden and socio-economic disadvantage can be observed.

Census tracts are flagged as disadvantaged communities (DAC) if they meet either or both:

- Greater than or equal to 23.59% of the population is below the federal poverty level
- Greater than or equal to 51.1% of the population identify as minority.

EJSCREEN was created and refined over the past decade by the US EPA to "develop a nationally consistent environmental justice screening and mapping tool" to support their public health and environmental responsibilities (US EPA 2019). The tool allows users to geospatially highlight areas according to environmental and demographic indicators of concern. As the name suggests, the tool is intended to help screen areas of interest that merit greater inquiry. The tool has been peer reviewed, updated frequently since its conception, and is well documented (US EPA 2019).

EJSCREEN data was downloaded from: https://gaftp.epa.gov/EJSCREEN/ →2021→ state_pcntile_tracts.

Note that data was downloaded for census tract level for this screening assessment. Data is also available at the same link for the census block group level.

EPA selected the environmental indicators (Table 3.6) to include in the tool based on extensive studies to determine the appropriate ones to estimate risk, pollution levels, or potential exposure. The list is not comprehensive, and the documentation lists many other possible pollutants that are worthy of consideration. The EJSCREEN tool employs a unique methodology to calculate a score for each environmental indicator, each being tailored to the appropriate way to characterize risk. For example, some of the indicators are estimates of potential exposure or health risk, quantified in terms of emissions, concentrations, or risk estimates. Some account for the probability of exposure by incorporating proximity into the scoring methodology (see US EPA 2019 for detailed description of all calculation methodologies including data sources, assumptions, and limitations).

Table 3.6 EPA-developed EJSCREEN Environmental Indicators employed to characterize the pollution burden on communities

Environmental Indicator	**Description**
Particulate Matter 2.5	Annual average PM2.5 concentration in the air
Ozone	The May-September (summer/ ozone season) average of daily maximum 8-hour-average ozone concentrations in the air
Diesel Particulate Matter	Diesel particulate matter concentration in the air
Air Toxics Cancer Risk	Lifetime cancer risk from inhalation of air toxics
Air toxics Respiratory Hazard Index	Ratio of exposure concentration to health-based reference concentration
Traffic Proximity	The count of vehicles per day within 500 meters of a block centroid with proximity adjustment
Lead Paint*	Percentage of housing units built before 1960, as an indicator of potential exposure to lead
Risk Management Plan Facility Proximity	The count of facilities that require a Risk Management Plan within 5 km with proximity adjustment
Hazardous Waste Proximity	The count of all commercial treatment, storage, and disposal facilities (TSDF) facilities with proximity adjustment
Superfund Proximity	The count of sites proposed and listed on the National Priorities List (NPL) (also known as Superfund) with proximity adjustment

Underground Storage Tanks (UST) and Leaking UST (LUST)	Count of LUSTs (multiplied by a factor of 7.7) and the number of USTs within a 1,500-foot buffered block group
Wastewater Discharge	The toxicity weighted concentration in stream reach segments within 500 meters of a block centroid with proximity adjustment

* Lead paint is omitted from the OSE assessment team method

The EJSCREEN tool does not aggregate information across environmental indicators and therefore does not provide a single score that can be used to quantify the extent of pollution burden on communities. The OSE assessment team used multiple dimensions of EJSCREEN information to understand pollution burden:

1. **Sum of normalized environmental indicator scores**: For each of the 11 environmental indicators (Table x with the exception of lead paint), the EPA-calculated scores were normalized to the study area so that each census tract has a unitless score between 0-1 for environmental indicators:

$$x' = \frac{(x - x_{\min\, of\ study\ area})}{(x_{\max\, of\ study\ area} - x_{\min\, of\ study\ area})}$$

   The 11 unitless scores were added together to generate a single value to represent pollution burden. The OSE assessment team recognizes that this aggregate score has shortcomings. EPA (2019) describes the rationale for not combining environmental indicators into one number: any form of aggregation is based on value judgments on how importance should be given to each of the environmental indicators. The risks associated with the environmental indicators are not easily comparable in terms of public health importance and public concern. While the assessment team acknowledges the inherent flaws of aggregation, this information is presented as one dimension of pollution burden, and the team believes it is an appropriate use of information at this stage of the assessment. Hers, all indicators are inherently weighted equally in terms of their contribution to the overall assessment of environmental justice.

2. **Count of Pollutants in Fourth Quartile of the Study Area**: The quartiles for the individual environmental indicator scores of census tract in the study area were calculated. Each score was binned into its respective quartile (0-25%, 24-50%, 50-75%, and 75%). The number of environmental indicator scores that were in the top quartile were counted. This serves to help understand how many elevated scores each census tract has, relative to the study area. A tract can have up to 11 elevated scores.

3. **Count of Pollutants above the Ninetieth Percentile in the Country**: EJSCREEN compares the scores of each census tract relative to all tracts in the country by using percentiles. The

percentile scores of each environmental indicator for each census tract is available in the EJSCREEN data. The number of environmental indicator scores that are in the ninetieth percentile for the country were counted in order to understand how many elevated scores each census tract has, relative to the country. A tract can have up to 11 elevated scores.

In order to layer demographic indicators and environmental indictors, census tracts were identified that meet the criteria for DAC and also have at least one environmental indicator from EJSCREEN that is in the 90th percentile for the country.

3.6.1. Environmental Justice Analysis Results

The three pollution burden dimensions described above are examined to understand the location of census tracts that are overburdened by sources of environmental harm. This information is also layered with demographic indicators for low-income and majority minority race, with the thresholds described above.

Distribution of Pollution Sources within the Study area

1. **Sum of normalized environmental indicator scores:** The sum of the 11 normalized EJSCREEN environmental indicator scores for census tracts in the study area range from zero to 5.5. Figure 3.3 shows the distribution of study area census tract scores. Approximately 600 tracts have a score in the range of 3-3.3, with the mean and median relatively similar. Table 3.7 shows the distribution of the scores in each of the study regions. Lower Hudson/ East River Region has the greatest proportion of its census tracts with score in the range of 3.46-5.46 (67%), followed by Upper Bay/Arthur Kill Region, Hackensack/Passaic Region, and Long Island Sound Regions with about 20% of tracts in that high category. Maps are shown in the next section for ease of comparison.

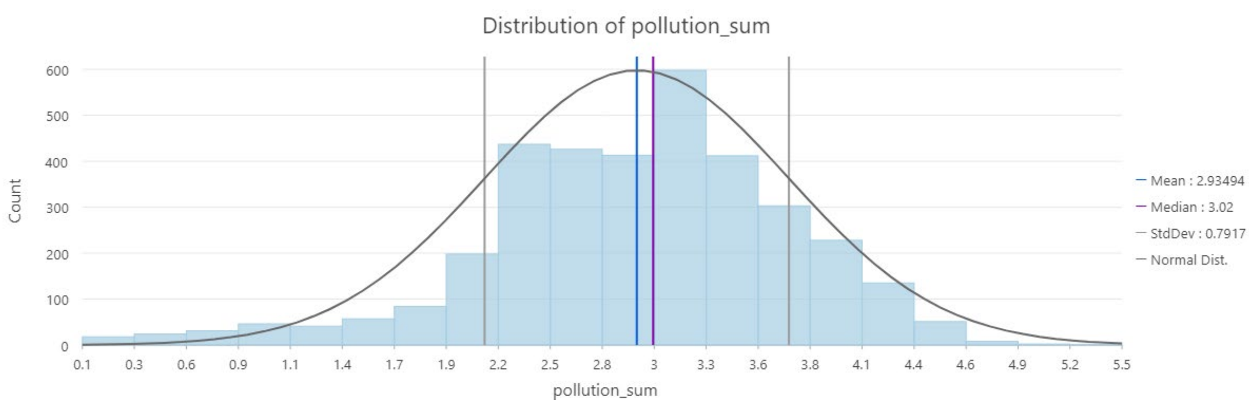


Figure 3.3 Histogram of census tracts, organized by the sum of normalized environmental indicator scores

Table 3.7 Regional distribution of pollution burden, as measured by the sum of normalized EJSCREEN pollutant source scores

	Capital District		Mid-Hudson Region		Lower Hudson/East River Region		Upper Bay/Arthur Kill Region		Lower Bay Region		Hackensack/Passaic Region		Raritan		Long Island Sound Region		Jamaica Bay Region	
	9		8		6		3		2		5		1		7		4	
No. census tracts	70		60		819		415		108		389		157		685		810	
0.05-2.45	70	100%	60	100%	70	9%	92	22%	104	96%	95	24%	103	66%	72	11%	215	27%
2.45-3.02	0	0%	0	0%	48	6%	150	36%	4	4%	123	32%	50	32%	249	36%	270	33%
3.02-3.46	0	0%	0	0%	155	19%	85	20%	0	0%	92	24%	4	3%	227	33%	310	38%
3.46-5.46	0	0%	0	0%	546	67%	88	21%	0	0%	79	20%	0	0%	137	20%	15	2%

2. **Count of Pollutants in Fourth Quartile of the Study Area:** A score is considered elevated relative to the **study area** if it falls in the top quartile of scores. The number of elevated scores for each tract is counted. Figure 3.4 shows the distribution of how many elevated scores the census tracts have. The most frequent number of elevated scores is 1-2, followed by 2-3 that are elevated. The maximum of the study area is 8 (11 is the global maximum). Table 3.8 shows the distribution of how many scores are elevated in each of the study regions. Lower Hudson/ East River Region has the greatest proportion of its census tracts with score in the range of 6-8 (17%), followed by Hackensack/Passaic Region (7%), Upper Bay/Arthur Kill Region (5%), and Long Island Sound Region of tracts in that high category. Maps are shown in the next section for ease of comparison.

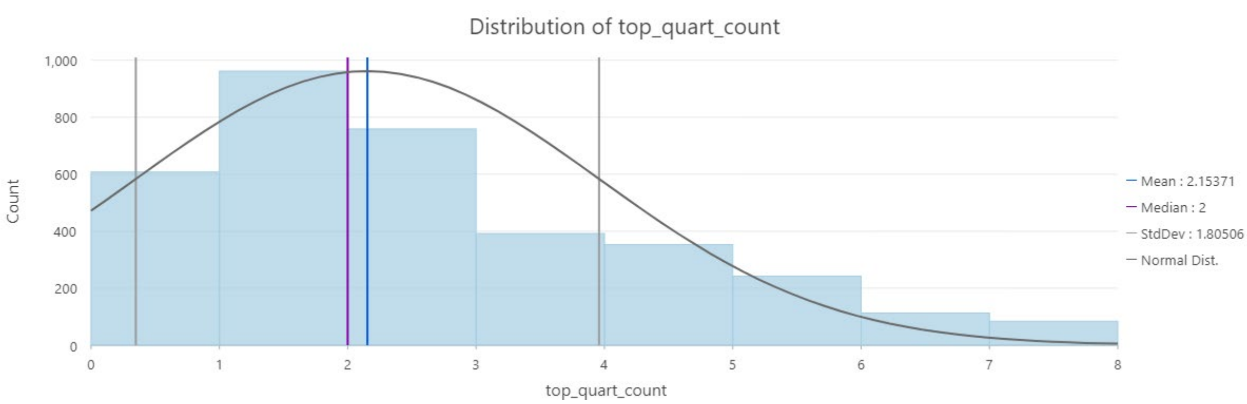


Figure 3.4 Histogram of census tracts, organized by the number of environmental indicator scores in the top quartile of the study area

Table 3.8 Regional Distribution of Pollution Burden, as measured by the number of EJSCREEN Environmental Indicators that census tracts score in the top quartile of the study area

	Capital District		Mid-Hudson Region		Lower Hudson/East River Region		Upper Bay/Arthur Kill Region		Lower Bay Region		Hackensack/Passaic Region		Raritan		Long Island Sound Region		Jamaica Bay Region	
	9		8		6		3		2		5		1		7		4	
No. census tracts	70		60		819		415		108		389		157		685		810	
0-1	60	86%	59	98%	96	12%	182	44%	95	88%	109	28%	48	31%	305	45%	616	76%
2-3	10	14%	1	2%	238	29%	146	35%	13	12%	174	45%	79	50%	302	44%	188	23%
4-5	0	0%	0	0%	346	42%	67	16%	0	0%	79	20%	30	19%	67	10%	6	1%
6-8	0	0%	0	0%	139	17%	20	5%	0	0%	27	7%	0	0%	11	2%	0	0%

3. **Count of Pollutants above the Ninetieth Percentile in the Country:** A score is considered elevated relative to the **country** if it falls in the top ninetieth percentile of scores. The number of elevated scores for each tract is counted. Figure 3.5 shows the distribution of how many elevated scores the census tracts have. The most frequent number of elevated scores is 0-1, followed by 2-3 that are elevated. The maximum is 10 in the study area out of a possible 11. Table 3.9 shows the distribution of how many scores are elevated in each of the study regions. Lower Hudson/ East River Region has the greatest proportion of its census tracts with score in the range of 6-8 (11%) and also the least tracks with 0 elevated score (9%).

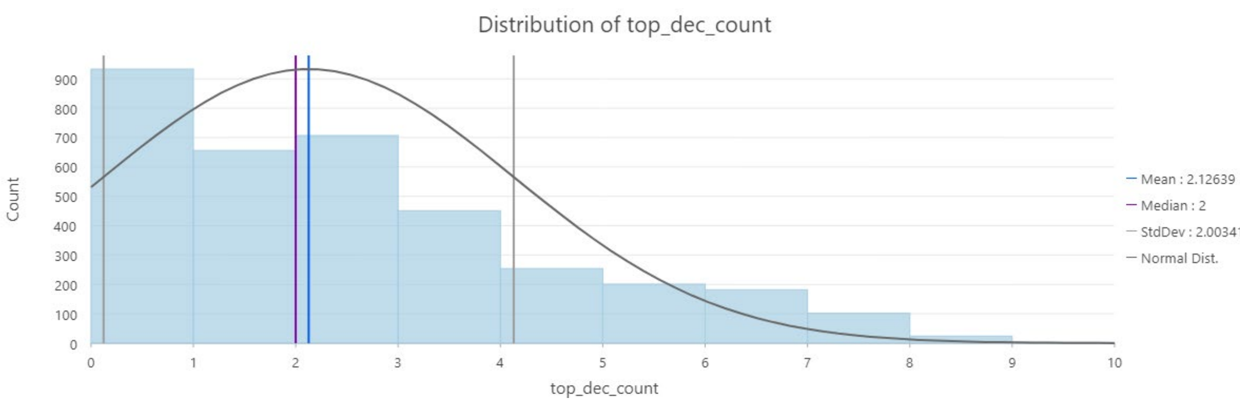


Figure 3.5 Histogram of census tracts, organized by the number of environmental indicator scores in the top ninetieth percentile for the country

Table 3.9 Regional distribution of pollution burden, as measured by the number of EJSCREEN Environmental Indicators that census tracts score in the top 90th percentile for the country

	Capital District		Mid-Hudson Region		Lower Hudson/East River Region		Upper Bay/Arthur Kill Region		Lower Bay Region		Hackensack/Passaic Region		Raritan		Long Island Sound Region		Jamaica Bay Region	
	9		8		6		3		2		5		1		7		4	
No. census tracts	70		60		819		415		108		389		157		685		810	
0	45	64%	49	82%	74	9%	116	28%	100	93%	120	31%	81	52%	91	13%	257	32%
1-2	25	36%	11	18%	121	15%	147	35%	8	7%	138	35%	66	42%	440	64%	407	50%
3-4	0	0%	0	0%	247	30%	105	25%	0	0%	59	15%	10	6%	140	20%	144	18%
5-6	0	0%	0	0%	287	35%	36	9%	0	0%	44	11%	0	0%	0	0%	2	0%
7-10	0	0%	0	0%	90	11%	11	3%	0	0%	28	7%	0	0%	0	0%	0	0%

The maps in Figure 3.6, Figure 3.7, and Figure 3.8 show the geographic distribution to pollution burden along the three dimensions calculated from EJSCREEN. Figure 3.9, Figure 3.10, and Figure 3.11 are the same maps with census tracts that meet the criteria for being disadvantaged highlighted in red.

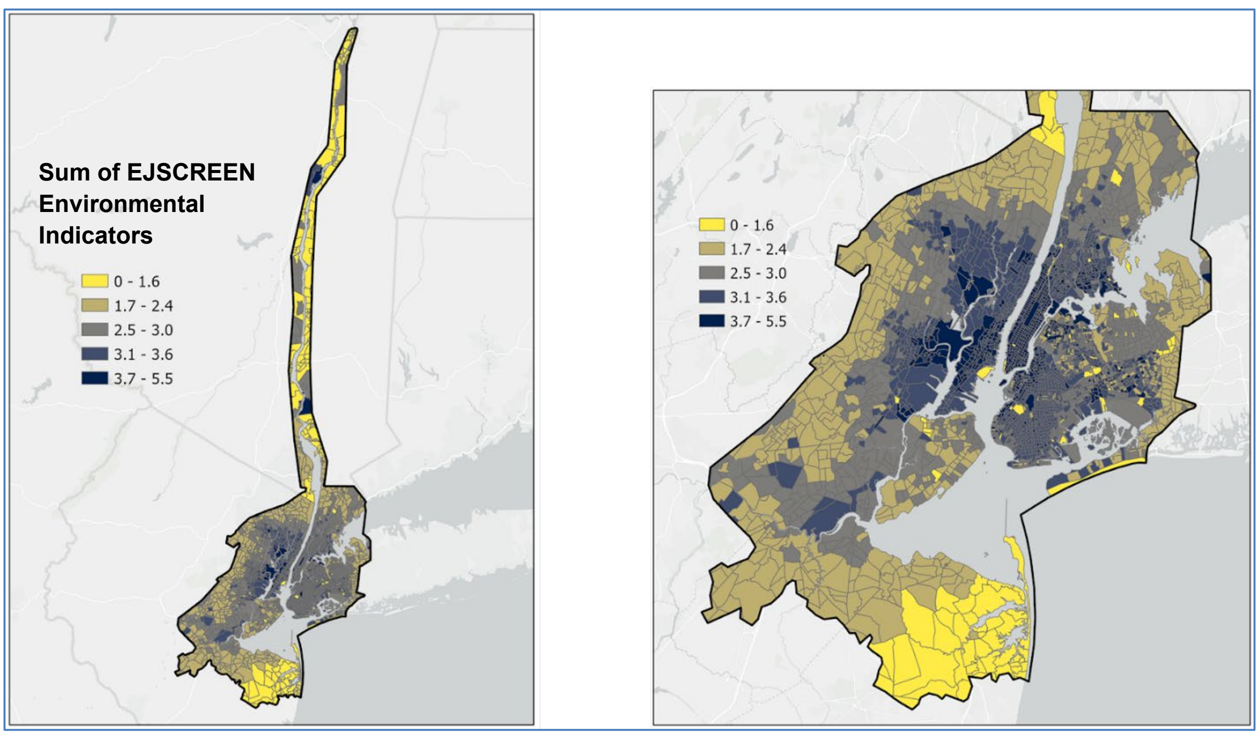


Figure 3.6 Geographic distribution of the sum of EJSCREEN environmental indicator score, where dark blue is the most elevated

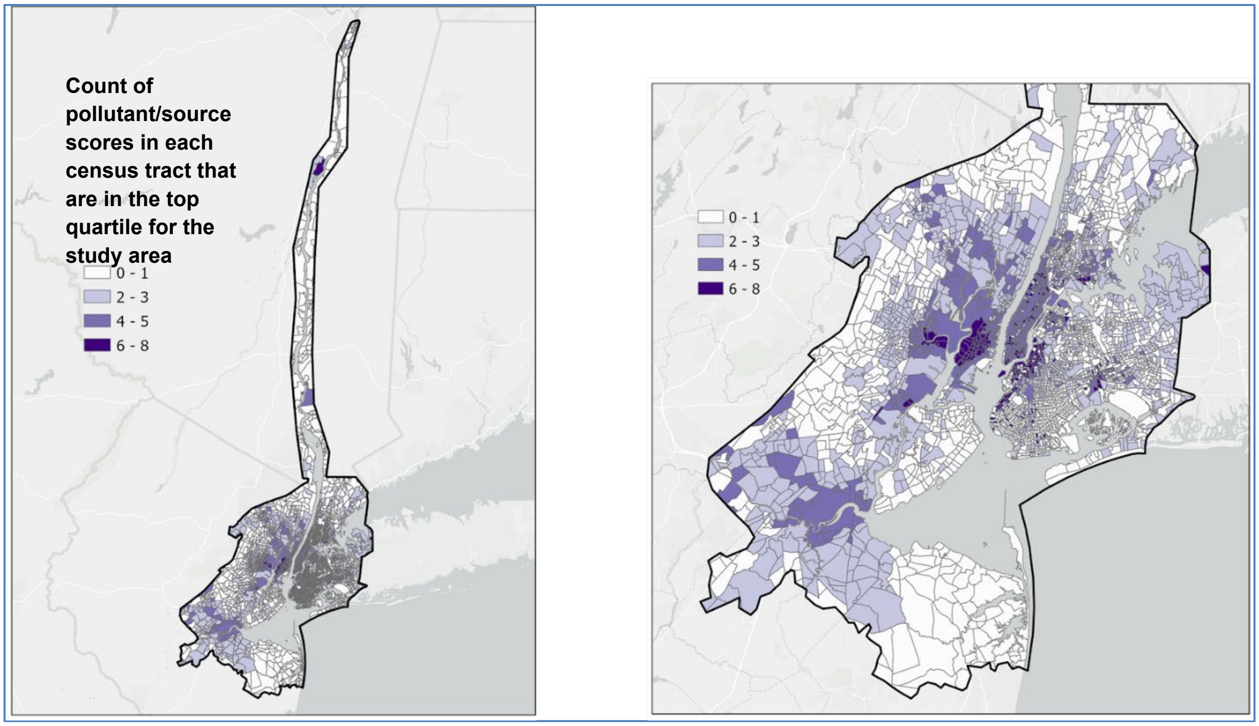


Figure 3.7 Geographic distribution of elevated scores relative to study area, where dark purple indicates that 6-8 environmental indicators are elevated

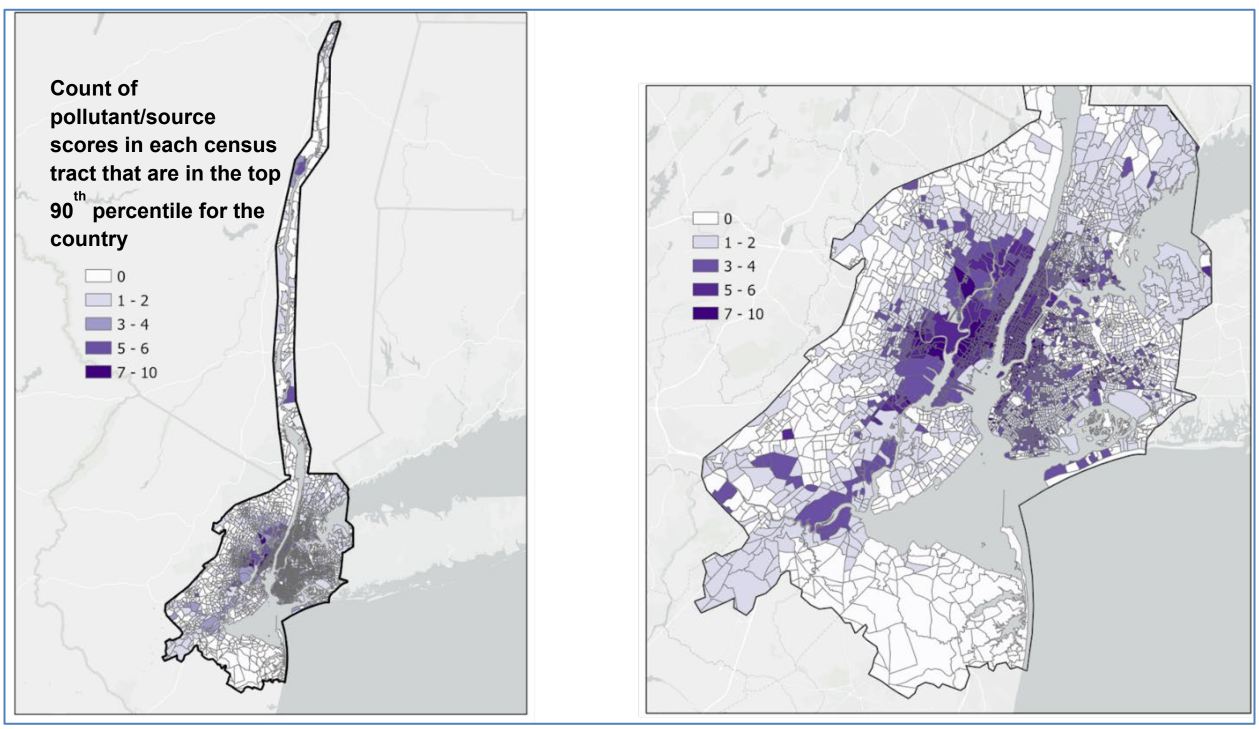


Figure 3.8 Geographic distribution of elevated scores relative to the country, where dark purple indicates that 7-10 environmental indicators are elevated relative to the country

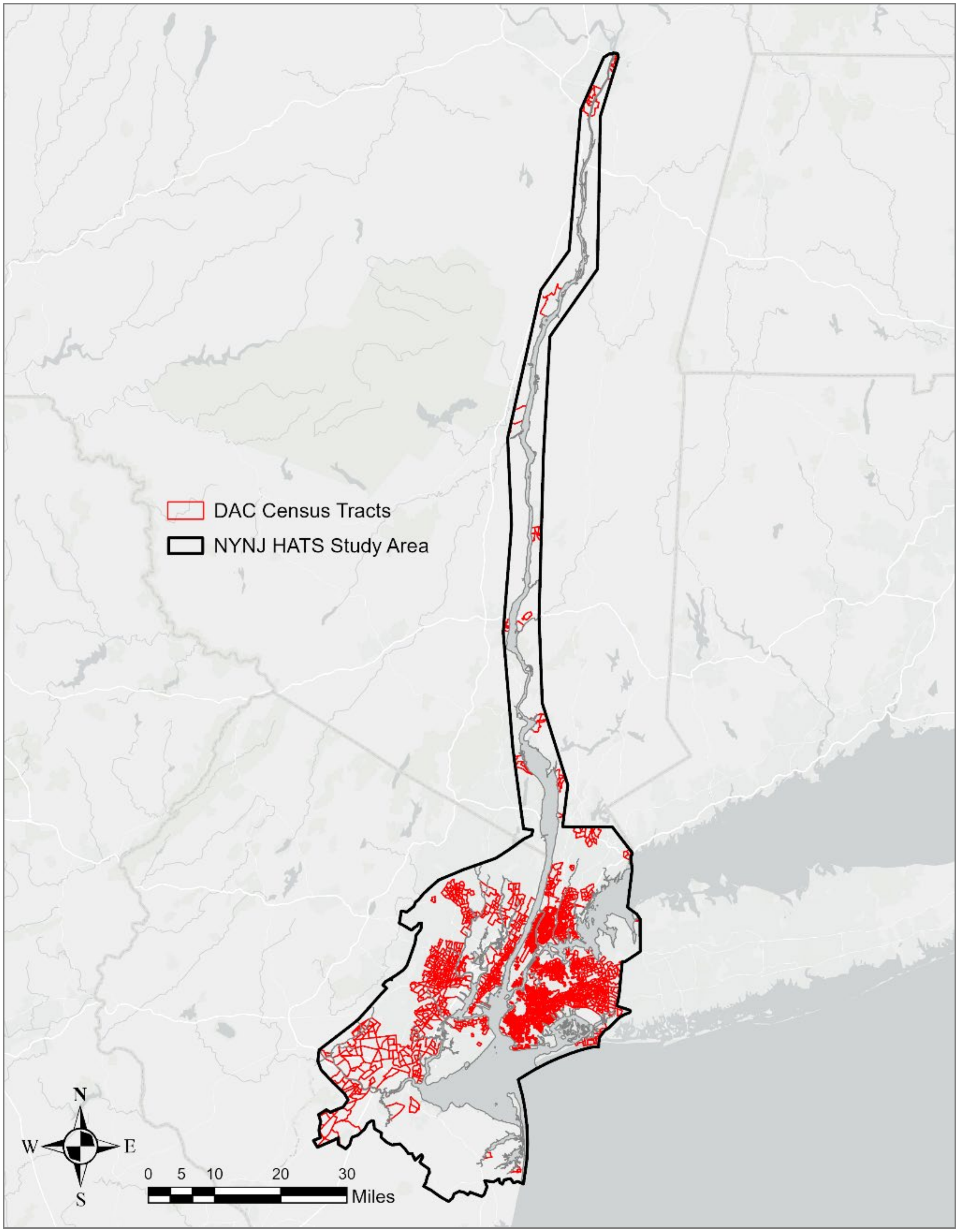


Figure 3.9 Map of Census Tracts that Meet the Criteria for DAC

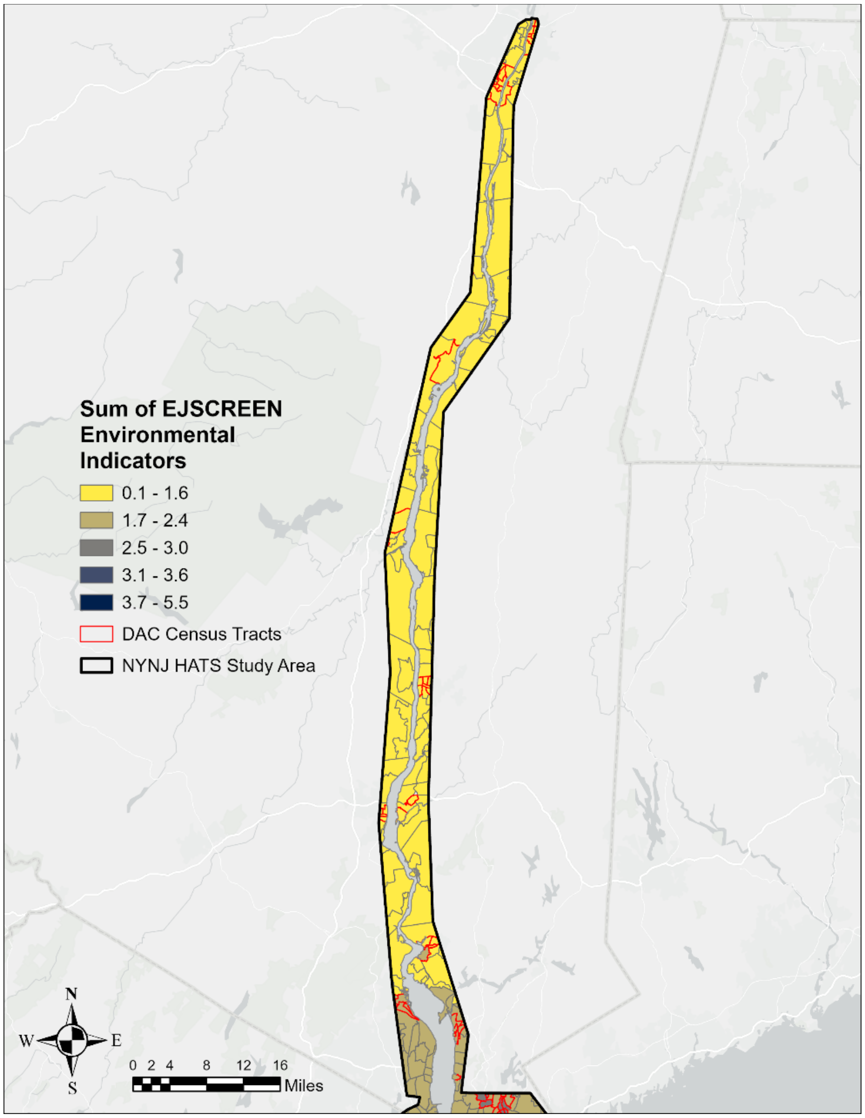


Figure 3.10 Overlay of Pollution Burden, as measured by sum of the EJSCREEN environmental indicators, and Census Tracts that Meet the Criteria for DAC (Northern portion of study area)

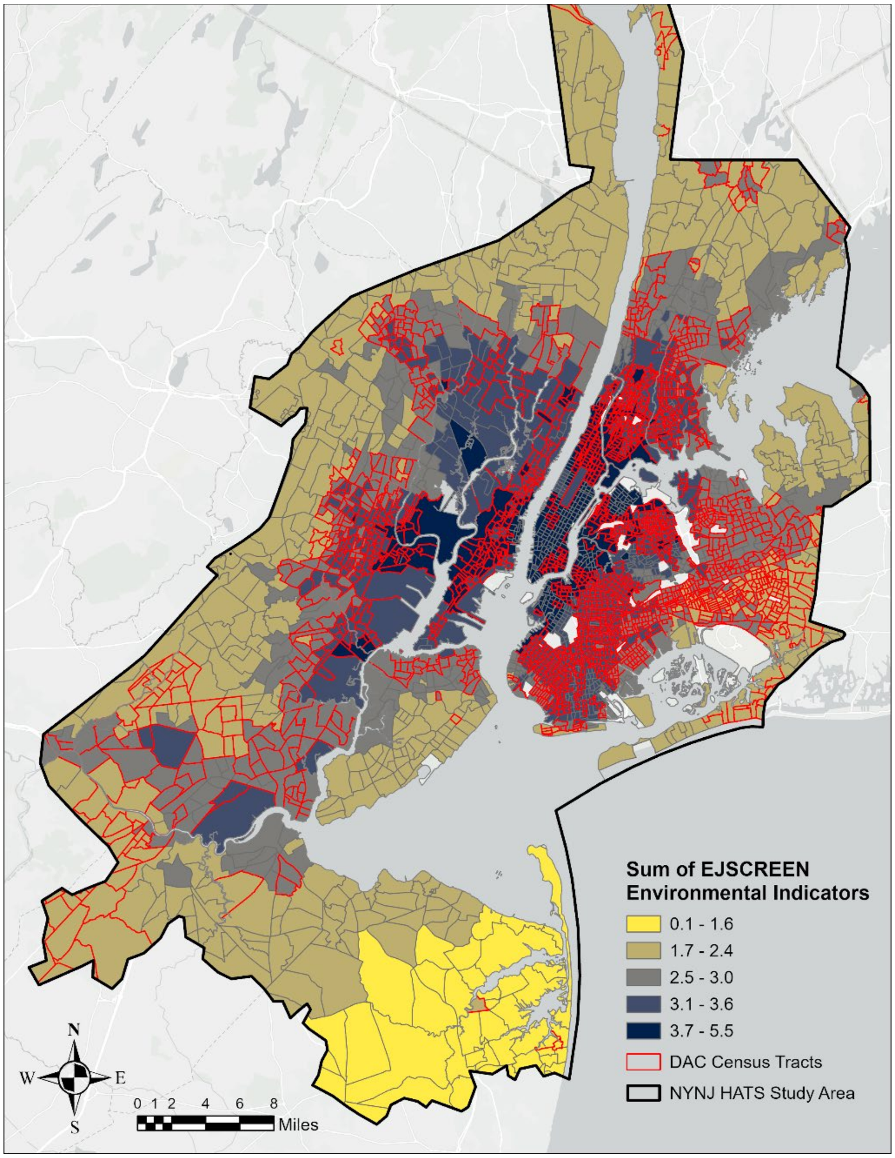


Figure 3.11 Overlay of Pollution Burden, as measured by sum of the EJSCREEN environmental indicators, and Census Tracts that Meet the Criteria for DAC (Southern portion of study area)

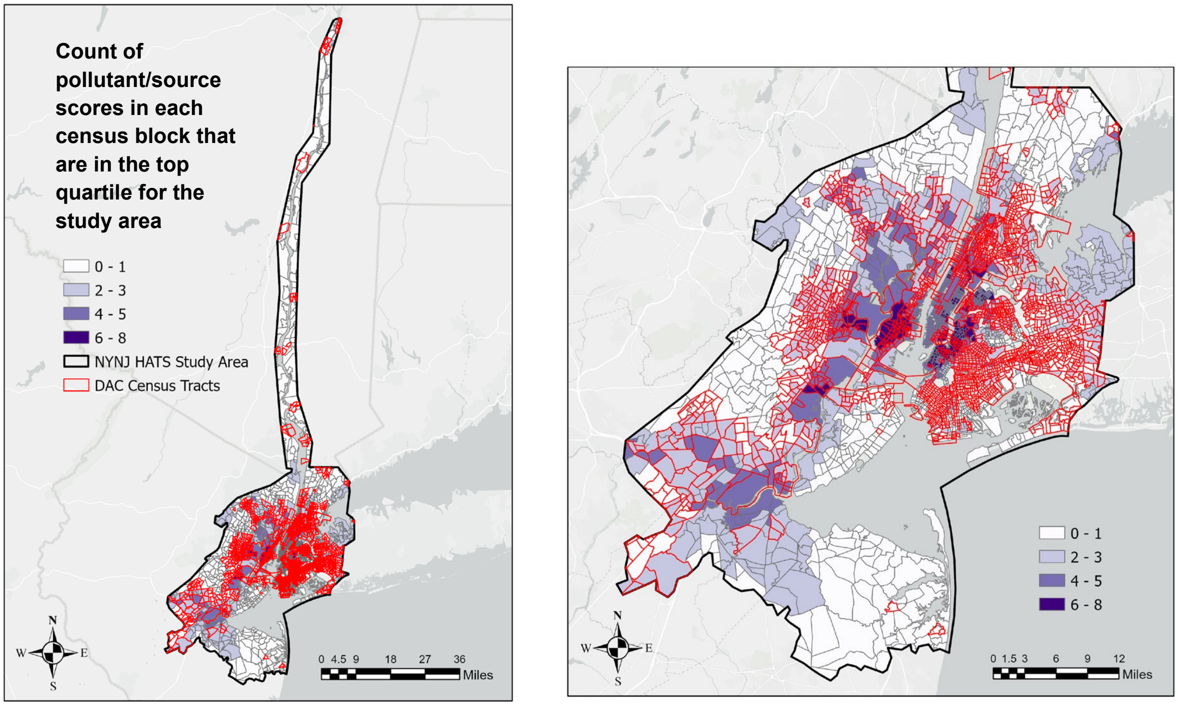
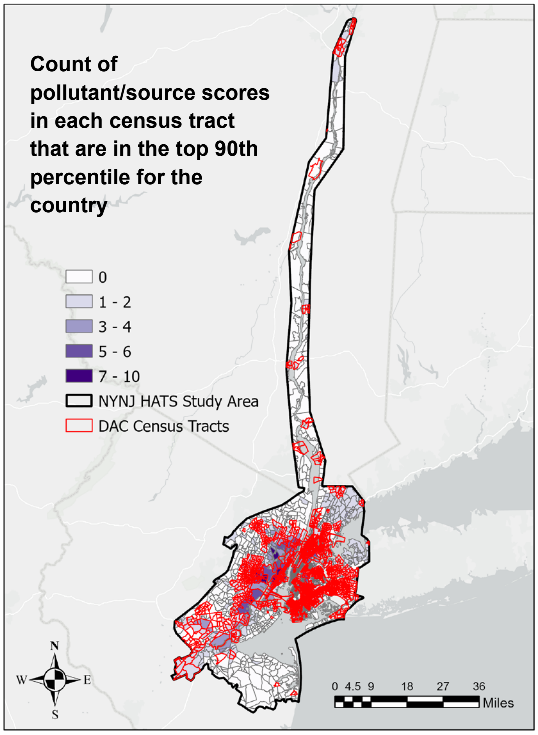


Figure 3.12 Overlay of Pollution Burden, as measured by the number of pollutant sources that score in the top quartiles for the study area, and Census Tracts that Meet the Criteria for DAC



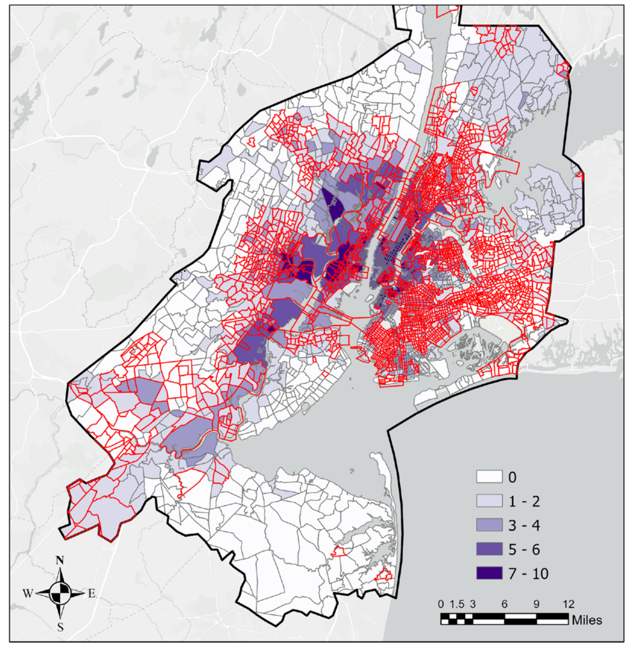


Figure 3.13 Overlay of Pollution Burden, as measure by the number of pollutant sources that score in the top ninetieth percent for the country, and Census Tracts that Meet the Criteria for DAC

Disadvantaged Communities and EJ

The results of layering demographic indicators for DAC and at least one environmental indicator from EJSCREEN that is in the 90th percentile for the country was identical counts of census tracts (Table 3.10). Whether the census tracts for DAC and EJ are a one-to-one match was not validated. 2,165 of 3,512 census tracks within the study area meet at least one of the criteria used to identify DACs, or 62% of census tracts.

Table 3.10 Distribution of DACs within the study area by regions as well as by the areas of impact of each alternative and the FWOP area.

Study Region	Capital District Region	Mid-Hudson Region	Lower Hudson/ East River Region	Upper Bay/Arthur Kill Region	Lower Bay Region	Hackensack/ Passaic Region	Raritan Region	Long Island Sound Region	Jamaica Bay Region	Total
# Census Tracts	70	60	819	415	108	389	157	685	810	3513
# Census Tracts that are DAC*	22	14	464	237	7	228	74	480	639	2165
% Census Tracts that are DAC*	31%	23%	57%	57%	6%	59%	47%	70%	79%	62%
Number of Census Tracts in the RRA of Each Alternative										
FWOP	0	15	291	136	71	110	24	128	216	991
Alt 2	0	15	290	136	69	110	24	102	212	958
Alt 3a	0	15	290	130	43	110	23	99	210	920
Alt 3b	0	0	108	111	2	109	1	19	210	560
Alt 4	0	0	96	64	0	75	0	17	210	462
Alt 5	0	0	72	2	0	4	0	0	0	78
Percent of Tracts in the RRA by Each Alternative that meet criteria of DAC*										
FWOP	0%	27%	52%	61%	8%	65%	21%	59%	62%	53%
Alt 2	0%	27%	52%	61%	9%	65%	21%	67%	62%	54%
Alt 3a	0%	27%	52%	62%	7%	65%	22%	68%	62%	56%
Alt 3b	0%	0%	56%	65%	0%	66%	100%	89%	62%	63%
Alt 4	0%	0%	53%	73%	0%	69%	0%	88%	62%	64%
Alt 5	0%	0%	54%	50%	0%	0%	0%	0%	0%	0%
Number of Tracts in the RRA of Each Alternative that are EJ**										
FWOP	0	4	151	83	6	72	5	75	134	530

Alt 2	0	4	151	83	6	72	5	68	132	521
Alt 3a	0	4	151	81	3	72	5	67	131	514
Alt 3b	0	0	60	72	0	72	1	17	131	353
Alt 4	0	0	51	47	0	52	0	15	131	296
Alt 5	0	0	39	1	0	0	0	0	0	40
Percent of Tracts in the RRA of Each Alternative that are EJ**										
FWOP	0%	27%	52%	61%	8%	65%	21%	59%	62%	53%
Alt 2	0%	27%	52%	61%	9%	65%	21%	67%	62%	54%
Alt 3a	0%	27%	52%	62%	7%	65%	22%	68%	62%	56%
Alt 3b	0%	0%	56%	65%	0%	66%	100%	89%	62%	63%
Alt 4	0%	0%	53%	73%	0%	69%	0%	88%	62%	64%
Alt 5	0%	0%	54%	50%	0%	0%	0%	0%	0%	0%
Number of Tracts in the Construction Footprint that are EJ**										
Alt 2	0	0	11	11	0	11	0	3	4	40
Alt 3a	0	0	11	12	1	11	2	3	9	49
Alt 3b	0	0	22	17	0	11	0	4	9	63
Alt 4	0	0	17	27	0	15	0	3	9	71
Alt 5	0	0	15	1	0	0	0	0	9	25

*DAC is defined as tracts that have greater than or equal to 23.59% of the population is below the federal poverty level or greater than or equal to 51.1% of the population identify as minority

**EJ is defined as tracts that meet the criteria of DAC AND have at least 1 pollutant in the 90th percentile for the country

Environmental Justice is addressed in two criteria, below, of the OSE assessment as well as in the Environmental Quality appendix, as is required by NEPA.

Intersection of Barrier with Environmental Justice Communities

For this criteria, the alternatives' infrastructural measures are scored based on whether they will exacerbate existing inequity in environmental exposures, in this case including construction, view obstruction, and other disruptions that would arise if the measure were built within an environmental justice community. The environmental justice shapefile is used to identify the number of intersections with environmental justice communities and score them on a scale of -3 (the alternative with the most intersections with environmental justice communities) to 0 (no flood measure intersections with environmental justice communities).

Environmental Justice Communities in Risk-Reduced Areas

Using the same measurements for environmental justice communities, this criterion examines the density of environmental justice community members in risk-reduced areas for each alternative. This criterion was scored from 0 (no environmental justice communities in risk-reduced area) to 3 (the risk-reduced area encompasses all environmental justice communities in the flood zone). Floodwaters themselves can be considered an environmental burden that compounds the effects of other hazards.

Socially Vulnerable Groups in Risk-Reduced Areas

There are multiple aggregations of social vulnerability indicators, and some of them repeat criteria that are already measured elsewhere in this assessment. For this analysis, the project team constructed a social vulnerability index (SVI) for the study region based on the methodology outlined in Flanagan et al. (2011). For each of the variables in the socioeconomic status, household composition & disability, and minority status & language themes, the analysis follows Flanagan et al.'s (2011) methodology, using year 2020 census data.

Because of NY/NJ's specific circumstances, the project team altered the remaining aggregation category for Housing Type and Transportation (see the omitted criteria in Table 3.12). They were replaced with criteria that the project team considered to be more relevant to housing cost burden in an urban area. These additional variables are shown in Table 3.11.

The OSE assessment team reviewed the draft criteria selected by the Climate Justice Working Group in NY, which has been working to identify disadvantaged communities using a wide range of criteria (45 indicators) for the purpose of equitably implementing the states' Climate Act (NYSCJWG 2022). There is substantial overlap between the NY draft DAC criteria and those used by this assessment, whether within the social vulnerability factor, environmental justice, or elsewhere.

The variables all contributed equally to their associated theme, and each theme contributed equally to the overall score of social vulnerability given to each census tract. This reflects the original CDC methodology (Centers for Disease Control and Prevention n.d.), with the exception of the substitution of the indicators relevant to shelter.

Table 3.11 NYNJHAT Study SVI variables and sources

Theme	Variable	Source
Socioeconomic Status	Percent Below Poverty	(U.S. Census Bureau 2020b)
	Percent Unemployed	(U.S. Census Bureau 2020b)
	Per Capita Income	(U.S. Census Bureau 2020f)
	Percent No High School Diploma	(U.S. Census Bureau 2020a)
Household Composition & Disability	Percent Age 65 or Older	(U.S. Census Bureau 2020d)
	Percent Age 17 or Younger	(U.S. Census Bureau 2020d)

	Percent Civilian with a Disability	(U.S. Census Bureau 2020a)
	Percent Single-Parent Households	(U.S. Census Bureau 2020a)
Minority Status & Language	Percent Minority	(U.S. Census Bureau 2020d)
	Percent Limited English	(U.S. Census Bureau 2020a)
Housing Cost Burden	Percent Renter Occupied Housing Units	(U.S. Census Bureau 2020c)
	Housing Cost to Income Ratio	(U.S. Census Bureau 2020c)
	Energy Cost Burden	(Ma et al. 2019)

Each census tract in the study region was assigned an SVI score from 0 (least vulnerable) to 1 (most vulnerable), and this value was multiplied by the census tract population to calculate a value for the socially vulnerable population for each census tract. Possible scores for this criteria range from 0 (no socially vulnerable population in the risk-reduced area) to 3 (socially vulnerable population of the risk-reduced area is equal to that of the FWOP floodplain).

Life Expectancy for Residents of Risk-Reduced Areas

The CDC social vulnerability aggregation and the EJ aggregation include indicators for many types of social vulnerability, but each one omits life expectancy. This is included as its own criteria since it is often an outcome of the other vulnerabilities experienced. Scores for this criterion were calculated based on the resident population of census tracts in the study area with average life expectancies below the U.S median. Possible scores for this criterion range from 0 (risk-reduced area include no people in census tracts with life expectancy below the U.S. median) to 3 (below-median life expectancy population in risk-reduced area equals that of the FWOP floodplain). Data for this criterion were taken from the U.S. Small-Area Life Expectancy Estimates Project (National Center for Health Statistics 2018)

Criteria Not Included in Social Vulnerability and Resilience

Table 3.12 Criteria not included in Social Vulnerability and Resilience

Rejected Criteria	Details	Reason for excluding
CDC Housing Type & Transportation	Multi-Unit Structure Mobile Home Crowding No vehicle Group Quarters	Not necessarily applicable to dense urban areas
Gentrification - low income areas protected	If low-income areas are protected, will the rent get more expensive and people become displaced?	Relationship to well-being is unclear; as a net for the region it can be positive. USACE guidance on gentrification is needed.
Gentrification - expected increase in rent	Will the rent increase if flood protection is provided?	Relationship to well-being is unclear; as a net for the region it can be positive. USACE guidance on gentrification is needed.
Residents of Rent Protected Housing or Rent Controlled Housing	Possibility that displacement would be most detrimental to these populations.	Not many people live in rent-controlled housing. It seemed the housing metric incorporated in Social Vulnerability should suffice.
People in nursing homes or other group homes	These populations are generally considered vulnerable to flooding.	It's unclear if this would entail great vulnerability to floods, since nursing homes may have evacuation plans that individuals living alone do not. The study team includes individuals over 65 within social vulnerability metrics.

3.7. Participation

This factor addresses the key human needs dimension of "feeling that one's participation is valued and recognized in community decision making" (Durden and Wegner-Johnson 2013). Ensuring that affected community members have meaningful access to the processes for identifying the need for a project and developing and assessing alternatives is a critical component of equity (Leach et al. 2018). Additionally, considering the experiences and values of the residents of the study area can result in more integrated and beneficial CSRM solutions.

Given the scale and scope of the NYNJHAT study, USACE has prioritized public outreach and discussion in the planning process. This effort has included public discussion meetings, inter-agency workshops with over 100 local government representatives in the study area, and elicitation of public comment through the NEPA Scoping Period. Aggregated themes and individual comments received with responses are published in the New York-New Jersey Harbor and Tributaries Interim Report, Public Engagement Appendix (USACE 2019). This criteria reflects many everyday effects, and the sensitivity analysis will consider this in the results.

Reflection of Community Priorities

Since all NYNJHAT study alternatives were developed under the same process, which included public outreach and engagement efforts by the New York District NYNJHAT study team, public access to the process is not useful as a criteria to distinguish meaningful participation between different alternatives. However, individual public comments solicited during the NEPA process and themes arising from the inter-agency workshops were used to define public priorities related to this project. Alternatives were then screened for how well they upheld these different stated priorities. Since the project study area is so large, densely populated, and diverse, values as expressed in the public comments are wide-ranging and at times are in direct conflict.

The District NYNJHAT study team identified seven themes from the public engagement workshops and public comments, which are discussed in the NYNJHAT Interim Report Public Engagement Appendix. These themes include: concern about the speed of the scoping process; concern about how Sea Level Rise (SLR) is being addressed in the study; concern about environmental impacts; concern about navigation impacts; questions about the project cost and construction impacts; questions about the overall study process; and concern about the possibility of induced flooding. Of these, questions and concerns and the overall study scoping and process and about the handling of SLR are not useful in distinguishing between project alternatives.

The 386 unique submitted public comments were assessed for detail which could distinguish how well each alternative reflects community priorities. Three major areas of community priority arose from this analysis: concern about environmental impact, concern about cost and economic impact, and concern about flood exposure. Table 3.13 provides information about these community priorities and concerns. The “Distinguishing features” column identifies which alternative characteristic or risk reduction feature is associated with each priority or area of concern. These priorities are all reflected elsewhere in the assessment of alternatives, including in the other OSE criteria and the Environmental Quality assessments, but here they are considered in terms of their importance to the community.

The NYNJHAT study team provided detailed responses to each public comment, often noting that further tiers of analysis for this project would investigate these concerns comprehensively (for example, noting that the Environmental Impact Statement would assess possible impacts on species and, if necessary, develop mitigation measures for those impacts). In assessing the priorities of the community, these responses are not taken into account (i.e., concerns about environmental impacts are not discounted because of assertions that USACE will mitigate environmental impacts).

Table 3.13 Reflecting major community priorities

Priority/concern	Distinguishing features
Environmental impacts to wetlands and marshes, Hudson River and tributaries, tidal flows, and riverine and marine species. This includes silting and subsequent dredging that may release **hazardous pollutants**, and retention of hazardous material behind barriers	Specific mentions of Alternatives 2, 3A, 3B, and 4 - primary association with storm surge gates and in-water barriers
Flood exposure	Population residing in risk-reduced areas
Cost and adverse **economic impacts** to the shipping and tourism industries due to in-water barriers	Specific mentions of in-water barriers. Return on investment of each alternative

Concern about environmental impacts was the most common type of comment received from members of the public by the NYNJHAT study team. 91% of all submitted remarks included concern about environmental impacts, with a specific focus on concerns about surge barriers (USACE 2019). Content of the unique comments submitted exhibit strong concern that the project will adversely affect local ecosystems. Examples of comments received include:

- "What about silt build-up; then dredging needs later which stir up sediments with POBs and other harmful chemicals?" (Item #18 in the NYNJHAT Interim Report Public Engagement Appendix Table 5, USACE 2019).
- "Alternatives 2, 3A, 3B, and 4 will pose significant environmental risks to the Hudson River watershed" (Item #19)
- "The in-water barriers will limit tidal ebb and flow endangering fish species and impeding flushing of contaminants out of the harbor" (Item #28)
- "What are the effects of the levee and berm tie-ins on the usability of the beach by shore-nesting birds?" (Item #95).
- "Environmental impacts must be studied and taken into account before narrowing down to 1-2 alternatives. This narrowing of alternatives should not be on cost alone" (Item #152).
- "In-water storm surge barriers would permanently damage the Hudson River estuary and its life and do nothing to stop damage from sea level rise" (Item #297).

The comments submitted during the public engagement and outreach efforts largely focus on the everyday effects of the proposed alternatives, rather than their associated reduced flood risk. Concerns about flood exposure were present in the public comments mostly as concerns about adequately addressing SLR (mentioned in 84% of the submissions) and preventing induced flooding from potential alternative features (mentioned in 72% of submissions). It should be noted that there is significant public support for the Feasibility Study in general, shown through letters of support sent to the Assistant Secretary of the Army and the Commanding General and Chief of Engineers by Members of Congress in the study area in 2018, 2020, and 2021 (see Attachment 1). In March 2021, 17 members of Congress wrote in support of reauthorizing the NYNJHAT study as it “is an important foundation to our community’s management of future flood risk.” Overall public demand for reducing flood risk in the aftermath of Hurricane Sandy is strong. To reflect this demand as expressed through elected officials and through public comment, flood exposure is included in the list of community priorities scored for this factor.

Questions about cost, impacts to businesses, and economic impacts of construction were another major theme of the submitted public comments and were present in 77% of submissions (USACE 2019). Submitted comments included questions about impact to the tug/barge industry (Item #184), tourism industry (Item #189), and costs of operation and maintenance over the lifecycle of the project (Item #249). The unique comments submitted about cost and economic impact were less forcibly worded than those about environmental impacts and more phrased as questions about how cost and economic impact would be measured for each alternative.

Many other community priorities were raised through the public engagement efforts that are not used here to distinguish between alternatives at this tier of analysis, which is foA public preference for inclusion of natural and nature-based features is better suited to the next tier of the project study, during the design of individual features. Desire for more in-depth community engagement across affected areas and concern about impacts to local community flood and resilience planning will require more public outreach and engagement by the NYNJHAT study team, which is planned for the next tier of the study. Concerns about the aesthetic impact of the alternative measures was mentioned in several comments but is considered elsewhere in this OSE analysis and not included here as it was not a major theme of public comment.

Concerns about environmental justice were mentioned in several public comments. One submission asks “How does the Army Corps plan to account for increased flood risk in low-income communities of color? What is the plan to not exacerbate environmental justice? Many communities of color and EJ communities are located outside of the so-called “protected” areas within the scope of in-water barriers” (Item #58). Environmental Justice is considered elsewhere in this OSE analysis and in the NEPA analysis for the study, and not included as a criterion for the Reflecting Community Values Participation factor as it was not a major theme of public comment.

Scoring Participation

Environmental impact, reduction of flood exposure, and cost and economic impact are the three criteria used to distinguish alternatives for how well they reflect major community priorities for the Participation factor. Scores for each alternative for these criteria are those calculated elsewhere in the NYNJHAT Study: environmental impact scores by alternative are taken from the Draft Tier 1 Environmental Impact Statement, Plan Comparison (Section 5.1 of that report; see for methodology). Those Environmental Impact Scores were calculated on a scale from 1 to 5 where five is the highest level of adverse environmental impact. To fit within the OSE analysis, these scores were translated into negative values. Scores for the reduction of flood exposure are taken from this report, as calculated for the Residents of Risk-Reduced Areas criterion. Scores for the cost and economic impact are taken from the BCR values calculated for the NYNJ HAT CSRM Feasibility Study Economic Appendix - NED Damage & Benefits Analysis report (Section 7.3 of that report, Table 20; see for methodology).

Environmental impact scores were weighted the most heavily for the Participation factor, at 70%, since concern about environmental impact was by far the most frequent and forcefully expressed community concern. Flood exposure scores and cost and economic impact scores were both weighted 15%, as those were important community concerns but were expressed much less frequently than concerns about environmental impact. Weighted scores were then averaged to produce a Participation factor score for each alternative. These scores are shown below in Table 3.14.

Table 3.14 Participation scoring

Criteria	Weight	Alt 2	Alt 3A	Alt 3B	Alt 4	Alt 5
Environmental impact	0.7	-2.5	-2.5	-2	-2.7	-2
Flood exposure	0.15	2.7	2.5	1.9	1.7	0.2
Cost and economic impact	0.15	0.8	2.1	2.8	2.6	2.2
Weighted Score:		**-1.2**	**-1.1**	**-0.7**	**-1.2**	**-1.0**

Criteria Not Included in Participation

Table 3.15 Criteria not included in Participation

Rejected Criteria	Details	Reason for exclusion
Reduced flood risk to municipal buildings and schools	Protecting these buildings facilitates civic engagement and participation.	These were included as community spaces in the Social Connectedness factor so not included here.
Aesthetics of alternative measures	Aesthetics were mentioned in some public comments and can be an important aspect of public participation in design	This is more suitable to later Tiers of the study when design of measures is underway
Presence of Natural and Nature-Based features	NNBFs were mentioned in some public comments and can be an important aspect of public participation in design	This is more suitable to later Tiers of the study when design of measures is underway

Access to the study process (time and location of public outreach meetings, etc.)	Meaningful participation is facilitated when many accessible opportunities for substantial engagement in the process are provided	This is important but is not useful in distinguishing between alternatives. In subsequent phases of the project, more outreach will be necessary.

Opportunities for Additional Analysis

One overwhelming theme that emerged from the public engagement comments is the desire for more access to the study process. 88% of submitted comments were requesting more time for the scoping process, more information to be publicly available, or for more public meetings to be held to facilitate engagement (USACE 2019). There are opportunities for this factor to be further refined in subsequent tiers of this study, especially as additional public engagement actions are taken. Public preference for mitigation feature types such as Natural and Nature-Based Features (NNBFs) can be incorporated into the project design at the next stage, and emphasis should be placed on meeting the priorities of the affected communities. As the NYNJHAT study progresses into the next tier, additional resources can be dedicated to meeting this demand for public participation, and community priorities for specific alternative measures should be well-reflected in the final designs.

3.8. Leisure and Recreation

Leisure time and recreation opportunities are important contributors to well-being. Visiting parks positively affects the visitors' health and well-being benefits (Romagosa et al. 2015). In urban areas, outdoor access to recreation promotes physical and mental health (Buchecker 2015). Nature-based activities like green exercise improve mental health outcomes for adults (Coventry et al. 2021) and students who actively and frequently engage with green spaces report higher quality of life, better overall mood, and lower perceived stress (Hold et al. 2019).

Outdoor Recreation/Leisure/Nature Space in Risk-Reduced Areas

This criterion measures the incorporation of recreational space in risk-reduced areas. This space is outdoors, which differentiates it from indoor community spaces criteria measured earlier. Within the generally urbanized study area there is an emphasis on creating and maintaining access to public space for leisure and recreation. These spaces include, but are not limited to parks, playgrounds, community gardens, community pools, greenways, community gardens, athletic fields, and biking and walking paths. These spaces are utilized for a myriad of activities.

There are over 2,000 public spaces identified within the study area from data maintained by New York City Parks Department, NYSDEC, and NJDEP. The NYC, New York and New Jersey city, national, and state parks in the flood zone were summed, and were similarly summed for the risk-reduced area of each alternative. The number of parks near the footprint of each barrier was considered a negative effect, and was subtracted from the value of parks in the risk-reduced areas for each alternative. These totals were converted to unitless measurements relative to the number of parks in the flood area that could have been protected, while a separate process calculated the unitless measures for the benefits of added elevated promenades, which are part of Alternatives 3A, 3B, and 5, as measured by miles. The unitless measures were combined with weights of 80% for the existing parks affected, and 20% for elevated promenades added as part of the alternatives.

Criteria Not included in Leisure and Recreation

Table 3.16 Criteria not included in Leisure and Recreation

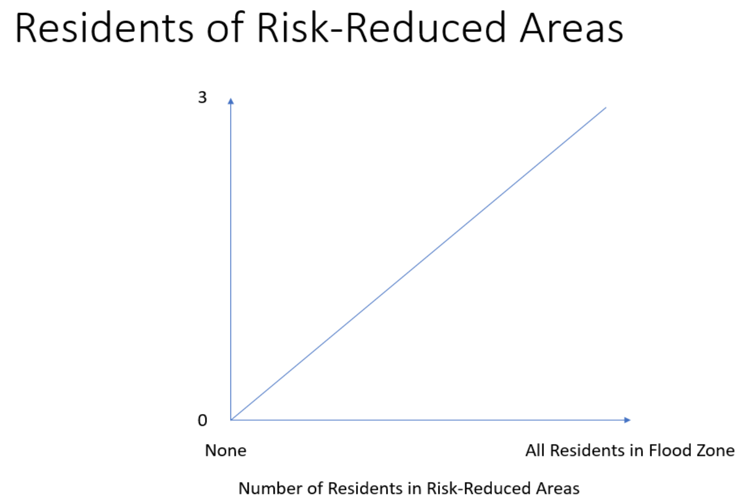
Rejected Criteria	Details	Reason for exclusion
Parks and natural features intersecting with barriers	Evaluating whether the barriers will prevent access to parks	Because some barriers are adding recreational space (elevated promenades), this was difficult to consistently assess.
Access to Nature	Evaluating whether measures promote access to nature	Hard to reliably differentiate from outdoor recreation space

4 Using Value Functions to Score Criteria

As mentioned above, criteria could receive possible scores ranging from -3 to 3, where a score of -3 indicates the most negative impacts, a score of 0 indicates no impacts or neutral impacts, and 3 indicates the most positive impacts. Most criteria had scores covering only half that range, for example, the possible scores for residents in risk-reduced areas range from 0 to 3 because a negative score would require an alternative increase the number of people exposed to flood risk. Similarly, the everyday effects usually range from negative to neutral (-3 to 0) because the flood infrastructure generally does not have positive impacts on days without flooding.

The project team used value functions to transform each criteria's data from the analysis into unitless -3 to 3 scores. A value function places the alternative scores on the x-axis and uses the shape of the function to calculate the unitless score. Each criteria had its own value function, which were all reviewed by the NAN team. Below are two examples.

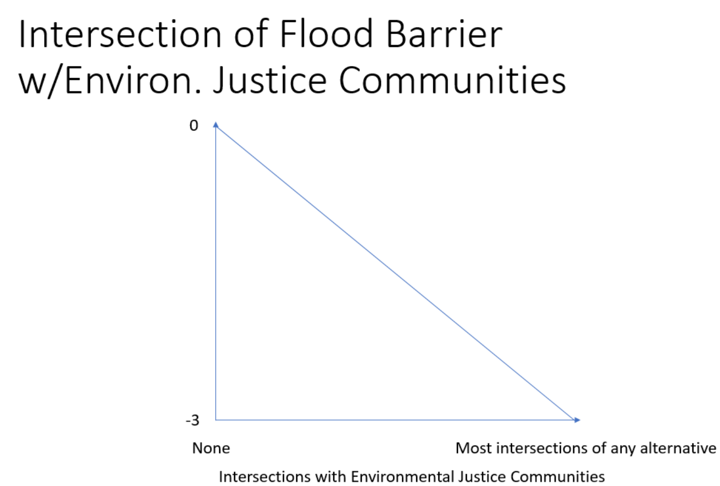
Example 1 - Scoring the benefits of a flood measure



The value function for Residents of Risk-Reduced Areas requires quantifying the number of residents in the flood zone of the project area (the number of people with flood risk in the current condition). This becomes the maximum value on the x-axis, which frames the scale for the numbers of people in risk-reduced areas in each alternative. Their scores will fall somewhere between that maximum value and zero. The straight line of the function shows how to transform those scores from 0-3, where a score of three is only possible if an alternative's risk-reduced area encompasses all residents.

The value functions that measured risk reduction, or the benefits of a flood measure, generally took this form.

Example 2 - Scoring the Negative Impacts of a Flood Measure



The everyday effects of a flood barrier can include its presence. In the case of environmental justice communities, the intersection of a flood barrier could entail demolitions, or loss of access between two neighborhoods. Though positive impacts are also possible, like increased recreation space, those are counted elsewhere. This criterion assumes that intersections are negative, and the shape of the function shows that more intersections are more negative. The x-axis ranges from no intersections to the most intersections of any alternative. Thus, this value function requires that one alternative receive the minimum score (-3). This differs from examining benefits (Example 1) because benefits were compared with the maximum possible benefits, which made it unlikely that any alternative would receive the maximum score of 3. For intersections of the barrier, there is no corresponding maximum possible number of intersections, so the values are compared against the other alternatives. This means that negative effects of alternatives effectively receive a higher magnitude of negative scores than positive effects receive positive scores, however this is justified for two reasons: 1) the psychological phenomenon of *loss aversion* shows that the pain of losing something is greater than the pleasure of gaining that same thing; losses have high impacts for well-being, and 2) the alternatives are compared against each other, so as long as they are all consistently scored, using different x-axes for negative and positive impacts will not affect the comparisons between them.

These value functions provided the basis for scoring the criteria to compare and contrast the alternatives.

5 Weighting the Criteria

The criteria and the factors that encompass them should not be assumed to have equal importance for the decision of which alternative to choose, and thus scoring the criteria is not enough to enable a useful comparison. Each factor should be weighted against the other factors, and the criteria within each factor should be similarly weighted against each other to establish relative importance. To obtain an idea of weights, the project team collected data from 5 stakeholders using Google Forms. The stakeholders comprised city and state representatives who chose the weights based on their knowledge of community concerns. The stakeholders ranked the metrics and criteria on a scale of 1-10, and these were averaged by stakeholder type (governance, environmental science, public health, and planning) normalized such that together the weights all added up to 1.

Some complications arose for the stakeholder weights: One of the criteria was mistakenly omitted (people with physical disabilities) when the weights were collected. To enable the analysis, the study team assigned this criterion a 9/10 weight for the stakeholders, recognizing that other criteria in the Health and Safety factor were also highly ranked on a scale of 1-10. Additionally, the weights for “schools and government buildings” and “community buildings” were averaged because these criteria were ultimately combined into one criterion in the analysis.

However, the data collected between the stakeholders was not consistent, suggesting that different people might differently weight the relative importance of each criterion. Additionally, a sample size of five is not representative of all the stakeholders in the study area. Therefore, the results of this analysis include a sensitivity analysis of the alternatives under different weighting schemes, imagining that different stakeholders have different priorities. This identifies the strengths and weaknesses of the respective alternatives under specific value sets. The sensitivity analysis examines the differences in results when prioritizing each factor, equity measures, environmental justice, and everyday effects, in turn.

6 Results

Most criteria used Geographic Information System (GIS) analysis or other spatial measurements to calculate scores, as described earlier in this Appendix, in Section 3.1. Table 6.1 presents the raw scores from the GIS analysis. Note that the scores for Aesthetics, Reflection of Community Priorities, Recreation/Leisure/Nature were not calculated in GIS and thus do not have scores included in this table.

Table 6.1 Results - Raw scores for alternatives by criteria

Criteria	Total in Flood Plain	Counts in Risk-Reduced Areas				
		Alt 2	Alt 3A	Alt 3B	Alt 4	Alt
Residents of Risk-Reduced Areas	1206208	1158120	1096150	890786	798734	128
Access to Healthcare	13	13	13	7	6	4
Population with physical vulnerabilities in Risk-Reduced Areas	131527	125805	117279	96933	87404	116
Point Sources of Contamination in Risk-Reduced Areas	708	704	685	601	360	16
Business Buildings in Risk-Reduced Areas	31546	30356	29070	22625	19538	384
Community Buildings in Risk-Reduced Areas	1077	1058	1017	845	775	267
Community Monuments in Risk-Reduced Areas	3374	3234	3192	2414	2288	152
Aesthetics of Barrier	n/a	n/a	n/a	n/a	n/a	n/a
Intersection of Barrier with Environmental Justice Communities	0	40	49	63	71	16
Environmental Justice Communities in Risk Reduced Areas	720009	701580	686961	572901	505300	765
Socially Vulnerable Groups in Risk-Reduced Areas	567680	541506	516592	426522	390974	601
Life Expectancy for Residents in Risk-Reduced Areas	371463	354715	316535	258649	217974	298
Reflection of Community Priorities	n/a	n/a	n/a	n/a	n/a	n/a
Change in Outdoor Recreation/Leisure/Nature Space	n/a	n/a	n/a	n/a	n/a	n/a

From the raw data, scores were calculated within a range of -3 (least favorable change) to 3 (most favorable change), where a score of zero indicated neutral or no change. As stated earlier, the criteria are divided between flood risk reduction effects and everyday effects of the alternatives. Criteria measuring flood risk reduction was scored from 0 to 3, reflecting the fact that during times with flooding, the infrastructure would provide benefits. The criteria for the everyday effects of the new flood management infrastructure were scored from -3 to 0 (unwanted to neutral impacts), based on the assumption that flood mitigation infrastructure was generally an imposition on the greater landscape during times without flooding. There is some nuance in these assumptions; examples can be found in the calculations for aesthetics scores and recreation scores. Thus, depending on the type of effect that a criterion measured, the scores were positive or negative.

Scores for flood risk reduction effects were calculated by examining each criteria's raw score for each alternative as compared to the overall score for the floodplain, which represented the maximum value that could possibly be protected by flood risk reduction infrastructure. An alternative that could protect everything at risk would receive a score of 3 for the criteria in question, such as Alternative 2 and 3A received for the criteria "Access to Healthcare" because each reduced risk for all thirteen healthcare buildings in the flood zone. For alternatives that reduced risk for less than the entire floodplain, the score was calculated as the fraction of risk reduced, where a score of 3 would represent 100% and a score of zero represented 0%.

Scores for everyday effects were calculated somewhat differently. Everyday effects have no maximum value analogous to the flood zone value - for example, there could be any number of intersections of the barrier with environmental justice communities. Therefore, this criterion calculated the -3 value using the value of the alternative with the most intersections. In this case, Alternative 4 has 71 intersections with environmental justice communities. The remaining scores were calculated as a fraction of the number 71, where a score of 3 represents 100% and zero represents 0%. The other everyday criteria similarly normalized the -3 to 0 scores using the most extreme score of any alternative as the -3 value.

Finally, there are three criteria without raw data in Table 6.1. Calculating these criteria scores involved additional mathematical operations that considered multiple features, and their methodologies are described in their respective subsections in Section 3. Table 6.2 shows the resulting scores for the criteria and alternatives.

Table 6.2 Results - Scaled scores for alternatives by criteria

Criteria	Scores				
	Alt 2	**Alt 3A**	**Alt 3B**	**Alt 4**	**Alt 5**
Residents of Risk-Reduced Areas	2.88	2.73	2.22	1.99	0.32
Access to Healthcare	3.00	3.00	1.62	1.38	0.92
Population with physical vulnerabilities in Risk-Reduced Areas	2.87	2.68	2.21	1.99	0.27
Point Sources of Contamination in Risk-Reduced Areas	2.98	2.90	2.55	1.53	0.07
Business Buildings in Risk-Reduced Areas	2.89	2.76	2.15	1.86	0.37

Community Buildings in Risk-Reduced Areas	2.95	2.83	2.35	2.16	0.75
Community Monuments in Risk-Reduced Areas	2.88	2.84	2.15	2.03	1.35
Aesthetics of Barrier	-1	-1.5	-2.5	-3	-2
Intersection of Construction Footprint with Environmental Justice Communities	-0.86	-1.00	-1.59	-3.00	-0.47
Environmental Justice Communities in Risk Reduced Areas	2.92	2.86	2.39	2.11	0.32
Socially Vulnerable Groups in Risk-Reduced Areas	2.86	2.73	2.25	2.07	0.32
Life Expectancy for Residents in Risk-Reduced Areas	2.86	2.56	2.09	1.76	0.24
Reflection of Community Priorities	-1.2	-1.1	-0.7	-1.2	-1
Change in Outdoor Recreation/Leisure/Nature Space	1.87	1.93	1.77	1.00	0.69

With the weights and scores in place, the scores for the alternatives can be calculated using the equation:

$$\sum\nolimits_{criteria} (weight * score)_{criteria}$$

Please note that criteria are specifically summed and presented by factor throughout the results.

The scores in Table 6.2 can be directly summed or averaged to determine overall OSE scores for each alternative, but that would assume equal weighting of the factors and criteria. It is one of many ways to present the results, and the text below will explore several others in a sensitivity analysis of the weighting schemes. Adding the criteria scores together constitutes the first weighting analysis, which weights all fourteen criteria equally (7.1% each). In Figure 6.1 below, and all subsequent figures, the left-most column shows the division of weights, aggregate to the factor level. The columns to its right show the aggregated scores for each alternative, with colors representing each factor. Note that all the results will be presented with a y-axis showing the values of -2 to 3, since no alternatives had values of less than -2, throughout the sensitivity analysis.

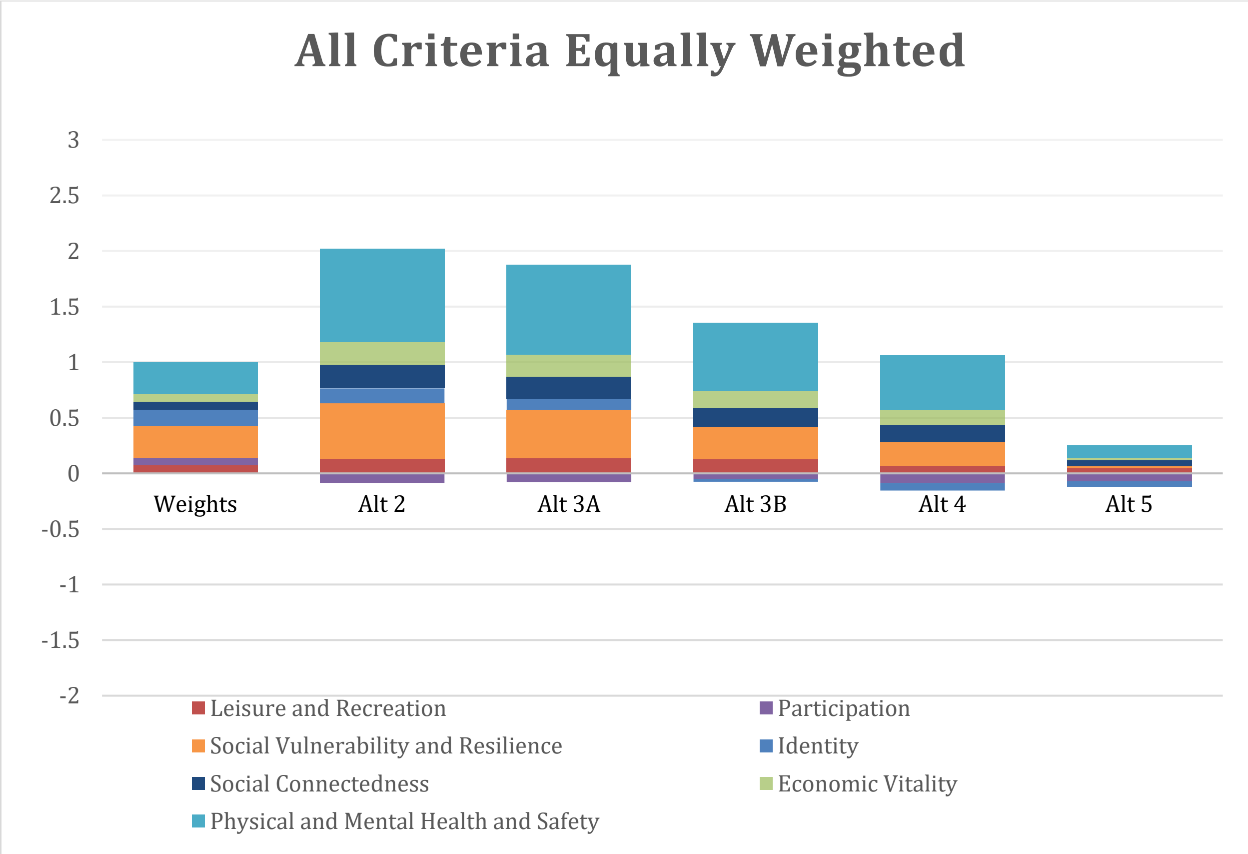


Figure 6.1 OSE Scores - All criteria equally weighted

This weighting scheme effectively favors factors with more criteria, like Physical and Mental Health and Safety and Social Vulnerability and Resilience which each have four criteria.

Next, a weighting scheme examines results if all the factors are deemed equally important (Figure 6.2), meaning that each factor is weighted 14.3%, and the weights of the criteria comprising each factor are equally divided. For Mental and Physical Health and Safety, that means each criteria receives a weight of 3.6%, whereas the Participation criteria receives the full 14.3% because it is the only criteria in its factor.

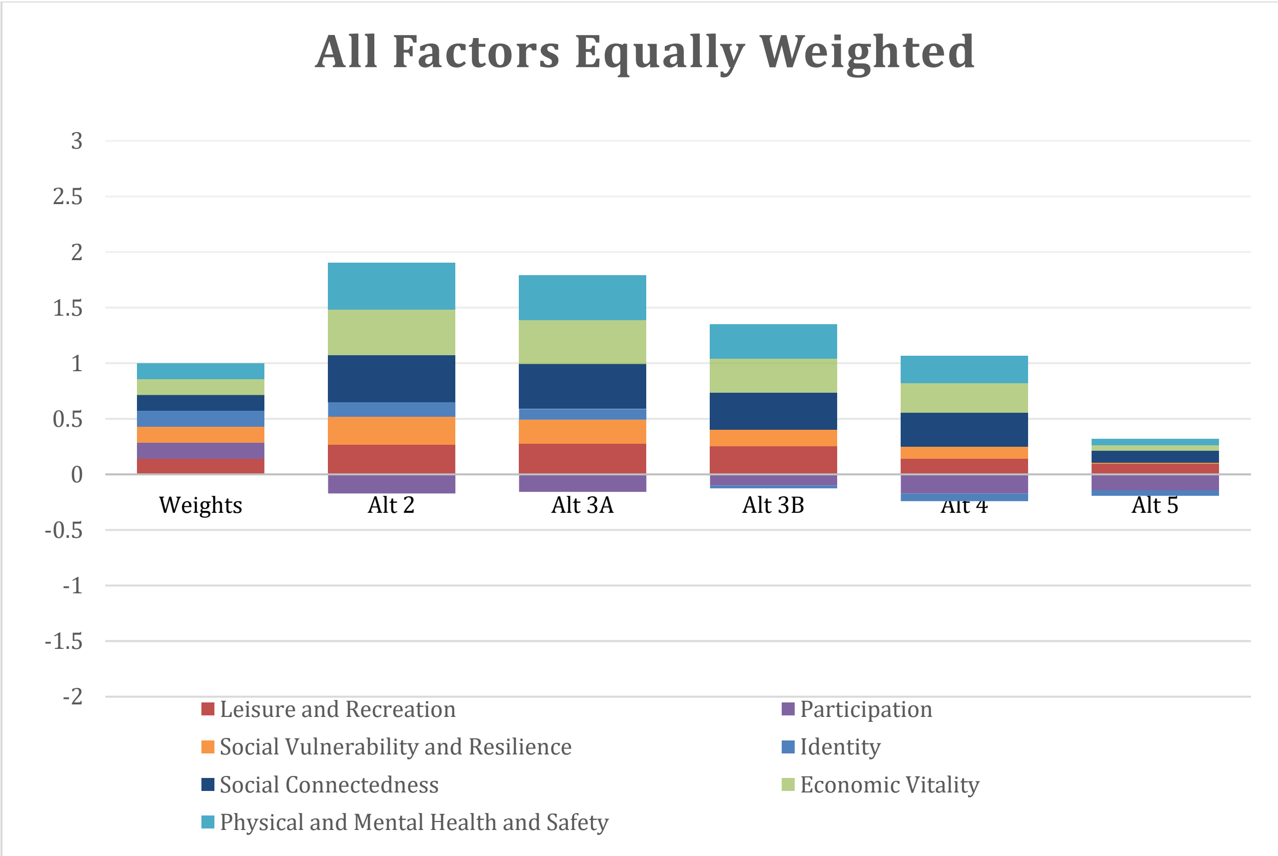


Figure 6.2 OSE Scores - All factors equally weighted

The stakeholder provided numeric answers for the factors and criteria – these were normalized first by factor, and then by the criteria within each factor. For example, Physical Health and Safety received a weight of 18.0% compared to the other factors, thus the criteria within it add up to 18% but using their respective importance to the other criteria in that factor, as specified in the survey. Figure 6.3 shows the results.

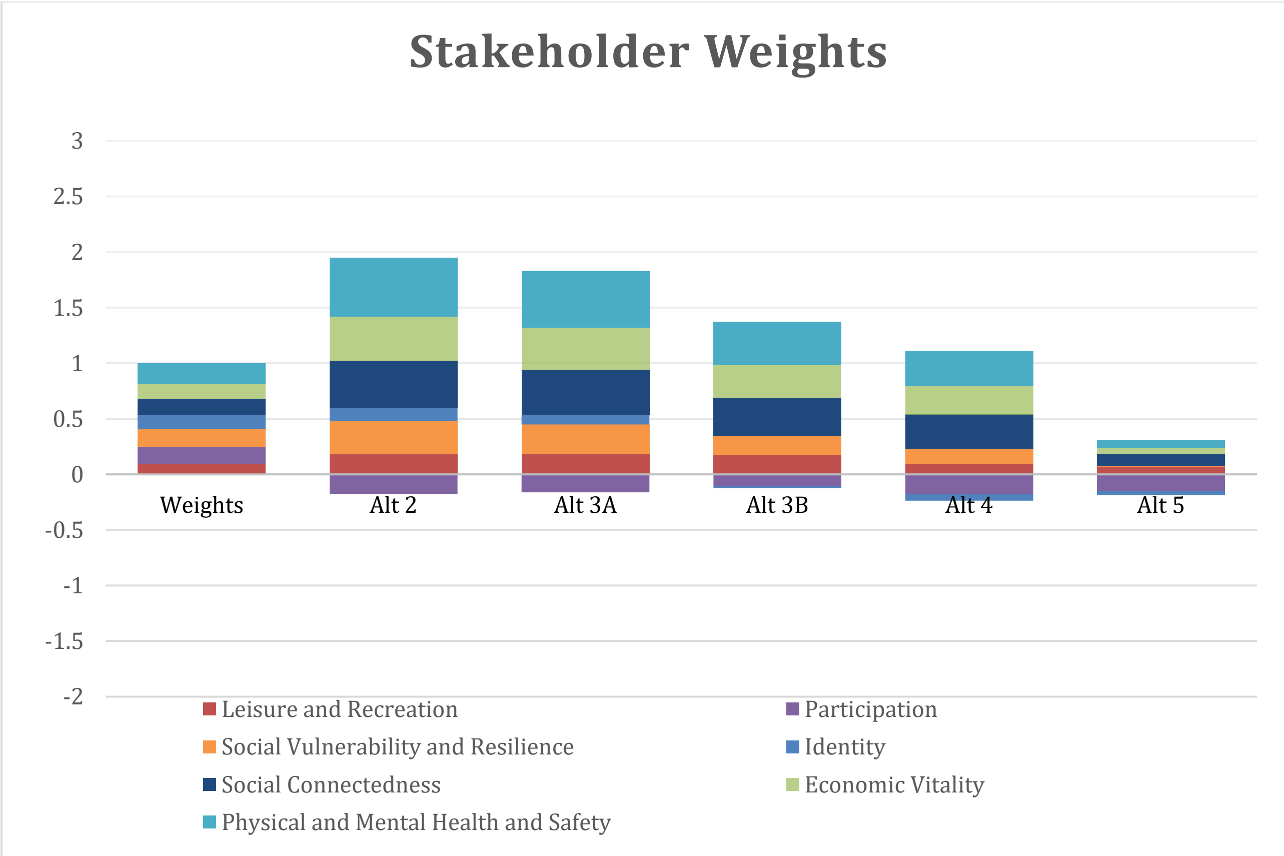


Figure 6.3 OSE Scores - Stakeholder preferred weights, normalized by factor

Moving from stakeholder weighting, Figure 6.4, Figure 6.5, Figure 6.6, Figure 6.7, Figure 6.8, Figure 6.9, and Figure 6.10 show the OSE score results for alternatives as each factor is given a weight of 80%, with the remaining weights equally divided between the other criteria.

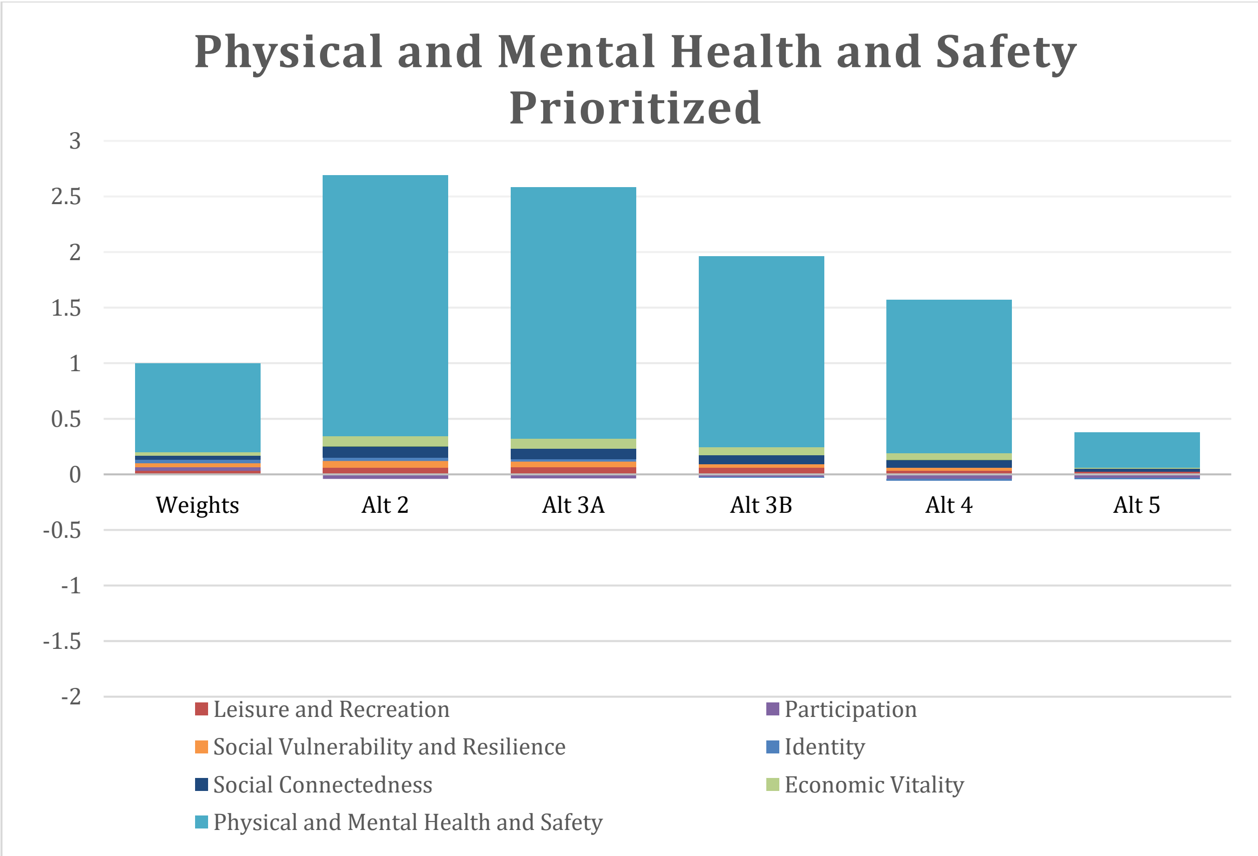


Figure 6.4 OSE Scores - Prioritizing physical and mental health and safety

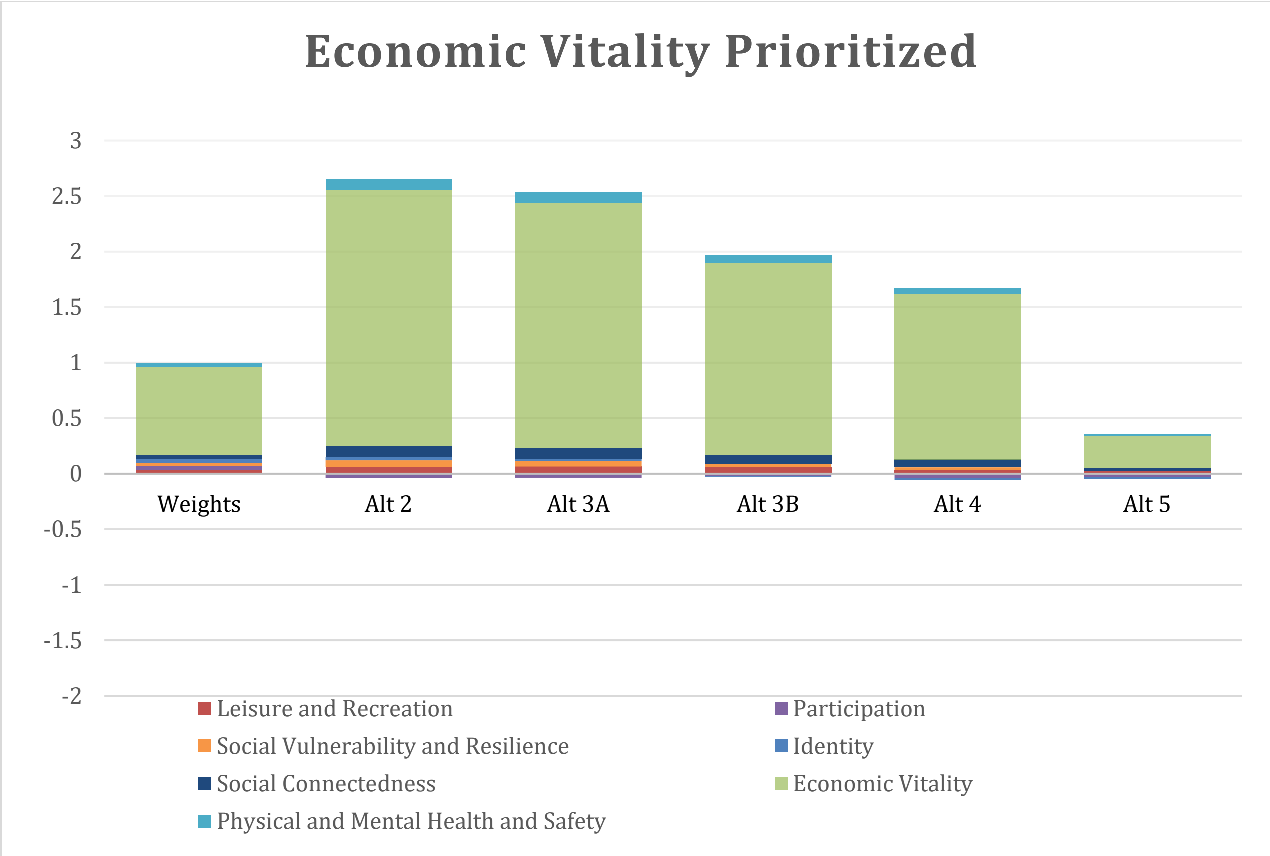


Figure 6.5 OSE Scores - Prioritizing Economic Vitality

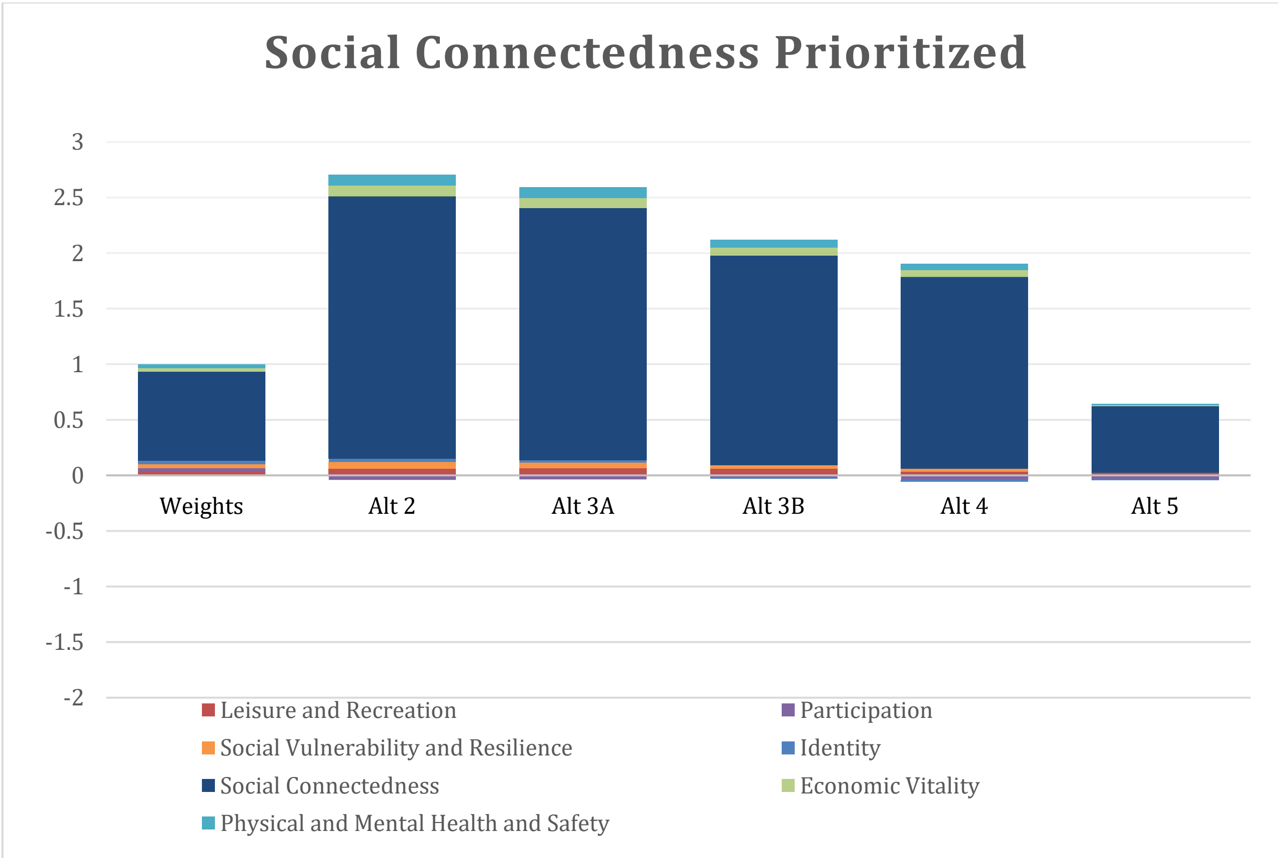


Figure 6.6 OSE Scores - Prioritizing Social Connectedness

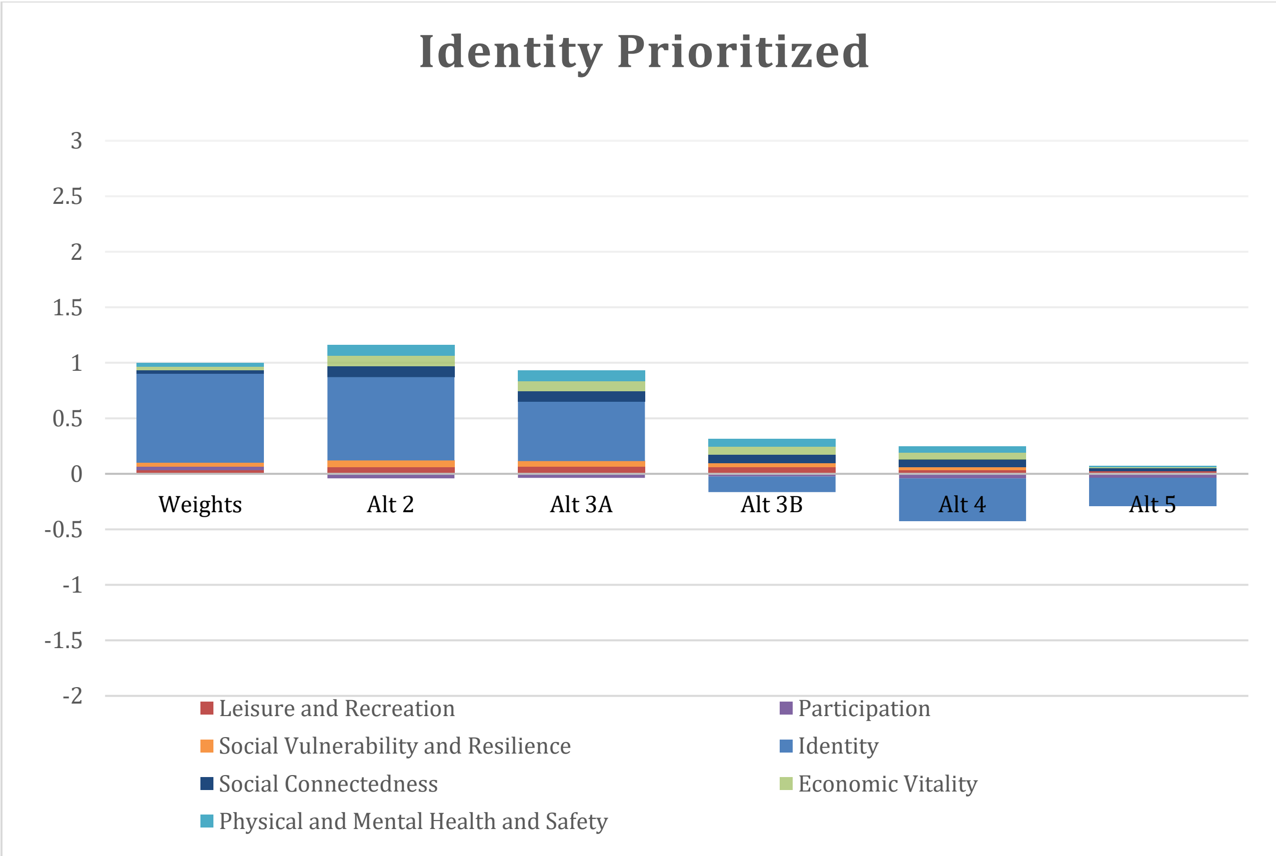


Figure 6.7 OSE Scores - Prioritizing Identity

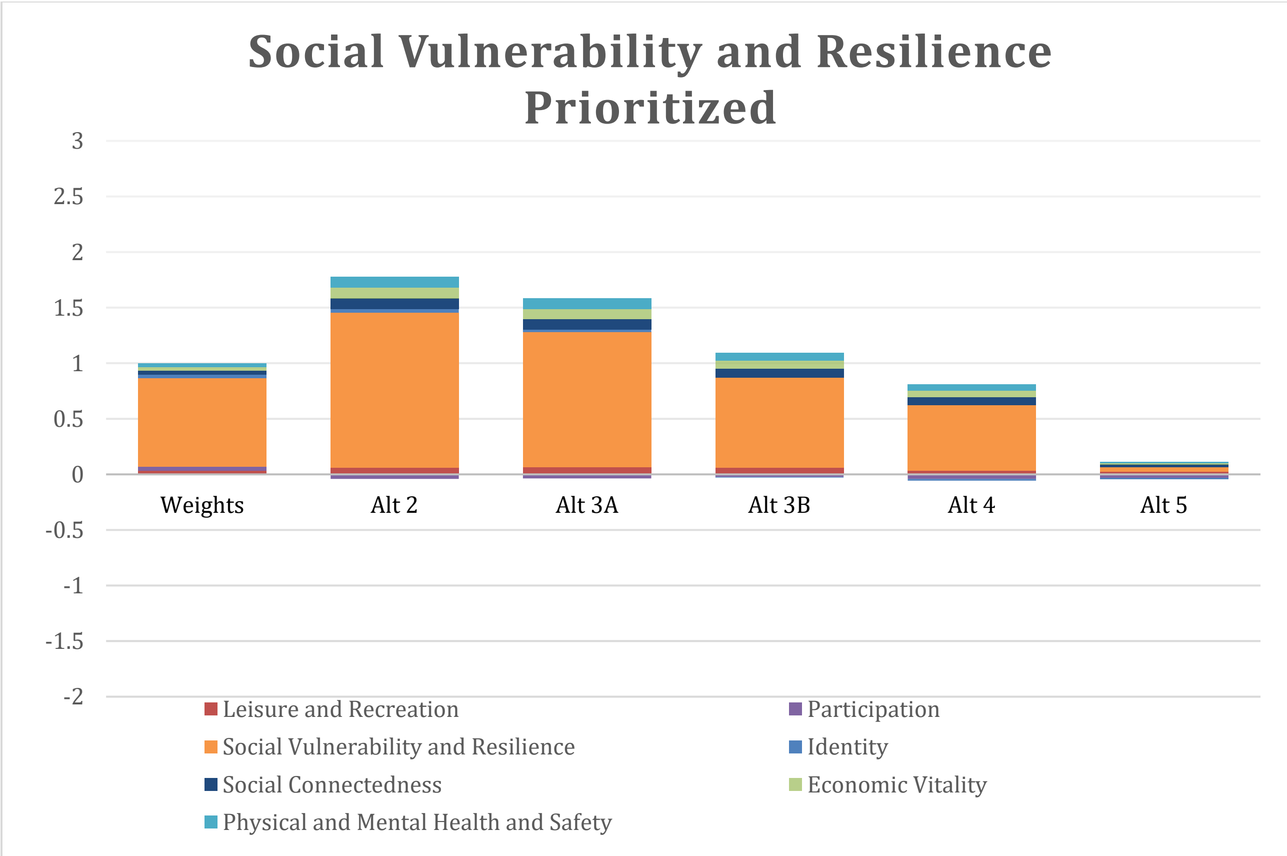


Figure 6.8 OSE Scores - Prioritizing Social Vulnerability and Resilience

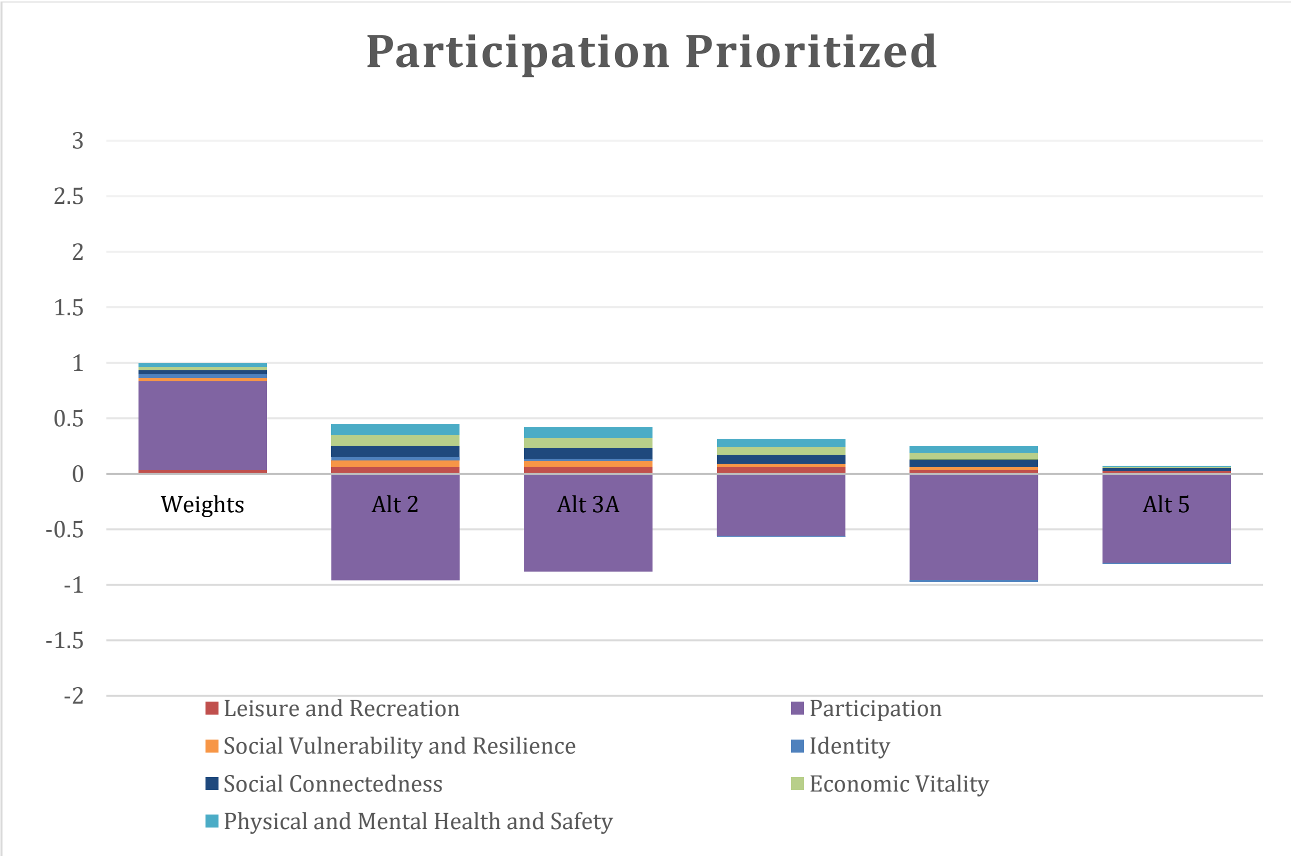


Figure 6.9 OSE Scores - Prioritizing Participation

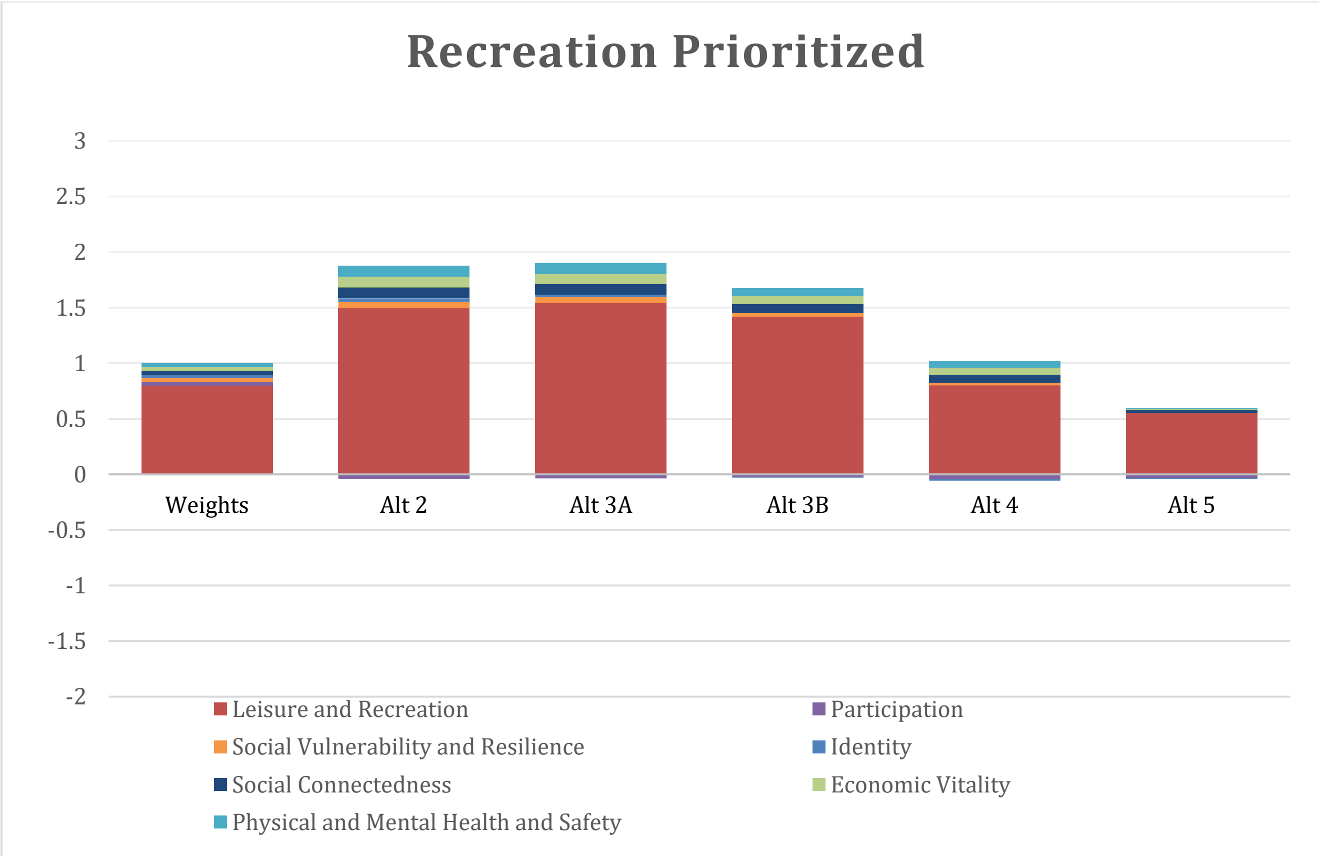


Figure 6.10 OSE Scores - Prioritizing Recreation

Next, scores were weighted by the three criteria representing everyday effects of the barrier infrastructure: aesthetics, participation, and the intersection of the barrier with environmental justice communities. They were each weighted 26.7%, and summed to 80%, with the remaining 20% divided equally between the other criteria (Figure 6.12)

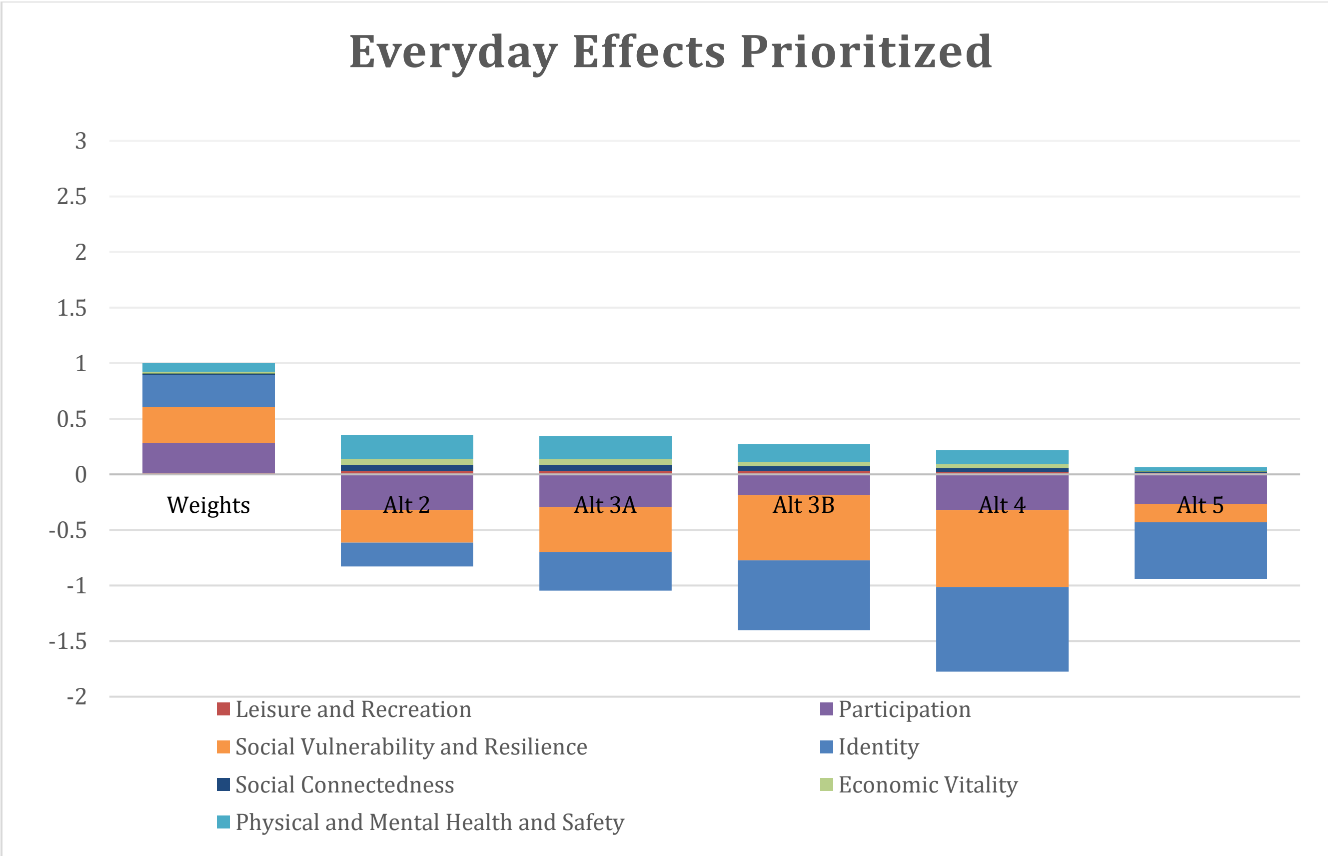


Figure 6.11 OSE Scores - Prioritizing Everyday Effects

The analysis examined environmental justice specifically by assigning each of its two criteria a weight of 40%, with the remaining 20% divided between the other criteria.

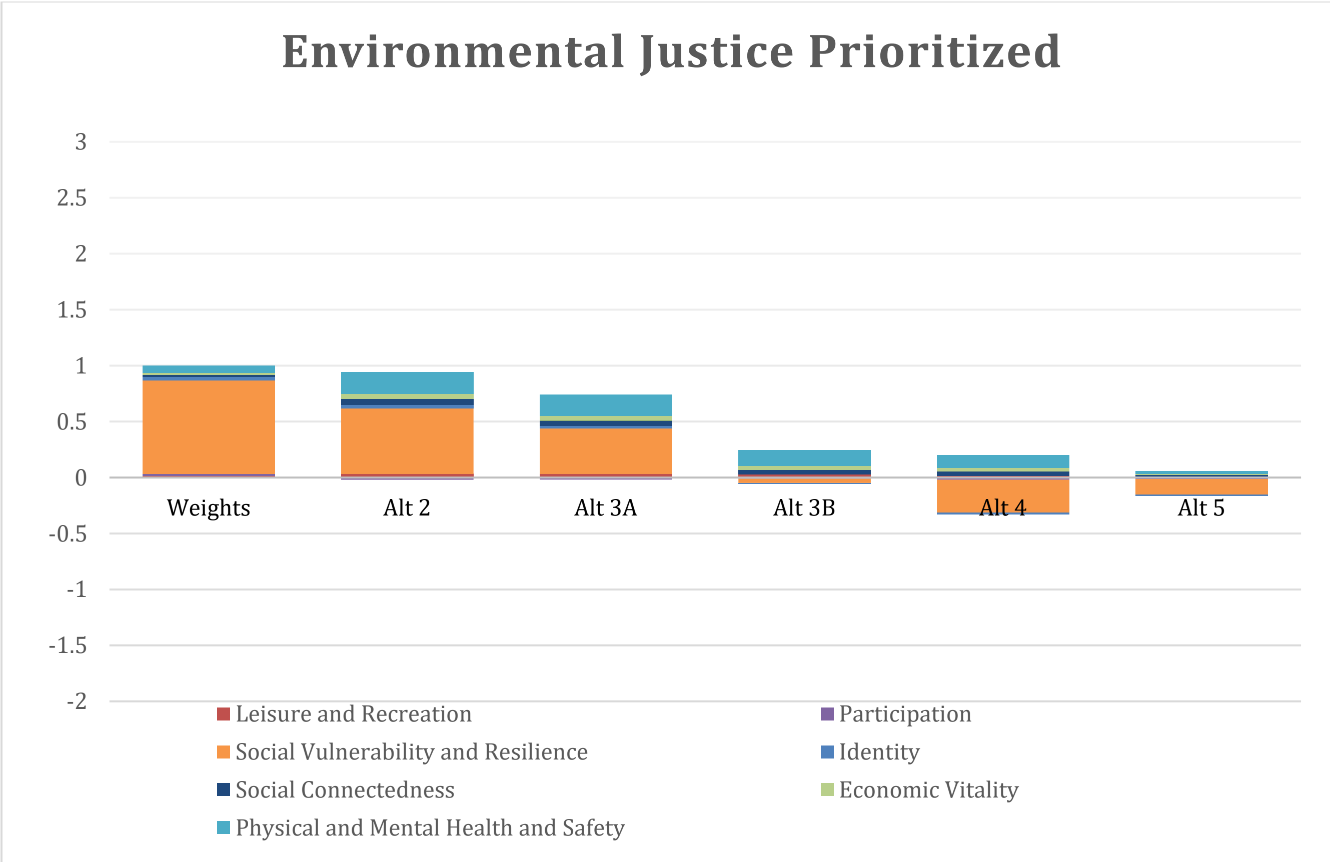


Figure 6.12 OSE Scores - Prioritizing Environmental Justice

The final weighting sensitivity analysis combined the four criteria of the Social Vulnerability and Resilience factor with two factors in Health and Safety with implications on vulnerability: Population with physical vulnerabilities in the risk-reduced area, and point-source contamination in the risk-reduced area. By combining these six criteria, these results emphasize the impacts on vulnerable people in the areas. The six criteria are each weighted 13.3%, and the remaining 8 criteria split the remaining 20%. Figure 6.14 shows the results

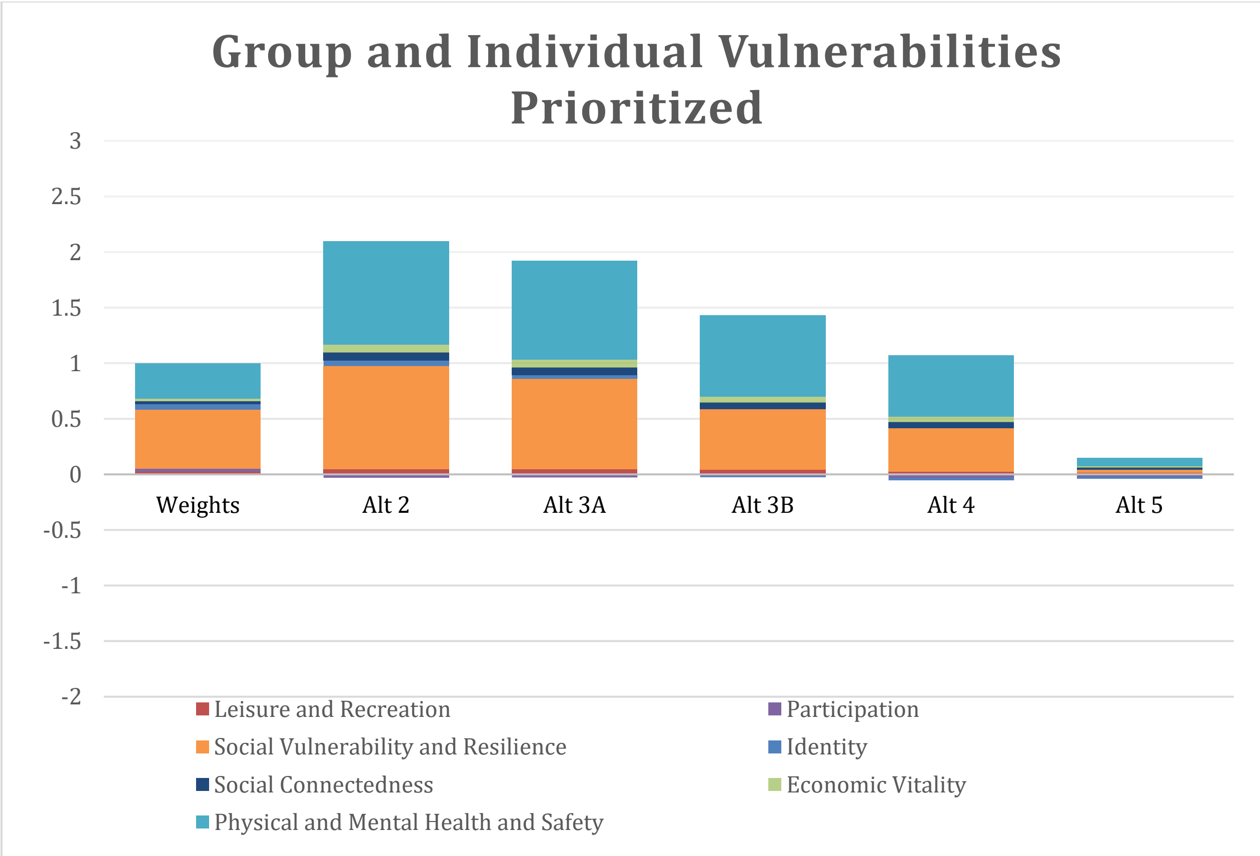


Figure 6.13 OSE Scores - Prioritizing Group and Individual Vulnerabilities

The sums of the sensitivity analysis nearly always favor Alternative 2. Alternative 3A is often a close second, and Alternative 5 frequently has the lowest score. Table 6.17 shows the overall sums with the highest score for each prioritization marked in green.

Table 6.3 OSE Scores by alternative for equal weights of criteria, factors, and for weights provided by stakeholders. Highest scores shown in green.

	Alt 2	Alt 3A	Alt 3B	Alt 4	Alt 5
All Criteria Equally Weighted	1.93	1.80	1.28	0.91	0.14
All Factors Equally Weighted	1.73	1.63	1.22	0.83	0.13
Stakeholder Weights	1.77	1.67	1.25	0.87	0.12

Table 6.4 Stress testing of OSE scores by weighting each topic at 80% of weight, and dividing the remaining 20% of weights between the remaining criteria.

	Alt 2	Alt 3A	Alt 3B	Alt 4	Alt 5
Physical and Mental Health and Safety Prioritized	2.65	2.55	1.93	1.51	0.33
Economic Vitality Prioritized	2.62	2.50	1.94	1.62	0.31
Social Connectedness Prioritized	2.66	2.55	2.09	1.85	0.60
Identity Prioritized	1.12	0.89	0.15	-0.18	-0.22
Social Vulnerability and Resilience Prioritized	1.74	1.55	1.07	0.75	0.07
Participation Prioritized	-0.52	-0.46	-0.25	-0.73	-0.74
Recreation Prioritized	1.84	1.86	1.64	0.96	0.56
Everyday Effects Prioritized	-0.47	-0.70	-1.13	-1.56	-0.88
Environmental Justice Prioritized	0.92	0.72	0.19	-0.13	-0.11
Group and Individual Vulnerabilities Prioritized	2.06	1.89	1.40	1.02	0.11

The analysis finds that Alternative 2 performs the best in a variety of weighting schemes. Additionally, the scores for Alternative 3A are often just short of the higher score for Alternative 2. Future OSE analyses could review the assumptions that led to these findings: for example, do the elements contributing to the Participation Score reflect the general public's priorities? Is there an iterative process through with the public might view the results and change their priorities? This criterion is particularly noteworthy since it is the only one that does not favor alternatives 2 and 3A. Furthermore, there might be important social effects that were not estimated that could be added to the analysis in the future.

Given the current analytical structure, Alternatives 2 and to a lesser extent 3A general score the highest among the social effects that are considered in this analysis.

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