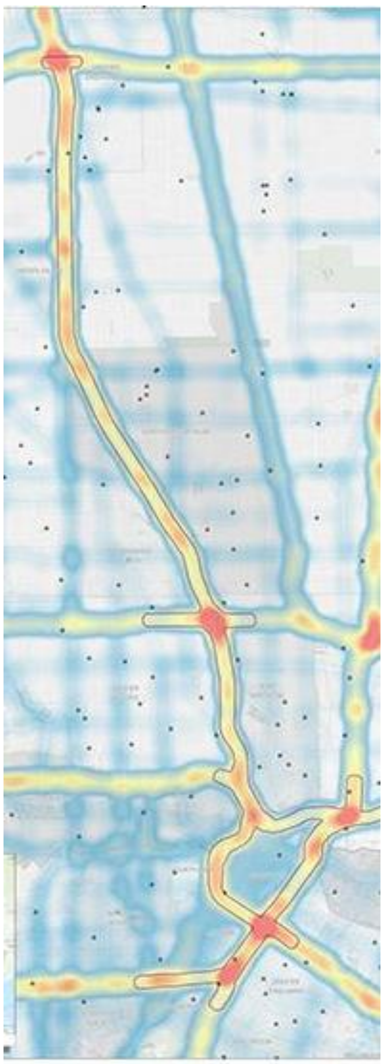
Health Impact Assessment of the North Houston Highway Improvement Project



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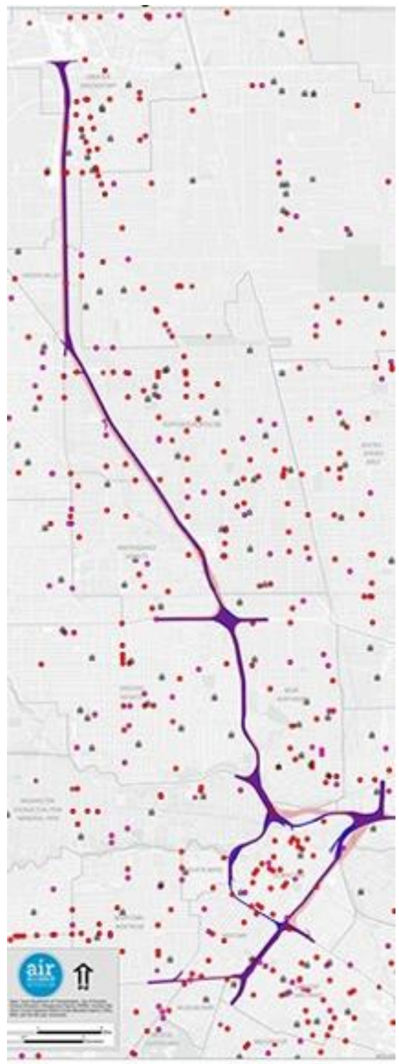

MOBILITY

FLOODING

Air Alliance Houston

May 2019

ACKNOWLEDGEMENTS

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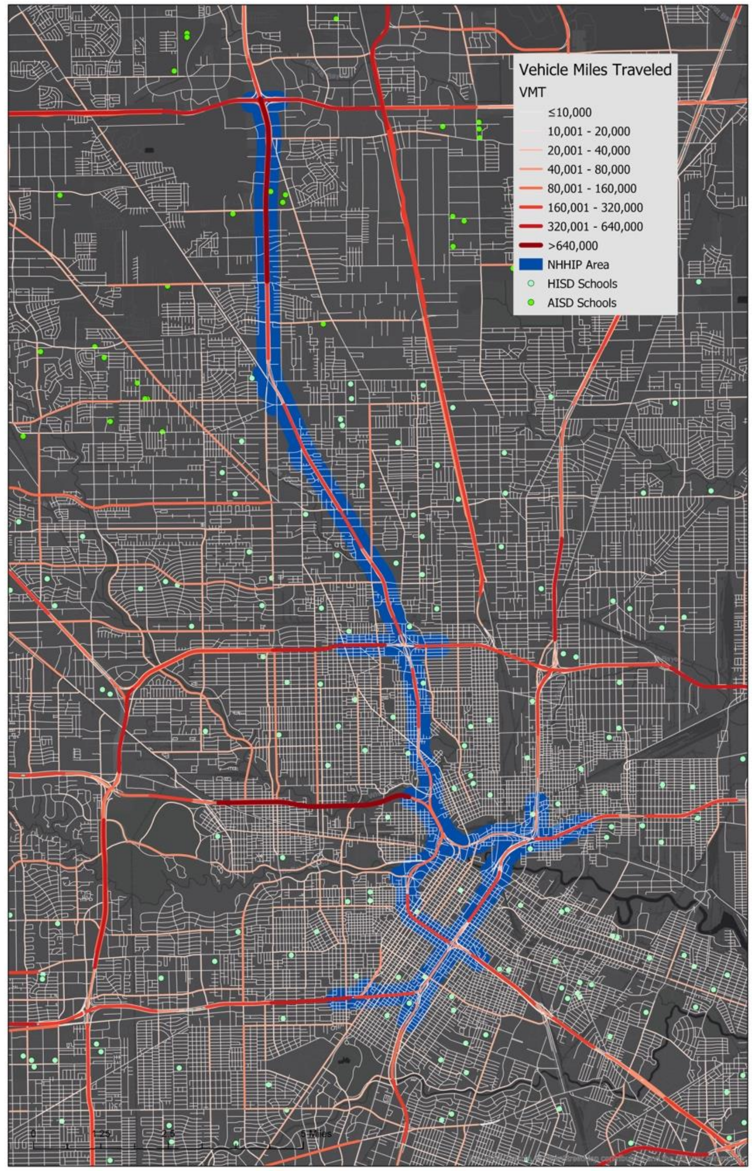
ACRONYMS

DEIS	Draft Environmental Impact Statement
EPA	Environmental Protect Agency
FEIS	Final Environmental Impact Statement
FEMA	Federal Emergency Management Agency
HAIS	Houston Academy of International Studies
HIA	Health Impact Assessment
HOV	High Occupancy Vehicle
IRIS	Integrated Risk Information System
MSATs	Mobile Source Air Toxics
NATA	National Air Toxics Assessment
NEPA	National Environmental Policy Act
NHHIP	North Houston Highway Improvement Project
NOx	Nitrogen Oxide
NO_2	Nitrogen Dioxide
PM	Particulate Matter
ROW	Right of Way
SDOH	Social Determinants of Health
TxDOT	Texas Department of Transportation
Secondary DAEP	Secondary Disciplinary Alternative Education
TRAP	Traffic-related air pollutants
VOC	Volatile Organic Compound
UD4H	Urban Design for Health
UHI	Urban heat island
YWCPA	Young Women's College Preparatory Academy

EXECUTIVE SUMMARY

The North Houston Highway Improvement Project (NHHIP) is a 25-mile highway expansion project running through downtown Houston and north along Interstate 45 to Beltway 8, proposed by the Texas Department of Transportation (TxDOT). The NHHIP has been put forth as the $10 billion solution to address traffic congestion, which has been identified by the respondents of the *2019 Kinder Institute Houston Area Survey* as the largest problem facing the Houston area.



The Houston-Galveston Area Council (H-GAC) has estimated that due to population growth, there will be a 61% increase in the number of vehicles on the road by 2045. This projection has significant implications for the future of air quality and public health in the Houston region. However, mobile sources are already a major source of air pollution contributing to the decline of Houston's air quality. In 2017, mobile sources accounted for 60% of emissions in Harris County. Moreover, according to the *2019 American Lung Association State of the Air Report*, Houston's air quality has gradually gotten worse, now ranking 9th (from 11th in 2018) among the top 25 most ozone-polluted cities in the United States.

The NHHIP Health Impact Assessment (HIA) aims to help inform decision makers about the potential health impacts to communities, specifically those impacting schools, school-aged children and their families that live, work, and go to school nearby. Based on findings, the HIA proposes recommendations to mitigate any potential adverse health outcomes identified and enhance positive outcomes based on the design of the NHHIP project.

Table 1 below outlines the project goals, the health effects considered, and the impact categories included in the assessment. Table 2 summarizes key results and recommendations.

Table 1. HIA overview: goals, health effects, impact categories.

<table>
<tr><th colspan="3">HIA Goals</th></tr>
<tr><td colspan="3">1. Quantify the NHHIP project’s potential positive and negative health effects for inclusion in the final environmental impact statement.
2. Serve as a model project to integrate HIAs into future mobility projects in the metro-Houston area.
3. Raise public awareness of the public health implications of highways.</td></tr>
<tr><th colspan="3">Health Effects</th></tr>
<tr><td colspan="3">Focusing on schools located within 150 m (500 ft) of the NHHIP project, the HIA used a combination of existing data sets, data gathering, literature review, and stakeholder input to assess the potential positive and negative health effects associated with:
• the proposed highway expansion; and,
• proposed mitigation strategies.</td></tr>
<tr><th colspan="2">Impact Categories</th><th>Schools Selected for Additional Analysis</th></tr>
<tr><td>Air quality
Mobility
Flooding
Low income communities
Economic development</td><td>Parks and green space
Noise
Visual impacts
Urban heat island</td><td>Aldine (Stovall Middle School, Aldine 9th, Aldine High School)
Bruce Elementary
Houston Academy of International Studies (HAIS)
Jefferson Elementary
Roosevelt Elementary
Secondary Disciplinary Alternative Education (Secondary DAEP)
Young Women’s College Preparatory Academy (YWCPA)</td></tr>
</table>

Table 2. HIA results and recommendations at a glance.

CONCERN	IMPACTS ON COMMUNITY	POSSIBLE SOLUTIONS
Student Health	Highway traffic next to the nine schools studied in the HIA currently averages seven times higher Vehicle Miles Travelled within 400m of campus (70,198), compared with the HISD/AISD average of 10,124. Asthma rates at many of the schools along the NHHIP route already greatly exceed the AISD/HISD average of 3.3%. E.g. Bruce El.: 7.2%; Aldine: 4-6%; YWCPA: 5%; Secondary DAEP: 5%. The expansion design would widen the highway width by as much as 70% in some areas and add several more lanes, bringing at least 26 existing school and daycare campuses within 500 feet of the highway. The increased volume of traffic anticipated will introduce more air and noise pollutants into the nearby communities. These pollutants are linked to poorer health, increased sick days from work and school, reduced academic performance, shorter lifespans, and lower quality of life. Furthermore, a number of traffic-related air pollutants are known carcinogens. Children attending schools near high traffic areas are particularly vulnerable to traffic-related pollution due to their developing brains, lungs, hearts, and circulatory systems. They receive even more exposure if they are active outside during high traffic times.	– Request that TxDOT fund sidewalks and tree lines along the borders of the lots facing I-45 and along major streets within 500 ft of the highway/students' main walking paths to and from school. Further request that TxDOT fund noise/pollution barriers along the highway edge. – Request that TxDOT locate construction staging areas at least 500 ft from sensitive uses like schools, senior living, residences, and health care facilities. Encourage the use of low and zero-emission equipment and dust control during construction. – Request that TxDOT provide funding for the installation of air monitors at sensitive receptors like schools, parks, and playgrounds during and after project completion. – Request that schools implement "No-Idle Zones" around campus for carpools, school buses, and deliveries. – Request that TxDOT provide funding for the ongoing installation of HEPA (high efficiency particle air) filters within buildings with sensitive occupants located within 500 ft of the highway.
Environmental Justice	The expansion would cause the removal or relocation of families in several public housing units, particularly Clayton Homes and Kelly Village in the 5th Ward. Several neighborhoods along Segments 1 (Beltway 8 to I-610) and 2 (I-610 to I-10) have higher poverty rates (up to 75.5%) and a higher percentage of persons of color (up to 94%), compared with the Houston average (43.2% and 73.7%, respectively). The current NHHIP design will further entrench barriers between neighborhoods on either side of the expansion route. Examples: SH-288 separates high income, majority white neighborhoods on the west side of SH-288 from low income, majority people of color neighborhoods on the east side; I-45N separates residents of Independence Heights (a food desert) on the west side of the highway from the closest grocery store, which is on the east side. More mitigation strategies have been incorporated into the design for the affluent Segment 3 (Downtown) than into the two segments north of I-10; negative impacts could disproportionately fall on low-income communities of color.	– Encourage TxDOT to work with the City of Houston and community organizations to reduce the highway width and improve the amenities provided along the northern segments of the project to mirror the investment going into Downtown. – Request that TxDOT fund appropriate structure for the deck park proposed to link Woodland Heights and Near Northside, so that it will be able to accommodate trees and other vegetation. Ensure that pedestrian access to the park is safe and inviting. – Request that TxDOT improve surface street connectivity between 5th Ward, the Near Northside, and the Central Business District to improve access to job opportunities. – Request that TxDOT provide funding for constructing all highway crossings and frontage roads in accordance with Complete Streets Principles to protect and promote pedestrians and cyclists.

CONCERN	IMPACTS ON COMMUNITY	POSSIBLE SOLUTIONS
Community Safety	A significant number of pedestrian/bike crashes have occurred within ½ mile radius of schools along the NHHIP corridor since 2010. Many of these have occurred under/adjacent to the highway or on preferred pedestrian routes to school. Furthermore, no school zone has been designated for any of the schools on the Aldine campus. The current NHHIP design will expand the highway width and increase the speed of cars traveling down the access road, increasing safety concerns for pedestrians and cyclists, many of whom are school children. Many of the schools along the NHHIP corridor are in areas ranked as most prone to dangerous urban heat island effects and/or flooding in Houston. E.g. Jefferson El. is in the top 9% of areas most likely to suffer from urban heat island effects, while the Aldine campus sits in both the 100-year and 500-year Federal Emergency Management Agency FEMA floodplains. The expansion will construct more impermeable concrete surfaces, which could increase flood risk and the urban heat island (UHI) effect.	– Request that the Houston-Galveston Area Council provide more funding for transit and active transportation projects; remove the caps on funding for Alternative Mode and Air Quality projects; and, prioritize projects serving disadvantaged communities. – Engage with METRO to support and provide feedback on the METRONext Plan and encourage fellow community members to vote in the upcoming bond elections to authorize funding for the expansions. – Request that TxDOT include parks, green spaces, and tree canopy in the NHHIP design to increase permeable surfaces, reduce flooding and the UHI, and encourage physical activity. – Request that TxDOT comply with the Harris County and City of Houston Flood Control design standard of 500-year flood events, rather than 100-year flood events.

COMMUNITY CONTEXT

The NHHIP is a proposed 25-mile highway expansion project running through downtown Houston and north along Interstate 45 to Beltway 8. Much of the traffic demand the project accommodates originates from exurban commuter traffic with final destinations inside the City of Houston, but the health impacts of the expansion will largely burden communities within the city and those that live, work, learn, and play in close proximity to the corridor. For this reason, it is critical that TxDOT deliver a project that considers the health and well-being of all Houston communities and takes care to ensure that the I-45 North expansion does not negatively impact Houston residents in order to deliver benefits to surrounding areas.

The NHHIP is divided into three segments (Figure 1), each of which exhibits distinguishing characteristics including the composition of the impacted communities and unique environmental contexts. These segments define the broader study area including communities that are adjacent to the three sections.

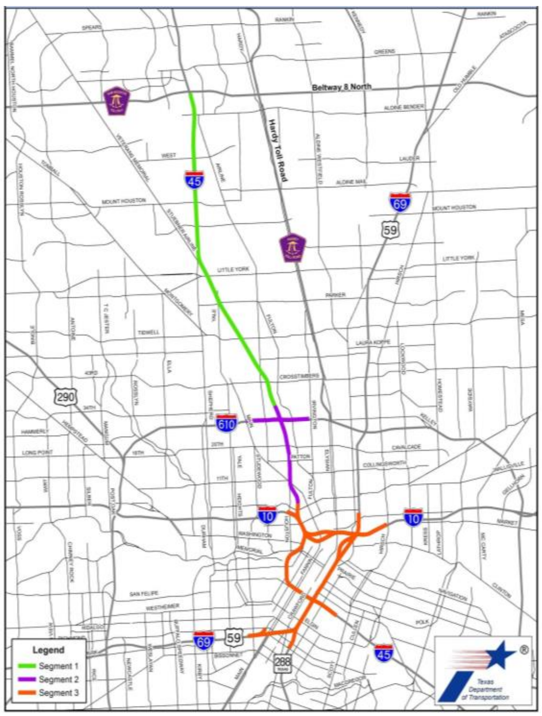


Figure 1. NHHIP project segments.

Characteristics of Segment 1: Beltway 8 to I-610 (Green)

- Higher poverty rate, lower income, higher Hispanic population than Houston as a whole.
- Significant flood damage along Halls Bayou during Harvey.
- NHHIP Design:
  - Section 1 will see the greatest number of lanes added to the highway and in some places the highway footprint will nearly double in width.
  - More lanes of increased width in most sections and few, if any, amenities such as greenspace or depressing the freeway.

Characteristics of Segment 2: I-610 to I-10 (Purple)

- Lower income and higher Hispanic population than Houston as a whole, but similar poverty rate.
- NHHIP Design:
  - Beyond additional lanes, the plans include a sunken tunnel with a deck that connects the Heights to Near Northside via Hollywood Cemetery.
  - Features a deck with a sunken tunnel that connects to the Heights and Near Northside.
  - Intersected Little White Oak Bayou.

Characteristics of Segment 3: Downtown loop to I-69 and 288 (Red)

- Near parity of racial/ethnic identity – White, African-American, Hispanic.
- NHHIP Design:
  - Proposals for this segment include many infrastructure changes beyond highway expansion including straightening meandering interchanges, removing the Pierce Elevated on the south and east sides of downtown, and installing decks and greenspace next to locations such as the convention center and Museum Park at I-69.
  - Contains the most perceived amenities proposed for the NHHIP project.
  - Proposed right of way would impact several public housing units (removal/relocation).
  - Maintains and fortifies the role of certain highways to demarcate the boundaries of socioeconomic disparity (i.e. isolating communities in the east and north side of the city from the Central Business District), while improving connectability between Downtown and Midtown areas with removal of the Pierce Elevated.

WHAT IS AN HIA?

An HIA is a tool used to evaluate the potential negative and positive health impacts of proposed policies, programs, or projects during the decision-making process and integrate mitigation strategies that can minimize the potential adverse impacts and enhance the positive impacts. This systematic process typically involves six steps and uses a variety of data sources, including input from stakeholders and community members. The NHHIP HIA aims to help inform decision makers about the potential health impacts to communities, specifically those impacting schools, school-aged children and their families that live, work, and go to school nearby. Based on findings, the HIA proposes recommendations to mitigate any potential adverse health outcomes identified and enhance positive outcomes based on the design of the NHHIP project.

Table 3. Summary of HIA process.

1. Screening – define project goals.
2. Scoping – establish parameters and methodology.
3. Assessment – identify potential co-benefits and co-harms to impacted communities.
4. Recommendations – develop recommendations based on assessment results and feedback from stakeholders.
5. Reporting – develop report and distribute to stakeholders.
6. Monitoring & Evaluation – evaluate the effectiveness of the HIA.

Source: Centers for Disease Control and Prevention, Department of Health and Human Services.
URL: https://www.cdc.gov/healthyplaces/hia.htm.

CONDUCTING AN HIA OF THE NHHIP

Air Alliance Houston (AAH) is a member of the "Make I-45 Better Coalition" – a group of organizations that believe the NHHIP must be evaluated in the context of our region's effort to develop "complete communities", particularly given the legacy of highway projects that divide communities of color and low-income.[1] Our groups share concerns about various aspects of the project's design that will include re-routing and rebuilding of the highway that will be at the expense of numerous neighborhoods, signature parks, and Houston's evolving linear park system, all of which bear the potential to impact the public health of our region.

AAH first considered the utility of implementing an HIA for the NHHIP after reviewing the Draft Environmental Impact Statement (DEIS) released by the Texas Department of Transportation in April 2017. Upon review, AAH determined that the document did not provide the depth of air quality analyses required by the National Environmental Policy Act (NEPA) and offered an inadequate evaluation of the potential impact of traffic-related air pollutants (TRAP) from the project. Along with concerns about the limited air quality analyses provided in the DEIS, many of the communities adjacent to the NHHIP corridor have historically experienced poor health outcomes compared to other communities, making them more vulnerable to any potential adverse health impacts from the NHHIP. Moreover, students attending some of schools within the TRAP zones along the proposed expansion route have a history of high utilization of emergency services to treat asthma. The expansion would place many of the schools in closer proximity to the highway and harmful air pollution.

Because the NHHIP project offers an opportunity to integrate protective and health-promoting design features that will reduce school children's exposure to the air pollution from the highway and help protect community health more broadly, AAH applied for and received funding through the Urban Institute and Robert Wood Johnson Foundation's 500 Cities Data Challenge to conduct an HIA of the NHHIP. With funding from the 500 Cities Data Challenge, the HIA Project Team initiated the assessment process and began to engage stakeholders in the summer of 2018. This included working with the existing Make I-45 Better Coalition and other interested groups to begin to identify how the HIA could be used to inform mitigation strategies to address potential adverse health impacts, and specifically, how the recommendations could be integrated into the final EIS (FEIS) expected to be released in 2019.

It is notoriously difficult to access health datasets at a scale smaller than the county level. Because of this, the 500 Cities Data was an integral component of this project and was used to assess existing health conditions and guide the activities of the HIA. The 500 Cities dataset essentially provided a health-based context to assess the social, environmental, and behavioral conditions of neighborhoods bordering the highway expansion. In the absence of primary sources such as hospitalization data, census tract-level crude prevalence rates from the 500 Cities dataset provided critical information which made the HIA possible. Moreover, it can be difficult to set the geographic scale for studies of large cities like Houston, because its extent could be defined in a number of ways. By setting a defined spatial extent for the study area, the 500 Cities Data for the City of Houston created a framework for consistent data acquisition and analyses across a range of indicators.

SCREENING

Through the screening step of the HIA a number of potential health effects were identified. While AAH is specifically interested in health outcomes related to air quality, several additional impacts were identified based on those listed in the Make I-45 Better Coalition letter during the public comment period of the DEIS. These were:

- Air quality
- Mobility
- Flooding
- Displacement of low-income communities
- Economic development
- Parks and green space
- Noise
- Visual impacts
- Urban heat island effects

A team led by AAH with support and input from independent researchers, stakeholders, and two technical advisory committees conducted the HIA between May 2018 and April 2019. Along with the concerns regarding the impact categories noted above, AAH identified a number of additional shortcomings associated with the air quality analysis provided in the DEIS. The DEIS noted that there may be localized areas where ambient concentrations of mobile source air toxics (MSATs) could be higher under the Preferred Build Alternative than the No Build Alternative, but the magnitude and duration of these increases could not be reliably quantified due to incomplete or unavailable information.[2] For example, the analysis did not identify "hot spots" where hazardous air pollutants are projected to surpass allowed levels nor, at that time, did TxDOT disclose baseline emissions along each segment of the roadway. Moreover, there was no analysis of the potential impacts on the schools located within the traffic-related air pollution zone. Children living or attending school near highly trafficked highways like I-45 are at greater risk of damage to their developing brains, lungs, hearts, and circulatory systems. Furthermore, a number of traffic-related air pollutants – such as diesel particulate matter, benzene, 1,3 butadiene, and formaldehyde – are known to cause cancer. We maintain that the lack of specific quantitative details in the DEIS summary represents a glaring omission from the impact analysis and precludes informed decision making regarding the dispersion of traffic-related air pollutants.

SCOPING

The scoping phase of the HIA identified the various pathways through which health could be impacted as a result of the expansion. Although not fully funded to-date, the NHHIP is estimated to cost $7-10 billion (exclusive of right-of-way purchases) to expand 25 miles of highway over a 10-year period. The TxDOT's goal is to "provide a safer facility with additional capacity for projected demand by incorporating transit opportunities, travel demand strategies, and flexible operations."

The I-45N highway expansion project (NHHIP) will result in:

- Changes to the highway design, including: expanding its width in some locations, adding a second level in some locations, sinking portions in the ground, and installing deck covers in some areas.
- Realigning three highways (I-45, I-10, and I-69) on the north and east sides of downtown Houston.
- Changes to highway access and entrance ramps.
- Changes to the width of the highway causing some campuses to be in closer proximity to traffic pollution.
- Rebuilding intersections crossing above or below the highway.

The scoping phase set the parameters and approach for the HIA. Due to limited resources, an abbreviated timeline (1 year), and the disproportionate impact of air pollution on the health of children, it was determined that the HIA would focus on how the selected design would impact schools in the TRAP zone, with a primary focus on impacts from air quality, mobility, and flooding. While the planned expansion could increase or decrease exposure to environmental pollution at all of the campuses within the TRAP zone however, nine schools were prioritized for detailed assessment. The campuses were prioritized applying two sets of criteria. First, schools were prioritized based on the potential for adverse air quality and health impacts:

- Location <= 50m or 150m of NHHIP
- High sum of vehicle miles traveled (VMT)
- High asthma rate

Next, schools were prioritized based on the potential for adverse mobility and health impacts:

- Does the campus fall within 400m (walk) or 1,600m (bike) of the NHHIP project?
- Does the school attendance zone intersect I-45?
- Does it fall within the highest quartile of summed VMTs within that buffer zone?
- Does it fall within the highest quartile of school age traffic-related injuries and deaths?

Because stakeholder engagement is critical to the HIA process, in addition to the above noted criteria, an additional criterion used to prioritize the campuses was whether there was an existing connection/relationship with the community through AAH and/or other Coalition members. Because of the HIA timeline, the HIA Project Team determined that community stakeholder engagement efforts would be more effective by leveraging existing community connections. This process resulted in nine schools being prioritized for inclusion in the HIA (Table 4). Figure 2 below displays the location of each of the priority campuses along the NHHIP corridor and Table 5 the goals of the HIA.

Table 4. Schools selected for additional analysis.

Aldine (Stovall Middle School, Aldine 9th, Aldine High School)
Bruce Elementary
Houston Academy of International Studies (HAIS)
Jefferson Elementary
Roosevelt Elementary
Secondary Disciplinary Alternative Education (Secondary DAEP
Young Women’s College Preparatory Academy (YWCPA)

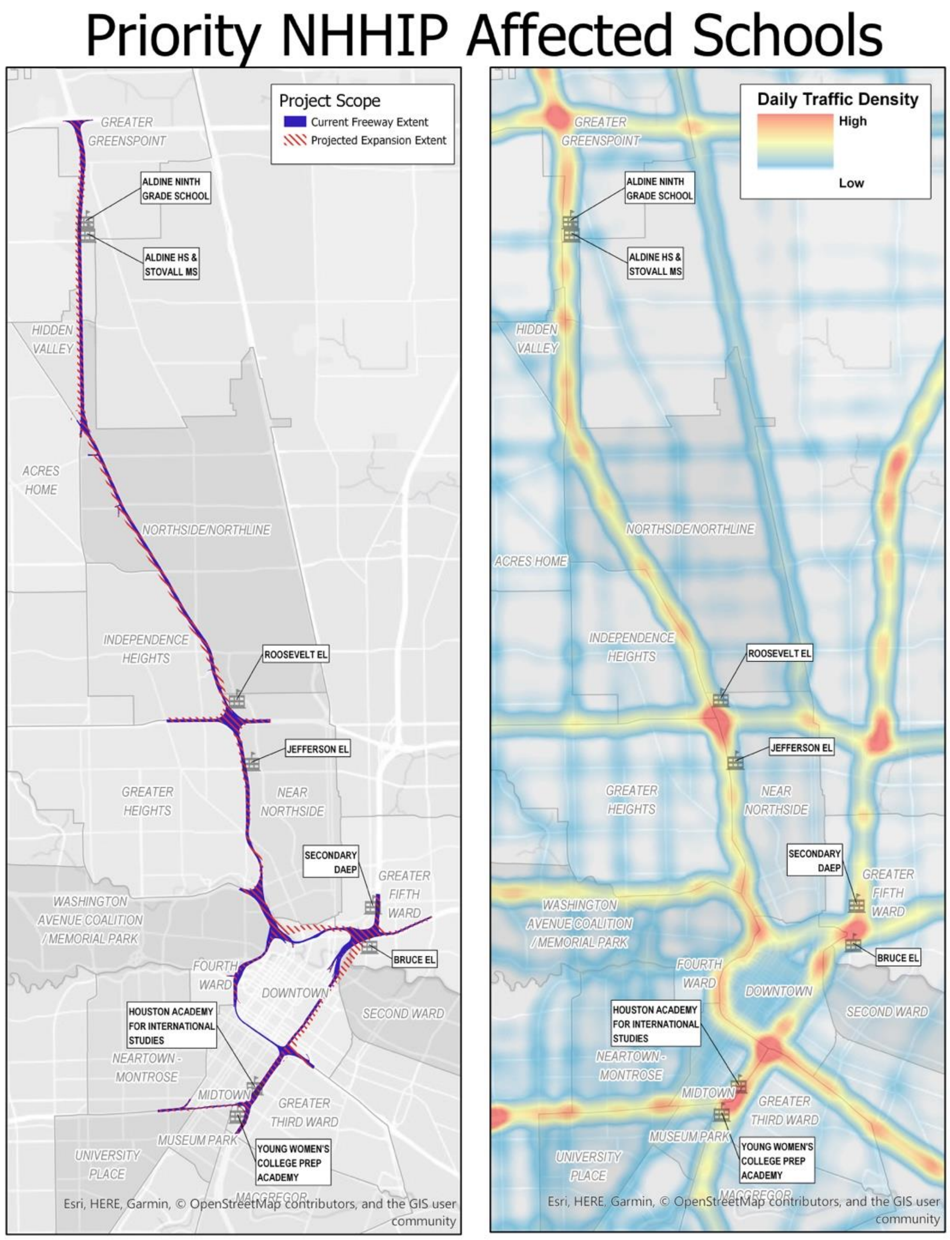


Figure 2. Location of schools selected for additional analysis.

Table 5. HIA overview: goals, health effects, impact categories.

HIA Goals	
1. Quantify the project's potential positive and negative health effects for inclusion in the final environmental impact statement. 2. Serve as a model project to integrate HIAs into future mobility projects in the metro-Houston area. 3. Raise public awareness of the public health implications of highways.	
Health Effects	
Focusing on schools located within 150 m (500 ft) of the NHHIP project, the HIA used a combination of existing data sets, data gathering, literature review, and stakeholder input to assess the potential positive and negative health effects associated with: ● the proposed highway expansion; and, ● proposed mitigation strategies.	
Impact Categories	
Air quality	Parks and green space
Mobility	Noise
Flooding	Visual impacts
Low income communities	Urban heat island
Economic development	

STAKEHOLDER ENGAGEMENT

A key step in the HIA process is to gather feedback from stakeholders. Through the screening and scoping process of the HIA, a number of key stakeholder groups were identified and engaged during key points of the HIA process. These stakeholders included representatives from a variety of entities including decision makers and TxDOT staff, the Make I-45 Better Coalition, local governments, school districts, community-based organizations, local businesses and civic groups. Additionally, two technical advisory committees were formed to provide input and share expertise on the identified impact categories, proposed assessment methodology, and the policies and decision-making processes that can influence the project. AAH also worked closely with LINK Houston, Lone Star Legal Aid, the Houston Parks Board, and other members of the Make I-45 Better Coalition to engage a variety of stakeholders throughout the HIA.

Effective and meaningful stakeholder engagement throughout the HIA is critical for a successful assessment and can lead to more sustainable, long-term outcomes. As the lead organization, AAH served to connect key stakeholders and engage where appropriate (and where resources allowed) throughout the steps of the HIA. LINK Houston, Lone Star Legal Aid, and Texas Housers were key partner organizations that supported the HIA community engagement activities. These organizations were able to leverage their existing outreach efforts and relationships to support the HIA and assist with the planning and facilitation of community meetings.

Key Stakeholder Groups

Stakeholder groups identified for this HIA included community-based organizations, advocacy groups and coalitions, local schools and independent school districts, content experts (on air quality, flooding, transportation, health, etc.), along with officials and decision makers (local, regional, and state). At the beginning of the HIA, AAH facilitated a workshop in September 2018 to "kick-off" the HIA. The goals of the workshop were to educate participants about the health effects of highways; familiarize them with the process of conducting an HIA; and give them opportunity for input on the focus of the assessment and associated recommendations. The objectives for the project team were to gain a better understating of the environmental impacts, health effects, and locations along the NHHIP corridor that are most important to stakeholders.

Following the completion of the assessment (6 months later), AAH facilitated 4 community workshops and three meetings with the leadership of each school district in March and April 2019. The workshops provided an opportunity for the impacted communities to share their perspectives on the locations along the NHHIP corridor they are currently concerned about regarding traffic-related pollution, locations and groups they felt were either missing or neglected in the current HIA focus, and what strategies and recommendations the HIA should include in the final report. Community member input were then used to inform the concerns and recommendations.

Because one of the stated goals was to raise awareness about the NHHIP HIA, beyond facilitated community workshops, the HIA Project Team gave numerous presentations at meetings with different stakeholders throughout the process. Table 6 below provides a brief summary of the various stakeholders engaged throughout the HIA and the rationale for including them in the process.

Table 6. Key stakeholder groups and the purpose and dates of their engagement.

Organization/Agency	Purpose of Engagement	Dates of Engagement
Texas Department of Transportation	Express concerns about the project design and impact on adjacent campuses. Provide information for possible inclusion in a Supplemental Environmental Impact Statement for the NHHIP project. Provide preliminary results of the HIA and recommendations to mitigate the identified impacts.	11/2017 3/2018 4/2018
Make I-45 Better Coalition[3]	Solicit feedback on which locations to target for mobile air monitoring. Solicit feedback on health issues of concern and which mitigation recommendations to prioritize. Assist with the development of communications materials targeted to other stakeholder groups. Assist with community outreach to impacted communities.	7/2018 3/2019
City of Houston	Request data for inclusion in the assessment. Solicit policy recommendations based on the results of the assessment.	8/2018 9/2018
Harris County	Request data for inclusion in the assessment. Solicit policy recommendations based on the results of the assessment.	4/2019
Houston & Aldine Independent School District	Request data for inclusion in the assessment. Solicit feedback on which locations to target for mobile air monitoring. Solicit feedback on health issues of concern and which mitigation recommendations to prioritize. Develop communications materials targeted to schools and parents.	9/2018 3/2019 4/2019
Houston Chronicle Editorial Board	Several members of the Make I-45 Better Coalition met with the Editorial Board to express concerns about NHHIP and provide information about the HIA.	1/2019
Houston Galveston Area Council[4]	Request data for inclusion in the assessment. Solicit feedback on the design of the assessment.	7/2018 9/2018 4/2019
Livable Houston Initiative	Presented the goals and preliminary findings of the HIA.	3/2019
Mayor's I-45 Committee[5]	Several members of the Make I-45 Better Coalition met with the Mayor's I-45 Committee to express concerns about NHHIP and provide information about the HIA.	11/2018
Elected Officials	Throughout the HIA, members of the Make I-45 Better Coalition met with local and state-level elected official to express concerns about NHHIP and educate them about the HIA.	2/2019

ASSESSMENT

One of the primary objectives of focusing AAH's assessment on schools was to identify opportunities for protecting and improving the health of children attending campuses along the corridor that would experience additional impacts from the proposed expansion. During preliminary HIA stakeholder engagement meetings, information was gathered about the perceived potential positive and negative health impacts of the NHHIP. Based on this feedback, while a range of impacts were considered in the HIA, air quality, mobility, and flooding were identified as the primary impacts of focus for the assessment.

The HIA used the 500 Cities Data, as well as other publicly available datasets, to identify baseline population vulnerabilities associated with demographics. Using the 500 Cities Data, the indicators were analyzed by census tract and then ranked by quartile relative to the census tracts in the Houston 500 Cities Dataset. Figure 3 provides a visual of the impacts that were included in the HIA. The analysis was also organized by highway segment to illustrate the geographic differences along the corridor from north to south. To evaluate the range of potential impacts, both positive and negative, the analysis included a review of demographics, socioeconomic status, environmental justice concerns, access to services, transportation issues, building conditions, and health status.

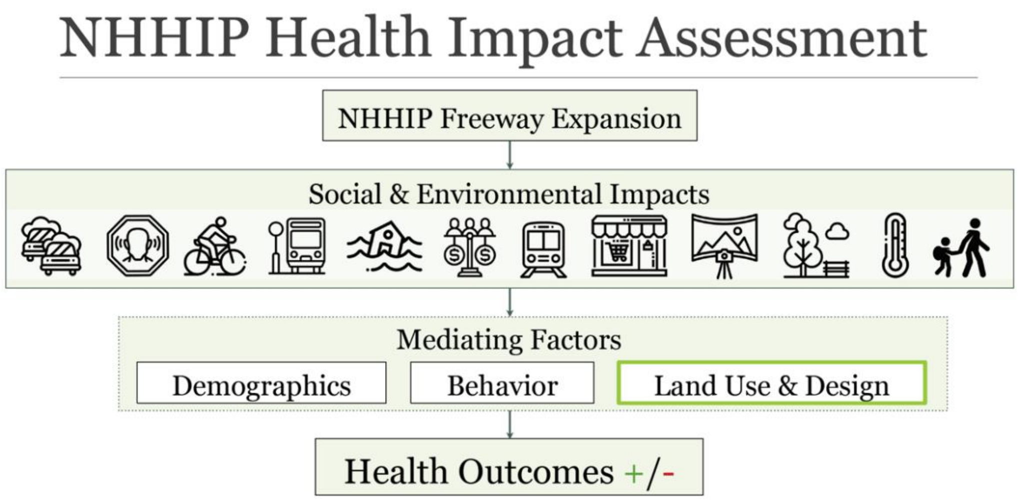


Figure 3. Impacts included in the HIA.

Baseline Health Indicators

The baseline health conditions of the campuses and the surrounding communities were assessed using model-based estimates for the crude prevalence of several Census tract-level indicators from the 500 Cities dataset. These indicators include:

- Cancer (excluding skin cancer) among adults aged >=18 years
- Current asthma among adults aged >=18 years
- Coronary heart disease among adults aged >=18 years
- Chronic obstructive pulmonary disease among adults aged >=18 years
- Obesity among adults aged >=18 years
- Mental health not good for >=14 days among adults aged >=18 years
- Physical health not good for >=14 days among adults aged >=18 years

It is important to note that community environments shape opportunities for health and that the health status of any given neighborhood is influenced by a range of contextual factors such as the physical environment, income inequality, access to and utilization of health care, and access to employment opportunities, among others.

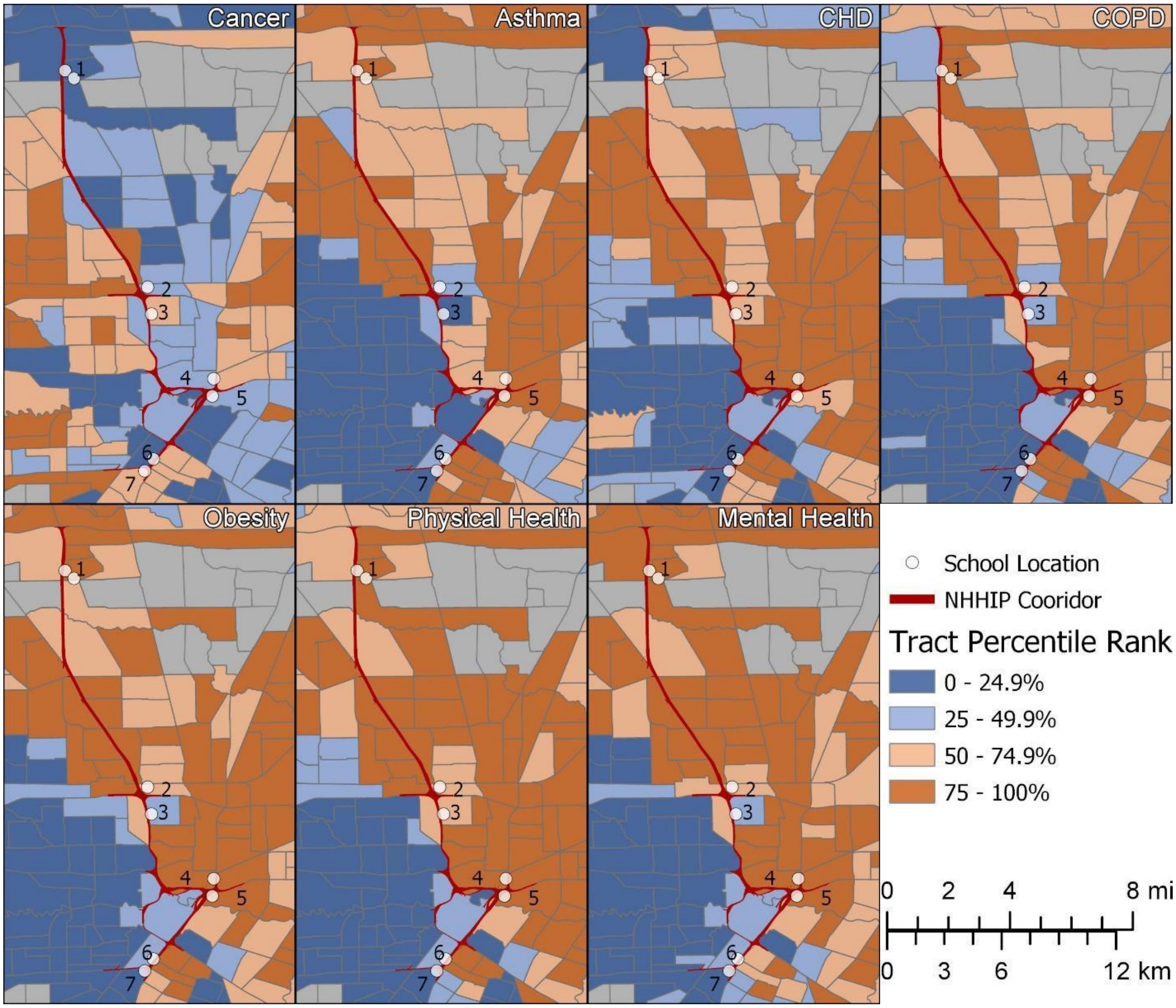


Figure 4. School locations along the NHHIP corridor and tract percentile rank.

Source: Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health. 500 Cities Project Data [online]. 2018 [accessed July 2018]. URL: https://www.cdc.gov/500cities.

Table 7. 500 Cities health data on the HIA campuses.

#	Harris County Tract #	Campus	Cancer		Asthma		Coronary Heart Disease		COPD		Obesity		Mental Health		Physical Health	
			Prev.	%	Prev.	%	Prev.	%	Prev.	%	Prev.	%	Prev.	%	Prev.	%
1	2225.03	Aldine Schools	3	0.1	9.9	0.78	6.3	0.66	7.4	0.8	42.5	0.86	18.7	0.98	20.5	0.95
2	2202	Roosevelt Elementary	4.1	0.35	8.6	0.46	6.6	0.72	5.9	0.56	37.9	0.64	14.4	0.67	16.8	0.73
3	2106	Jefferson Elementary	4.1	0.65	10.7	0.21	6.7	0.68	7.8	0.42	42.5	0.46	15.9	0.37	17.4	0.52
4	2123	Secondary DAEP	4.2	0.4	9.3	0.66	9.4	0.96	8.5	0.89	43.5	0.91	17.1	0.92	22.5	0.99
5	2114	Bruce Elementary	4.1	0.35	10.7	0.88	6.7	0.74	7.8	0.83	42.5	0.86	15.9	0.84	17.4	0.78
6	3125	HAIS	3.6	0.22	7.9	0.27	4.1	0.24	4.1	0.24	32.6	0.42	10.3	0.3	9.6	0.29
7	3126	YWCP	4.8	0.56	7.3	0.13	3.5	0.14	3	0.63	25.8	0.16	7.6	0.09	6.8	0.06

The Aldine schools (school #1 in Figure 4) and Roosevelt Elementary (school #2) fall within Segment 1. Jefferson Elementary (school #3) falls within Segment 2. Secondary DAEP (school #4) and Bruce Elementary (school #5) straddle the border between Segments 2 and 3. And, HAIS (school #6) and YWCPA (school #7) fall within Segment 3.

Several neighborhoods along Segments 1 (Beltway 8 to I-610) and 2 (I-610 to I-10) have higher poverty rates (up to 75.5%) and a higher percentage of persons of color (up to 94%), compared with the Houston average (43.2% and 73.7%, respectively). Based on the 500 Cities Data presented in Table 7, the Aldine schools, Bruce Elementary, and Secondary DAEP are communities that generally experience worse health outcomes than other areas of Houston, ranking in the highest quartile for six out of the seven indicators. Among these campuses, physical health is among the worst in census-tracts surrounding the Aldine schools and Bruce Elementary. It is also important to note that some of these campuses are within census tracts with extreme rates of poverty. This suggests that any potentially adverse health impacts caused by the NHHIP would likely exacerbate existing conditions and place additional disproportionate burdens on the health of these communities.

Impact Categories

In addition to the 500 Cities Data, and other datasets that were used to assess baseline conditions, a school questionnaire was distributed to each priority campus to better evaluate their environmental conditions and gain insight on their perceptions of the highway expansion and how it might impact air quality at their schools. The survey included questions about idling behavior during drop-off and pick-up times, the times of day children go outside for recess and/or physical education, student/staff mobility and infrastructure (e.g. how many children walk/bike to school), dangerous intersections, and flooding. The results of these surveys were used to inform the development of campus-specific recommendations to reduce students'/staff exposure to air pollution and dangerous mobility conditions. Summaries of the campus-specific assessment findings and recommendations can be found in Appendix I.

During the community meeting held in September 2018, stakeholders were asked to share a list of the changes they anticipate the NHHIP expansion will bring to their community, both positive and negative. Significantly, the following changes were included in either or both the positive and negative columns of most stakeholder responses:

- Congestion, idling, commute time
- Impact on connectivity
- Impact on traffic-related air pollution

- Impact on flooding
- Impact on economic development

The following groups were identified by a majority of stakeholders as the people who will be most impacted by the project (positively and/or negatively):

- Residents, businesses, and institutions near the highway
- Low income communities and communities of color
- Commuters into downtown
- Children, particularly during outdoor playtime at school

These results suggested that further research should be conducted to understand the underlying levels of vulnerability among neighborhoods adjacent to the highway as well as which opportunities for modifying the current design would benefit the groups that are at highest risk of negative health and economic outcomes associated with the project.

The impact categories described in the following sections include air quality, mobility, flooding, environmental justice concerns, and other impacts. Each section provides background information, supporting evidence, and the assessment findings.

AIR QUALITY

Background

Ground-level ozone concentrations in the Houston region have been steadily increasing during the past few years. In addition to ranking among the top ten of the most ozone-polluted cities in the country, mobile sources account for the majority of ozone precursor emissions in the region (~60%). Areas with higher levels of traffic can contribute to increased levels of ozone precursors in the atmosphere. Ground-level ozone is a secondary pollutant that is formed by a chemical reaction between oxides of nitrogen (NO_x) and volatile organic compounds (VOCs) such as benzene, and sun light/heat. Exposure to elevated levels of ozone can trigger asthma attacks, reduce lung function, and exacerbate other respiratory conditions, especially among vulnerable groups such as children.[6]

Supporting Evidence

The burning of fossil fuels, along with the emissions from brakes and tire wear, make traffic a major contributor to air pollution.[7] Exposure to traffic-related air pollution has been linked to the development of cardiovascular, cerebrovascular, and respiratory diseases in children and adults, including stroke, heart disease, chronic obstructive pulmonary disease, lung cancer, and asthma.[8] Traffic-related air pollution aggravates existing asthma and can even lead to the development of asthma, especially for those living near high-volume roadways.[9,10] Persons with greater exposure to high concentrations of traffic pollution can suffer both short-term and long-term health consequences, and children in low-income areas who currently have asthma are especially vulnerable.[11]

Children are especially vulnerable to reduced lung functioning, impaired lung development, and asthma-related impacts from air pollution because their respiratory systems are not fully developed and they have higher exposure rates due to more rapid breathing.[12,13] The census tract that contains the Aldine schools not only has the highest projected number of unhealthy ozone days but is also in the highest quartile for school-age children. Recent studies have demonstrated that although asthma cases attributable to traffic-related air pollution has decreased overall between 2000 and 2010, 40%, 28%, and 18% of pediatric asthma cases in Harris County were attributable to exposure to traffic-related particulate matter with aerodynamic size of less than 2.5 microns ($PM_{2.5}$) and/or 10 microns (PM_{10}) and NO_x, respectively; and in the Houston area, there are an estimated 400 new asthma cases per 100,000 children per year with 25% of these cases attributable to exposure to nitrogen dioxide (NO_2) from traffic pollution.[14,15] Moreover, research has linked traffic-related air pollution in schools to negative consequences for cognitive development (i.e., working memory and attention),[16,17] major depression,[18] and metabolic dysfunction.[19] Collectively, the impacts of air pollution on community health and well-being are significant and necessitate careful consideration, especially among vulnerable communities such as those near busy roadways and children.

Findings

The VMTs within 400 meters (0.25 miles) of the nine schools studied in the HIA currently averages seven times higher – 70,198 – compared with the HISD/AISD average of 10,124. The expansion design would widen the highway width by as much as 70% in some areas and add several more lanes, bringing at least 26 existing school and daycare campuses within 500 feet of the highway. The anticipated increase in traffic volume will introduce more air pollutants into the nearby communities. Figure 5 illustrates that Segment 1 has the greatest number of high ozone days in the census tracts adjacent to both sides of the NHHIP corridor. Because children are more vulnerable to the effects of air pollution such as ozone, children attending these campuses may be vulnerable to increased health risks, miss more days of school due to sickness, exhibit lower academic performance, and experience a lower quality of life as traffic along the corridor increases and the distance to high-traffic areas decreases. Not only are asthma rates at many of the schools along the NHHIP route already higher than each of the school districts average of 3.3%, but some campuses also experience a high rate of asthma-related emergency service use.[20,21]

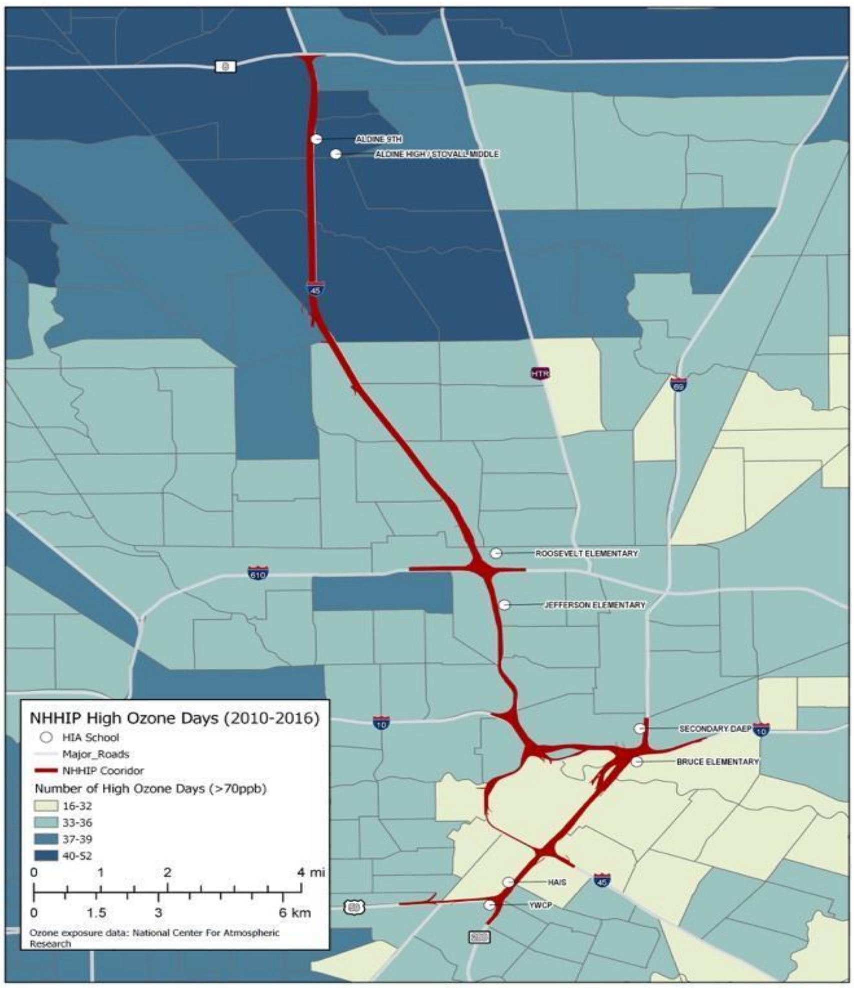


Figure 5. NHHIP high ozone days (2010-2016).

In addition to health risks from ground level ozone, a number of traffic-related air pollutants are known to cause other health effects such as cancer. The Environmental Protect Agency (EPA) has prioritized nine mobile source air toxics (MSAT) as a result of the serious cancer and non-cancer associated health effects from these pollutants. According to the National Air Toxics Assessment (NATA), the majority of the census tracts directly adjacent to the NHHIP corridor are already in the highest quartile of risk for cancer from on-road mobile sources.

To better understand the dispersal of air quality impacts on the school, AAH partnered with Urban Design for Health (UD4H) who helped identify an accessible method to model potential air quality impacts of the NHHIP in the areas near the nine priority campuses. The modeling focused on the variability of community-level changes in pollutant concentrations instead of simply the maximum values in the TxDOT analysis. UD4H and AAH employed the use of the Community Line Source Model Version 3 (C-Line)[22] that was specifically designed by researchers at the University of North Carolina and the US Environmental Protection Agency to help community residents better understand local air quality issues related to transportation infrastructure design and use. Though this model is not yet used for regulatory purposes due to its simplified simulation techniques for some procedures, researchers have been working towards the goal of broad use of C-Line for official uses.[23]

For the initial comparative analysis, the UD4H modelling team generated pre and post exposure surfaces for 10 traffic-related air pollutants and also selected specific site locations within the broader community surrounding Bruce Elementary to evaluate the potential change in air quality for locations on and near the school property. An example of the output of the C-Line model is presented in Figure 6 and the projected increases in benzene at the various sites around the campus are displayed in Table 8.[24] The results indicate that the sites around the priority campuses have the highest changes in exposure for all pollutants compared to other sites. Results for all ten of the pollutants follow similar patterns. While all of the numbers were below the reference concentration thresholds developed by the EPA's Integrated Risk Information System (IRIS), chronic exposure impacts for many pollutants are not well defined, particularly for grade school children. As mitigation solutions are being evaluated for the impacted campuses, minimizing exposure to higher concentrations of these pollutants should be given the highest consideration despite modeled values being within EPA guidelines. Too little is known regarding the health impacts of long-term multi-year exposure among children to determine if current guidelines provide adequate life-long protection.

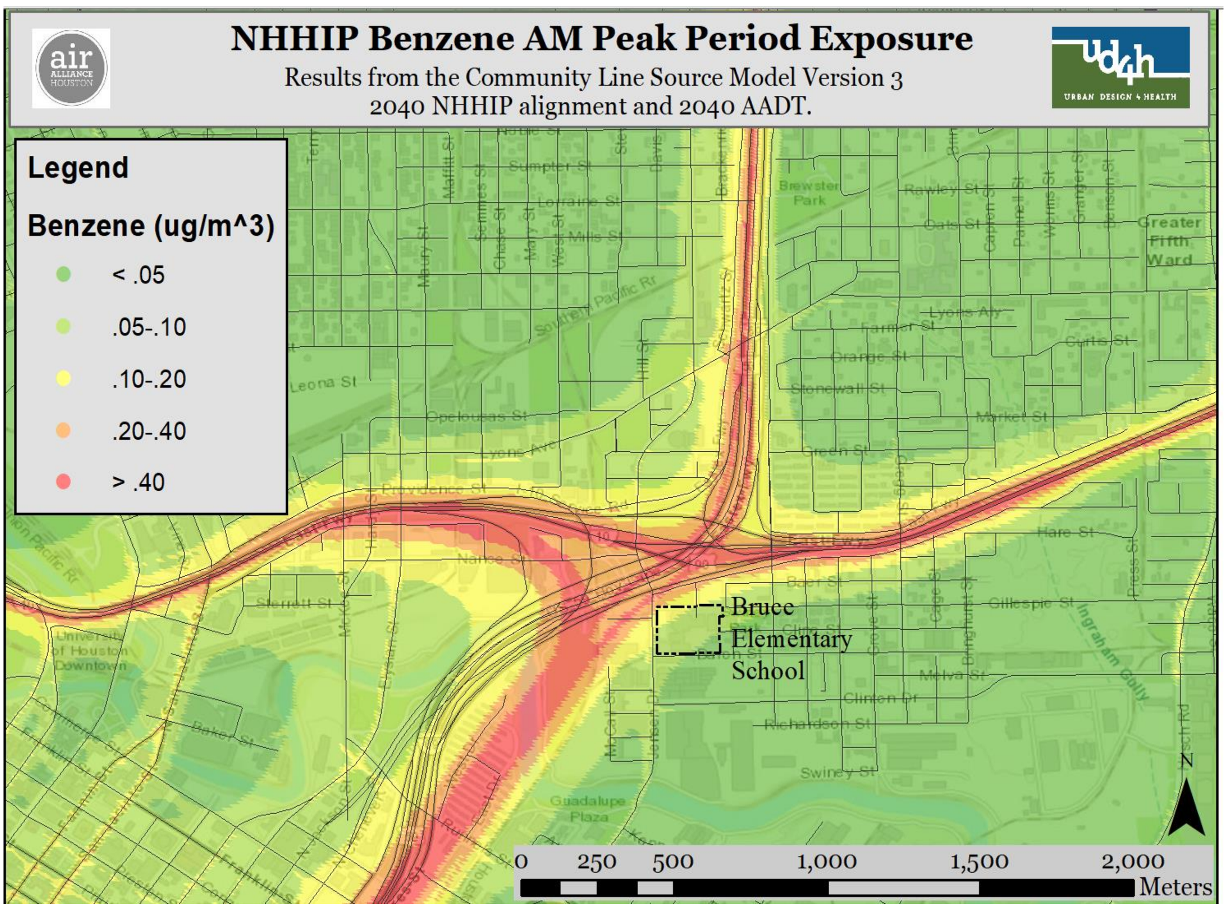


Figure 6. AM peak hour benzene exposure (ug/m3).

Table 8. Hourly benzene exposure (ug/m³).

		AM Peak			Mid-Day		
ID	Description	Baseline	NHHIP	*Increase*	Baseline	NHHIP	*Increase*
3	Corner of School Property	0.0829	0.2193	*164.7%*	0.0815	0.1940	*138.1%*
1	Bruce Elem Front Door	0.0610	0.1377	*125.8%*	0.0542	0.1195	*120.6%*
2	Bruce Elem Side Door	0.0427	0.0896	*109.9%*	0.0439	0.0935	*113.2%*
4	Bruce Elem Playground	0.0268	0.0540	*101.0%*	0.0274	0.0556	*103.2%*
7	East River 1	0.0163	0.0313	*91.8%*	0.0172	0.0334	*94.2%*
5	Swiney Park	0.0300	0.0554	*84.9%*	0.0305	0.0577	*89.4%*
10	Kelly Village	0.0507	0.0868	*71.2%*	0.0510	0.0900	*76.5%*
6	Hare St Site	0.0191	0.0282	*47.6%*	0.0189	0.0304	*60.4%*
8	East River 2	0.0095	0.0139	*45.7%*	0.0094	0.0148	*57.6%*
9	East River 3	0.0100	0.0125	*25.2%*	0.0100	0.0138	*37.0%*

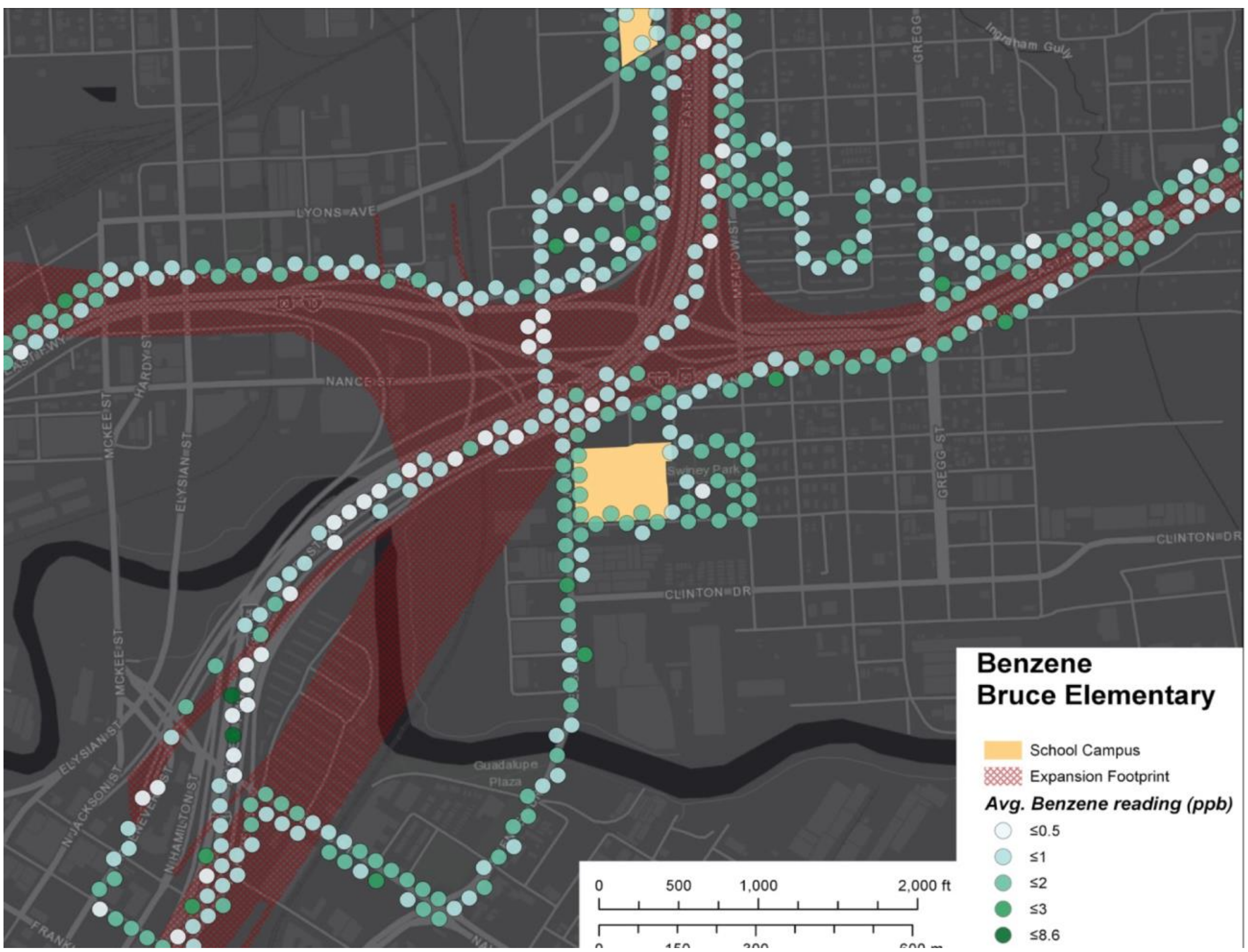


Figure 7. Benzene at Bruce Elementary School. The monitored levels are higher than the estimates in the C-Line model. **Source:** NHHIP HIA mobile air monitoring data (Appendix IV).

MOBILITY

Background

Highways can significantly impact the safety of people on adjacent surface streets, both parallel access and crossing streets, particularly in urban areas such as the neighborhoods impacted by the NHHIP expansion. Meetings with community stakeholders revealed a number of concerns regarding children walking and biking to school both during construction and post-expansion. School district staff and residents expressed concern about the impact of speeding and increasing volumes of traffic during the construction period.

People, including students, choose to walk, bike, or ride transit in communities around the NHHIP expansion project – including many students going to the nine priority campuses. Grade school children and youth must be able to safely access their school, without undue stress and risk, before they can learn in the classroom. Major transportation infrastructure projects like the NHHIP expansion must address access for all road users and must especially prioritize the creation of safe facilities for children walking and biking to and from school – the most vulnerable road users.

Supporting Evidence

Many school-aged children do not meet the recommended levels of physical activity, and obesity remains a prominent health crisis in this age-group. Approximately 24% of children aged 6-17 years of age in the U.S. meet the recommended levels of physical activity[25]and 17.2-25% of youth in the U.S. are overweight or obese.[26] In fact, while there have been slight improvements in physical activity among adults in recent years, there has been a decrease in physical activity during adolescence. Overall, the 2018 U.S. Report Card on Physical Activity for Children and Youth indicated that 20-28% of children and youth meet overall physical activity guidelines, with a greater percentage of boys meeting recommendations compared to girls.[13]

The neighborhood environments in which school-age children live appear to influence activity levels.[27] For example, children living in neighborhoods perceived as less walkable and not close to transit and recreation spaces engaged in less out-of-school moderate-to-vigorous physical activity (MVPA).[15] Further, communities with more-walkable streets, access to a high-quality park, and healthier food outlets are negatively associated with the prevalence of adolescent overweight and obesity.[28]Brisk walking and bicycle riding are both considered examples of moderate-to-vigorous physical activity among school-aged children.[29] In fact, children who engage in active transportation (i.e., walking or biking) are more likely to meet physical activity recommendations compared to those who travel by motor vehicle[13].

In response to the current levels of physical inactivity and obesity rates among school-age children, researchers recommend a comprehensive, multi-sector strategy be implemented to increase physical activity among youth and adolescents.[30] Effective interventions include school-based physical activity programming and education, after-school physical activity programming, improving the built environment to include access and proximity to recreational facilities, activating youth sport participation, and re-normalizing active transport to school.[18]

Findings

A large number of pedestrian/bike crashes have occurred within ½ mile of schools along the I-45 corridor since 2010 (e.g. YWCPA: 100; HAIS: 95; Aldine: 56). Many of these crashes have occurred under/adjacent to the highway or on preferred pedestrian routes to school. Moreover, at the Aldine schools there is currently no school zone that has been designated. The current NHHIP design will expand the highway width and increase the speed of cars traveling down the access road, increasing safety concerns for pedestrians and cyclists, many of whom are school children. During community stakeholder meetings residents identified a number of barriers to walking and biking safely. For example, participants at the Bruce Elementary/Secondary DAEP identified the absence of sidewalks and bike lanes, poor drainage, and metro stops without sidewalks leading up to it at a dangerous intersection. Bruce Elementary School currently sits across the street from a major highway interchange, I-69 at I-10, on the northeast corner of downtown Houston. The proposed NHHIP design is estimated to increase the footprint near the school by 37.4% and bring it to the corner of school property. Until recently, the school paid for the crossing guards at six locations out of their own budget. However, HISD recently formally recognized the dangers for pedestrians by taking responsibility for financing this safety measure.[31] School staff are also concerned about the speed at which cars transition from I-10 East to city streets using Exit 770B Eastbound, which flows into Jensen Drive at the corner of the school. School staff reported that the school repairs the fence at the corner of the campus several times a year due to crashes stemming from vehicles exiting the highway too quickly. Staff also feel that the speed of street traffic on Jensen Drive puts at risk students who use that route to walk to and from school.[32] Across all nine priority campuses continuous sidewalks, crosswalks with high-visibility markings, pedestrian lighting, street trees for shade and protection, and reducing traffic speed can create safer walking and biking conditions and better promote health for children and staff attending these campuses.

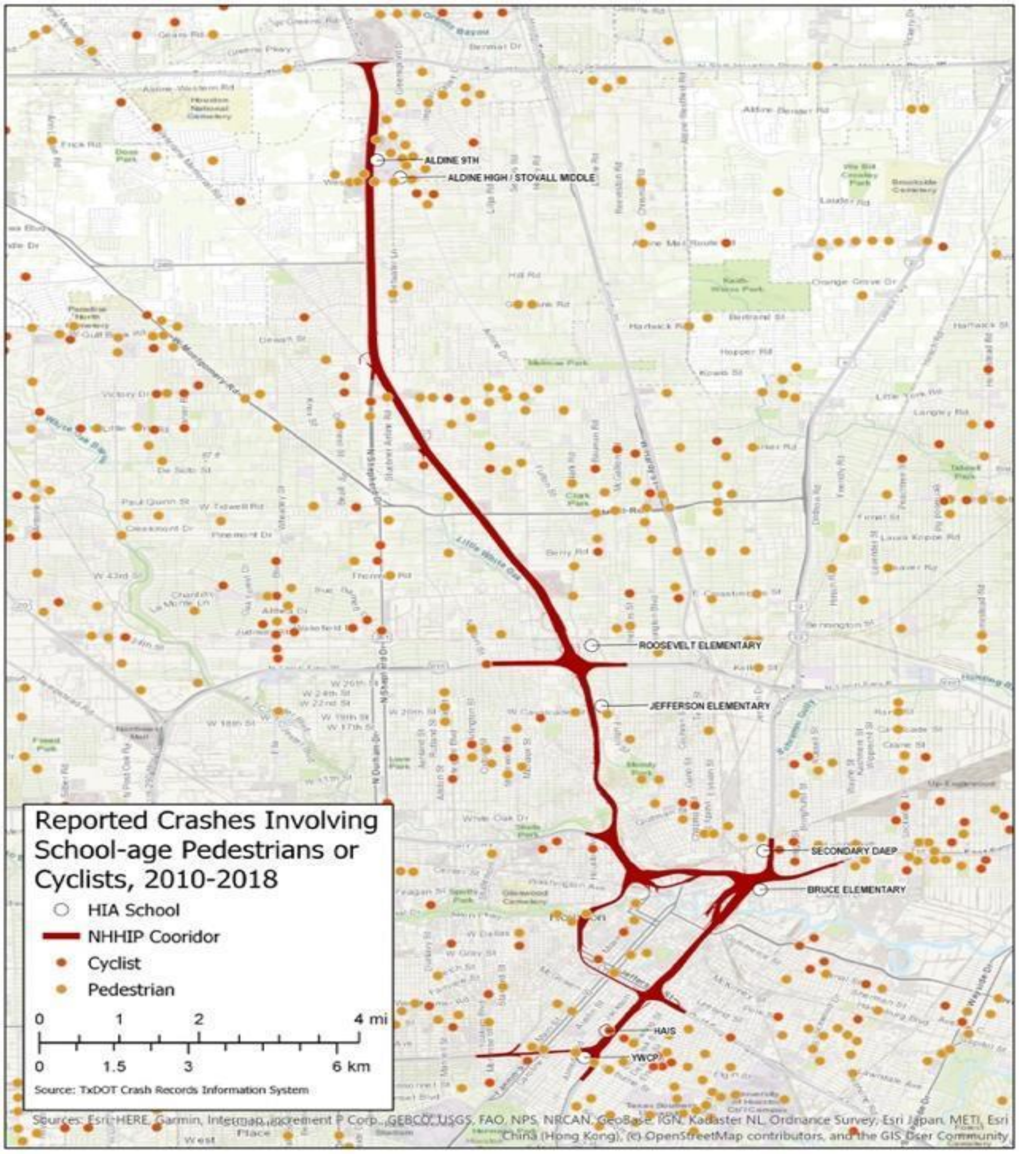


Figure 8. Reported crashes involving school-age pedestrians or cyclists, 2010-2018.

FLOODING

Background

Because the recent trauma of Hurricane Harvey continues to linger in the consciousness of many within the Houston community, much of the anecdotal information provided by school officials related to the flooding experienced during that storm. Harvey caused flooding throughout Houston communities and exposed our collective vulnerabilities to both property damage and the human toll on health from disasters. Among many in the Houston area, there is a sense that Harvey represented the penultimate test of regional flood resilience, but a recent routine seasonal rain event proved that even properties that survived Harvey may still be vulnerable to flooding from the variability in storm patterns.[33] Flooding remains a perennial threat to property and safety in the Houston region, and that vulnerability is exacerbated by the region's proximity to the coast, historically lax regulation of urban development, and – in some instances – a willful reluctance to acknowledge and mitigate the worsening storm risk that results from a changing climate.

Flooding poses a number of environmental and health risks including contamination of air, water, and land. According to the Greater Houston Flood Mitigation Consortium, Harvey caused a range of hazardous spills and toxic releases.[34] Exposure to floodwater can increase vulnerability to infectious diseases, injuries, and chemical hazards. A number of health surveys post-Harvey have indicated the storm contributed to a range of these health impacts including significant mental health challenges.[35] Thus, since Harvey, mitigating flooding risk has been a leading topic of policy conversations with regard to steps that need to be taken to ensure a more resilient Houston *moving forward.*

Over a three-day period, rainfall from Harvey was measured as high as 32.5 inches. This exceeded the previous three-day rainfall record in the continental U.S. – set in 1980 – by more than eight inches.[36] During Harvey, many of the homes that were damaged were outside of the designated 100-year floodplain. Significant levels of inundation also occurred within the 500-year floodplain and areas with no designated flood risk. Consequently, both the City of Houston and Harris County recognized the inadequacy of the 100-year standard in promulgating protective land-use policies and have since updated their development codes to require new structures in flood plains be built two feet above the 500-year flood level.[37] The Draft EIS of the NHHIP project, however, explicitly states that the project is designed to comply with the FEMA 100-year base level flooding standard applicable to Section 60.3(d)(3) of the National Flood Insurance Program regulation. Given the scale of the NHHIP, and the project's close interaction with several flood-prone streams, the 100-year standard appears to be an insufficient standard for a project of such magnitude and assumed longevity.

Supporting Evidence

Flooding causes both direct and indirect health effects. Direct effects include injury or drowning, usually associated with traveling through or near flood waters.[38] Indirect effects include waterborne diseases caused by contact with contaminated flood water;[39] respiratory conditions caused by mold and mildew after the flooding event;[40] mosquito-borne disease a few weeks after the flood waters have receded;[41] and, mental illness from the trauma of losing one's home, belongings, job, and/or social network after a flood.[42]

Roadways, parking lots, and residential and commercial developments all increase the amount of impervious surface in an urban environment. Areal increases in impervious surfaces, in turn, intensify stormwater runoff from rain events by limiting the amount of land available for stormwater infiltration. Significant increases in impervious surface area are therefore considered the primary agent of hydrologic change in urbanized watersheds and may significantly alter water quality as well as streamflow and flooding characteristics. Highway areas with more than 50 percent impervious surface have been shown to exhibit increased peak discharge by a factor of four and decreased time-to-concentration by more than half compared to equivalently sized, undeveloped reference basins.[43]

Findings

The Right of Way (ROW) footprint in some areas of the NHHIP is estimated to widen by as much as 70%, and the increases in impervious surfaces may be assumed to be similarly proportional. In many of these areas, the NHHIP corridor runs closely parallel or intersects with flood-vulnerable bayous and streams including:

- Halls Bayou
- Little White Oak Bayou

- White Oak Bayou
- Buffalo Bayou
- Several flood-prone drainage ditches

As the Draft EIS is currently written, an engineering or "no-rise" certification must be obtained that is supported by technical data stating that construction of the proposed project would not impact the base flood (100-year) elevation, floodway elevations, or floodway data widths that are present prior to construction. Given the inadequacy of the 100-year flood model to accurately reflect annual flooding probability, a more stringent standard would provide greater resilience for future flooding events and should be incorporated into this and future large-scale construction projects.

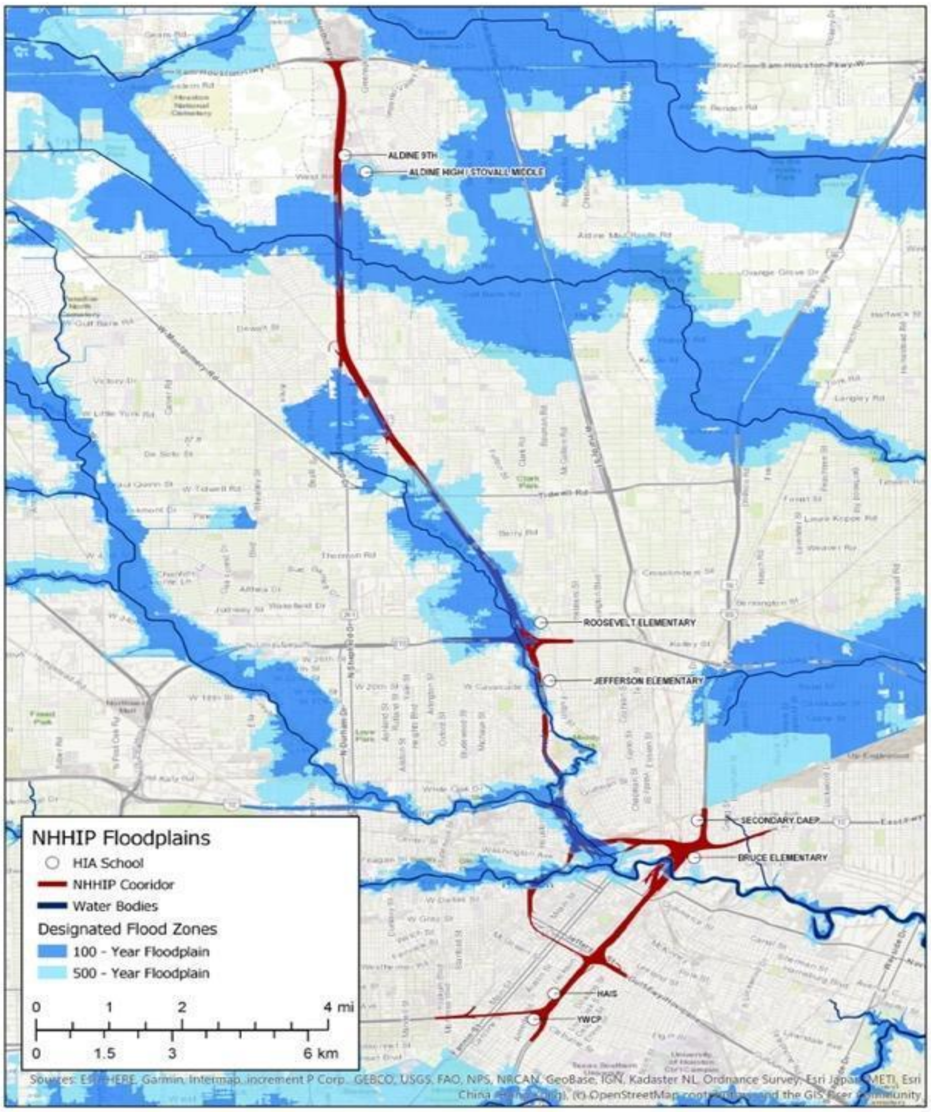


Figure 9. NHHIP floodplains.

Therefore, a diverse range of mitigative strategies should be utilized to offset the expected increase in runoff from the project such as detention ponds, stream improvement, and bioretention strategies. These steps should be taken to provide a more protective standard that anticipates a precipitation event equivalent to the standard set by Harvey (i.e. three-day +30" rainfall events), and maintains a no-rise certification.

Impacts to the streamflow of the bayous and streams listed above that may result from the construction process must be anticipated and proactively mitigated. This includes stream remediation of construction debris and sediment from building materials (i.e. sand, concrete, and aggregates) as well as zero-tolerance for trash or waste migration from the construction site.

One of the design features of the NHHIP is the inclusion of below-grade lanes that will run beneath several local roadways. Representatives from TxDOT have explained that the NHHIP design includes plans to mitigate flooding in these areas with increased detention ponds and pumping systems.[44] However, given the regional propensity for flooding, the removal of the Pierce Elevated as an alternative route, and the designation of the I-45 corridor as a major hurricane evacuation route, placing enclosed below-ground lanes in the major north evacuation route may have the psychological effect of discouraging evacuation during a major storm event due to the perceived risk. In addition, news media has reported that any highway that collects a life-threatening amount of water would be closed.[45] Realistic or not, the possibility of such a scenario is not likely to inspire confidence among last-minute evacuees, and could put lives at risk.

ENVIRONMENTAL JUSTICE

Background

Transportation policies that have prioritized the building of roads and highway infrastructure, coupled with poor land use planning, have contributed to many health and environmental inequities in Houston. Since the 1950s, highway construction has disrupted communities of color and low-income neighborhoods, creating physical barriers from opportunity. These policy decisions have fragmented and displaced many communities, undermined funding for alternative modes of transportation, facilitated a sprawling landscape, increasing the distance between homes and jobs, and advanced residential segregation. These factors have all been shown to contribute to poor and inequitable health outcomes.

The impact of creating the interstate highway system was a primary justification of need for the 1994 Executive Order 12898, which directed federal agencies to make part of their mission "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". Following suit, the U.S. Department of Transportation and its sub-agency the Federal Highway Administration, in 1997 and 1998 respectively, issued subsequent orders to address environmental justice in transportation projects impacting minority populations and low-income populations. These orders, coupled with the National Environmental Policy Act of 1969 (NEPA), continue to guide the assessment of risks and benefits of proposed major transportation projects.

Supporting Evidence

Long term exposure to high traffic roadways has been associated with an increased risk of death from all causes, including an increased risk of death from heart disease.[46] Communities of color and low-income are disproportionately exposed to air pollution from highways. For example, a recent study in California found that, on average, African Americans and Latinos are exposed to 40% more particulate matter from mobile sources than Whites.[47,48] Historically, policies such as the Federal-Aid Highway Act of 1956, zoning ordinances, and race-based deed restrictions have facilitated segregation along racial and economic lines – a pattern that remains pervasive in Houston.

Because public policies shape the racial and socioeconomic profiles of neighborhoods and, by extension, the health-promoting opportunities and constraints that exist within them, health is also intimately tied to income and race. Neighborhoods with a high concentration of poverty and people of color often have more environmental hazards, limited economic opportunities, unsafe housing, higher rates of crime and incarceration, less access to healthy food, fewer outlets for physical activity, and lower performing schools. Consequently, residential segregation is consistently cited as a fundamental cause of racial differences in health.[49]

One indicator that illustrates this difference is life expectancy by race and income. A recent analysis found that nationally, there is a 15-year difference in life expectancy between men in the top 1 percent of income compared with those in the bottom 1 percent – and the gap is growing. There is an almost five-year difference in life expectancy for black and white males. However, national trends obscure vast differences in health at the community level where health is produced. According to research funded by the Robert Wood Johnson Foundation, in New Orleans, there is a 25-year gap in life expectancy between communities just a few miles apart. Although less pronounced, there is a 10-year gap in life expectancy between the census tract surrounding the YWCP and Bruce Elementary campuses. According to the 2013-2017 American Community Survey, the median household income for the census tract containing YWCP is $96,492 compared to $23,025 in the Bruce Elementary School's census tract.[50] The data for these census tracts follow the same pattern and support research that shows place and health outcomes are inextricably linked.

Table 9. Life expectancy by campus.

#	Harris County Tract #	Campus	Life Expectancy at Birth	
			Age	%
1	2225.03	Aldine Schools	78.6	0.55
2	2202	Roosevelt Elementary	77.5	0.43
3	2106	Jefferson Elementary	76.9	0.37
4	2123	Secondary DAEP	76.8	0.36
5	2114	Bruce Elementary	71.8	0.07
6	3125	HAIS	74.6	0.16
7	3126	YWCP	82.6	0.91

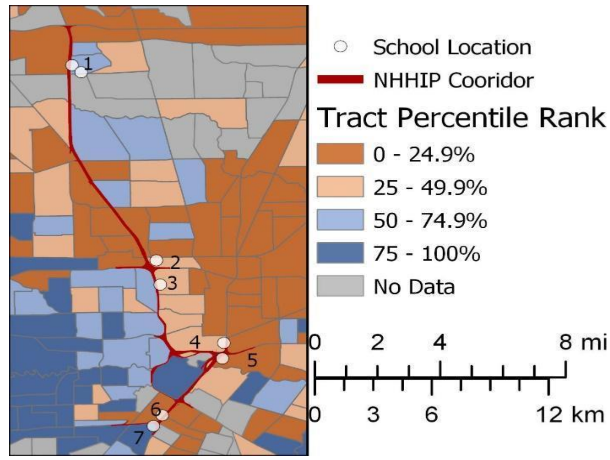


Figure 10. Percentile rank of life expectancy at birth by census tract.

Findings

The expansion will cause the removal or relocation of families in several public housing units, particularly Clayton Homes and Kelly Village in the 5th Ward. Several neighborhoods along Segments 1 (Beltway 8 to I-610) and 2 (I-610 to I-10) have higher poverty rates (up to 75.5%) and a higher percentage of people of color (up to 94%), compared with the Houston average (43.2% and 73.7%, respectively). The current NHHIP design will further entrench barriers between neighborhoods on either side of the expansion route. For example, high income, majority White neighborhoods on the west side of SH-288 and low income, majority people of color neighborhoods on the east side; the highway separates residents of Independence Heights (a food desert) from the closest grocery store: Walmart. More mitigation strategies have been incorporated into the design for the affluent Segment 3 (Downtown) than into the two segments north of I-10; thus, negative impacts would disproportionately fall on low-income communities of color. Thus, the impact of NHHIP on these communities would perpetuate a legacy of displacement caused by the building of highway infrastructure and the subsequent adverse health impacts that are associated with displacement such as weakened social networks and social cohesion.[51]

OTHER IMPACT CATEGORIES (URBAN HEAT ISLAND, ACCESS TO PARKS/GREEN SPACE, VIEWS, AND NOISE)

Background

In addition to the issues already discussed, the Make I-45 Coalition submitted a public comment letter to TxDOT outlining its concerns about impacts on access to parks, views, and noise of the NHHIP. Urban heat island (UHI) is also a health concern, given the links between increasing the percentage of impervious surface caused by freeway expansion projects and the resulting increase in surface temperatures.

Supporting Evidence

The census tracts surrounding the Aldine, Jefferson, and Roosevelt campuses lack park space within 400 meters of the schools. Parks and greenspace are important components of a healthy and physically active community and have been associated with greater general health,[52] increased physical activity,[53] reduced prevalence of obesity,[54] increased social interaction[55] and collective efficacy (community impact on behavior),[56] and reduced stress,[57] depression and anxiety,[58] mental fatigue,[59] and attention deficit hyperactivity disorder (ADHD) symptoms,[60] while improving attention and self-discipline.

The extent of tree canopy in an area can have a direct effect on temperatures and health. Higher levels of tree canopy coverage can help curb urban heat island effects by lowering temperatures.[61] Not only is extreme heat the primary weather-related cause of death in the U.S. according to 2018 National Weather Service Office estimates[62] but hot temperatures also create the weather conditions necessary to produce ground-level ozone. A recent study found that in Texas, children experience the highest risk of asthma-related hospital admissions associated with ozone levels, with an increased risk when ozone concentrations exceed 40ppb, well below the current NAAQS standard of 70ppb.[63]

Noise is considered an unwanted sound because as unlike other types of sounds it is not produced purposefully but rather as an unintended consequence of an activity or action. Noise impacts by highway traffic and or projects produce noise at high volumes. There are various stages in which the highways impact noise levels, i.e. construction phase and traffic. The impacts to health cause by highways vary as but “highway traffic noise is a dominant source in urban and rural environments.” Studies show that the various effects to health as a result of noise pollution consist of hearing impairment, hypertension, ischemic heart disease, and sleep disturbances.[64]

Findings

H-GAC's Urban Forestry Analysis (2016) dataset was used to estimate the current tree canopy, which is notably sparse along the I-45 corridor. Many of the schools along the I-45 are in areas ranked as most prone to dangerous urban heat island effects and/or flooding in Houston. For example, Jefferson Elementary School is in the top 9% of areas most likely to suffer from urban heat island effects, while the Aldine campus sits in both the 100-year and 500-year FEMA floodplains. The expansion will construct more impermeable concrete surfaces, which could exacerbate the urban heat island effect. The increased volume of traffic anticipated will introduce more noise disturbances into nearby communities. Furthermore, as one example, according to the Houston Parks Board, as currently proposed the highway structure would impose significant visual intrusion along White Oak Bayou Greenway, disrupting the current sense of open space with seven new highway over-passes above the Greenway’s widest stretch.[65] Moreover, an analysis of bayou greenway and park impacts conducted by the Houston Parks Board indicates that Houston will lose approximately 27 acres of current open bayou space because of the NHHIP.[66] Collectively, the impacts from increased noise, urban heat island effects, and limited access to greenspace are linked to poorer health, causing more sick days from work and school, which can contribute to reduced academic performance, shorter lifespans, and lower quality of life.

CONCLUSION

Air Quality

Mitigating negative health implications from traffic-related air pollution typically involves strategies that either decrease the concentration of the pollutants (i.e., vegetation, displace car travel with active travel, etc.) or reduce the duration of exposure to the pollutants (i.e., limit time spent at stop lights near idling car emissions, monitor outdoor air pollution and the opening of windows in buildings). Roadside vegetation has been shown to reduce exposure to air pollution, as plants' surfaces absorb gaseous air pollutants and airborne particles.[67] Prevention strategies such as increasing alternative transportation options (transit, rideshare, walking, cycling), providing incentives to reduce vehicle miles traveled, promoting the use of electric and low emission vehicles and implementing land-use policies that limit new development close to heavy traffic areas, while also creating roadside barriers and improved ventilation systems in homes and buildings, help mitigate the impacts of emissions.[68] Prevention and mitigation strategies specific to schools should include both site-related strategies (i.e., transportation policy, site selection, vegetation) and building design and operation strategies (i.e., ventilation, filtration).[69] Site related strategies include anti-idling and reducing idling near the school, upgrading buses and carpools, and encouraging more active forms of transportation. In addition, increasing the urban green space in the community, along with roadside vegetation, can help to mitigate traffic-related air-pollution.

Mobility

Active transportation, such as walking, cycling, and their use to connect with public transit systems, not only improve air quality as a result of fewer vehicle emissions but also increase physical activity-related health benefits among children and adults. There are many ways that the design, placement and connectivity of buildings and communities can encourage more active transportation. These include increased sidewalk connectivity, greater land-use mix and residential density, walking and cycling facility maintenance, crosswalks at intersections, school zone signage and traffic calming, bike-lanes, street buffers and aesthetically pleasing routes (tree canopy, scenic, active store fronts, etc.). In addition, the Safe Routes to School initiative can improve safety related concerns through community policy and school programming, such as the Walking School Bus program.

Environmental Justice

While greening practices of increased and improved parks, green spaces and vegetation can help to mitigate traffic-related air pollution, these also can lead to gentrification if appropriate policies are not put in place. "Environmental" or "green" gentrification and displacement can result in worsening health outcomes for vulnerable populations.[70] As land-value increases as a result of improved spaces, some families are at risk of becoming displaced and may be forced to live in overcrowded conditions and unhealthy conditions, or face a high housing cost burden, which is associated with poor health outcomes.[71] Gentrification and displacement can cause vulnerable populations to be relocated to areas where they may not have access to resources, goods, and services that promote health (i.e., healthy food outlets, jobs, parks, sidewalks, etc.). Further, displacement undermines community stability and social cohesion, which are also known to be associated with improved health, well-being and crime. Another potential result of displacement is homelessness, which puts families at risk for communicable diseases, chronic conditions, behavioral and mental health conditions, and injury.[72] Thus, gentrification should be proactively addressed.[73]

Other Impacts

Parks/green spaces in communities have been associated with greater general health,[74] increased physical activity,[75,76] reduced prevalence of overweight,[77,78] increased social interaction[79] and collective efficacy (community impact on behavior),[80] and reduced stress,[81] depression and anxiety,[82] mental fatigue,[83,84] and attention deficit hyperactivity disorder (ADHD) symptoms,[85,86] while improving attention and self-discipline. There is some evidence, albeit limited, that suggests neighborhood vegetation may also improve air quality[87] and reduce obesity-related morbidities,[88,89] asthma,[90,91] and vehicular collisions.[92,93] Tree canopy, in particular, has been shown to be associated with better overall health as a result of lower prevalence of overweight and obesity and better social cohesion, and also slight associations with reduced type 2 diabetes, high blood pressure, and asthma in communities.[94] When designing and increasing green spaces, the quality, size, amenities, facilities, recreational opportunities and safety are all important factors to consider, as these influence the utilization and, therefore, impact of the space.[95] Noise barriers, when used in combination with vegetation, result in reduced particulate matter concentrations.[96] Vegetation in urban settings offers co-benefits known as "ecosystem services," which in addition to improved air quality, include temperature and stormwater regulation, noise reduction, opportunities to be active and interact with nature.[97] Green spaces can also be included in active transportation networks, further increasing health-related benefits from walking and biking space.[98]

Vegetation, such as increased tree canopy and green space, have potential disadvantages that must be considered and addressed. For example, trees can obstruct visibility on the road, cause damage and injury if they fall, and can create hazardous debris on the road if not strategically planted.[99] In addition, the particles that trees "intercept" from the air can be returned to the air during windy, precipitous, or other natural weather conditions. They also require ongoing care and maintenance. To address potential negative environmental and health consequences from re-suspended particles, careful consideration must be given to the land-uses that surround roadside vegetation (bodies of water, species selected, etc.).[100] Although urban tree canopy is known to remove pollution and improve air quality, several studies associate tree pollen with increased asthma prevalence and severity, and that tree pollen may exacerbate the impact of other air pollutants on asthma.[101,102]

Summary of Proposed Mitigation Strategies for NHHIP

The ultimate goal of the HIA is to share recommendations for changes in land use and design, both in terms of changing the final design of the highway expansion itself and implementing protective measures at the nine schools that will be acutely impacted by the NHHIP. Campus-specific findings and recommendations can be found in Appendix I.

Air Quality and Noise Impacts

- TxDOT should fund sidewalks and tree-lined buffers along the borders of the lots facing I-45 and along major streets within 500 ft. of the highway/students' main walking paths to and from school. Further request that TxDOT fund noise/pollution barriers along the highway edge.
- TxDOT should locate construction staging areas at least 500 ft. from sensitive uses like schools, senior living, residences, and health care facilities and encourage the use of low and zero-emission equipment and dust control during construction.
- TxDOT should provide funding for the installation of air monitors at sensitive receptors like schools, parks, and playgrounds during and after project completion.
- Schools should implement "No-Idle Zones" around campus for carpools, school buses, and deliveries.
- TxDOT should provide funding for the ongoing installation of HEPA (high efficiency) filters within buildings with sensitive occupants located within 500 ft. of the highway.

Mobility and Flooding Impacts

- The Houston-Galveston Area Council should provide more funding for transit and active transportation projects; remove the caps on funding for Alternative Mode and Air Quality projects; and, prioritize projects serving disadvantaged communities.
- Residents and other stakeholders should engage with METRO to support and provide feedback on the METRONext Plan and encourage fellow community members to vote in the upcoming bond elections to authorize funding for the expansions.
- TxDOT should comply with the new Harris County and City of Houston Flood Control design standard of 500-year flood events, rather than 100-year flood events.

Environmental Justice Impacts

- Encourage TxDOT to work with the City of Houston and community organizations to reduce the highway width and improve the amenities provided along the northern segments of the project to mirror the investment going into Downtown.

- Request that TxDOT fund appropriate structure for the deck park proposed to link Woodland Heights and Near Northside, so that it will be able to accommodate trees and other vegetation. Ensure that pedestrian access to the park is safe and inviting.
- Request that TxDOT improve surface street connectivity between 5th Ward and the Central Business District to improve access to job opportunities.
- Request that TxDOT provide funding for constructing all highway crossings in accordance with Complete Streets Principles to protect and promote pedestrians and cyclists.

Other Impacts

- TxDOT should include parks, green spaces, and tree canopy in the NHHIP design to increase permeable surfaces, reduce flooding, minimize noise impacts, and encourage physical activity.

Summary of Regional Transportation Policy Recommendations

Background

The region's guiding transportation planning document should stress the significant role transportation plays in public health. Safety is an important component, but public health as a guiding principle should also address issues such as air quality, quality of life, and accessibility. Harris County and the surrounding region is facing a public health crisis in which many of the drivers are directly related to adverse air quality and other structural impediments to the accessibility of healthy lifestyle choices (i.e. limited access to healthy foods, lack of outdoor activity, urban heat islands, etc.):

- 34% of high school students are overweight or obese.[103]
- 66.7% of surveyed adults are overweight (BMI of 25.0-29.9) or obese (BMI of 30.0 or above).[104]
- 10.2% of Houston-area adults have been diagnosed with diabetes.[104]
- 5.6% of Houston-area adults have been diagnosed with some form of heart disease.[104]
- 29.4% of Harris County adults have been diagnosed with high blood pressure.[104]
- 99,000 children and 250,000 adults in Harris County have been diagnosed with asthma.[105]

One of the goals of conducting the NHHIP HIA was to provide a preliminary model that could be further developed and integrated systematically into the Houston region's transportation planning processes. As such, the HIA Project Team presented to various H-GAC committees throughout the entire HIA process to ensure ongoing dialogue, obtain feedback, and share results and recommendations. Appendix H of the 2040 Regional Transportation Plan (RTP) recommends implementing a Healthy Planning Framework to strengthen the consideration of public health outcomes into transportation planning. In Appendix H, in regards to future RTPs, it was recommended that H-GAC "include positive public health outcomes as a goal of the plan, or complete a health impact assessment on plan recommendations." The 2045 RTP includes strategies, analyses, and policy recommendations that are innovative and ambitious and align with the region's vision for the future of transportation. Most notably, the High Capacity Transit Task Force's report lays out a plan to not only relieve the congestion crisis the region is facing, but to take on the challenges of accessibility and equity for an exponentially growing region. However, the 2045 RTP does not adequately implement the Healthy Planning Framework recommendations.

There are several peer cities throughout the country who have successfully implemented frameworks similar to that outlined in Appendix H of the 2040 RTP. We suggest incorporating these models to ensure a more proactive focus on public health. For example, the Nashville's MPO employs a model in which 80 points in an 100-point transportation project scoring factor are weighted towards improving public health through active transportation, air quality, and road safety improvements. Additionally, the Nashville MPO has partnered with the Centers for Disease Control to implement the Integrated Transport and Health Impact Model, which performs a range of health impact evaluations on transportation projects.

Air Quality

While the plan for the entire region may be in compliance with federal air quality standards, the H-GAC should adopt an assessment model that measures localized air quality impacts in addition to regional trends, particularly when evaluating the merits of proposed projects. Adopting a more holistic scoring factor that accounts for air quality impacts in transportation projects and employing Health Impact Assessments to assess existing and future conditions, such as the NHHIP HIA, would support a more robust planning process with public health and equity as its guiding principles.

Environmental Justice

As previously discussed, it is anticipated that the NHHIP will disproportionately impact communities of color and low-income. To better address environmental justice impacts of transportation projects moving forward, the Environmental Justice Report (Appendix I), includes a comprehensive analysis of issues facing disadvantaged and vulnerable communities. The data in the document (Appendix I) underscores the disparities inherent in the current transportation system, which does not adequately serve these communities, even as they remain burdened by an outsized share of transportation-related pollution. The document recommends that H-GAC "investigate new models, tools, and metrics that improve the measurement of transportation's impact on the population and expand ways to identify disproportionate harm to the protected communities" and cites the need for "fresh analyses that study the impact of transportation projects on less considered subjects like public health, household economics, and community cohesion." Following these recommendations should be the focus of the regional planning body in the short term, and the overarching goal in the long term. The current metrics used to evaluate projects included in the RTP are not sufficient in regards to measuring public health and environmental justice impacts. Many of the projects included in the RTP, including the NHHIP, should be reevaluated under revamped metrics that holistically score the merits of a project.

Local Recommendations

- Use positions within the H-GAC to foster greater coordination between the various planning organizations.
- Develop goals and additional performance measures that aim to improve public health outcomes. Overhaul the metrics used to score projects for inclusion into the RTP and the TIP, so that projects that improve public health outcomes, address issues of equitable access and exposure to air pollution and reduce mobile source emissions impacts are given priority. Once these metrics have been overhauled, consider reevaluating many of the projects currently included in the RTP.
- Prioritize adopting and funding a version of the Vision network laid out in the High Capacity Transit Task Force Report
- Implement policy recommendations and adopt the performance measures listed in the Active Transportation RTP (Draft Regional Active Transportation Plan, 70-80).[106.]
- Integrate the priorities listed in the Environmental Justice Report into future planning documents. These priorities should become an integral part of any changes to project planning scoring factors in future call for projects:
    - Increase environmental justice awareness within the transportation management area.
    - Enhance sensitivity to Title VI and environmental justice in transportation investment decisions.
    - Support local efforts to improve transportation service in underserved communities.
    - Improve safety in environmental justice communities.
    - Increase public involvement in decision-making processes by underserved groups.
- Create an Environmental Justice subcommittee to the Technical Advisory Committee to further study EJ issues and be a permanent voice within the organization to advocate on behalf of EJ communities.
- Many of City of Houston planning ordinances are specifically designed to encourage car usage and have the effect of fostering urban sprawl. While the city technically has no "zoning", several ordinances affect how and where land is developed in a way that discourages active transportation and transit use. Lowering required parking ratios, altering setback and building lines, and integrating other transit-oriented development concepts into Chapter 42 can increase density and encourage alternative mode use.
- Expand Complete Communities and Walkable Places programs to other parts of Houston while ensuring that equitable criteria are used to select communities for program expansions along with implementing strategies that prevent displacement.
- Build on existing active transportation initiatives, such as Precinct 1 Commissioner Rodney Ellis' cooperative project with the City of Houston to build 50 miles of bike lanes in Precinct 1 (Ellis has pledged

$10 million towards the project, under the conditions that City Council move forward on the project within a year).

- o Advocate for increased alternative mode connections to population centers that lie in unincorporated parts of Harris County.

State-Level Recommendations

- o Expand the five-member Texas Transportation Commission to seven members, requiring two of the members to be public health professionals.
- o Health Impact Assessment Account and Health Impact Assessment Requirements:
  - Health Impact Assessment Account – implement legislation that will create a Health Impact Assessment Account to be used to conduct HIAs that meet the threshold decided upon. Funds for this account will come from an annual transfer of .075% or $750,000, whichever is lower, from the State Highway Fund (in 2019, the deposit to the SHF was $1.38 billion).
  - SHF dollars are constitutionally directed, and may only be used for "constructing, maintaining, and acquiring rights-of-way for public roadways other than toll roads."
  - Create legislation that will require TxDOT to perform a HIA on projects that meet a certain threshold (e.g. expected cost of $X, expand VMT on affected roadway by X, X number of people within a mile radius on length of project, or within a municipality of a certain population).
  - The HIA should be conducted by the Environmental Affairs division of the Project Planning and Development Department of TxDOT, in conjunction with Texas Health and Human Services, Texas Commission on Environmental Quality, and the local MPO OR TxDOT may use funds from the HIA Account to contract with a qualified NGO to conduct the HIA.
- o Expand criteria of the "Design Consideration" listed in Texas Transportation Code 201.615 to cover more quality of life and public health considerations and tie the criteria to measurable targets. In addition, implement a contractor proposal scoring system that favors bids that demonstrate the ability to meet these targets.

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[3] Member organizations of the Make I-45 Better Coalition include: Air Alliance Houston, Avenue CDC, Bayou City Waterkeeper, BikeHouston, Buffalo Bayou Partnership, Eastwood Civic Association, Freedman's Town Preservation Committee, Friends of Woodland Park, Galveston Bay Foundation, Germantown Historic District, Greater Heights Super Neighborhood 15, Heritage Society, Hermann Park Conservancy, Houston Parks board, I-45 Coalition, LINK Houston, Montie Beach Civic Club, Museum Super Neighborhood 66, Scenic Houston, Trees for Houston, Washington Avenue Coalition/Memorial Park Super Neighborhood 22, White Oak Bayou Association, Woodland Heights Civic Association.

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APPENDIX I – CAMPUS SPECIFIC ASSESSMENT SUMMARIES

North Houston Highway Improvement Project (NHHIP) Health Impact Assessment

3rd Ward/Midtown/Museum District Recommendations

CONCERN	IMPACTS ON COMMUNITY	POSSIBLE SOLUTIONS
Student Health	Houston Academy of International Studies is exposed on its East to 10 times the Vehicle Miles Travelled/square mile as an average HISD/AISD campus. Young Women's College Preparatory Academy is exposed on three sides to 7 times the district average of traffic-related air pollution. HAIS: 102,100. YWCP: 70,219. HISD/AISD Average: 10,124. The expansion would move the highway closer to Young Women's College Preparatory Academy, double the width of the highway in some areas, and bring at least 26 existing school campuses within 500 feet of the freeway. The increased volume of traffic anticipated will introduce more air and noise pollutants into the communities near the highway. These pollutants are linked to poorer student and community health (exacerbating heart disease, respiratory diseases like asthma, and cognitive function), causing more sick days from work and school, reduced academic performance, shorter lifespans, and lower quality of life. Furthermore, a number of traffic-related air pollutants – such as diesel particulate matter, benzene, 1,3 butadiene, and formaldehyde – are known to cause cancer. At 5%, asthma rates at Young Women's College Preparatory Academy currently exceed the AISD/HISD average of 3.3% by 50%. Children attending schools near high traffic areas are some of the most exposed and vulnerable populations to traffic-related pollution due to their developing brain, lungs, heart, and circulatory systems. They receive even more exposure if they're active outside during high traffic times.	– Request that TxDOT fund the implementation of tree lines and noise/pollution barriers along the freeway edge throughout the project. Further request that TxDOT fund street tree planting and sidewalk repair/construction along streets used by pedestrians within 500 ft of the freeway. – Request that TxDOT locate construction staging areas at least 500 ft from sensitive uses like schools, senior living, residences, and health care facilities. Encourage the use of low and zero-emission equipment and dust control during construction. – Request that TxDOT provide funding for the installation of air monitors at sensitive receptors like schools, parks, and playgrounds during and after project completion. – Request that schools implement "No-Idle Zones" around campus for carpools, school buses, and deliveries. – Request that TxDOT provide funding for the ongoing installation of HEPA (high efficiency) filters within buildings with sensitive occupants (such as schools, senior living, homes, and health care facilities) located within 500 ft of the freeway.
Environmental Justice	The current freeway demarcates a 500 ft barrier between high income, majority white on the west side of SH-288 and low income, majority people of color neighborhoods on the east side of SH-288. The current proposal for the expansion will further entrench the separation between the Museum District/Midtown on the west side of the freeway with 3rd Ward on the east side.	– Request that TxDOT provide funding for constructing the bridges across SH-288 in 3rd Ward/Midtown/Museum District in accordance with Complete Streets Principles.
Community Safety	95 pedestrian and bicycle crashes have occurred within a ½ mile of Houston Academy of International Studies since 2010 and 100 within ½ mile of Young Women's College Preparatory Academy, by far the most in the HIA's study area. Most of them occurred in the Museum District, 4+ blocks west of the schools. However, a number of them occurred under or adjacent to the freeway. The current NHHIP design does not invest in design features that would protect pedestrians and cyclists traveling parallel to or crossing the freeway. The expansion will construct more impermeable concrete surfaces, which could increase flood risk and the urban heat island effect. Young Women's College Preparatory Academy is currently ranked among the top 15 percent of areas in Houston that are most likely to experience dangerous urban heat island effects.	– Request that the Houston-Galveston Area Council provide more funding for transit and active transportation projects; remove the caps on funding for Alternative Mode and Air Quality projects; and, prioritize projects serving disadvantaged communities. – Engage with METRO to support and provide feedback on the METRONext Plan and encourage fellow community members to vote in the upcoming bond elections to authorize funding for the expansions. – Request that TxDOT include parks, green spaces, and tree canopy in future plans to increase permeable surfaces, reduce flooding, and encourage physical activity.

YOUR OPPORTUNITY TO PROVIDE FEEDBACK

There is still time to provide further input on the project! The best way to do so is to directly speak to your local officials. Here is a list of people to contact and events to attend for your community. Use the information from this flyer as talking points to frame your concerns.

COMMUNITY LEADERS

Houston Mayor
Sylvester Turner: 713.837.0311 | mayor@houstontx.gov

Harris County Commissioners
Rodney Ellis, Precinct 1: (713) 274-1000
Adrian Garcia, Precinct 2: (713) 755-6220
Lina Hidalgo, County Judge: (713) 274-7000

District D City Council Member
Dwight Boykins: 832.393.3001 | districtd@houstontx.gov
City Hall Annex, 900 Bagby, First Floor, Houston, 77002

At-Large City Council Members
Mike Knox: 832.393.3014 | atlarge1@houstontx.gov
David Robinson: 832.393.3013 | atlarge2@houstontx.gov
Michael Kubosh: 832.393.3005 | atlarge3@houstontx.gov
Amanda Edwards: 832.393.3012 | atlarge4@houstontx.gov
Jack Christie: 832.393.3017 | atlarge5@houstontx.gov

SCHOOL OFFICIALS

Houston ISD Superintendent Dr. Grenita Lathan (Interim):
713.556.6300 | HISDSuperintendent@HoustonISD.org

Houston ISD Trustees, District IV
Jolanda Jones: jjones57@houstonisd.org

Houston ISD Board President
Diana Dávila: ddavila3@houstonisd.org

State Board of Education, District 4
Mr. Lawrence A. Allen Jr.: 713-203-1355 | sboesupport@tea.texas.gov

OTHER CONTACTS

Harris County Public Health Executive Director, Umair Shah:
(713) 439-6016 | Umair.Shah@phs.hctx.net, @ushahmd (Twitter)

Houston-Galveston Area Council Director of Transportation Planning,
Alan Clark: Alan.Clark@h-gac.com | PublicComments@h-gac.com

METRO Next: http://www.metronext.org/
Submit a comment: https://www.ridemetro.org/Pages/METRONext.aspx

State Senator, District 6 Carol Alvarado:
512-463-0106 | carol.alvarado@house.texas.gov

State Representative Armando Walle:
512-463-0924 | Armando.Walle@house.texas.gov

State Representative Senfronia Thompson:
512-463-0720 | Senfronia.Thompson@house.texas.gov

COMMUNITY RESOURCES

If you are concerned about being displaced due to the expansion, please contact the following resources:

LONE STAR LEGAL AID
Kimberly Brown: 713-652-0077 | KBrown@lonestarlegal.org

TEXAS HOUSERS
Sophie Dulberg: 346-291-6262 | sophie+i45@texashousing.org

EVENTS

Houston City Council Public Comment Sessions (Every Tuesday 1:30 PM; Schedule: www.houstontx.gov/citysec/calendar.pdf)
2nd floor of City Hall, 901 Bagby, Houston, TX 77002. *Sign up to speak: 832.393.1100, citysecretary@houstontx.gov, or by coming by the office.*

City Council Transportation, Technology, and Infrastructure Committee Meetings (April 4th; May 2nd | Thursdays at 10:00 AM)
City Hall Council Chambers, 901 Bagby, Houston 77002. *Email Julia.Retta@houstontx.gov to be added to email list.*

Houston-Galveston Area Council Transportation Policy Council (April 5th | 9:30 AM)
TxDOT Houston District Auditorium, 7600 Washington Ave, Houston, TX 77002. *Schedule: http://www.h-gac.com/transportation-policy-council/*

Harris County Commissioner's Court (Tuesday, April 9th, 10:00 AM; Schedule: https://agenda.harriscountytx.gov/)
1001 Preston Street, Suite 934, Houston, TX 77002. *Request an appearance: https://appearancerequest.harriscountytx.gov/.*

Houston ISD Board Meetings (Thursday, April 11th, 5:00 PM; Sign up to speak: www.houstonisd.org/Page/32478)
Board Auditorium, Hattie Mae White Educational Support Center; 4400 W 18th St, Houston, TX 77092.

Midtown Super Neighborhood #62 Meeting (Thursday, April 11th, 6:00 PM)
Crime Stoppers, 3001 Main St., 77002. *Contact Cynthia Aceves-Lewis, President, at info@MidtownSN.org to be added to email list.*

Greater Third Ward Super Neighborhood #67 Meeting (Thursday, April 18th, 6:00 PM) 3rd Ward Multi-Service Center, 3611 Ennis St., 77004.
Contact Lynn Henson, Complete Communities Administration Manager, at 832.393.6600 or CC_ThirdWard@houstontx.gov to be added to email list.

Texas Transportation (TX DOT) Commission Meeting (Thursday, April 25, 9:00 AM)
125 East 11th St, Austin, TX 78701. *Sign up to speak: 512-305-9509; https://www.txdot.gov/contact-us/form.html?id=transcom-email*

Air Alliance Houston believes everyone has a right to breathe clean air and where you live, work, learn, and play should not determine your health. Learn more: http://airalliancehouston.org. 713.528.3779.

North Houston Highway Improvement Project (NHHIP) Health Impact Assessment

5th Ward Recommendations

CONCERN	IMPACTS ON COMMUNITY	POSSIBLE SOLUTIONS
Student Health	Bruce Elementary and Secondary DAEP are located diagonal to each other across the I-69/I-10 interchange. Both schools are exposed to more than 4 times the Vehicle Miles Travelled/square mile as an average HISD/AISD campus: Bruce: 40,797. Secondary DAEP: 64,512. HISD/AISD Average: 10,124. The expansion design brings the highway to the property line of both Bruce Elementary and Secondary DAEP and within 500 feet of at least 26 existing school campuses. The increased volume of traffic anticipated will introduce more air and noise pollutants into the communities near the highway. These pollutants are linked to poorer student and community health (exacerbating heart disease, respiratory diseases like asthma, and cognitive function), causing more sick days from work and school, reduced academic performance, shorter lifespans, and lower quality of life. Furthermore, a number of traffic-related air pollutants – such as diesel particulate matter, benzene, 1,3 butadiene, and formaldehyde – are known to cause cancer. Asthma rates at both Bruce Elementary (7.2%) and Secondary DAEP (5%) already greatly exceed the AISD/HISD average of 3.3%. Children attending schools near high traffic areas are some of the most exposed and vulnerable populations to traffic-related pollution due to their developing brain, lungs, heart, and circulatory systems.	– Request that TxDOT fund the implementation of tree lines along the borders of the lots facing I-45 and along students' main walking paths to and from school. – Request that TxDOT locate construction staging areas at least 500 ft from sensitive uses like schools, senior living, residences, and health care facilities. Encourage the use of low and zero-emission equipment and dust control during construction. – Request that TxDOT provide funding for the installation of air monitors at sensitive receptors like schools, parks, and playgrounds during and after project completion. – Request that schools implement "No-Idle Zones" around campus for carpools, school buses, and deliveries. – Request that TxDOT provide funding for the ongoing installation of HEPA (high efficiency) filters within buildings with sensitive occupants located within 500 ft of the freeway.
Environmental Justice	The expansion would cause the removal or relocation of families in several public housing units, particularly Clayton Homes and Kelly Village. Poverty rates along the expansion are higher than the Houston average: 65.5% in Bruce neighborhood and 75.5% in DAEP neighborhood, compared with 43.2% in Houston as a whole. The percentage of persons of color is much higher in these neighborhoods than in Houston as a whole: 92.6% in the Bruce neighborhood, 94% in the DAEP neighborhood, compared with 73.7% in Houston. Of the three segments, the affluent Segment 3 (Downtown) has considerable differences in strategies for mitigation than the other two segments; negative impacts of the highway could disproportionately fall on low-income communities of color.	– Encourage TxDOT to work with the City of Houston and community organizations to improve the amenities provided along the northern segments of the project to mirror the investment going into Downtown. – Request that TxDOT improve surface street connectivity between 5th Ward and the Central Business District to improve access to job opportunities.
Community Safety	20% of Bruce Elementary students walk to school, exposing them to the locations with the highest pedestrian and cycling crashes historically in the neighborhood: Jensen Drives and under and next to the freeway. 15 pedestrian and bicycle crashes have occurred within a ½ mile of Bruce Elementary since 2010; 35 have occurred within a ½ mile of Secondary DAEP. The NHHIP design will move the freeway closer to both schools and increase the speed of cars traveling down the access road, increasing safety concerns for pedestrians and cyclists. Both schools are currently ranked among the top 10 percent of areas in Houston that are most likely to experience dangerous urban heat island effects. The expansion will construct more impermeable concrete surfaces, which could increase flood risk and the urban heat island effect.	– Request that the Houston-Galveston Area Council provide more funding for transit and active transportation projects; remove the caps on funding for Alternative Mode and Air Quality projects; and, prioritize projects serving disadvantaged communities. – Engage with METRO to support and provide feedback on the METRONext Plan and encourage fellow community members to vote in the upcoming bond elections to authorize funding for the expansions. – Request that TxDOT include parks, green spaces, and tree canopy in future plans to increase permeable surfaces, reduce flooding, and encourage physical activity.

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Adrian Garcia, Precinct 2: (713) 755-6220
Lina Hidalgo, County Judge: (713) 274-7000

District B City Council Member
Jerry Davis: 832.393.3009 | districtb@houstontx.gov,
City Hall Annex, 900 Bagby, First Floor, Houston, 77002

At-Large City Council Members
Mike Knox: 832.393.3014 | atlarge1@houstontx.gov
David Robinson: 832.393.3013 | atlarge2@houstontx.gov
Michael Kubosh: 832.393.3005 | atlarge3@houstontx.gov
Amanda Edwards: 832.393.3012 | atlarge4@houstontx.gov
Jack Christie: 832.393.3017 | atlarge5@houstontx.gov

SCHOOL OFFICIALS

Houston ISD Superintendent
Dr. Grenita Lathan (Interim): 713.556.6300 | HISDSuperintendent@HoustonISD.org

Houston ISD Board President
Diana Dávila: ddavila3@houstonisd.org

Houston ISD Trustees
District I, Elizabeth Santos: Elizabeth.Santos@houstonisd.org
District II, Rhonda Skillern-Jones: rskille2@houstonisd.org

State Board of Education, District 4
Mr. Lawrence A. Allen Jr.:
713-203-1355 | sboesupport@tea.texas.gov

OTHER

Harris County Public Health Executive Director, Umair Shah:
(713) 439-6016 | Umair.Shah@phs.hctx.net, @ushahmd (Twitter)

Houston-Galveston Area Council Director of Transportation Planning,
Alan Clark: Alan.Clark@h-gac.com | PublicComments@h-gac.com

METRO Next: http://www.metronext.org/
Submit a comment: https://www.ridemetro.org/Pages/METRONext.aspx

State Senator, District 6 Carol Alvarado:
512-463-0106 | carol.alvarado@house.texas.gov

State Representative Armando Walle:
512-463-0924 | Armando.Walle@house.texas.gov

State Representative Senfronia Thompson:
512-463-0720 | Senfronia.Thompson@house.texas.gov

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www.lonestarlegal.org

TEXAS HOUSERS
Sophie Dulberg: 346-291-6262 | sophie+i45@texashousing.org
https://texashousers.net

EVENTS

Houston City Council Public Comment Sessions (Every Tuesday 1:30 PM; Schedule: www.houstontx.gov/citysec/calendar.pdf)
2nd floor of City Hall, 901 Bagby, Houston, TX 77002. *Sign up to speak: 832.393.1100, citysecretary@houstontx.gov, or by coming by the office on the public level of the City Hall Annex by 1:30 p.m. that Tuesday.*

Super Neighborhood #55 Meeting (Wednesday, April 3rd 6:00 PM)
Fifth Ward MSC, 4014 Market Street, Houston, 77020. *Contact Joetta Stevenson, SN President, at 713-502-7181 to speak at the meeting.*

City Council Transportation, Technology, and Infrastructure Committee Meetings (April 4th; May 2nd | Thursdays at 10:00 AM)
City Hall Council Chambers, 901 Bagby, Houston 77002. *Email Julia.Retta@houstontx.gov to be added to email list.*

Houston-Galveston Area Council Transportation Policy Council (April 5th | 9:30 AM)
TxDOT Houston District Auditorium, 7600 Washington Ave, Houston, TX 77002. *Schedule: http://www.h-gac.com/transportation-policy-council/*

Harris County Commissioner's Court (Tuesday, April 9th, 10:00 AM; Schedule: https://agenda.harriscountytx.gov/)
1001 Preston Street, Suite 934, Houston, TX 77002. *Request an appearance: https://appearancerequest.harriscountytx.gov/.*

Houston ISD Board Meetings (Thursday, April 11th, 5:00 PM)
Board Auditorium, Hattie Mae White Educational Support Center; 4400 W 18th St, Houston, TX 77092.
Sign up to speak: www.houstonisd.org/Page/32478.

Texas Transportation (TX DOT) Commission Meeting (Thursday, April 25, 9:00 AM)
125 East 11th St, Austin, TX 78701. *Sign up to speak: 512-305-9509; https://www.txdot.gov/contact-us/form.html?id=transcom-email*

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North Houston Highway Improvement Project (NHHIP) Health Impact Assessment

Greater Northside/Northline Recommendations

CONCERN	IMPACTS ON COMMUNITY	POSSIBLE SOLUTIONS
Student Health	Roosevelt Elementary and Jefferson Elementary are located across 610 from each other on the east side of I-45. Jefferson Elementary is exposed to more than 5 times the Vehicle Miles Travelled/square mile as an average HISD/AISD campus. Jefferson: 55,292. HISD/AISD Average: 10,124. The expansion would double the width of the highway in some areas and add several more lanes, bringing at least 26 existing school campuses within 500 feet of the freeway, including Jefferson and Roosevelt. The increased volume of traffic anticipated will introduce more air and noise pollutants into the communities near the highway. These pollutants are linked to poorer student and community health (exacerbating heart disease, respiratory diseases like asthma, and cognitive function), causing more sick days from work and school, reduced academic performance, shorter lifespans, and lower quality of life. Furthermore, a number of traffic-related air pollutants – such as diesel particulate matter, benzene, 1,3 butadiene, and formaldehyde – are known to cause cancer. Children attending schools near high traffic areas are some of the most exposed and vulnerable populations to traffic-related pollution due to their developing brain, lungs, heart, and circulatory systems. They receive even more exposure if they're active outside during high traffic times.	– Request that TxDOT fund the implementation of tree lines along the borders of the lots facing I-45 and along major streets within 500 ft of the freeway. – Request that TxDOT locate construction staging areas at least 500 ft from sensitive uses like schools, senior living, residences, and health care facilities. Encourage the use of low and zero-emission equipment and dust control during construction. – Request that TxDOT provide funding for the installation of air monitors at sensitive receptors like schools, parks, and playgrounds during and after project completion. – Request that schools implement "No-Idle Zones" around campus for carpools, school buses, and deliveries. – Request that TxDOT provide funding for the ongoing installation of HEPA (high efficiency) filters within buildings with sensitive occupants (such as schools, senior living, homes, and health care facilities) located within 500 ft of the freeway.
Environmental Justice	Poverty rates and representation of people of color are higher in the neighborhood surrounding Roosevelt Elementary than Houston as a whole. The poverty rate is 52% in the Roosevelt neighborhood, compared with 43.2% in Houston. The percentage of persons of color is 94% in the Roosevelt neighborhood, compared with 73.7% in Houston. Of the three segments, the affluent Segment 3 (Downtown) shows considerable differences in strategies for mitigation than the other two segments; negative impacts of the highway could disproportionately fall on low-income communities of color.	– Encourage TxDOT to work with the City of Houston and community organizations to improve the amenities provided along the northern segments of the project to mirror the investment going into Downtown. – Request that TxDOT fund appropriate structure for the deck park proposed to link Woodland Heights and Near Northside, so that it will be able to accommodate trees and other vegetation. Ensure that pedestrian access is safe and inviting to residents wishing to use the park.
Community Safety	13 pedestrian and bicycle crashes have occurred within a ½ mile of Jefferson Elementary since 2010. All of them are located on the two streets students use to walk across the freeway: Link and Cavalcade. Most of the 21 ped/bike crashes near Roosevelt have taken place under or next to the freeway. The NHHIP design will expand the width of the freeway and increase the speed of cars traveling down the access road, increasing safety concerns for pedestrians and cyclists. The expansion will construct more impermeable concrete surfaces, which could increase flood risk and the urban heat island effect. Jefferson Elementary is currently ranked among the top 9 percent of areas in Houston that are most likely to experience dangerous urban heat island effects. Both schools are located in the floodplain, which crosses the freeway from Little White Oak Bayou along the two streets students use to cross the freeway.	– Request that the Houston-Galveston Area Council provide more funding for transit and active transportation projects; remove the caps on funding for Alternative Mode and Air Quality projects; and, prioritize projects serving disadvantaged communities. – Engage with METRO to support and provide feedback on the METRONext Plan and encourage fellow community members to vote in the upcoming bond elections to authorize funding for the expansions. – Request that TxDOT include parks, green spaces, and tree canopy in future plans to increase permeable surfaces, reduce flooding, and encourage physical activity. – Request that TxDOT comply with the Harris County Flood Control design standard of 500-year flood events, rather than 100-year flood events.

YOUR OPPORTUNITY TO PROVIDE FEEDBACK

There is still time to provide further input on the project! The best way to do so is to directly speak to your local officials. Here is a list of people to contact and events to attend for your community. Use the information from this flyer as talking points to frame your concerns.

COMMUNITY LEADERS

Houston Mayor
Sylvester Turner: 713.837.0311 | mayor@houstontx.gov

Harris County Commissioners
Rodney Ellis, Precinct 1: (713) 274-1000
Adrian Garcia, Precinct 2: (713) 755-6220
Lina Hidalgo, County Judge: (713) 274-7000

District H City Council Member
Karla Cisneros: 832.393.3003 | districth@houstontx.gov
City Hall Annex, 900 Bagby, First Floor, Houston, 77002

At-Large City Council Members
Mike Knox: 832.393.3014 | atlarge1@houstontx.gov
David Robinson: 832.393.3013 | atlarge2@houstontx.gov
Michael Kubosh: 832.393.3005 | atlarge3@houstontx.gov
Amanda Edwards: 832.393.3012 | atlarge4@houstontx.gov
Jack Christie: 832.393.3017 | atlarge5@houstontx.gov

SCHOOL OFFICIALS

Houston ISD Superintendent
Dr. Grenita Lathan (Interim): 713.556.6300 | HISDSuperintendent@HoustonISD.org

Houston ISD Trustees
District I, Elizabeth Santos: Elizabeth.Santos@houstonisd.org
District II, Rhonda Skillern-Jones: rskille2@houstonisd.org

Houston ISD Board President
Diana Dávila: ddavila3@houstonisd.org

State Board of Education, District 4
Mr. Lawrence A. Allen Jr.:
713-203-1355 | sboesupport@tea.texas.gov

OTHER

Harris County Public Health Executive Director, Umair Shah:
(713) 439-6016 | Umair.Shah@phs.hctx.net, @ushahmd (Twitter)

Houston-Galveston Area Council Director of Transportation Planning
Alan Clark: Alan.Clark@h-gac.com | PublicComments@h-gac.com

METRO Next: http://www.metronext.org/
Submit a comment: https://www.ridemetro.org/Pages/METRONext.aspx

State Senator, District 6 Carol Alvarado:
512-463-0106 | carol.alvarado@house.texas.gov

State Representative Armando Walle:
512-463-0924 | Armando.Walle@house.texas.gov

State Representative Senfronia Thompson:
512-463-0720 | Senfronia.Thompson@house.texas.gov

COMMUNITY RESOURCES

If you are concerned about being displaced due to the expansion, please contact the following resources:

LONE STAR LEGAL AID
Kimberly Brown: 713-652-0077 | KBrown@lonestarlegal.org
www.lonestarlegal.org

TEXAS HOUSERS
Sophie Dulberg: 346-291-6262 | sophie+i45@texashousing.org
https://texashousers.net

EVENTS

Houston City Council Public Comment Sessions (Every Tuesday 1:30 PM; Schedule: www.houstontx.gov/citysec/calendar.pdf)
2nd floor of City Hall, 901 Bagby, Houston, TX 77002. *Sign up to speak: 832.393.1100, citysecretary@houstontx.gov, or by coming by the office on the public level of the City Hall Annex by 1:30 p.m. that Tuesday.*

Super Neighborhood #51 Meeting (Every 4th Thursday, at 6:00 PM)
2101 South St., Houston, TX 77009. *Email Jack.valinski@houstontx.gov to be added to email list.*

City Council Transportation, Technology, and Infrastructure Committee Meetings (April 4th; May 2nd | Thursdays at 10:00 AM)
City Hall Council Chambers, 901 Bagby, Houston 77002. *Email Julia.Retta@houstontx.gov to be added to email list.*

Houston-Galveston Area Council Transportation Policy Council (April 5th | 9:30 AM)
TxDOT Houston District Auditorium, 7600 Washington Ave, Houston, TX 77002. *Schedule: http://www.h-gac.com/transportation-policy-council/*

Harris County Commissioner's Court (Tuesday, April 9th, 10:00 AM; Schedule: https://agenda.harriscountytx.gov/)
1001 Preston Street, Suite 934, Houston, TX 77002. *Request an appearance: https://appearancerequest.harriscountytx.gov/.*

Houston ISD Board Meetings (Thursday, April 11th, 5:00 PM)
Board Auditorium, Hattie Mae White Educational Support Center; 4400 W 18th St, Houston, TX 77092.
Sign up to speak: www.houstonisd.org/Page/32478.

Texas Transportation (TX DOT) Commission Meeting (Thursday, April 25, 9:00 AM)
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North Houston Highway Improvement Project (NHHIP) Health Impact Assessment

Aldine/Greenspoint Recommendations

CONCERN	IMPACTS ON COMMUNITY	POSSIBLE SOLUTIONS
Student Health	The Aldine schools currently have the highest Vehicle Miles Travelled/square mile of any public school in HISD or AISD: 142,938 compared with the HISD/AISD average of 10,124. The expansion would double the width of the highway in some areas and add several more lanes, bringing at least 26 existing school campuses within 500 feet of the freeway. The increased volume of traffic anticipated will introduce more air and noise pollutants into the communities near the highway. These pollutants are linked to poorer student and community health (exacerbating heart disease, respiratory diseases like asthma, and cognitive function), causing more sick days from work and school, reduced academic performance, shorter lifespans, and lower quality of life. Furthermore, a number of traffic-related air pollutants – such as diesel particulate matter, benzene, 1,3 butadiene, and formaldehyde – are known to cause cancer. Asthma rates on the Aldine campus currently range from 4% to more than 6%, far exceeding the AISD/HISD average of 3.3%. Children attending schools near high traffic areas are some of the most exposed and vulnerable populations to traffic-related pollution due to their developing brain, lungs, heart, and circulatory systems. They receive even more exposure if they're active outside during high traffic times.	– Request that TxDOT fund sidewalks and the planting of street trees along the borders of the lots facing I-45 and along major streets within 500 ft of the freeway. – Request that TxDOT locate construction staging areas at least 500 ft from sensitive uses like schools, senior living, residences, and health care facilities. Encourage the use of low and zero-emission equipment and dust control during construction. – Request that TxDOT provide funding for the installation of air monitors at sensitive receptors like schools, parks, and playgrounds during and after project completion. – Request that schools implement "No-Idle Zones" around campus for carpools, school buses, and deliveries. – Request that TxDOT provide funding for the ongoing installation of HEPA (high efficiency) filters within buildings with sensitive occupants (such as schools, senior living, homes, and health care facilities) located within 500 ft of the freeway.
Environmental Justice	Poverty rates along the freeway expansion in Aldine/Greenspoint are higher than the Houston average (11.6%, compared with 6.8% across the city). 72.6% of residents near the Aldine campus identify as Hispanic, compared with 44.5% in Houston. Of the three segments, the affluent Segment 3 (Downtown) shows considerable differences in strategies for improving the project than the two segments north of I-10 in spite of the fact that negative impacts of the highway could disproportionately fall on low-income communities of color.	– Encourage TxDOT to work with the City of Houston and community organizations to improve the amenities provided along the northern segments of the project to mirror the investment going into Downtown.
Community Safety	46% of Aldine 9th Graders walk to school, including a significant portion who must pass under I-45 and cross the dangerous intersection at I-45 and West Rd. to reach the campus. 56 pedestrian and bicycle crashes have occurred within a ½ mile of school since 2010, many of them at the West Rd/I-45 intersection and at the West Rd/Airline Dr intersection, both of which fall on preferred pedestrian routes to school. Furthermore, the carpool lane for Aldine 9th spills over into the highway feeder road. And, no school zone has been designated for any of the schools on the campus. The NHHIP design will increase the width of the freeway and the speed of cars traveling down the access road, increasing safety concerns for pedestrians and cyclists. The expansion will construct more impermeable concrete surfaces, which could increase flood risk and the urban heat island effect. The Aldine campus currently sits in both the 100-year and 500-year FEMA floodplain and is ranked among the top 20 percent of areas in Houston that are most likely to experience dangerous urban heat island effects	– Request that the Houston-Galveston Area Council provide more funding for transit and active transportation projects; remove the caps on funding for Alternative Mode and Air Quality projects; and, prioritize projects serving disadvantaged communities. – Request the Aldine ISD implement school zones in portions of streets with heavy pedestrian traffic. – Engage with METRO to support and provide feedback on the METRONext Plan and encourage fellow community members to vote in the upcoming bond elections to authorize funding for the expansions. – Request that TxDOT comply with the Harris County Flood Control design standard of 500-year flood events, rather than 100-year flood events and include parks, green spaces, and tree canopy in the NHHIP plan to increase permeable surfaces and encourage physical activity.

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Adrian Garcia, Precinct 2: (713) 755-6220
Lina Hidalgo, County Judge: (713) 274-7000

District B City Council Member
Jerry Davis: 832.393.3009 | districtb@houstontx.gov,
City Hall Annex, 900 Bagby, First Floor, Houston, 77002

At-Large City Council Members
Mike Knox: 832.393.3014 | atlarge1@houstontx.gov
David Robinson: 832.393.3013 | atlarge2@houstontx.gov
Michael Kubosh: 832.393.3005 | atlarge3@houstontx.gov
Amanda Edwards: 832.393.3012 | atlarge4@houstontx.gov
Jack Christie: 832.393.3017 | atlarge5@houstontx.gov

SCHOOL OFFICIALS

Aldine ISD Superintendent
Dr. LaTonya Goffney: @drgoffney (Twitter)

Houston ISD Trustees
District I, Elizabeth Santos: Elizabeth.Santos@houstonisd.org
District II, Rhonda Skillern-Jones: rskille2@houstonisd.org

Aldine ISD School Board President
Steve Mead: smead@board.aldineisd.org

State Board of Education, District 4
Mr. Lawrence A. Allen Jr.:
713-203-1355 | sboesupport@tea.texas.gov

OTHER

Harris County Public Health Executive Director, Umair Shah:
(713) 439-6016 | Umair.Shah@phs.hctx.net, @ushahmd (Twitter)

Houston-Galveston Area Council Director of Transportation Planning, Alan Clark:
Alan.Clark@h-gac.com | PublicComments@h-gac.com

METRO Next: http://www.metronext.org/
Submit a comment: https://www.ridemetro.org/Pages/METRONext.aspx

State Senator, District 6 Carol Alvarado:
512-463-0106 | carol.alvarado@house.texas.gov

State Representative Armando Walle:
512-463-0924 | Armando.Walle@house.texas.gov

State Representative Senfronia Thompson:
512-463-0720 | Senfronia.Thompson@house.texas.gov

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www.lonestarlegal.org

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https://texashousers.net

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Harris County Commissioner's Court (Tuesday, April 9th, 10:00 AM; Schedule: https://agenda.harriscountytx.gov/)
1001 Preston Street, Suite 934, Houston, TX 77002. *Request an appearance: https://appearancerequest.harriscountytx.gov/*.

Houston ISD Board Meetings (Thursday, April 11th, 5:00 PM)
Board Auditorium, Hattie Mae White Educational Support Center; 4400 W 18th St, Houston, TX 77092**.** *Sign up in advance to speak: www.houstonisd.org/Page/32478*.

Aldine ISD Board Meeting (Tuesday, April 16, 7:00 PM)
Donaldson Administration Building, 2520 W. W. Thorne Blvd, Houston, TX 77073. *Trustees allow three minutes for each public comment*.

Texas Transportation (TX DOT) Commission Meeting (Thursday, April 25, 9:00 AM)
125 East 11th St, Austin, TX 78701. *Sign up to speak: 512-305-9509; https://www.txdot.gov/contact-us/form.html?id=transcom-email*

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APPENDIX II – PROPOSED MITIGATION STRATEGIES

North Houston Highway Improvement Project HIA

Potential Mitigation Strategies

For School Campuses

Building & Operations			
STRATEGY	COST	ENVIRONMENTAL IMPACT	HEALTH CO-BENEFITS
No idle zone around campus for carpools, school buses, deliveries.	$	- Reduce air pollution generated on-site.	- Asthma, respiratory disease - Cognitive development
Separate major sources of air pollution from outdoor air intakes, doors, operable windows.	$$	- Reduce the quantity of airborne toxins entering the building.	- Asthma, respiratory disease - Cognitive development
Install HEPA/MERV 13 air filters.	$$	- Remove pollutants (particularly particulate matter) from indoor air.	- Asthma, respiratory disease - Cognitive development
Schedule outdoor activities around ozone action days and times of day with higher traffic passing the school.	$	- Reduce exposure of students to outdoor air pollution.	- Asthma, respiratory disease - Cognitive development
Develop active indoor recess curriculum using free and low cost resources like GoNoodle.	$	- Reduce exposure of students to outdoor air pollution.	- Asthma, respiratory disease. - Cognitive development - Mental health (e.g., depression, anxiety, aggression, ADHD) - BMI, Diabetes
Introduce a walking school bus in coordination with a Safe Routes to School program to encourage students to walk or cycle to school.	$	- Reduce traffic congestion and related air pollution around the school.	- Mental health (e.g., depression, anxiety, aggression, ADHD) - BMI, Diabetes

Campus			
STRATEGY	COST	ENVIRONMENTAL IMPACT	HEALTH CO-BENEFITS
Organize the campus so that outdoor activities are located as far from major roadways as possible, screened by a building and/or greenery.	$-$$$	- Reduce exposure of students to outdoor air pollution.	- Asthma, respiratory disease - Cognitive development. - Mental health (e.g., depression, anxiety, aggression, ADHD). - BMI, Diabetes.
Design a safe route for pedestrians and cyclists from the edge of campus to the main entries of the school.	$$	- Reduce ped/bike exposure to unsafe traffic conditions. - Encourage active transportation, which can reduce traffic-related air pollution.	- Rate of bike/ped traffic-related crashes. - Mental health (e.g., depression, anxiety, aggression, ADHD). - BMI, Diabetes.
Fill in gaps in sidewalks on and surrounding campus.	$$	- Reduce ped/bike exposure to unsafe traffic conditions. - Encourage active transportation, which can reduce traffic-related air pollution.	- Rate of bike/ped traffic-related crashes. - Asthma, respiratory disease.
Plant drought-resistant shade trees along the sidewalks to reduce urban heat island for pedestrians.	$$	- Reduce the urban heat island. - Reduce flooding risk. - Encourage active transportation, which can reduce traffic-related air pollution.	- Mental health (e.g., depression, anxiety, aggression, ADHD). - BMI, Diabetes. - Heat-related illness. - Flooding-related injury or death.
Plant drought-resistant trees and bushes around play areas to screen children from particulates and traffic noise and to increase access to nature.	$$	- Reduce exposure to traffic-related air pollution. - Reduce the urban heat island. - Reduce flooding risk.	- Mental health (e.g., depression, anxiety, aggression, ADHD). - BMI, Diabetes. - Heat-related illness. - Flooding-related injury or death.
Plant drought-resistant plants outside school room windows to give students a view of nature.	$$	- Increase access to parks and green space.	- Mental health (e.g., depression, anxiety, aggression, ADHD). - Cognitive development.
Install bike rack for cyclists	$$	- Reduce traffic-related air pollution emissions by encouraging cycling.	- Asthma, respiratory disease. - Mental health (e.g., depression, anxiety, aggression, ADHD). - BMI, Diabetes.

Convert detention ponds into outdoor recreation spaces.	$$$	- Reduce flooding risk. - Increase access to physical activities and green space.	- Mental health (e.g., depression, anxiety, aggression, ADHD). - Cognitive development. - BMI, Diabetes. - Flooding-related injury or death.
Transportation Infrastructure			
STRATEGY	COST	ENVIRONMENTAL IMPACT	HEALTH CO-BENEFITS
Depress and cover the freeway with a deck park as much as possible.	$$$$$	- Reduce exposure to traffic-related air pollution and noise pollution through the cap and by encouraging active transportation. - Reduce ped/bike exposure to unsafe traffic conditions. - Increase access to parks and green space. - Reduce the urban heat island. - Reduce flooding risk.	- Rate of bike/ped traffic-related crashes. - Asthma, respiratory disease. - Mental health (e.g., depression, anxiety, aggression, ADHD). - Cognitive development. - BMI, Diabetes. - Heat-related illness. - Flooding-related injury or death.
Improve the freeway/city street interface to calm traffic and increase ped/bike safety.	$$$$	- Reduce ped/bike exposure to unsafe traffic conditions. - Encourage active transportation, which can reduce traffic-related air pollution.	- Rate of bike/ped traffic-related crashes. - Asthma, respiratory disease. - Mental health (e.g., depression, anxiety, aggression, ADHD). - Cognitive development. - BMI, Diabetes.
Build bike/ped infrastructure to support a walking/cycling school bus.	$$$$	- Reduce ped/bike exposure to unsafe traffic conditions. - Encourage active transportation, which can reduce traffic-related air pollution.	- Rate of bike/ped traffic-related crashes. - Asthma, respiratory disease. - Mental health (e.g., depression, anxiety, aggression, ADHD). - Cognitive development. - BMI, Diabetes.

APPENDIX III – BRUCE ELEMENTARY SCHOOL CASE STUDY

With the exception of modeling the air quality impacts, due to limited time and resources, the HIA Project Team was not able to develop alternative scenarios for each of the HIA impact categories to further inform recommendations for mitigation strategies to reduce the potential adverse health impacts. However, the HIA Project Team worked with Urban Design 4 Health (UDH4) consultants to produce an in-depth a case study of one of the priority campuses. These two approaches to evaluating the potential health impacts of the NHHIP can be used to inform a regional health impact assessment strategy and process.

URBAN DESIGN 4 HEALTH

HEALTH ASSESSMENT OF THE BRUCE ELEMENTARY SCHOOL COMMUNITY

Final Report

Prepared for: Bakeyah Nelson
Air Alliance Houston

Prepared by: Urban Design 4 Health

Date: May 2, 2019

ALLIANCE HOUSTON

URBAN DESIGN 4 HEALTH

ACKNOWLEDGEMENTS

About This Report

This report was prepared by Urban Design 4 Health, Ltd. (UD4H). UD4H specializes in applied research on the interactions between land use, transportation, air quality, climate change, and public health. UD4H's mission is to support clients with innovative and objective information and tools to realize health promotion, environmental, economic, and quality of life goals that are intrinsic in efforts to build new communities and to retrofit existing ones. Learn more at www.ud4h.com.

This report was prepared in fulfillment of a contract with Air Alliance Houston. The contents of this report are the responsibility of the authors and do not necessarily reflect the official views of Air Alliance Houston.

UD4H Authors

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Ms. Nicole Alfonsin, MPH, WELL AP, Health and Built Environment Specialist

Mr. Eric H. Fox, MScP, Planning Associate & GIS Manager

Dr. Behram Wali, PhD, MS, Lead Research Scientist

Dr. Lawrence D. Frank, PhD, AICP, ASLA, President

Billy Bachman was the UD4H Project Manager for the *Community Health Assessment for Schools in the I-45N Freeway Expansion Area* and led the assessment of air quality exposure risk for the planned freeway design and developed exposure maps for site-specific challenges, and wrote this report. Eric Fox and Behram Wali helped with mapping of baseline conditions as estimated by NPHAM, conducted a sensitivity analysis of built and natural environment scenarios to improve health, and assisted with preparation and review of the analysis report. Nicole Alfonsin identified mitigation methods to reduce exposures based on Task 3A and 3B and assisted with preparation and review of the final report. Dr. Lawrence Frank reviewed the results and contributed to the analysis report.

Air Alliance Houston was funded by the Baxter Trust to evaluate the potential health impacts of the proposed North Houston Highway Improvement Project (NHHIP) on Bruce Elementary School.

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1. Baseline Conditions

The Bruce Elementary School community, comprised of the current school attendance zone as shown in Figure 1, lies east of downtown Houston and in close proximity to I-69, I-10, and the Buffalo Bayou. As part of an effort to explore the health impacts of the Texas Department of Transportation's proposed North Houston Highway Improvement Project (NHHIP), the Air Alliance Houston (AAH) team contracted with Urban Design 4 Health (UD4H) to evaluate the potential health impacts on the Bruce Elementary School community using the National Public Health Assessment Model (N-PHAM)[1]. This draft report discusses the initial findings of the baseline assessment of health outcomes, physical activity, and park accessibility.

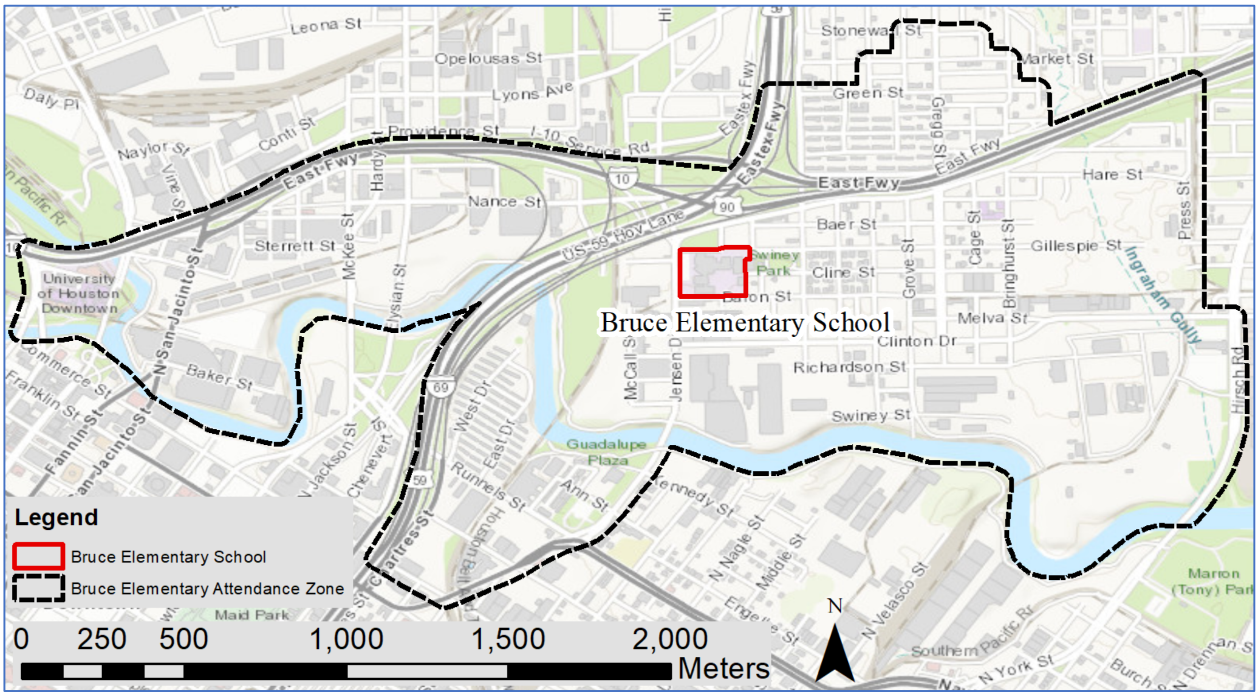

Figure 1 - Bruce Elementary School Attendance Zone

National Public Health Assessment Model (N-PHAM)[1]

N-PHAM is a model developed by UD4H with support from the US Environmental Protection Agency (EPA). It uses evidence-based inferential statistics to relate health outcomes with built, natural and social environment features. N-PHAM uses a pre-built national database developed by UD4H of baseline input conditions and estimates health outcomes using equations developed from the analysis of health interview surveys and household travel surveys[a], and built/natural/social environmental data. N-PHAM baseline conditions are estimated at the US Census block group geographic level (a geographic unit that is the minimum size for published sample demographic data) . N-PHAM supplements the Centers for Disease Control's (CDC) 500 Cities[2] US Census Tract level data in that N-PHAM has health outcomes and physical activity linked to built environment features. This linkage allows researchers and analysts to estimate changes in future health outcomes due to changes in environmental characteristics, such as those changes being planned as part of the NHHIP freeway expansion.

There is growing evidence of a *causal* relationship between the built environment and residents' opportunities to engage in healthy lifestyles relevant to chronic disease prevention[3-5]. Numerous studies have identified how exposure to different types of built environments impact physical activity, diet, and chronic disease[6-9]. These research findings suggest that tools such as N-PHAM could be helpful in identifying changes to the built environment that could have a significant impact on health and physical activity outcomes of communities such as the Bruce Elementary School community.

For predicting health and physical activity outcomes, N-PHAM relies on associations between the built/natural environment and health and physical activity outcomes; these relationships only explain a small amount of the variance in health outcomes[1]. Baseline estimates and subsequent model changes that indicate a positive or negative change should be considered as indicators, not as a deterministic outcome. Regardless, N-PHAM allows planners the ability to evaluate community investments in planned infrastructure based on their likely impact on community health.

The N-PHAM baseline assessment of the Bruce Elementary community includes the health and physical activity outcomes shown in Table 1 and Table 2, respectively. This initial assessment will include comparison metrics for the full NHHIP corridor, the city of Houston, Harris County, Metro Houston (Houston Metropolitan Statistical Area), and the state of Texas. The comparisons across these geographic levels will be useful in understanding how this particular community compares to others in and around Houston.

Childhood Health and Communities

All of the N-PHAM health outcome data used to generate the relationships between the health and the built environment are based on survey data for adults. One of the primary objectives of AAH's assessment of Bruce Elementary and other schools is to develop opportunities for protecting and improving the health of grade-school children. There is evidence to suggest that the health-related lifestyles related to obesity (e.g., diet and physical activity) of parents translate to children, however the correlation is not strong[10]. There is, however, sufficient evidence to support the notion that regular physical activity in school-aged children, defined as 60 minutes or more of moderate-to-vigorous aerobic, muscle-strengthening, and bone-strengthening physical activity each day, results in higher levels of cardiorespiratory fitness, stronger muscles, lower body fat, and stronger bones[11]. Importantly, regular physical activity also has brain health benefits for school-aged children, such as improved cognitive functions (memory, executive function, processing speed, attention, and academic performance) and reduced symptoms of depression[11]. While

[a] This model uses data from the 2011-2012 adult data from the California Health Interview Survey (CHIS) and the most recent edition of the California Household Transportation Survey (CHTS), which sampled 42, 431 households across California in 2010-2012.

chronic diseases (e.g., heart disease, hypertension, type 2 diabetes, osteoporosis) do not typically develop during youth and adolescence, obesity and other risk factors for these diseases (elevated blood lipids and blood pressure) are increasingly present among children and adolescents[11]. Regular physical activity can help to combat these risk factors, improving health and fitness not only during youth and adolescence, but also increase the likelihood of remaining healthy adults[11,12].

Despite these known benefits, many school-aged children do not meet the recommended levels of physical activity, and obesity remains a prominent health crisis in this age-group. Approximately 24% of children aged 6-17 years of age in the U.S. meet the recommended levels of physical activity[13] and 17.2-25% of youth in the U.S. are overweight or obese[14]. In fact, while there have been slight improvements in physical activity among adults in recent years, there has been a decrease in physical activity during adolescence. Overall, the 2018 U.S. Report Card on Physical Activity for Children and Youth indicated that 20-28% of children and youth meet overall physical activity guidelines, with a greater percentage of boys meeting recommendations compared to girls.

The neighborhood environments in which school-age children live appear to influence activity levels[15-19]. For example, children living in neighborhoods perceived as less walkable and not close to transit and recreation spaces engaged in less out-of-school moderate-to-vigorous physical activity (MVPA)[15]. Further, communities with more-walkable streets, access to a high-quality park, and healthier food outlets are negatively associated with the prevalence of adolescent overweight and obesity[18,19]. Brisk walking and bicycle riding are both considered examples of moderate-to-vigorous physical activity among school-aged children[12]. In fact, children who engage in active transportation (i.e., walking or biking) are more likely to meet physical activity recommendations compared to those who travel by motor vehicle[13].

In response to the current levels of physical inactivity and obesity rates among school-age children, researchers recommend a comprehensive, multi-sector strategy be implemented to increase physical activity among youth and adolescents[16]. Effective interventions include school-based physical activity programming and education, after-school physical activity programming, improving the built environment to include access and proximity to recreational facilities, activating youth sport participation, and re-normalizing active transport to school[16].

Health Outcomes for Baseline Conditions

The estimated health outcomes for the Bruce Elementary School community and other areas of interest are shown in Table 1. These results are household-weighted aggregations of US Census block groups. The Bruce Elementary attendance zone is highlighted in blue and Metro Houston is highlighted in orange. Figure 11 through Figure 14 (found in the appendix) provide US Census block group maps of the health outcome metrics. These maps include a "zoomed in" portion of the Bruce Elementary community as well as show the NHHIP corridor (yellow) and other schools of interest. For the Bruce Elementary inset map, a 1 KM network-based walking distance buffer, and a 1 KM Euclidean (or crow-fly) distance buffer are provided. The 1 KM walking distance on the network shows areas within a reasonable walking distance from the elementary school. The Euclidean distance buffer shows areas that should be accessible if road/trail connectivity was available.

Table 1 – N-PHAM estimated health outcomes (adults, age 20 – 65 years old)[b]

US Census Block Group Aggregation	Average Body Mass Index	% Obesity	% Psychological Distress	% Poor Health Status
Bruce Elementary Attendance Zone	28.26	31.13%	29.41%	28.57%
NHHIP Study Area	28.25	29.63%	27.65%	26.38%
City of Houston	27.91	26.25%	24.28%	17.02%
Harris County	27.97	26.73%	23.86%	15.89%
Metro Houston	28.00	26.82%	22.88%	13.82%
Texas Statewide	28.12	28.30%	22.93%	13.67%
Metro Houston Weighted Standard Deviation	*0.78*	*1.15%*	*4.87%*	*8.38%*

Body Mass Index (BMI) and Obesity

BMI is a common metric to estimate adiposity and for adults is calculated as weight in kilograms divided by the height in meters squared. Obesity is defined as percent of the adult population with a BMI over 30. In addition to a wide range of demographic variables (e.g., income, age, employment, education, etc.), which are controlled for in all the health-outcome and physical activity models in NPHAM, these metrics show an association to the following selected N-PHAM built environment metrics:

- Population density
- Tree canopy
- Job accessibility by transit
- Percent developed open space

Results indicate that the Bruce Elementary community has estimated average BMI values similar to Houston and Texas, however, the percentage of the community with obesity is higher than average. This difference could be explained by a higher than typical variability in BMI in this community. Maps of US Census block group BMI and Obesity are provided in the appendix, Figure 11 and Figure 12.

Psychological Distress

A measure of psychological distress was included based on the mental health benefits associated with increased physical activity. The N-PHAM metric of psychological distress was originally developed from analyses of surveys that followed the Kessler-6 protocol[c]. Psychological distress in N-PHAM is estimated primarily from economic and demographic variables (employment, home ownership, age, income, and

[b] Health outcomes are based on 2011-2012 adult data from the California Health Interview Survey (CHIS).

[c] The Kesslet-6 is a 6-item, validated ental health instrument intended to measure non-specific psychological distress. It ranges 0-24 where a higher score indicates greater psychological distress. A score of 13 or higher indicates serious mental illness.

education). Results indicate that the Bruce Elementary community has a higher than average psychological distress at baseline values of key model inputs. A map of US Census blocks with the percent of the population under psychological distress at baseline is provided in the appendix, Figure 13.

Poor Health Status

The N-PHAM metric of Fair or Poor Health Status was originally developed from survey responses where participants provided a self-rating. In addition to a wide range of demographic variables (income, age, employment, education, etc.), Percent Poor Health Status shows an association to the following selected N-PHAM built environment metrics:

- Employment density
- Tree canopy
- Transit accessibility
- Population density

Results indicate that the Bruce Elementary community (and the full NHHIP corridor) has a higher than average Percent Poor Health Status. Maps of US Census block group Percent Poor Health Status at baseline are provided in the appendix, Figure 14.

Physical Activity

The estimated levels of physical activity for the areas of interest are shown in Table 1. These results are household-weighted aggregations of US Census block groups. The Bruce Elementary attendance zone is shown in blue and Metro Houston is shown in orange. Metro Houston (the metropolitan statistical area) is highlighted because this area captures all of the Houston area communities. Figure 15 through Figure 21 (found in the appendix) provide US Census block group maps of the physical activity metrics. These maps include a zoomed in portion of the Bruce Elementary community as well as show the NHHIP corridor (yellow) and other schools of interest. For the Bruce Elementary inset map, a 1 KM network-based walking distance buffer, and a 1 KM Euclidean distance buffer are provided.

Table 2 – N-PHAM estimated physical activity[d]

US Census Block Group Aggregation	% Walking for Utilitarian Transport	% Walking for Leisure	% Cycling for Utilitarian Transport	% Rec. Physical Activity	Walkability Index
Bruce Elementary Attendance Zone	15.39%	48.92%	2.07%	13.19%	37.41
NHHIP Study Area	15.52%	47.96%	2.06%	13.43%	34.37
City of Houston	13.24%	50.65%	1.45%	15.87%	26.57
Harris County	12.65%	50.70%	1.43%	15.80%	25.41
Metro Houston	11.46%	51.15%	1.30%	15.89%	23.57
Texas Statewide	10.68%	50.71%	1.36%	14.93%	21.82
Metro Houston Weighted Standard Deviation	4.32%	4.03%	0.80%	3.46%	4.81

[d] Based on data from the 2011-2012 adult data from the California Health Interview Survey (CHIS) and the most recent edition of the California Household Transportation Survey (CHTS), which sampled 42, 431 households across California in 2010-2012.

Walking for Utilitarian Transportation

The "percent walking for utilitarian transportation" is the percent of the population engaging in any daily walking for transportation (any trip purpose except leisure or recreation). Utilitarian transport is important to community health because higher levels suggest that residents typically have more physical activity in their daily activity patterns than those that live in auto-centric communities. Even small amounts of walking or biking, to access work, school, or retail, can have significant impacts on chronic disease risk. In addition to demographic variables (vehicle ownership, home ownership, employment status, age, income, education, and family size), the following select built/natural environment variables are used to estimate the percent Walking for Utilitarian Transport.

- Population density
- Employment density
- Tree canopy
- Job accessibility by transit
- % developed open space
- % forest landcover

Results indicate that the percentage of the population walking for utilitarian transport in the Bruce Elementary community (and the full NHHIP corridor) falls within the standard deviation (not statistically different) than Metro Houston. The value, however, is higher than average, which is a positive finding for community health. Evaluated at baseline values of model inputs, a map of US Census block group percent Walking for Utilitarian Transport are provided in the appendix, Figure 15.

Walking for Leisure

The "percent walking for leisure" is the percent of the population engaging in any weekly walking for leisure. In addition to demographic variables (vehicle ownership, home ownership, employment status, age, income, education, and family size), the following built/natural environment variables are used to estimate the percent Walking for Leisure.

- Population density
- Employment density
- Employment entropy
- Percent natural open space
- Percent jobs near fixed transit

Results indicate that the percentage of the population walking for leisure in the Bruce Elementary community (and the full NHHIP corridor) falls within the standard deviation (not significantly different than Metro Houston) but, has an equivalent or slightly lower than average percent walking for leisure compared to all of Houston. This value contrasts with the percent of utilitarian travel suggesting that there are potential negative factors influencing walkability. Evaluated at baseline values of model inputs, a map of US Census block group percent Walking for Utilitarian Transport are provided in the appendix, Figure 16.

Cycling for Utilitarian Transportation

The "percent cycling for utilitarian transportation" is the percent of the population engaging in any daily biking for transportation (any trip purpose except leisure or recreation). In addition to demographic variables (vehicle ownership, home ownership, employment status, age, income, education, and family size), the following select built/natural environment variables are used to estimate the percent Cycling for Utilitarian Transport.

- Population density
- Network density
- Percent natural open space

Results indicate that the percentage of the population cycling for utilitarian transport in the Bruce Elementary community (and the full NHHIP corridor) falls within the standard deviation and has a higher than average compared to all of Houston. A map of US Census block group percent cycling for utilitarian transport (at baseline values) are provided in the appendix, Figure 17.

Recreational Physical Activity

The percent Recreational Physical Activity is the percent of the population engaging in any daily recreational physical activity. In addition to demographic variables (vehicle ownership, home ownership, employment status, age, income, education, and family size), the following select built/natural environment variables are used to estimate the percent Recreational Physical Activity.

- Population density
- Employment density
- Tree canopy
- Transit accessibility

Results indicate that the percentage of recreational activity in the Bruce Elementary Community (and the full NHHIP corridor) falls within the standard deviation but has a lower than average compared to all of Houston. A map of US Census block group percent Recreational Physical Activity are provided in the appendix, Figure 18.

Walkability Index

The N-PHAM Walkability Index is a composite metric that includes employment entropy (mix), intersection density, residential density, public transit density, and vehicle miles traveled. The index is shown on a 1-100 scale. This index is the National Walkability Index that was developed by UD4H for the Robert Wood Johnson Foundation(https://www.rwjf.org/en/cultureofhealth/taking-action/creating-healthier-communities/built-environment.html).

Results indicate that the Bruce Elementary community has a higher than average walkability score when compared to the rest of Metro Houston, likely due to it's access to transit, intersection density, and population density. This indicates that the community has many things working in its favor to encourage active transportation and physical activity. More detailed assessment of the influence of neighborhood level walkability using factors that are not readily available at a national scale, may reveal local realities that confirm or conflict this estimate. Figure 20 shows a map of walkability for the region.

Parks and Greenspace

Parks and greenspace are important components of a healthy and physically active community. Table 3 shows the US census block group average result of three metrics comparing the Bruce Elementary community to the rest of Houston.

Table 3 – N-PHAM estimated parks and greenspace

US Census Block Group Aggregation	% of Park Acreage	Total Park Acres Within 1km Walking Distance	Percent Tree Cover
Bruce Elementary Attendance Zone	0.83%	9.45	2.40%
Freeway Expansion Study Area	1.89%	17.75	9.41%
City of Houston	8.32%	28.00	14.75%
Harris County	6.61%	23.40	15.97%
Metro Houston	1.79%	18.45	18.37%
Texas Statewide	NA	NA	17.65%

Percent of Park Acreage and Total Park Acreage Within 1 KM Walking Distance

The percent of Park Acreage is the sum of actively managed park acreage within the US Census block group divided by the total land acreage. The Bruce Elementary community has lower than average acreage of active parks compared with Houston. Figure 2 shows the active parks in the Bruce Elementary area. Swiney Park and Community Center provide the only active park close to the school, but it is not large enough to contain active sports fields. Furthermore, the school campus does not house a dedicated gym or active sports fields.

The total park acreage within 1 KM walking distance from the center of the Bruce Elementary community US Census block group is less than average for the Houston area. The Buffalo Bayou Greenway is the primary source of park acreage accessible from this community.

Percent Tree Cover

Percent tree cover is developed from the National Land Cover Database[e] and is a metric in N-PHAM that is associated with a number of health and physical activity metrics. Figure 21 shows a map of US Census block group tree cover percentage for the Bruce Elementary Community and Houston area. It should be noted that the Bruce Elementary community has significantly less tree canopy coverage than other areas of Houston.

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[e] https://catalog.data.gov/dataset/national-land-cover-database-nlcd-land-cover-collection

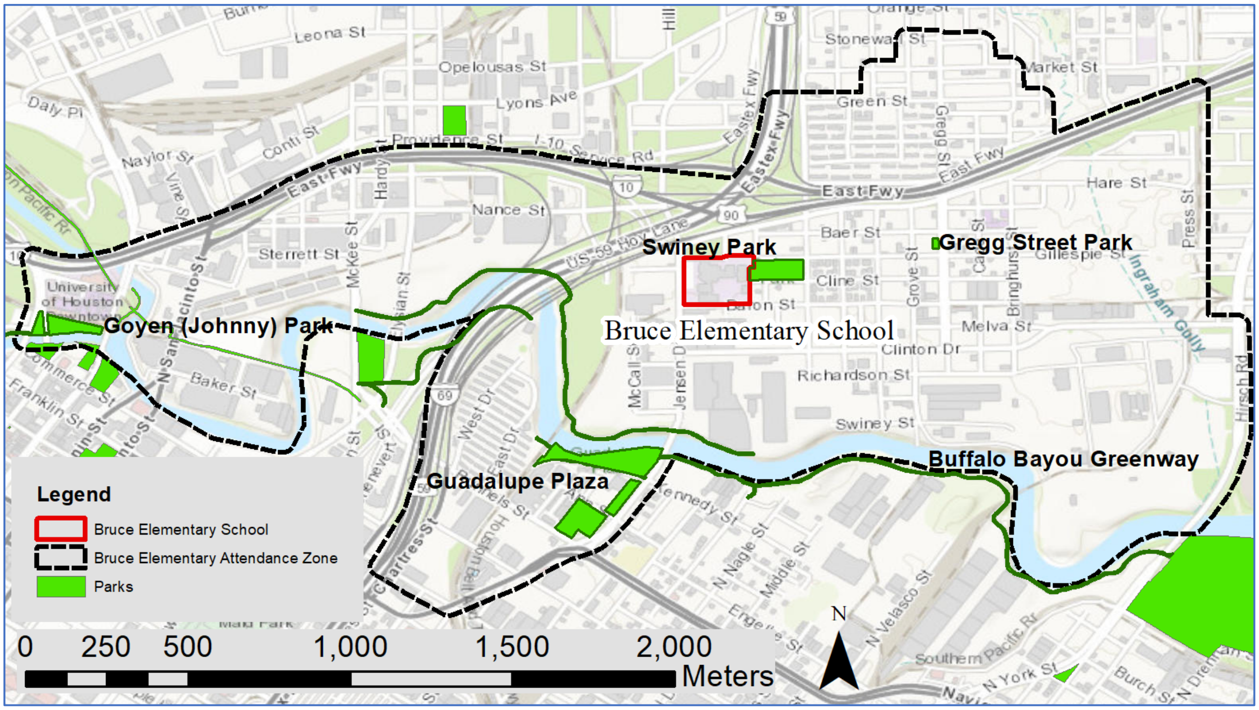

Figure 2 - Bruce Elementary School Community Parks

Discussion of baseline conditions

This initial review of baseline health and physical activity metrics provides a broad perspective of conditions in the Bruce Elementary community when using nationally available estimates at the US Census block group level . The Bruce Elementary community is lower than average in estimated health outcome metrics when compared to Metro Houston. Despite an abundance of vacant land, the Bruce Elementary community has less than average active park acreage and no managed sports fields within the school attendance zone. The community has opportunities for increases in health-related active transportation by taking advantage of its proximity to downtown and by increasing park accessibility.

Figure 3 shows the existing and proposed freeway alignments. Given the new alignment and proposed land use and connectivity changes, there are a number of opportunities to expand and improve active park space, tree canopy, greenspace, bike/pedestrian connectivity, and land use. These challenges and opportunities are further explored in the next section to find proactive solutions for preserving and enhancing the health of the students at Bruce Elementary School and the surrounding community.

Existing Freeway Alignment NHHIP Proposed Freeway Alignment

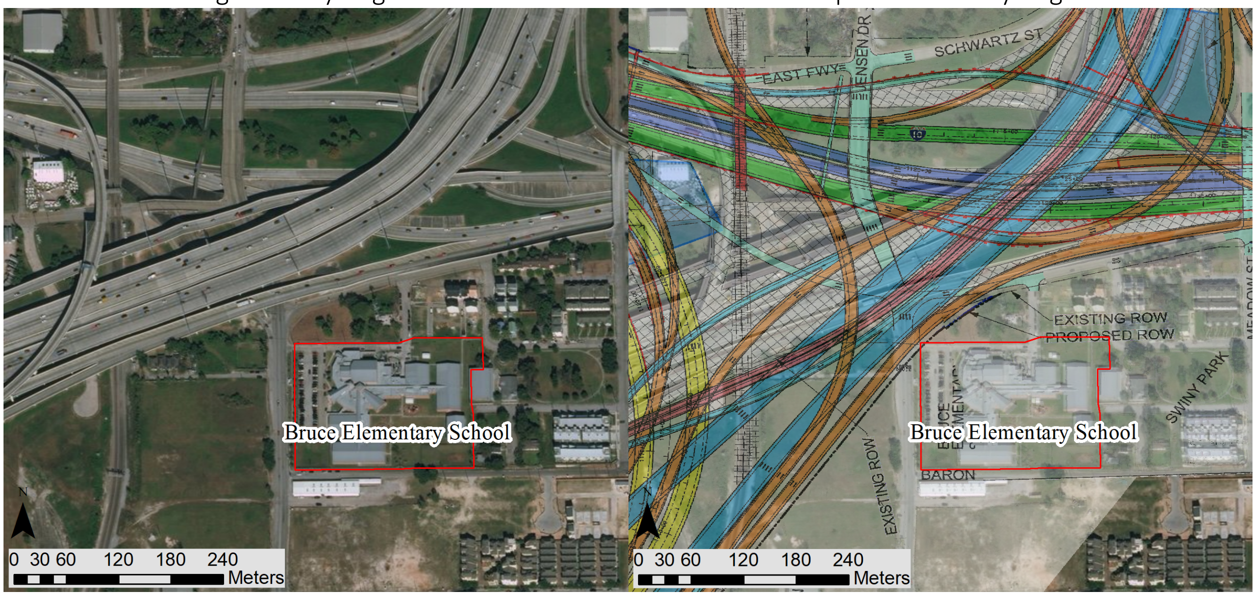

Figure 3 - Existing and proposed freeway alignment (Texas DOT: http://www.ih45northandmore.com/)

2. Analysis of Future Community Health Factors

Air Quality Exposure Analysis

The burning of fossil fuels, along with the emissions from brakes and tire wear, make traffic a major contributor to air pollution[20]. Exposure to traffic-related air pollution has been linked to the development of cardiovascular, cerebrovascular, and respiratory diseases in children and adults, including stroke, heart disease, chronic obstructive pulmonary disease, lung cancer, and asthma[21]. Traffic-related air pollution aggravates existing asthma and can even lead to the development of asthma, especially for those living near high-volume roadways [22,23]. Persons with greater exposure to high concentrations of traffic pollution can suffer both short-term and long-term health consequences, and children in low-income areas who currently have asthma are especially vulnerable[20]. Children are especially vulnerable to reduced lung functioning, impaired lung development, and asthma-related impacts from air pollution because their respiratory systems are not fully developed and they have higher exposure rates due to more rapid breathing[24,25]. Recent research has linked traffic-related air pollution in schools to negative consequences for cognitive development (i.e., working memory and attention)[26,27], major depression[28], and metabolic dysfunction[30]. Collectively, the impacts of air pollution on population health and well-being are significant and necessitate careful consideration, especially among at-risk communities such as those near busy roadways.

The Bruce Elementary School currently lies approximately 75 meters from the I-69 NB to I-10 Eastbound Ramp and approximately 100 meters from the I-69 NB mainline. The proposed North Houston Highway Improvement Project (NHHIP) reduces those distance to 45 and 55 meters respectively and elevates the freeway 15-20 meters above the school property. A synthesis report by Karner et al. reported that most freeway-generated pollutants dissipated to background levels at a distance of 400 meters from the source and that the highest concentrations were found within 150 meters[72]. The impacts of increased freeway elevation on air quality dispersion are not as well understood. However, a report by the Texas Transportation Institute in 1997 indicated that increased road elevation increased the opportunity for dispersion, thereby reducing ground level impacts[74].

The Texas Department of Transportation (TxDOT) released a Draft Carbon Monoxide (CO) Traffic Air Quality Analysis report for the NHHIP in May 2018. The focus of the report was to assess the 1-hour and 8-hour CO levels to ensure adherence to the National Ambient Air Quality Standards. The 2040 worst case CO concentrations for the freeway right-of-way (ROW) near the school was 3.7 ppm for the 1-hour test and 2.6 ppm for the 8-hour test. These results are within the NAAQS limits. The report did note that this section of freeway showed the highest traffic volumes and therefore the highest concentrations of CO (?).

Bruce Elementary Air Quality Analysis Methodology

To aid in the evaluation of the location and intensity of air quality impacts on the school, Urban Design 4 Health conducted air quality modeling of the NHHIP proposed alignment in the area close to Bruce Elementary School. The modeling focused on the variability of community-level changes in pollutant concentrations instead of simply the maximum values in the TxDOT analysis. The team employed the use of the Community Line Source Model Version 3 (C-Line)[f] that was specifically designed by University of North Carolina and the US Environmental Protection Agency to help community residents better understand local air quality issues related to different transportation geometric and operational changes. Though this model is not yet used for regulatory purposes due to its simplified simulation techniques for some procedures, researchers have been working towards the goal of broad use of C-Line for official uses. C-Line can be accessed on the CMAS (Community Modeling and Analysis System)[g] website and the simulation model can be run on the server at the University of North Carolina at Chapel Hill. Users can run different scenarios for different pollutants as well as make changes to road centerlines, traffic volumes, traffic speeds, season, day-of-week, time period, and wind direction. There are twelve pollutants that can be modeled and each are associated with serious health risks (as sourced from CDC's Agency for Toxic Substances & Disease Registry (ATSDR):

- **CO** (carbon monoxide): Can cause irritation of the lower respiratory system, https://www.atsdr.cdc.gov/phs/phs.asp?id=1146&tid=253, OSHA 8 hour exposure limit: 9 ppm.
- **NOx** (nitrogen oxides): Risk of respiratory problems and an asthma trigger, https://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=396&tid=69, OSHA 8 hour exposure limit: 5 ppm.
- **SO2** (sulfur dioxide): Lower and upper respiratory irritant, https://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=46
- **PM2.5** (particulate matter with aerodynamic diameter less than 2.5 µm), **D-PM2.5** (PM2.5 emitted by diesel vehicles), **EC2.5** (elemental carbon portion of PM2.5), **OC2.5** (organic carbon portion of PM2.5): Risk of respiratory problems, an asthma trigger, and associated with cancer. https://www.cdc.gov/air/particulate_matter.html, https://ephtracking.cdc.gov/showAirHealth, https://www.atsdr.cdc.gov/HAC/pha/IndustrialPipeInc/Industrial_Pipe_Inc_EI-HC_08-21-2017_508.pdf, https://www.lung.org/assets/documents/advocacy-archive/health-and-medical-groups-1.pdf
- **Benzene:** Can cause irritation of the upper respiratory system, irritation of the eyes, can have an anesthetic effect, and associated with the development of Leukemia, https://www.atsdr.cdc.gov/mmg/mmg.asp?id=35&tid=14, OSHA 8 hour exposure limit: 1 ppm.
- **Formaldehyde, Acrolein, Acetaldehyde**: Can cause irritation of the upper respiratory system, headaches, and dermatitis, https://www.atsdr.cdc.gov/mmg/mmg.asp?id=216&tid=39, OSHA 8 hour exposure limit: .1 ppm
- **1,3-butadiene**: Affects the central nervous system, an irritant for the upper respiratory system, and consider a probable carcinogenic (Cancer Group 2), https://www.atsdr.cdc.gov/mmg/mmg.asp?id=455&tid=81, OSHA 8 hour exposure limit: 1 ppm

Additional details about each of these pollutants, their known impacts, and other details are available at the weblinks provided above. The C-Line simulation results provide outcomes in a tabular format (*.csv), allowing users to download these files from the server, and conduct additional processing and analysis. Additional details regarding C-Line can be found at https://www.cmascenter.org/c-tools/documentation/3.0/C-LINE_Users_Guide.pdf.

[f] https://www.epa.gov/healthresearch/community-line-source-model-c-line-estimate-roadway-emissions
[g] https://www.cmascenter.org/

The C-Line system is pre-loaded with baseline transportation and climate data. For this analysis, the default data within C-Line was used as the baseline, including the alignments and the traffic conditions for I-69, I-10 and other ramps and surface streets. For the analysis conditions, we opted for modeling during the winter season, on typical weekdays, for an average morning (AM) peak-travel hour and an average midday hour (these are the times of day when the school is most active). The default wind rose was used, which has wind from multiple directions, but primarily from the south and southeast. Each of the ten pollutants was modeled for each time period resulting in 20 different baseline exposure datasets.

For the future post NHHIP air quality modeling, we only changed the freeway and ramp alignments and adjusted the forecasted average annual daily traffic (AADT) counts to be equivalent to the Texas DOT Draft Carbon Monoxide (CO) Traffic Air Quality Analysis report for this section. The altered transportation system model runs included the same ten pollutants for both the AM peak hour and average midday hour.

Limitations of this approach include both the simplified nature of the C-Line design and intent and results should be considered “sketch” estimates. Secondly, the future year model run did not include any vehicle or fleet technology changes. Lastly, the analysis does not consider the impact of freeway elevation on the resulting concentrations as this capability is not yet developed within the model. These results do, however, provide estimates of locations of higher exposure risk that can be considered when mitigation measures are being planned.

In addition to generating the pre and post exposure surfaces for each pollutant, the research team also selected 10 specific site locations for comparative analysis (see Figure 4). These sites were selected to specifically evaluate locations on the school property (1-4), the closest park (5), open space where development is expected (6-9), and a primary housing development (10). The sites are::

- Site #1 – Main entrance to Bruce Elementary School
- Site #2 – West side entrance to Bruce Elementary School
- Site #3 – Corner of the Bruce Elementary School property closest to the freeway
- Site #4 – Bruce Elementary School playground
- Site #5 – Swiney Park
- Site #6 – Vacant land between Hare St and Clinton Dr
- Site #7 – East River Development West End
- Site #8 – East River Development Central
- Site #9 – East River Development East End
- Site #10 – Kelly Village

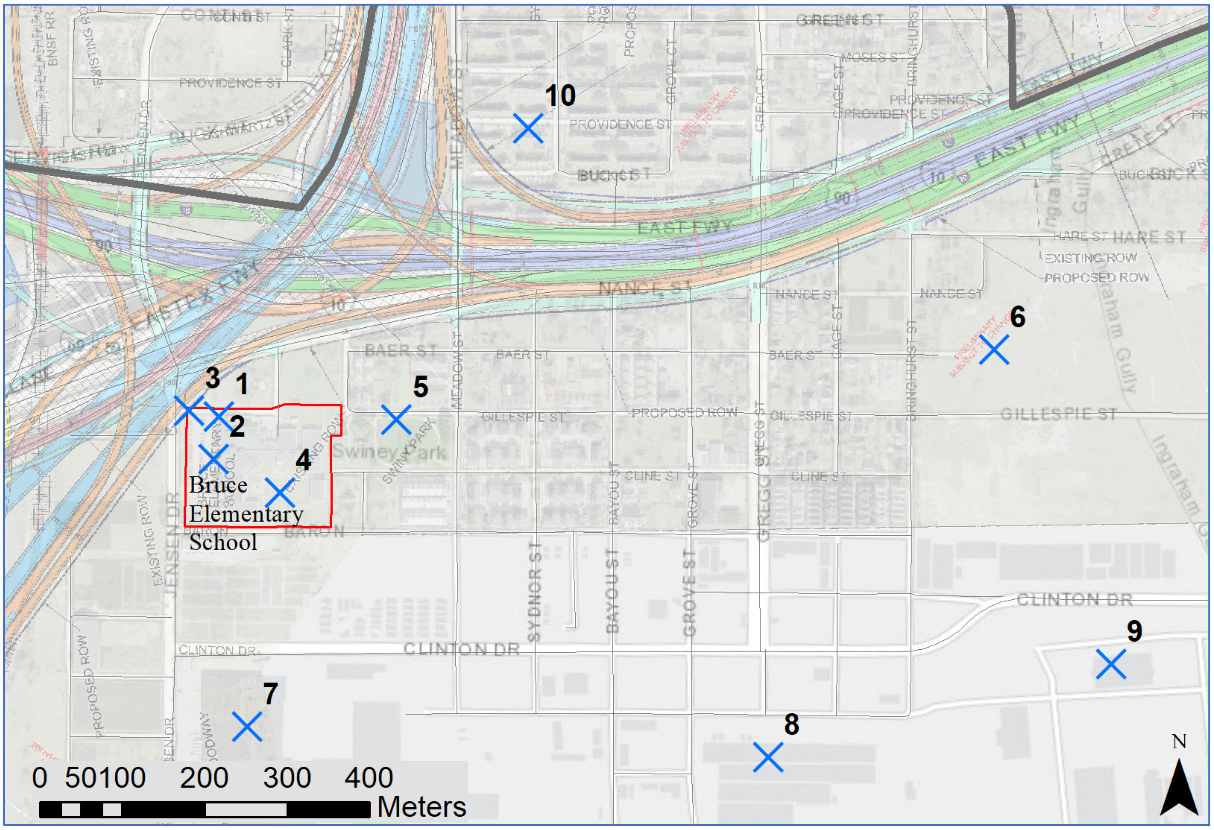

Figure 4 – Ten investigatory sites for air quality exposure comparison

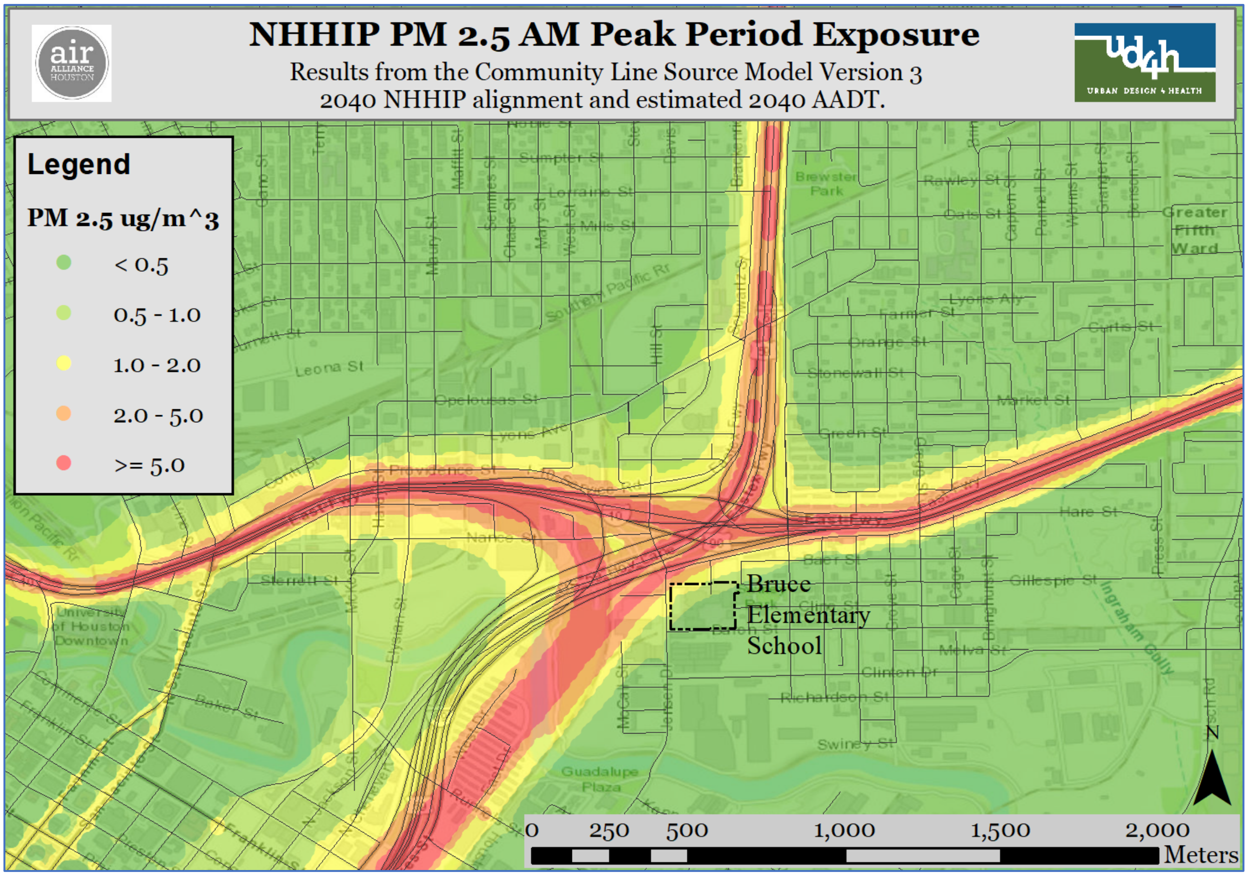

Figure 5 - AM peak hour PM 2.5 exposure (ug/m^3)

Table 4 – AM peak hour and midday average hourly PM 2.5 exposure (ug/m^3)

		AM Peak			Mid-Day		
ID	Description	Baseline	NHHIP	*Increase*	Baseline	NHHIP	*Increase*
3	Corner of School Property	0.6424	1.7757	*176.4%*	0.7386	1.8573	*151.5%*
1	Bruce Elem Front Door	0.4871	1.1169	*129.3%*	0.5055	1.1435	*126.2%*
2	Bruce Elem Side Door	0.3383	0.7224	*113.6%*	0.4060	0.8901	*119.2%*
4	Bruce Elem Playground	0.2137	0.4353	*103.7%*	0.2546	0.5294	*108.0%*
7	East River 1	0.1276	0.2500	*95.9%*	0.1549	0.3130	*102.1%*
5	Swiney Park	0.2393	0.4472	*86.9%*	0.2852	0.5499	*92.8%*
10	Kelly Village	0.4061	0.6992	*72.2%*	0.4795	0.8558	*78.5%*
6	Hare St Site	0.1523	0.2258	*48.2%*	0.1763	0.2869	*62.7%*
8	East River 2	0.0756	0.1109	*46.8%*	0.0859	0.1384	*61.1%*
9	East River 3	0.0778	0.0979	*25.8%*	0.0886	0.1246	*40.6%*

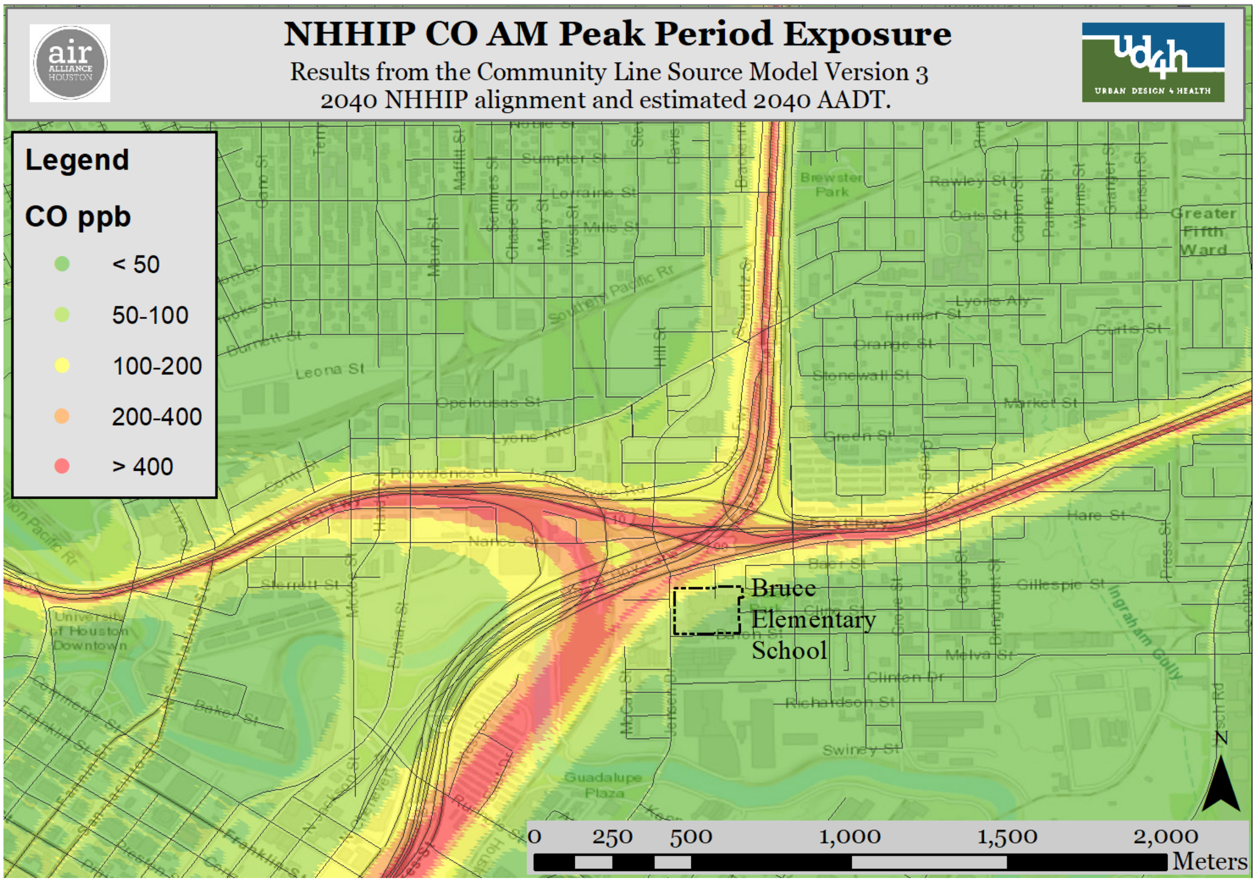

Figure 6 - AM peak hour CO exposure (ppb)

Table 5 – AM peak hour and midday average hourly CO exposure (ppb)

		AM Peak			Mid-Day		
ID	Description	Baseline	NHHIP	*Increase*	Baseline	NHHIP	*Increase*
3	Corner of School Property	63.1681	178.0360	*181.8%*	62.2280	157.6270	*153.3%*
1	Bruce Elem Front Door	49.6014	114.4320	*130.7%*	43.2233	98.0601	*126.9%*
2	Bruce Elem Side Door	34.0439	73.8019	*116.8%*	34.5403	76.3561	*121.1%*
4	Bruce Elem Playground	21.5167	44.5880	*107.2%*	21.6419	45.4581	*110.0%*
7	East River 1	12.4218	25.3327	*103.9%*	12.8111	26.6578	*108.1%*
5	Swiney Park	24.2429	45.8835	*89.3%*	24.3609	47.2881	*94.1%*
10	Kelly Village	41.4897	72.0849	*73.7%*	41.2440	73.9391	*79.3%*
6	Hare St Site	15.2705	23.1718	*51.7%*	15.0014	24.6957	*64.6%*
8	East River 2	7.3078	11.2475	*53.9%*	7.0793	11.7947	*66.6%*
9	East River 3	7.3301	9.7216	*32.6%*	7.1866	10.4559	*45.5%*

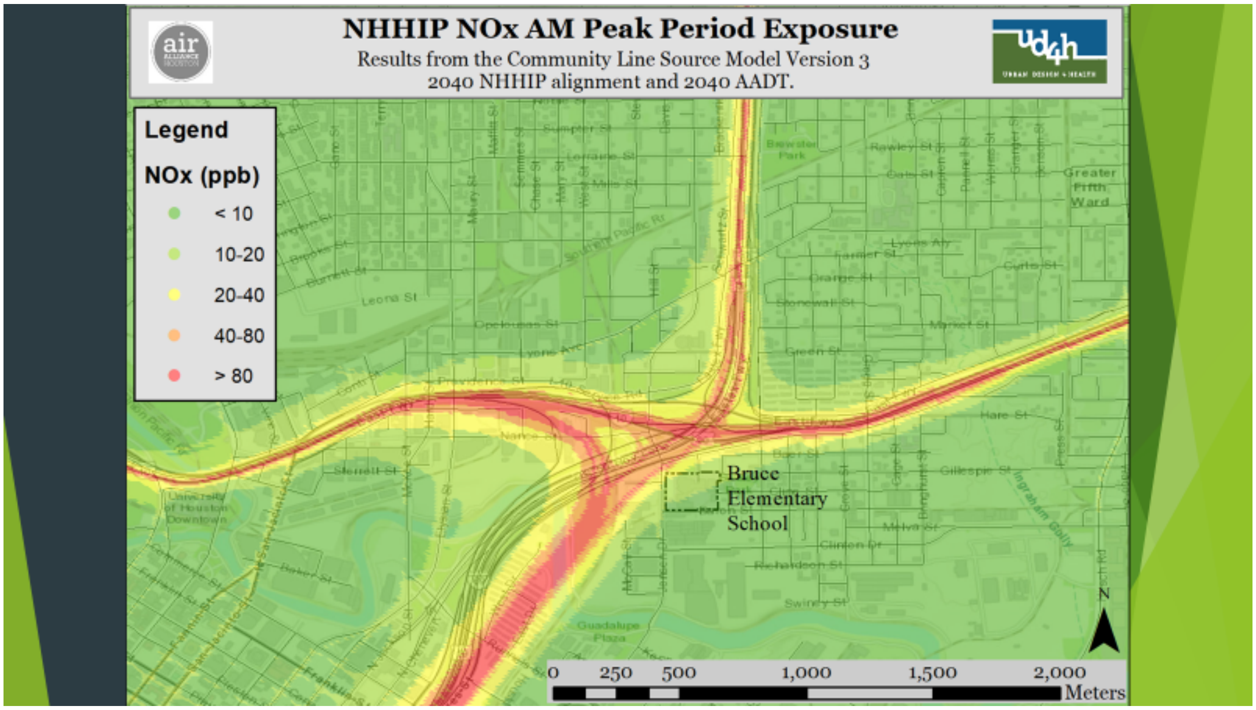

Figure 7 - AM peak hour NOx exposure (ppb)

Table 6 – AM peak hour and midday average hourly NOx exposure (ppb)

		AM Peak			Mid-Day		
ID	Description	Baseline	NHHIP	*Increase*	Baseline	NHHIP	*Increase*
3	Corner of School Property	10.2900	29.1382	*183.2%*	11.3302	29.1208	*157.0%*
1	Bruce Elem Front Door	8.1600	18.8372	*130.8%*	7.9734	18.1921	*128.2%*
2	Bruce Elem Side Door	5.5900	12.1413	*117.2%*	6.3511	14.1549	*122.9%*
4	Bruce Elem Playground	3.5400	7.3421	*107.4%*	3.9868	8.4324	*111.5%*
7	East River 1	2.0300	4.1616	*105.0%*	2.3253	4.9158	*111.4%*
5	Swiney Park	3.9900	7.5576	*89.4%*	4.4987	8.7763	*95.1%*
10	Kelly Village	6.8300	11.8836	*74.0%*	7.6365	13.7389	*79.9%*
6	Hare St Site	2.5100	3.8158	*52.0%*	2.7646	4.5760	*65.5%*
8	East River 2	1.2000	1.8481	*54.0%*	1.2943	2.1741	*68.0%*
9	East River 3	1.2000	1.5877	*32.3%*	1.2918	1.9010	*47.2%*

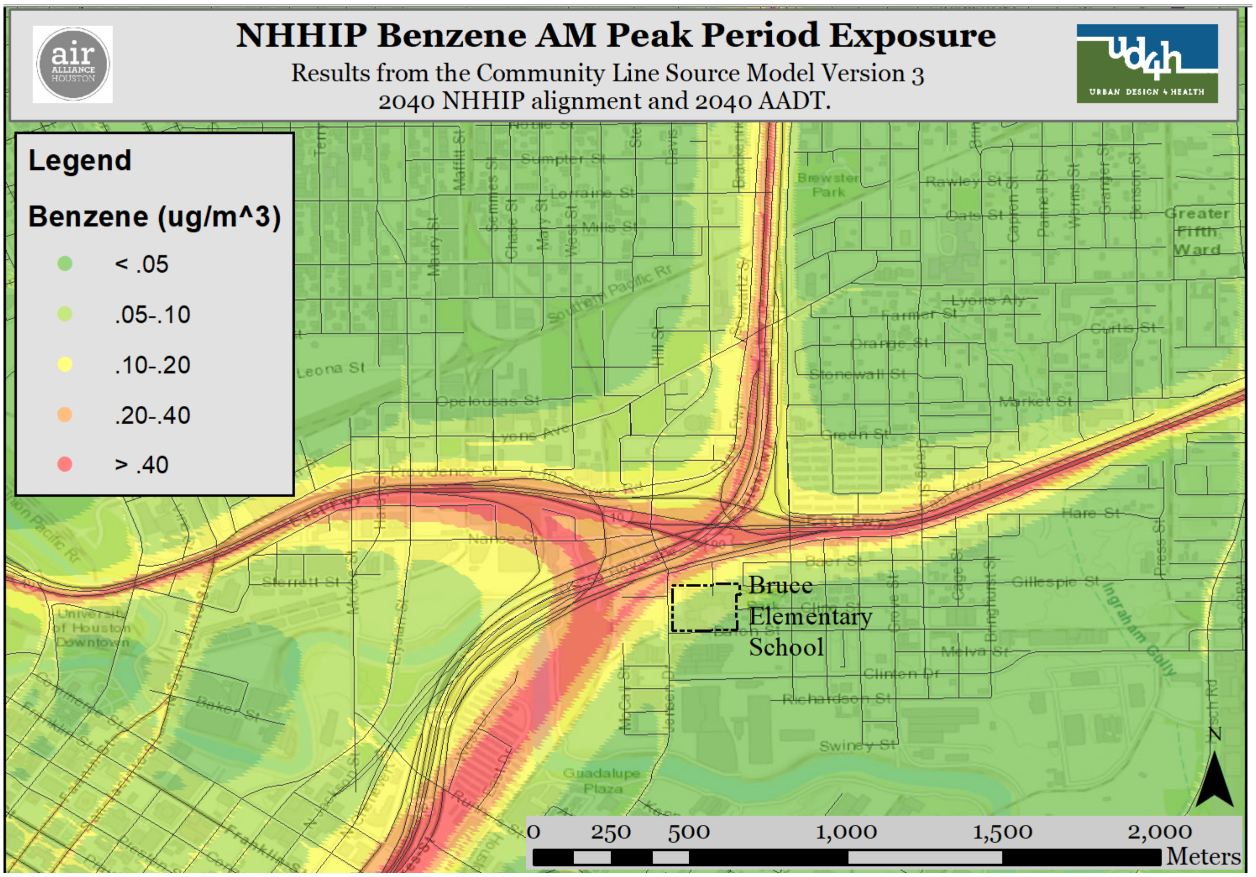

Figure 8 - AM peak hour Benzene exposure (ug/m3)

Table 7 - - Hourly Benzene Exposure (ug/m^3)

		AM Peak			Mid-Day		
ID	Description	Baseline	NHHIP	*Increase*	Baseline	NHHIP	*Increase*
3	Corner of School Property	0.0829	0.2193	*164.7%*	0.0815	0.1940	*138.1%*
1	Bruce Elem Front Door	0.0610	0.1377	*125.8%*	0.0542	0.1195	*120.6%*
2	Bruce Elem Side Door	0.0427	0.0896	*109.9%*	0.0439	0.0935	*113.2%*
4	Bruce Elem Playground	0.0268	0.0540	*101.0%*	0.0274	0.0556	*103.2%*
7	East River 1	0.0163	0.0313	*91.8%*	0.0172	0.0334	*94.2%*
5	Swiney Park	0.0300	0.0554	*84.9%*	0.0305	0.0577	*89.4%*
10	Kelly Village	0.0507	0.0868	*71.2%*	0.0510	0.0900	*76.5%*
6	Hare St Site	0.0191	0.0282	*47.6%*	0.0189	0.0304	*60.4%*
8	East River 2	0.0095	0.0139	*45.7%*	0.0094	0.0148	*57.6%*
9	East River 3	0.0100	0.0125	*25.2%*	0.0100	0.0138	*37.0%*

As seen from the previous tables and figures, the sites around the Bruce Elementary School have the highest changes in exposure for all pollutants compared to other sites. While only four of the pollutants are shown, results for all ten follow the same patterns. For the regulated pollutants, all of these numbers are below National Ambient Air Quality Standards, but the safe thresholds for short and long term exposure are not well defined, particularly for grade school children regarding mobile source air toxics. As mitigation solutions are being evaluated for Bruce Elementary School, minimizing exposure to higher concentrations of these pollutants should be given the highest consideration despite modeled values being within regulated thresholds. Not enough is known regarding the health impacts of long-term multi-year exposure to determine if current thresholds provide adequate life-long protection.

NPHAM-based Sensitivity Analysis of Neighborhood Built and Natural Environment

Methodology

There is mounting empirical evidence suggesting causal linkages between transportation land development and investments, and physical activity (such as walking and biking), which has implications for chronic disease prevention. However, the ability to apply this evidence in practice has been limited primarily due to the complexity, inconsistency of research methods, and lack of direct connection with the planning contexts in which decisions need to be made. Additionally, up until recently, practical tools that allow decision makers to evaluate alternative land development and transportation investment decisions in terms of preventing chronic disease outcomes have not existed. Recognizing this major need, the U.S. Environmental Protection Agency (EPA) funded Urban Design 4 Health (UD4H) to develop the National Public Health Assessment Module (N-PHAM)[74]. The first nationally consistent health assessment module adds physical activity (PA) and public health analysis capabilities to land use and spatial planning decisions at a range of geographic scales. The predictive models in N-PHAM are generated from large-scale place-based built and natural environment data at the block-group level and large population surveys to model the relationships of the environment with several PA and health outcomes. For a range of age and income groups, N-PHAM allows decision makers to explore how different transportation land development strategies can help improve PA and public health outcomes (obesity, diabetes, cardiovascular disease, mental, and general health).

Table 8 lists the built, natural, and social variables used within N-PHAM and

Table 9 lists the demographic co-variates. Table 10 lists the health and physical activity outcomes.

Table 8 - N-PHAM built, natural, and social variables

NPHAM Variable	Built, Natural, and Social Variable Description
popdens_ac	Gross population density in terms of people per acre on unprotected land (EPA Smart Location Database (SLD)[h] d1b)
empdens_ac	Gross employment density in terms of workers per acre on unprotected land (EPA SLD d1c)
jobacc45tr	Jobs within a 45-minute transit commute, distance decay, walk network and General Transit Feed Specification (GTFS)[i] schedule travel time weighted (EPA SLD d5br)
empentropy	Employment entropy index using 5-tier employment classification scheme (EPA SLD d2b_e5mixa)
p_wrkage	Percent of population that is working age (EPA SLD p_wrkage)
pct_autoo0	Percent of households that own zero automobiles (EPA SLD pct_ao0) Cube root 1.345 (0.975)
retailempl	Retail jobs within 5-tier employment classification scheme (EPA SLD e5_ret10)
totpop2010	2010 Census total population (EPA SLD totpop10)
empbytrans	Proportion of CBG employment within 1/4 mile of a fixed guideway transit stop (EPA SLD d4b025)
notrdata	Binary flag indicating transit data is missing (derived from EPA SLD)
ntwkdenped	Network density in terms of facility miles of pedestrian-oriented links per square mile (EPA SLD d3apo)

[h] https://www.epa.gov/smartgrowth/smart-location-mapping#SLD
[i] https://gtfs.org/ and https://transitfeeds.com/

intrsndens	Street intersection density, weighted, auto-oriented intersections eliminated (EPA SLD d3b)
trpequilib	Trip production and attraction equilibrium index - closer to one indicates more balanced trip making (EPA SLD d2c_tripeq)
opens_nlcd	Percent of land cover that is developed open space, e.g., parks, golf courses (derived from NLCD[j] classification layer)
treec_nlcd	Percent of land area covered by a tree canopy (derived from NLCD tree canopy cartographic layer)
forst_nlcd	forst_nlcd Percent of land cover that is forest (derived from NLCD)
natrl_nlcd	natrl_nlcd Percent of land cover that is natural (derived from NLCD)
topenspace	Percent of land cover that is developed open space or natural space

Table 9 - N-PHAM demographic co-variate descriptions

NPHAM Variable	Demographic Co-variate Variable Description
pct_autoo0	Household owns zero automobiles
avg_hhsize	Average household size (2014 American Community Survey (ACS)[k] 5-year estimates)
pct_ownocc	Households is owner-occupied (2014 ACS 5-year estimates)
pct_rentoc	Household is renter-occupied (2014 ACS 5-year estimates)
pct_popfem	Respondent is female (2014 ACS 5-year estimates)
pct_popmal	Respondent is male (2014 ACS 5-year estimates)
pct_worker	Respondent is employed (2014 ACS 5-year estimates)
pct_senior	Respondent is age 65+ (2014 ACS 5-year estimates)
pct_popwht	Respondent is white, non-Hispanic or Latino (2014 ACS 5-year estimates)
pct_lowinc	Household is classified as low income, $0-$35k (2014 ACS 5-year estimates)
pct_medinc	Household is classified as medium income, $35k-$100k (2014 ACS 5-year estimates)
pct_higinc	Household is classified as high income, $100k+ (2014 ACS 5-year estimates)
pct_nohsed	Respondent has educational attainment LESS THAN high school diploma (2014 ACS 5-year estimates)
pct_hseduc	Respondent has educational attainment of high school diploma (2014 ACS 5-year estimates)
pct_2ycoll	Respondent has educational attainment of some college or 2-year degree (2014 ACS 5-year estimates)
pct_4ypcol	Respondent has educational attainment of 4-year college degree or higher (2014 ACS 5-year estimates)
pct_hhkids	Household has with one or more children age 0–17 (2014 ACS 5-year estimates)

Table 10 – N-PHAM Health and Physical Activity Outcomes

NPHAM Variable	Health and Physical Activity Outcomes
autotr	Auto Travel (Sedentary)
biketr	Biking for Transportation (percentage)
recrpa	Recreational Physical Activity
walkle	Walking for Leisure
walktr	Walking for Transportation

[j] https://catalog.data.gov/dataset/national-land-cover-database-nlcd-land-cover-collection
[k] https://www.census.gov/programs-surveys/acs/

bmi	Body Mass Index
gen_health	Fair or Poor Health (percentage)
mnt_health	Mental Health
obese	Body Mass Index greater than 30 (percentage)
overweight	Body Mass Index between 25 and 30 (percentage)

In this project, N-PHAM was used to model the impact of policy-relevant transportation land development strategies on improving physical activity and public health in the Bruce Elementary School area. The Census block group (CBG) level analysis scheme used herein is two-fold:

1. Altering base values of natural environment variables to identify changes in health and PA outcomes.
2. Creating a future build scenario that included estimates of planned built and natural environmental variables to identify changes in health and PA outcomes.

Under the first scheme, the base values for five natural environment variables were individually increased, from current conditions, by 25% and 50% (while keeping all other inputs at CBG-level mean values) to predict the impact on PA and health outcomes in five Census block groups (including Bruce Elementary). In particular, current, or base, values were altered for tree canopy, percent developed open and natural space, percent developed open space, percent of land cover that is forest, and percent of land cover that is natural. See Table 8 above for details about these variables.

To avoid implications of ecological fallacy, the analysis was separately conducted for each CBG and the results then averaged across all five CBGs to deduce area-level (Bruce Elementary School area) inferences. Under the second scheme, an additional N-PHAM scenario was considered that altered built and natural environmental variables in line with the NHHIP and the planned future developments for 2040. In particular, base values for network density, intersection density, total employment, retail employment, employment density, job accessibility by transit, total households and population density, plus the five natural environment variables included in the first analysis, were altered to predict PA and health outcomes under planned built and natural environment estimates for 2040.

Scenario 1

In scenario 1, the team increased the percentages of the natural variables by 25% and 50% to test the response of the health and physical activity outcomes. The logic behind this test is that a likely mitigation strategy in the Bruce Elementary community is to increase park space, tree canopy, and natural space as part of the NHHIP development process. Therefore, the N-PHAM test holds all other variables unchanged (built environment, social environment, and demographics) and only alters those environmental variables that are likely to change. Results are hypothesized to indicate a positive impact on estimated physical activity and health in the community. The results will also identify the magnitude of the impact.

In the Bruce Elementary community, 0.83% of land is park space and 3.11% is developed open/natural space. On average, residents in this area have 9.45 acres of parks available within a 1 KM walk from the center of their CBG and 2.90% of the land in this area has tree coverage. Increasing the developed open/natural space by 25% and 50% is a reasonable and likely component of the planned NHHIP development based on stated goals and preliminary drawings. Results of these changes as calculated using N-PHAM show that these levels of change would have a minor but positive benefit to the community in terms of health and physical activity outcomes. Table 11 and Table 12 show the expected changes in comparison with other baseline estimates from the region (as shown in Chapter 1).

Scenario 2

In scenario 2, the team estimated the full impact of the planned NHHIP and potential community developments in the US Census Block Group that contains Bruce Elementary School. Proposed development plans include the addition of 17 acres of park and open space, 3 miles of bike/walk paths, and a mixed-use development that includes retail, office, and residential properties. This planned development concept would actively promote a healthy lifestyle design with improved access to downtown Houston, and improvements and connections to the Buffalo Bayou bike and trail system.

The N-PHAM changes in scenario 2 included increases in the variables of population density, job accessibility by transit, retail employment, total population, density of bike/pedestrian facilities, walkable road network intersection density, employment, households, vacant land, total numbers of workers, and industrial acreage (see Table 8 for variable definitions). All demographic co-variates were held constant. Results of these changes from N-PHAM show that the levels of change would have a positive benefit to the community in terms of health and physical activity outcomes and bring this particular US Census block group into averages similar to the broader Houston community, and in fact exceeding average values for Physical Activity. Table 11 and Table 12 show the expected changes in comparison with other baseline estimates.

Table 11 - Health outcomes from improvement scenarios

US Census Block Group Aggregation	Average Body Mass Index	% Obesity	% Poor Health Status
Bruce Elementary Attendance Zone	28.26%	31.13%	28.57%
Scenario 1A -Bruce Elementary with a 25% increase in parks and/or tree canopy	28.25%	31.06%	28.51%
Scenario 1B -Bruce Elementary with a 50% increase in parks and/or tree canopy	28.24%	31.01%	28.45%
Scenario 2 -Bruce Elementary Block Group with full NHHIP and Community Development	27.71%	24.80%	16.50%
NHHIP Study Area	28.25	29.63%	26.38%
City of Houston	27.91	26.25%	17.02%
Harris County	27.97	26.73%	15.89%
Metro Houston	28.00	26.82%	13.82%
Texas Statewide	28.12	28.30%	13.67%

Table 12- Physical activity outcomes from improvement scenarios

US Census Block Group Aggregation	% Walking for Utilitarian Transport	% Walking for Leisure	% Cycling for Utilitarian Transport	% Rec. Physical Activity
Bruce Elementary Attendance Zone	15.39%	48.92%	2.07%	13.19%
Scenario 1A -Bruce Elementary with a 25% increase in parks and/or tree canopy	15.56%	48.97%	2.08%	13.28%
Scenario 1B -Bruce Elementary with a 50% increase in parks and/or tree canopy	15.66%	49.03%	2.09%	13.37%
Scenario 2 -Bruce Elementary Block Group with full NHHIP and Community Development	17.25%	52.46%	2.29%	15.51%
NHHIP Study Area	15.52%	47.96%	2.06%	13.43%
City of Houston	13.24%	50.65%	1.45%	15.87%
Harris County	12.65%	50.70%	1.43%	15.80%
Metro Houston	11.46%	51.15%	1.30%	15.89%
Texas Statewide	10.68%	50.71%	1.36%	14.93%

Discussion

The N-PHAM analysis showed improvements to the health and physical activity outcomes with the proposed changes to community. It is important to note that the current version of N-PHAM does not evaluate the health impacts of the air quality changes. The reported health impacts are due to the built environment changes. While the expected hourly thresholds are expected to be within safe limits, the long-term impacts, particularly on children, are unknown and could be significant. Current modeling capabilities are limited in the understanding of these direct impacts despite evidence from numerous studies suggesting elevated health risk with increased exposure.

An additional limitation of the N-PHAM analyses is that existing Bruce Elementary School community residents may not directly benefit from community development that might occur and raise rent premiums. Because existing residents may face displacement and gentrification as a result of community development projects, the health and physical activity benefits may only represent new residents. Existing residents may be displaced to other communities. More detailed models and policy review need development to better understand the micro-scale impacts of new connectivity, gentrification and displacement, and access to new jobs in the area.

With these recognized limitations, mitigation strategies should focus on community improvement concepts that encourage physical activity in areas further from the NHHIP alignment to avoid the higher concentrations of pollutants and on projects that encourage community connections with and use of new planned developments. Mitigation strategies should also consider implications for existing residents, including metrics for displacement and gentrification.

3. Community Health Improvement

Active transportation, such as walking, cycling, and their use to connect with public transit systems, not only improve air quality as a result of fewer vehicle emissions but also increase physical activity-related health benefits among children and adults. There are many ways that the design, placement and connectivity of buildings and communities can encourage more active transportation. These include increased sidewalk connectivity, greater land-use mix and residential density, walking and cycling facility maintenance, crosswalks at intersections, school zone signage and traffic calming, bike-lanes, street buffers and aesthetically pleasing routes (tree canopy, scenic, active store fronts, etc.). In addition, the Safe Routes to School initiative can improve safety related concerns through community policy and school programming, such as the Walking School Bus program. UD4H offers this discussion of important considerations and specific opportunities for the Bruce Elementary community.

Traffic-related air pollutant concentrations are highest outdoors, with the highest level of motor vehicle pollutant concentrations generally within the first 500 feet (~150 meters) of a roadway[11]. These pollutants can also elevate pollutant concentrations inside classrooms[24]. Mitigating negative health implications from traffic-related air pollution typically involves strategies that either decrease the concentration of the pollutants (i.e., vegetation, displace car travel with active travel, etc.) or reduce the duration of exposure to the pollutants (i.e., limit time spent at stop lights near idling car emissions, monitor outdoor air pollution and the opening of windows in buildings). Prevention strategies such as increasing alternative transportation options (transit, rideshare, walking, cycling), providing incentives to reduce vehicle miles traveled, promoting the use of electric and low emission vehicles and implementing land-use policies that limit new development close to heavy traffic areas, while also creating roadside barriers and improved ventilation systems in homes and buildings, help mitigate the impacts of emissions[20]. Prevention and mitigation strategies specific to schools should include both site-related strategies (i.e., transportation policy, site selection, vegetation) and building design and operation strategies (i.e., ventilation, filtration)[5]. Site related strategies include anti-idling and reducing idling near the school, upgrading buses and carpools, and encouraging more active forms of transportation. In addition, increasing the urban green space in the community, along with roadside vegetation, can help to mitigate traffic-related air-pollution.

Increasing the use of active transportation is a promising mitigation strategy, but certain safety and exposure considerations must be addressed. Safety concerns are not only about traffic-related injuries and fatalities, but also criminal activity and violence. To improve safety and the likelihood to participate in walking and biking to school, the Safe Routes to School initiative provides comprehensive set of strategies to address crime and violence in the community that might deter active travel[62]. The physical design of the community also influences crime and violence by reducing the opportunity for crime to occur and encouraging interaction among people. Crime Prevention Through Environmental Design (CPTED) principles are often used to inform design of outdoor spaces that foster safety. For example, the principle of natural surveillance (i.e., “eyes on the streets”) can be fostered through Safe Route to Schools initiatives’ walking school bus programs, corner captains and neighborhood watch programs, safe havens and passages, and regular programming and participation in shared use/public spaces. Similarly, natural access control is achieved when people are strategically directed through a space to reduce potential offenders’ perceived ability to avoid observation. Territorial reinforcement involves creating a sense of ownership through placemaking and fostering social cohesion. The “broken windows theory” provides the basis for placemaking, a sense of ownership and cohesion, as people who have a sense of ownership in a community are likely to maintain the aesthetics of an area. Well-maintained and aesthetically pleasing spaces attract users in the space, which fosters natural surveillance and discourages criminal activity. Case Studies from Taking Back the Streets and Sidewalks[l] include:

- Safe Corridors in Philadelphia
  - "Taking Back the Streets and Sidewalks" page 21
- Pasos Seguros – Community Leadership for Safe Passages
  - "Taking Back the Streets and Sidewalks" page 24
- School Resource Officers in Denver
  - "Taking Back the Streets and Sidewalks" page 34
- Clarksdale, MS, Neighborhood Watch Association
  - "Taking Back the Streets and Sidewalks" page 31

Roadside vegetation has been shown to reduce exposure to air pollution, as plants' surfaces absorb gaseous air pollutants and airborne particles[31]. Noise barriers, when used in combination with vegetation, result in reduced particulate matter concentrations[31]. Vegetation in urban settings offers co-benefits known as "ecosystem services," which in addition to improved air quality, include temperature and stormwater regulation, noise reduction, opportunities to be active and interact with nature[32].

Vacant and underutilized spaces can be used for parks/green spaces in the community, which have been associated with greater general health[33], increased physical activity[34–42], reduced prevalence of overweight[43–45], increased social interaction[44] and collective efficacy (community impact on behavior)[46], and reduced stress[47], depression and anxiety[33], mental fatigue[48–50], and attention deficit hyperactivity disorder (ADHD) symptoms[51,52], while improving attention and self-discipline. There is some evidence, albeit limited, that suggests neighborhood vegetation may also improve air quality[53] and reduce obesity-related morbidities[33,54], asthma[33,55], and vehicular collisions[56–58]. Tree canopy, in particular, has been shown to be associated with better overall health as a result of lower prevalence of overweight and obesity and better social cohesion, and also slight associations with reduced type 2 diabetes, high blood pressure, and asthma in communities[59]. When designing and increasing green spaces, the quality, size, amenities, facilities, recreational opportunities and safety are all important factors to consider, as these influence the utilization and, therefore, impact of the space[60]. Green spaces can also be included in active transportation networks, further increasing health-related benefits from walking and biking space[61].

Vegetation, such as increased tree canopy and green space, have potential disadvantages that must be considered and addressed. For example, trees can obstruct visibility on the road, cause damage and injury if they fall, and can create hazardous debris on the road if not strategically planted[32]. In addition, the particles that trees "intercept" from the air can be returned to the air during windy, precipitous, or other natural weather conditions. They also require ongoing care and maintenance. To address potential negative environmental and health consequences from re-suspended particles, careful consideration must be given to the land-uses that surround roadside vegetations (bodies of water, species selected, etc.)[31]. Although urban tree canopy is known to remove pollution and improve air quality, several studies associate tree pollen with increased asthma prevalence and severity, and that tree pollen may exacerbate the impact of other air pollutants on asthma[65–67].

[ll] https://www.saferoutespartnership.org/sites/default/files/resource_files/taking-back-the-streets-and-sidewalks.pdf

While greening practices of increased and improved parks, green spaces and vegetation can help to mitigate traffic-related air pollution, these also can lead to gentrification if appropriate policies are not put in place. "Environmental" or "green" gentrification and displacement can result in worsening health outcomes for vulnerable populations[68]. As land-value increases as a result of improved spaces, some families are at risk of becoming displaced and may be forced to live in overcrowded conditions and unhealthy conditions, or face a high housing cost burden, which is associated with poor health outcomes[69]. Gentrification and displacement can cause vulnerable populations to be relocated to areas where they may not have access to resources, goods, and services that promote health (i.e., healthy food outlets, jobs, parks, sidewalks, etc.). Further, displacement undermines community stability and social cohesion, which are also known to be associated with improved health, well-being and crime. Another potential result of displacement is homelessness, which puts families at risk for communicable diseases, chronic conditions, behavioral and mental health conditions, and injury[70]. Thus, gentrification should be proactively addressed through zoning and affordable housing production, retention, and asset building[71].

Bruce Elementary School Community Ideas

The following specific mitigations methods are offered for the Bruce Community as early-stage concepts that have the objectives of:

- Increasing physical activity
- Increasing bike/ped transportation and leisure
- Increase access to jobs
- Minimizing exposure to poor air quality

Freeway Barriers

A California study by Lee et al. found that a combination of sound walls and vegetation had a significant impact on reducing PM 2.5 and the larger Ultra-Fine-Particles (UFPs, diameter ≤ 100 nm)[75]. The sound-wall barrier was more effective for reducing PM2.5 (25-53%) than UFPs (0-5%), and was most effective (51-53% for PM2.5) when the wind speed ranged between 1 and 2 m/s. Under the same range of wind speed, the vegetation barrier had little effect (0-5%) on reducing PM2.5; but was effective at reducing UFP (up to 50%). For both types of roadside barrier, decreasing wind speed resulted in greater net reduction of UFPs (i.e., total number particle concentrations; inversely proportional). While limited to particulate matter, this study suggests a combination of sound walls and vegetation along the freeway mainline and ramps in proximity to Bruce Elementary and other population centers could help reduce some of their negative impacts.

Bruce Elementary Site and Operations

The air quality exposure maps (Figure 5 through Figure 8) and supporting research suggest that outdoor exposure for students should be limited within 150 meters of the freeway. The current playground on the southeast side of the school is right at 150 meters from the NHHIP freeway alignment. The main entrance of the school, however, is approximately 50 meters and well within the increased exposure model estimates and foundation research.

A sound and vegetative barrier (see Figure 9) can help reduce exposure in these two areas. To further reduce exposure and increase physical activity, the team recommends that a walk/bike access point at the end Cline Street near Swiney Park to Bruce Elementary be converted to the main point of access. This access point could be combined with street treatments and plantings to make this an inviting entrance that is furthest from the potential air quality risks associated with the NHHIP.

Efforts to reduce vehicle idling in carpool or bus lines before and after school should be strongly considered if not already in place.

Monitoring of prevalent wind direction should also be considered at the school. The greatest exposure to pollutants will occur when the wind direction is light and out of the North or West. Fortunately for this community, these wind directions occur infrequently. Higher winds result in more dispersion of pollutants and lower concentration. On days with wind levels and directions that increase exposure, outdoor activity should be minimized on the school grounds.

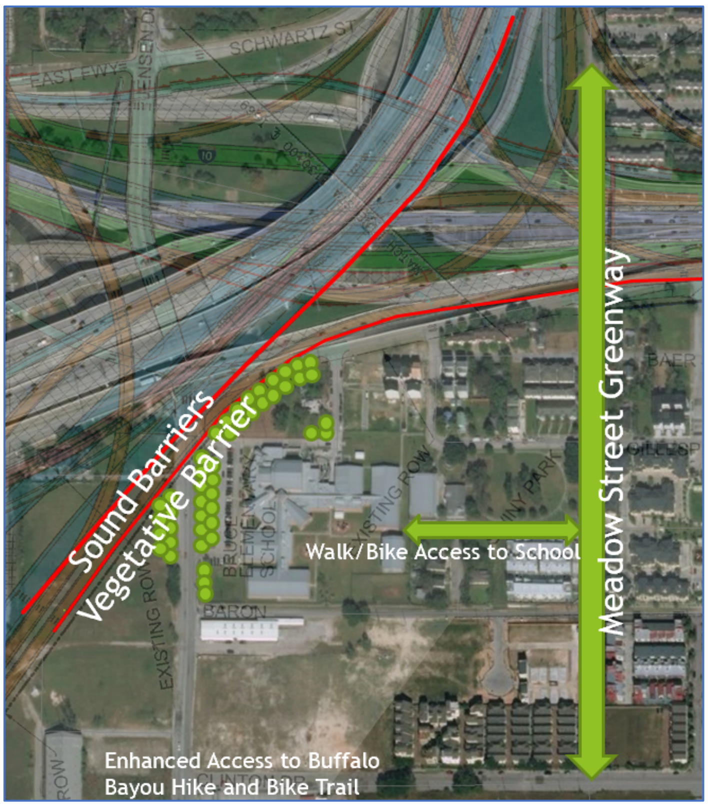

Figure 9 - Bruce elementary site specific mitigation concepts

Greenways

Also shown in Figure 9 is the suggested location of the Meadow Street Greenway. Greenways that alter streetscapes to promote more bike/ped activity are proven to be successful in increasing community physical activity. A recent study regarding a similar greenway development in Vancouver[76] found that residents along the greenway reduced vehicle trips and increased active transportation by as much as 20%.

A greenway concept that includes safety measures and visual appeal along Meadow Street from Kelly Village to Clinton Drive would encourage more north/south connectivity to the school, Swiney Park, the Buffalo Bayou Hike and Bike Trail, and the potential new retail developments in planned projects.

Parks and open space

Additional parks and greenspace in close proximity to the Bruce Elementary community are indicated in the NHHIP development plans. There are two challenges to existing plans that limit their benefit to this study area. First, the recommended space is in close proximity to the revised alignment. In fact, it is directly under the freeway main lines and ramps and therefore well within the highest thresholds of air pollution exposure. Secondly, access to this area is blocked by the rail line that runs north/south through the study area. The only access points would be from Nance Street on the north and from the Buffalo Bayou Hike and Bike Trail (that currently has no direct street access from the North side of the river).

Active park spaces with sport fields are absent from this area and currently not planned. Increasing active sports, particularly among youth and teenagers, is a direct way of improving health and community interaction. The closest fields to the Bruce Elementary community is Marron (Tony) Park on the south side of the river off of Hirsch Road (2.5 km from Bruce Elementary School).

Active transportation connectivity

At the heart of an active and healthy community is a well-connected active transportation system. Outside of the maintenance and repair of existing sidewalks and crossings, improving access to downtown Houston and the Buffalo Bayou Hike and Bike Trail should be considered. Currently, the Buffalo Bayou Hike and Bike Trail on the North side of the river is only 350 meters from the Bruce Elementary School, yet access points are over 800 meters away, inconvenient, and under-developed. Planned new developments may improve the access and connectivity to downtown, however the details of those connections are not finalized, including the private/public nature of those trails. Improving access to downtown and to the Hike and Bike system can occur along Jensen street. Bike/pedestrian safety measures along this road and direct street level access to both sides of the river would improve this community's connectivity to important destinations and engage local residents in the use of these spaces.

Additional improvements to the Hike and Bike trail system and connectivity to surface streets on the west side of the Bruce Elementary community are already planned as part of the NHHIP development.

NHPP reconstructs and expands transportation for vehicles between the neighborhood and downtown and must leverage the opportunity to also create two additional key connections for people walking and biking.. The first is a safe, direct and inviting bike/pedestrian facility from this neighborhood to downtown Houston where jobs, events, and retail establishments are in abundance. This path could be included in the NHHIP construction plan and cross Buffalo Bayou as well as the rail lines east of the river.

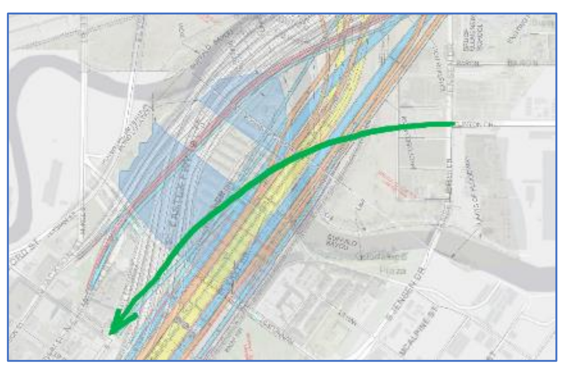

Figure 10 - Bike/ped access option to downtown

Similarly, there should be a safe access to the northwest area where jobs are available.

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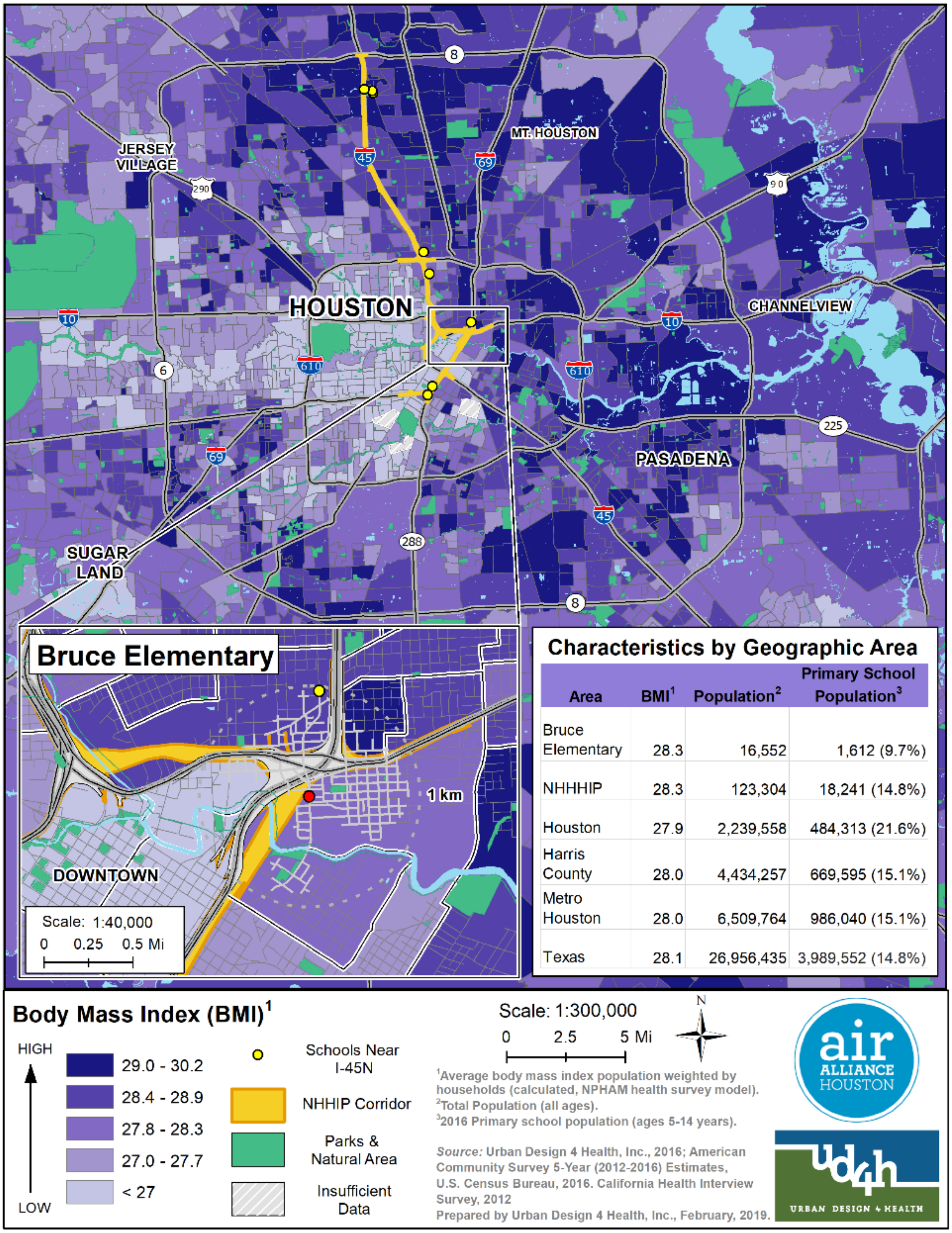
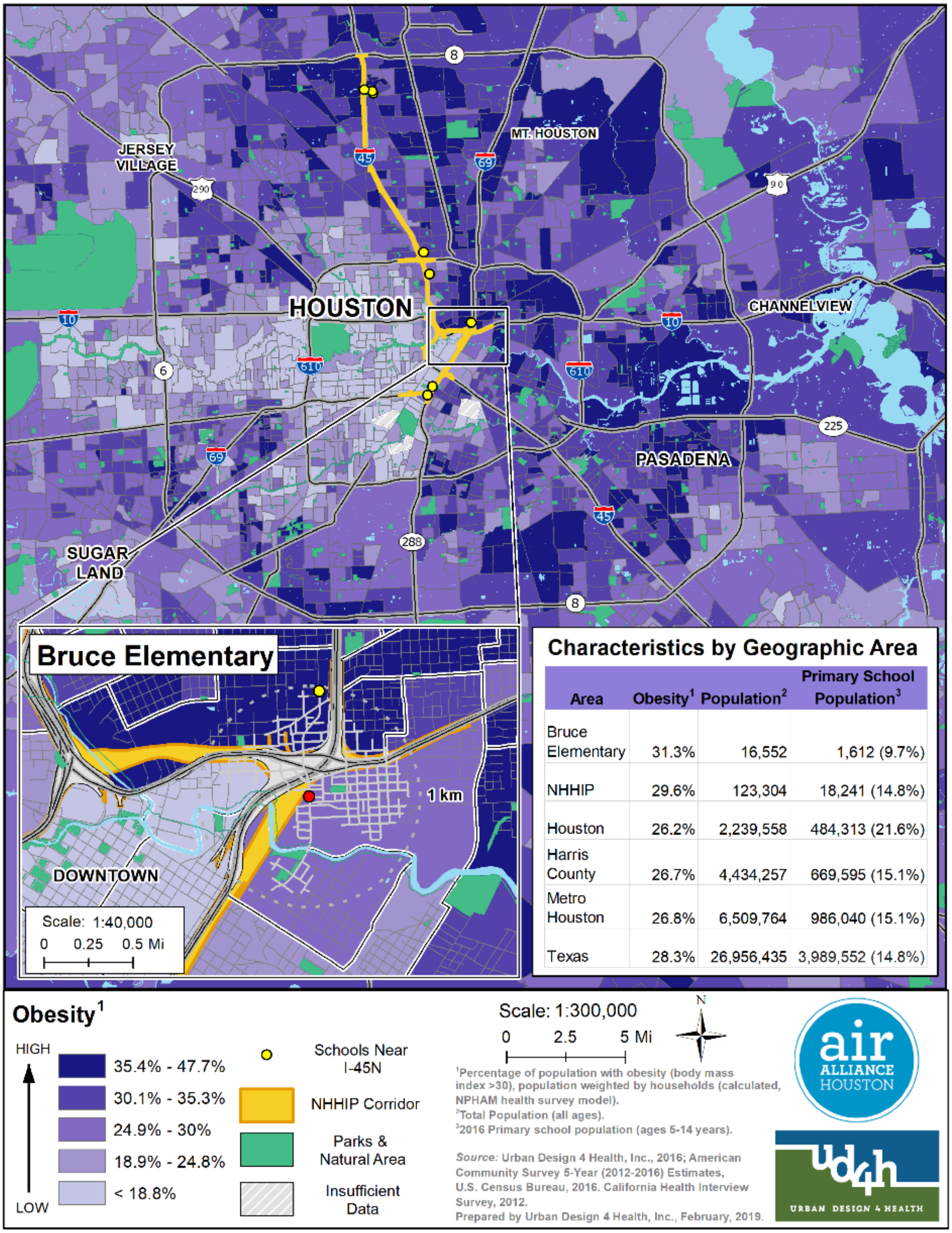
Appendix – Maps



Characteristics by Geographic Area

Area	BMI[1]	Population[2]	Primary School Population[3]
Bruce Elementary	28.3	16,552	1,612 (9.7%)
NHHHIP	28.3	123,304	18,241 (14.8%)
Houston	27.9	2,239,558	484,313 (21.6%)
Harris County	28.0	4,434,257	669,595 (15.1%)
Metro Houston	28.0	6,509,764	986,040 (15.1%)
Texas	28.1	26,956,435	3,989,552 (14.8%)

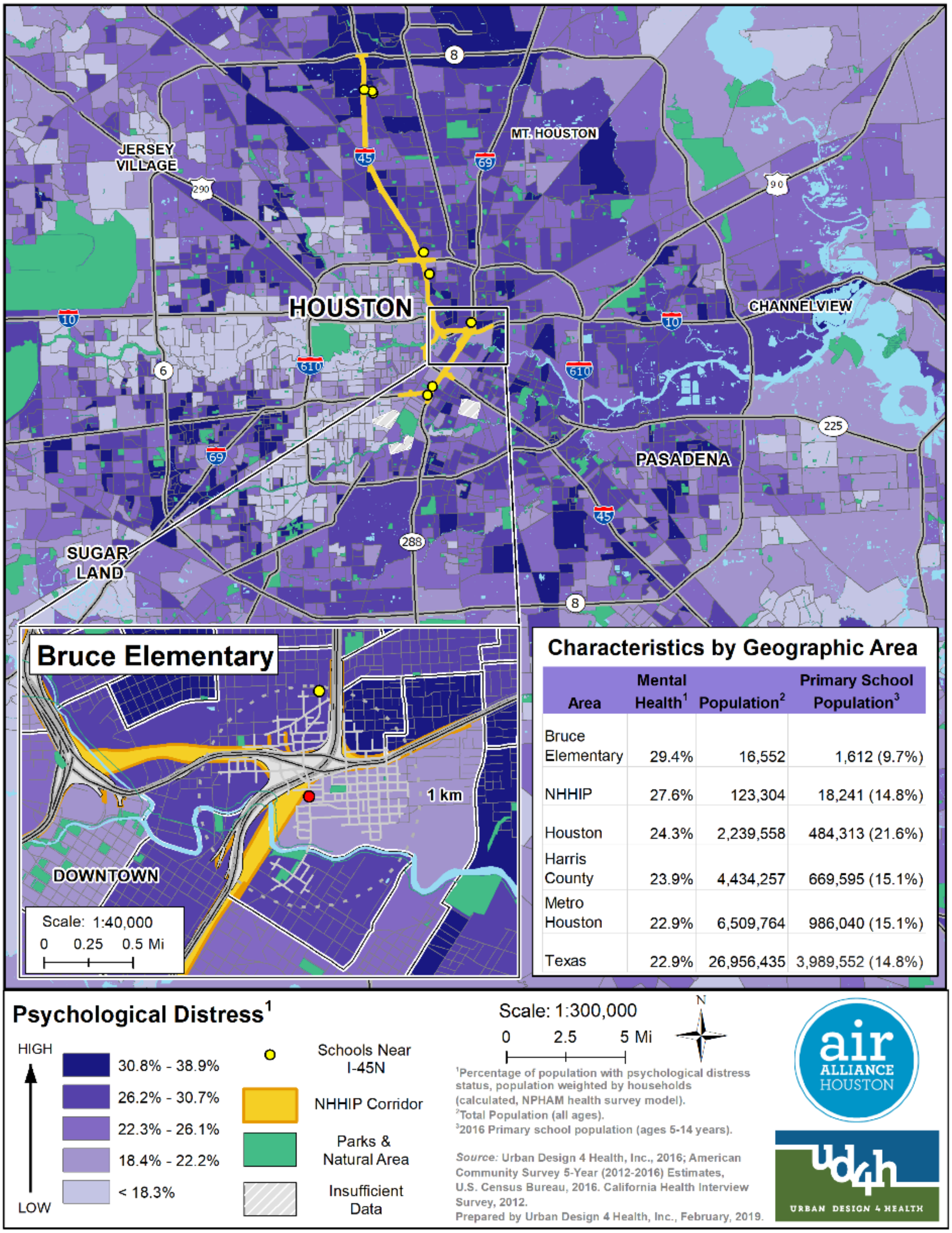
Figure 11 - Baseline conditions: Body Mass Index (adult population)



Characteristics by Geographic Area

Area	Obesity[1]	Population[2]	Primary School Population[3]
Bruce Elementary	31.3%	16,552	1,612 (9.7%)
NHHIP	29.6%	123,304	18,241 (14.8%)
Houston	26.2%	2,239,558	484,313 (21.6%)
Harris County	26.7%	4,434,257	669,595 (15.1%)
Metro Houston	26.8%	6,509,764	986,040 (15.1%)
Texas	28.3%	26,956,435	3,989,552 (14.8%)

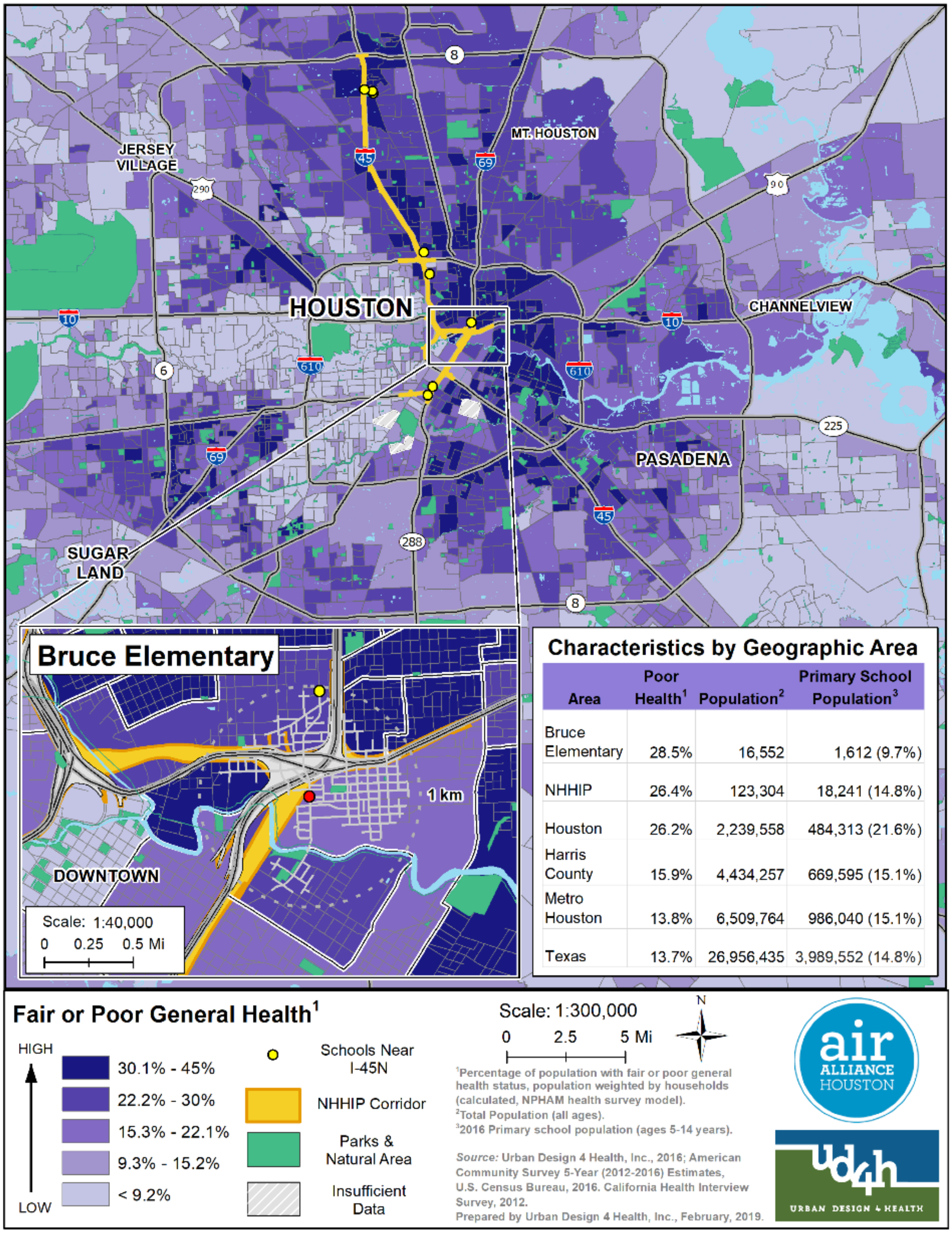
Figure 12 - Baseline conditions: Obesity (adult population)



Characteristics by Geographic Area

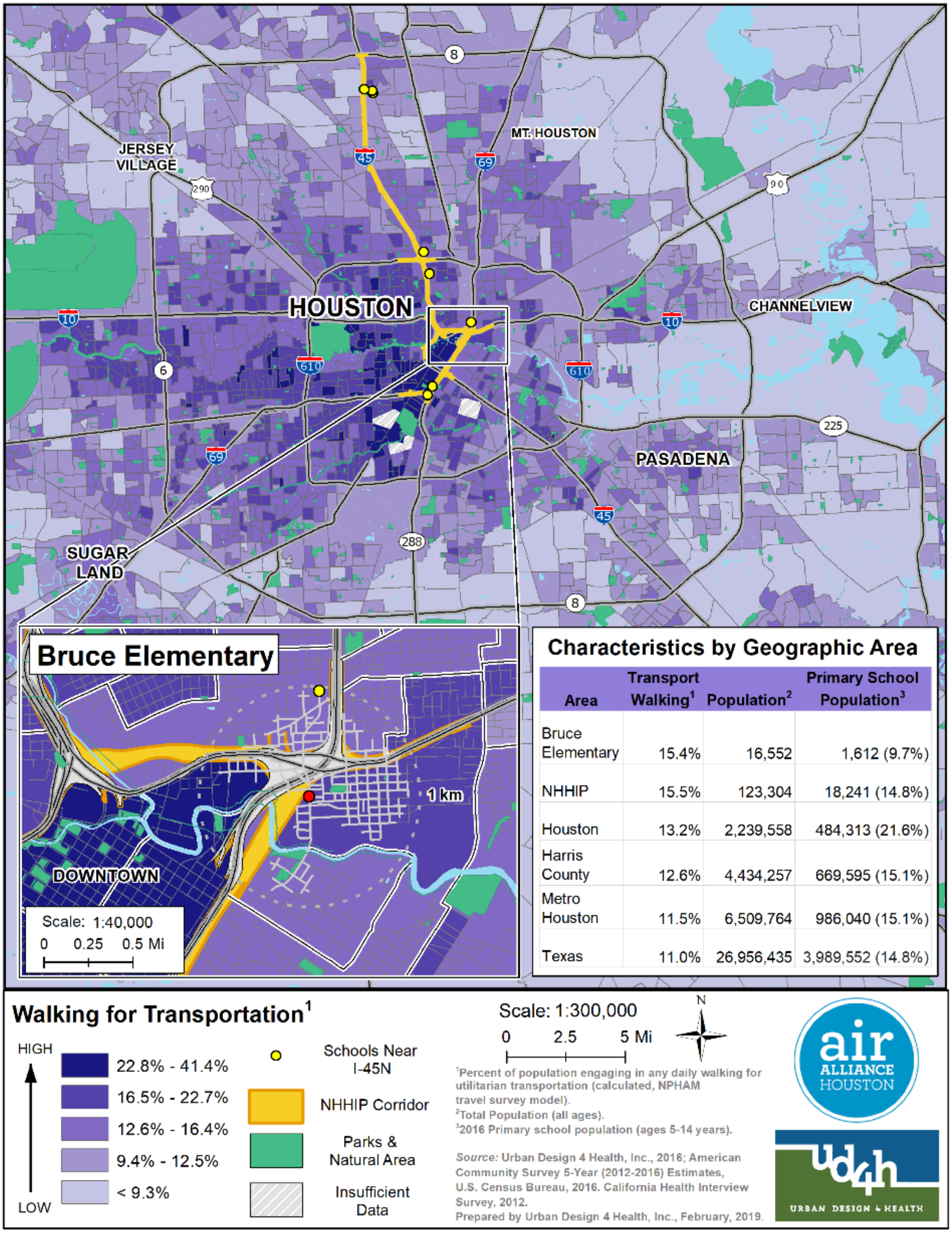
Area	Mental Health[1]	Population[2]	Primary School Population[3]
Bruce Elementary	29.4%	16,552	1,612 (9.7%)
NHHIP	27.6%	123,304	18,241 (14.8%)
Houston	24.3%	2,239,558	484,313 (21.6%)
Harris County	23.9%	4,434,257	669,595 (15.1%)
Metro Houston	22.9%	6,509,764	986,040 (15.1%)
Texas	22.9%	26,956,435	3,989,552 (14.8%)

Figure 13 - Baseline conditions - Psychological Distress (adult population)



Area	Poor Health[1]	Population[2]	Primary School Population[3]
Bruce Elementary	28.5%	16,552	1,612 (9.7%)
NHHIP	26.4%	123,304	18,241 (14.8%)
Houston	26.2%	2,239,558	484,313 (21.6%)
Harris County	15.9%	4,434,257	669,595 (15.1%)
Metro Houston	13.8%	6,509,764	986,040 (15.1%)
Texas	13.7%	26,956,435	3,989,552 (14.8%)

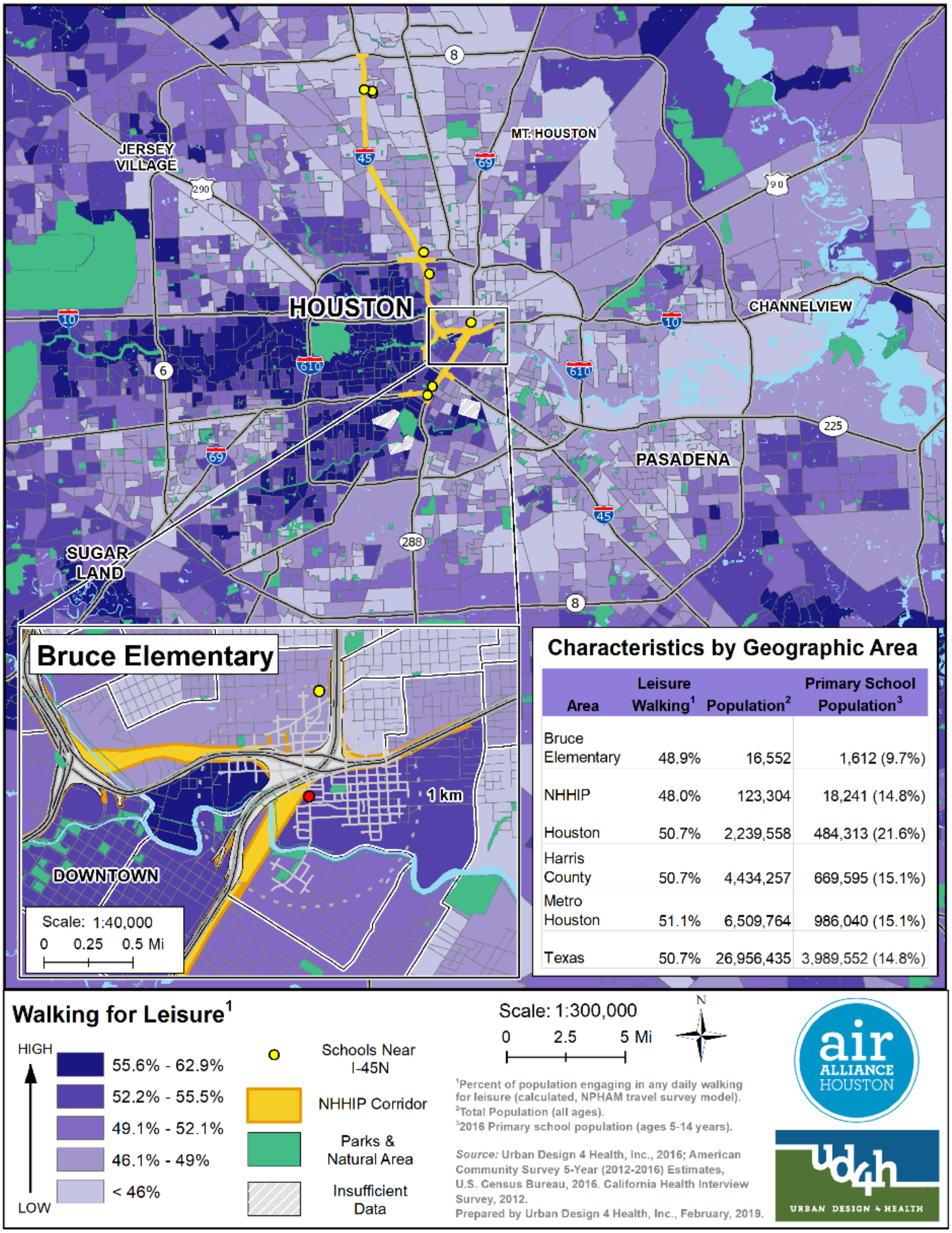
Figure 14 - Baseline conditions - Fair or Poor General Health (adult population)



Characteristics by Geographic Area

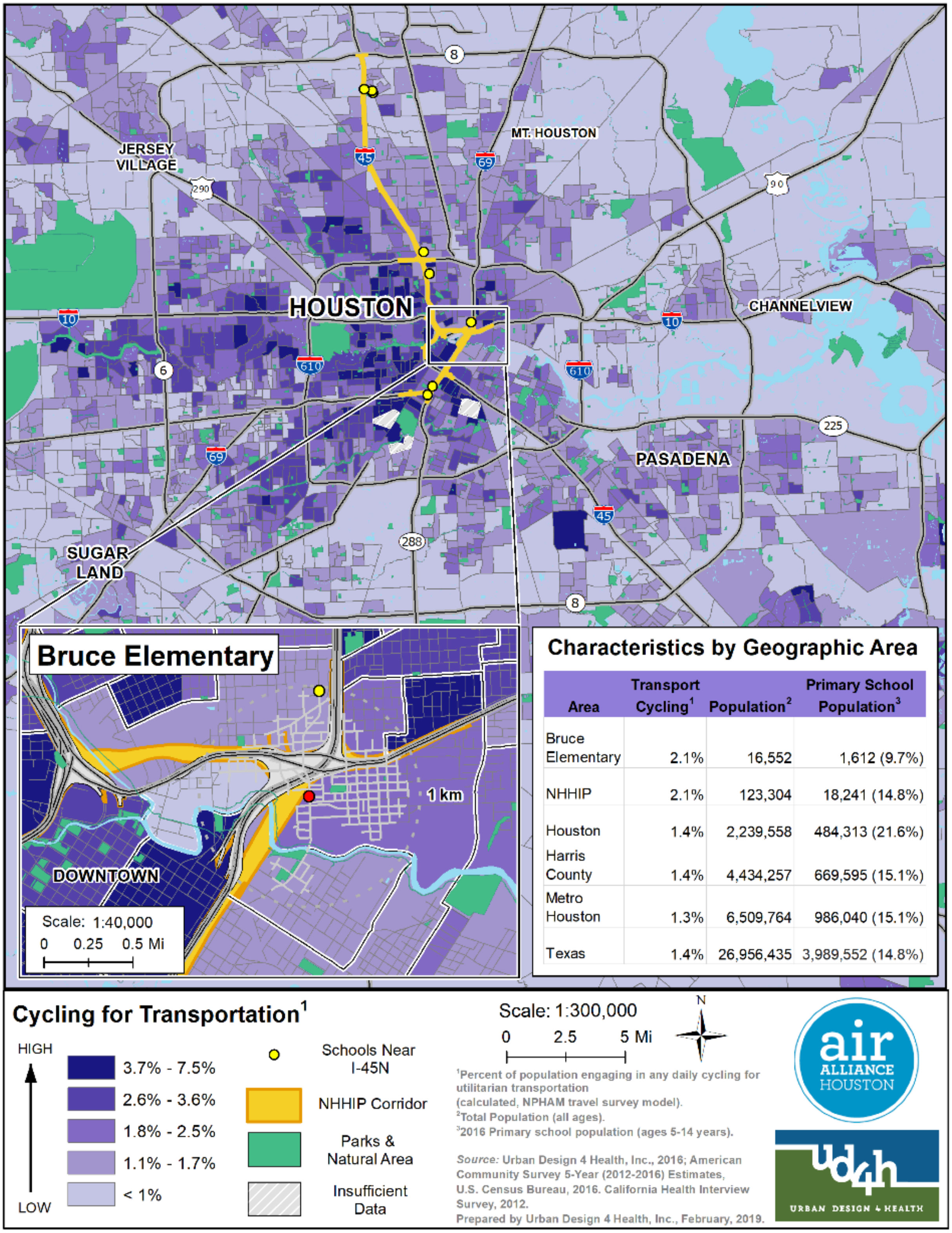
Area	Transport Walking[1]	Population[2]	Primary School Population[3]
Bruce Elementary	15.4%	16,552	1,612 (9.7%)
NHHIP	15.5%	123,304	18,241 (14.8%)
Houston	13.2%	2,239,558	484,313 (21.6%)
Harris County	12.6%	4,434,257	669,595 (15.1%)
Metro Houston	11.5%	6,509,764	986,040 (15.1%)
Texas	11.0%	26,956,435	3,989,552 (14.8%)

Figure 15 - Baseline conditions - Walking for Transportation (adult population)



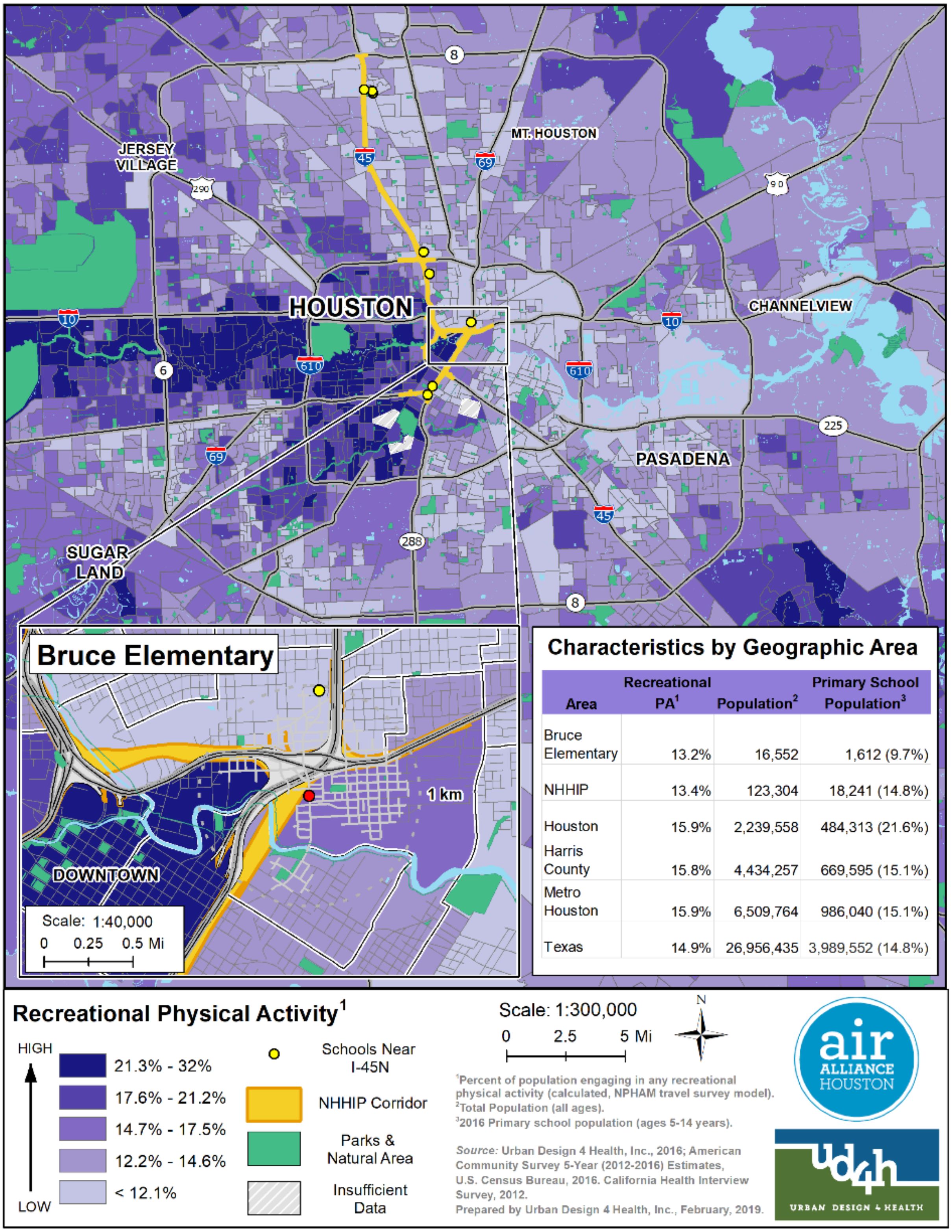
Area	Leisure Walking[1]	Population[2]	Primary School Population[3]
Bruce Elementary	48.9%	16,552	1,612 (9.7%)
NHHIP	48.0%	123,304	18,241 (14.8%)
Houston	50.7%	2,239,558	484,313 (21.6%)
Harris County	50.7%	4,434,257	669,595 (15.1%)
Metro Houston	51.1%	6,509,764	986,040 (15.1%)
Texas	50.7%	26,956,435	3,989,552 (14.8%)

Figure 16 - Baseline conditions - Walking for Leisure (adult population)



Area	Transport Cycling[1]	Population[2]	Primary School Population[3]
Bruce Elementary	2.1%	16,552	1,612 (9.7%)
NHHIP	2.1%	123,304	18,241 (14.8%)
Houston	1.4%	2,239,558	484,313 (21.6%)
Harris County	1.4%	4,434,257	669,595 (15.1%)
Metro Houston	1.3%	6,509,764	986,040 (15.1%)
Texas	1.4%	26,956,435	3,989,552 (14.8%)

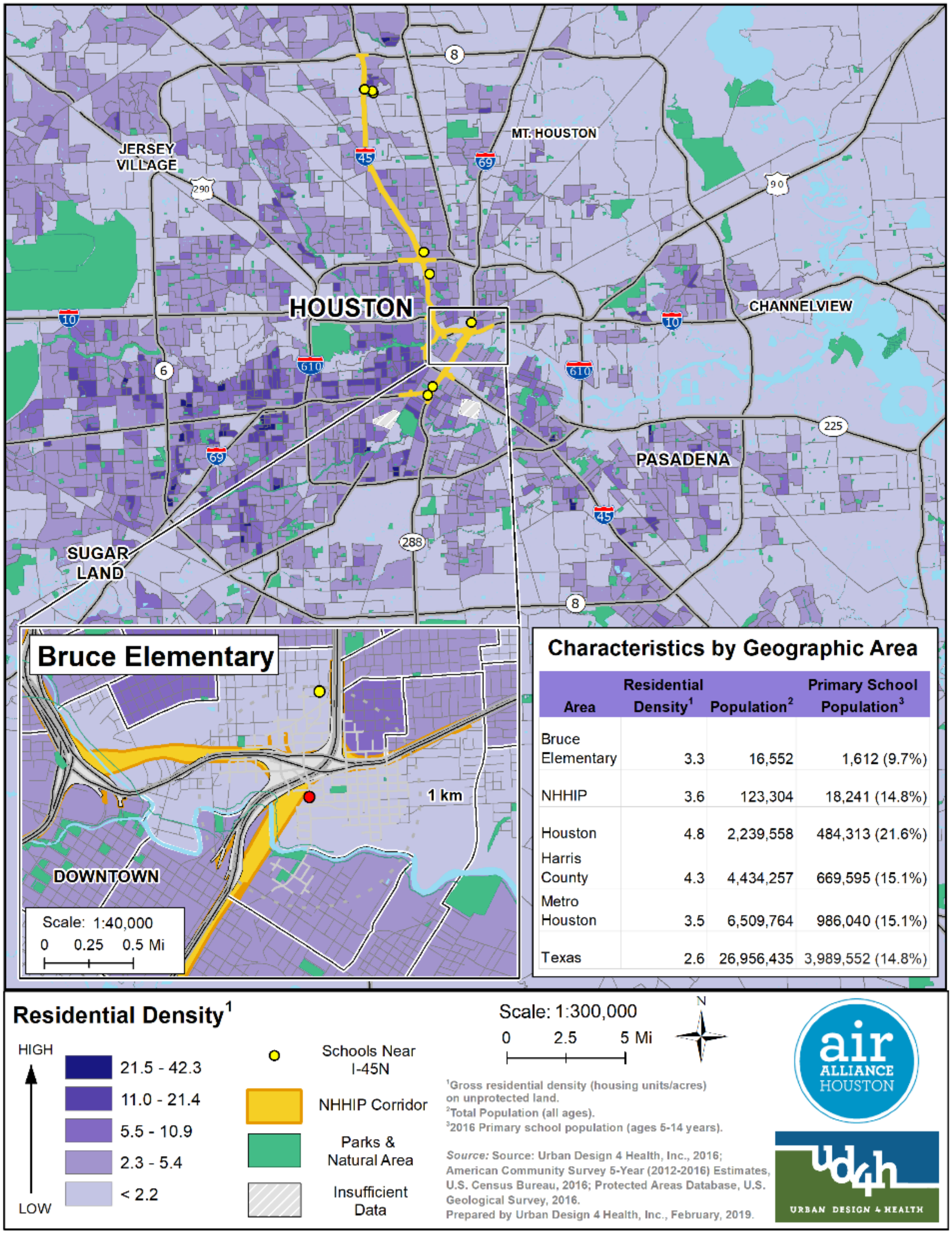
Figure 17 - Baseline conditions - Cycling for Transportation (adult population)



Characteristics by Geographic Area

Area	Recreational PA[1]	Population[2]	Primary School Population[3]
Bruce Elementary	13.2%	16,552	1,612 (9.7%)
NHHIP	13.4%	123,304	18,241 (14.8%)
Houston	15.9%	2,239,558	484,313 (21.6%)
Harris County	15.8%	4,434,257	669,595 (15.1%)
Metro Houston	15.9%	6,509,764	986,040 (15.1%)
Texas	14.9%	26,956,435	3,989,552 (14.8%)

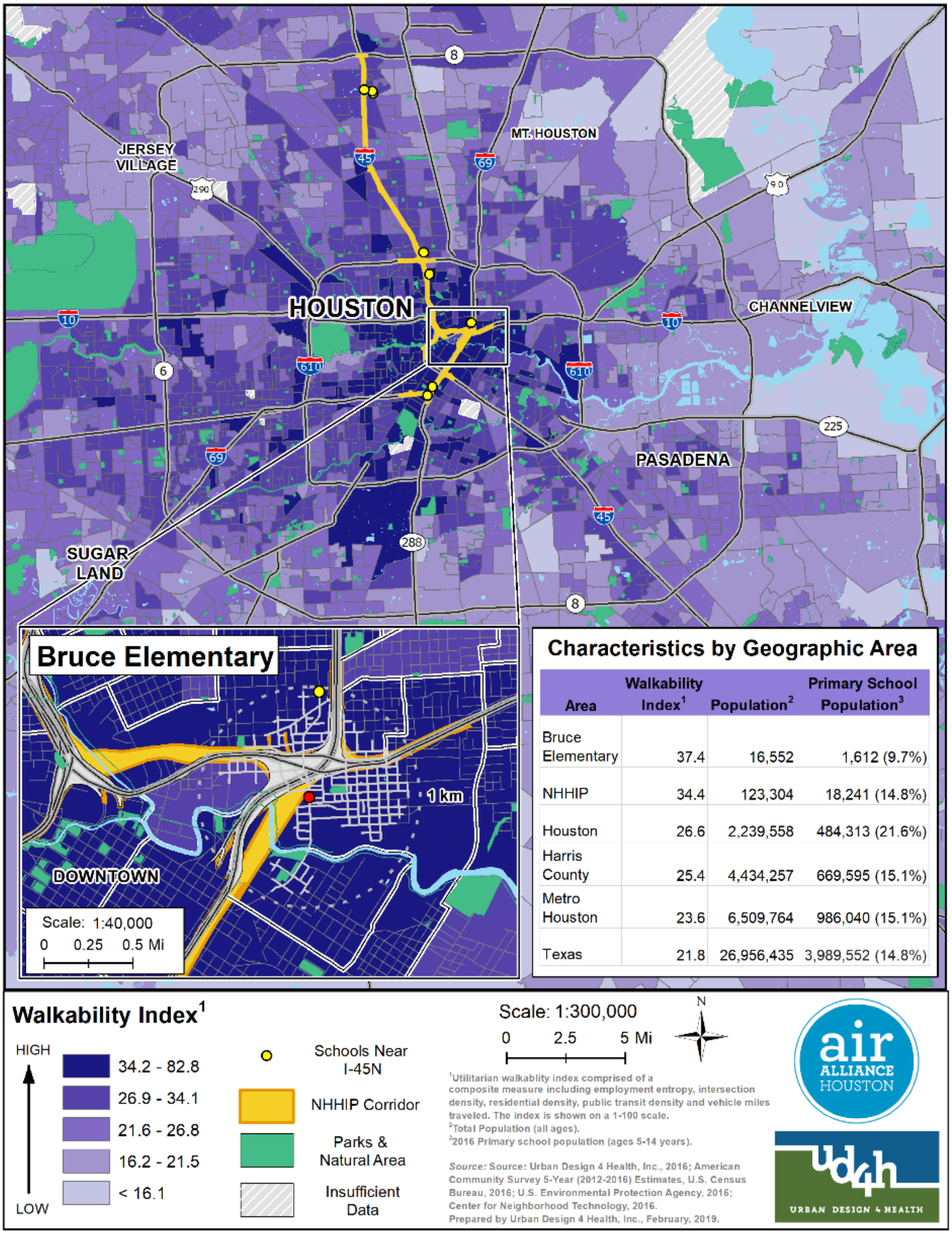
Figure 18 - Baseline conditions - Recreational Physical Activity (adult population)



Characteristics by Geographic Area

Area	Residential Density[1]	Population[2]	Primary School Population[3]
Bruce Elementary	3.3	16,552	1,612 (9.7%)
NHHIP	3.6	123,304	18,241 (14.8%)
Houston	4.8	2,239,558	484,313 (21.6%)
Harris County	4.3	4,434,257	669,595 (15.1%)
Metro Houston	3.5	6,509,764	986,040 (15.1%)
Texas	2.6	26,956,435	3,989,552 (14.8%)

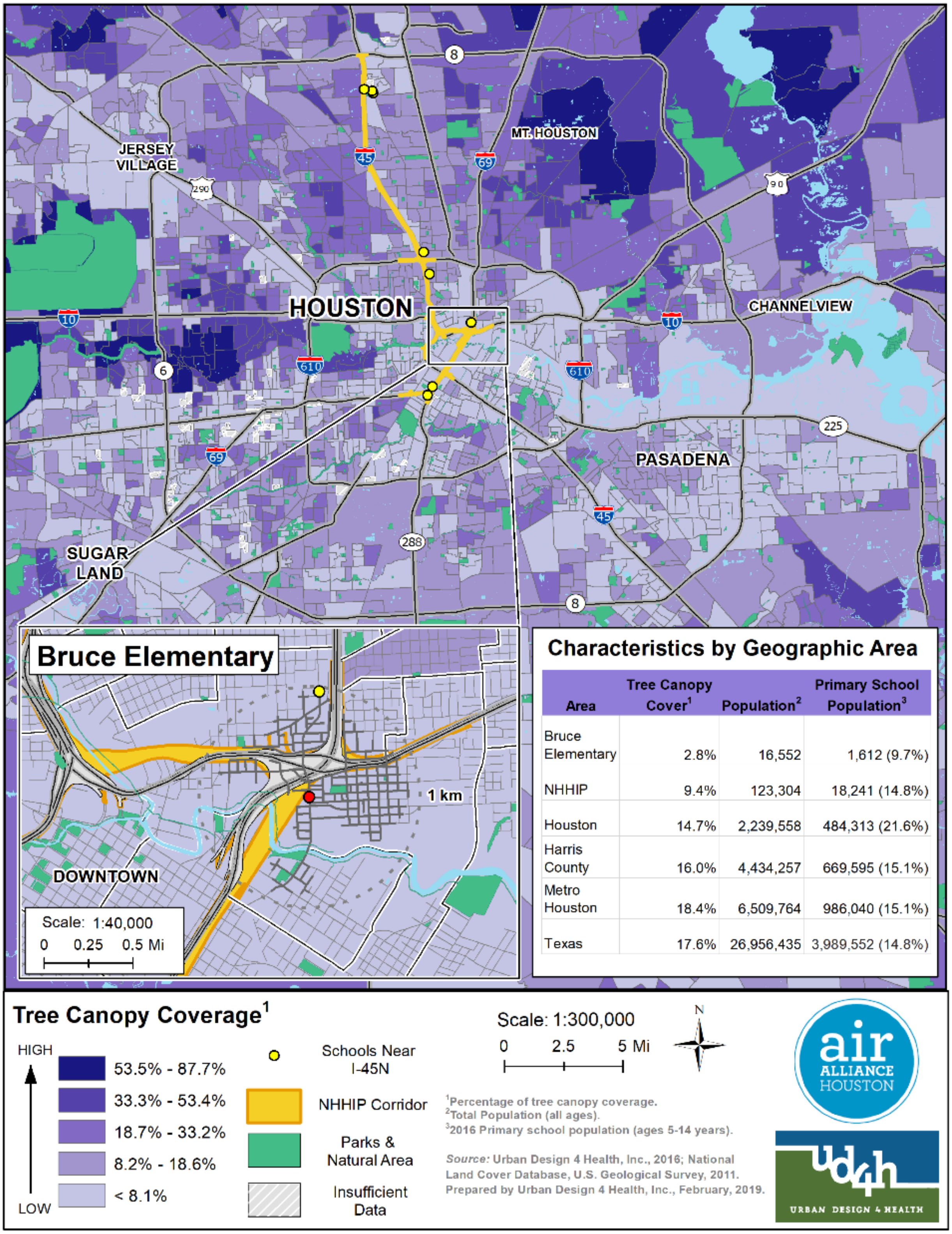
Figure 19 - Baseline conditions - Residential Density (adult population)



Characteristics by Geographic Area

Area	Walkability Index[1]	Population[2]	Primary School Population[3]
Bruce Elementary	37.4	16,552	1,612 (9.7%)
NHHIP	34.4	123,304	18,241 (14.8%)
Houston	26.6	2,239,558	484,313 (21.6%)
Harris County	25.4	4,434,257	669,595 (15.1%)
Metro Houston	23.6	6,509,764	986,040 (15.1%)
Texas	21.8	26,956,435	3,989,552 (14.8%)

Figure 20 - Baseline conditions - Walkability Index (adult population)



Area	Tree Canopy Cover[1]	Population[2]	Primary School Population[3]
Bruce Elementary	2.8%	16,552	1,612 (9.7%)
NHHIP	9.4%	123,304	18,241 (14.8%)
Houston	14.7%	2,239,558	484,313 (21.6%)
Harris County	16.0%	4,434,257	669,595 (15.1%)
Metro Houston	18.4%	6,509,764	986,040 (15.1%)
Texas	17.6%	26,956,435	3,989,552 (14.8%)

Figure 21 - Baseline conditions - Tree Canopy Coverage (adult population)

APPENDIX IV – MOBILE AIR MONITORING

North Houston Highway Improvement Project HIA
Mobile Air Monitoring of I-45

A major component of the assessment was mobile air monitoring along the NHHIP corridor. The original intent was to assess the current and potential future burden of 9 priority mobile source air toxic (MSAT) pollutants: 1,3-butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter (diesel PM), ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter.

Mobile air monitoring was incorporated into the assessment because:

- No stationary air quality monitors collect data on MSAT pollutants along the NHHIP corridor. A single monitor is located at the northwest corner of I-610 and I-45, which collects data on carbon monoxide (CO) concentrations, oxides of nitrogen (NOx) concentrations, and meteorological data. Mobile monitoring is therefore the only feasible option for gathering relevant data.
- In compliance with FHWA requirements, TX DOT released a Draft Mobile Source Air Toxics (MSAT) Quantitative Technical Report in May 2018. While the draft analysis appears to comply with FHWA minimum requirements, by aggregating emissions across the 8-county transportation network it does not address the areas along the corridor where MSATs are projected to increase by 5% or more. It is possible that these locations house sensitive receptors such as schools and/or communities that are already exposed to high levels of toxic air pollution.
- If the project generates new capacity in the range of 140,000-150,000 annual average daily traffic (AADT) or greater by the design year, the Federal Highway Administration (FHWA) will require a quantitative assessment of the 9 priority MSATs in order for the NHHIP project to move forward.

The original objectives of the mobile air monitoring were to:

1. Measure traffic-related air pollution (9 priority MSATs, particulate matter ($PM_{2.5}$, PM_{10}, BC), carbon monoxide (CO), and nitrous oxides (NO_x) along the NHHIP corridor to assess current emissions on I-45 itself and at several distances away from the freeway. Also, collect meteorological data (wind speed, wind direction, ambient temperature, barometric pressure, relative humidity, solar radiation, and precipitation) alongside the AQ data.
2. Measure air pollution at nine high-risk schools located within a 150m buffer zone on either side of the freeway: Aldine Ninth, Stovall Middle School, Aldine High School, Roosevelt Elementary, Jefferson Elementary, Bruce Elementary, Secondary DAEP, Houston Academy for International Studies, Young Women's College Prep. Monitored locations were both at the school and at a location demonstrating the school's closer location to the freeway after the expansion has been constructed.

The Houston Advanced Research Center (HARC) deployed a mobile laboratory over the course of two weeks in January 2019. The laboratory consists of a Ford F-350 passenger van outfitted with a Proton Transfer Reaction-Mass Spectrometer (PTR-MS), CO analyzer, GPS unit, and a portable meteorological station.

Mobile Air Monitoring Methodology

1. Select high-risk schools along the NHHIP corridor (see above).
2. Select key monitoring locations along the corridor, including the high-risk schools: On-road, 10m from roadway, 150m from roadway, 300m from roadway, 1,000m from roadway (background).
3. Use historical meteorological and traffic data to define peak exposure times – both for all traffic counts and for diesel trucks.
4. Conduct the monitoring during morning and afternoon peak exposure times (est. 7am-10am and 3pm-6pm) during two planned periods, one warm weather and one cold weather.

VOC measurements

Benzene toluene, ethyl benzene and xylenes concentrations were measured by a compact proton transfer reaction mass spectrometer (compact PTR-MS) from Ionicon Analytik GmbH, Austria. One of the advantages of the compact PTR-MS is portability, which allows its use for continuous measurements on a mobile moving platform. Another important advantage of the compact PTR-MS is that the volatile compound samples do not need to be specially prepared before the measurement, e.g., involving preconcentration procedures; thus, headspace samples can be introduced directly into the reaction chamber consisting of the drift tube. The fact that, due to their low proton affinities, H3O + ions do not react with any of the major components present in clean air is an additional advantage as it allows the analyzed air to be used directly as the buffer gas. The PTR-MS response time for measurement of an individual compound is less than 1 sec and typical detection limits are under 1 ppbv.

The main air toxics monitored by the HARC PTR-MS were benzene, toluene, and C2-benzenes. Note that C2-benzenes consist of both ethyl benzene and xylenes, which have the same mass-to-charge ratio (m/z) in the PTR-MS ion stream.

- Benzene (m/z=79)
- Toluene (m/z=93)
- ethyl benzene and xylenes (m/z=107)

For this project, the air sample to be analyzed was introduced into the drift tube which was maintained at about 2 mbar and 70 ˚C with a drift voltage of 2000 V. To set a correct transmission in the software, a gas standard GASCO BTEX Calibration Gas (1 ppm benzene, 10 ppm toluene, 10 ppm ethylbenzene, 20 ppm m-xylene, 20 ppm o-xylene, balance air) was used daily.

CO Measurement

CO concentration was measured with a Thermo Environmental Instruments Model 48C-Trace Level (TEI 48C TLE) CO analyzer. This instrument uses an advanced method based on the measurements with non-dispersive infrared (NDIR) spectrophotometry using gas filter correlation (GFC). For this project, the instrument's range was set to 0 to 5.0 ppm (0 to 5000 ppb). To calibrate the instruments daily both before and after the experiment, a gas standard (GASCO carbon monoxide calibration gas (CO 10 ppm, balance air)) was used.

Sampling System

A ¼" PFA sample line drawn from the top of the van to the CO analyzer and PTR-MS allowed air to be sampled. A Gast vacuum compressor pump was used to pull air through the sample line to minimize residence time within the sample line and ensure fast response.

Temperature & Humidity Measurements

A temperature and relative humidity probe (R.M. Young Model 41382) was mounted on top of the van to record the ambient air temperature and humidity.

GPS Location Measurement

To record the van's GPS co-ordinates, a global positioning system (Garmin GPS 19x HVS) was mounted at the center of the van's roof.

Limitations of Mobile Air Monitoring

Mobile air monitoring is a useful tool for identifying air pollution hotspots. However, it has several limitations related to its mobile nature, such as:

- Variable speed roadways (traffic lights and stop signs) - We are monitoring air quality close to the source (the vehicles). Vehicle emissions vary due to number of factors, including engine load. A vehicle driving at a steady speed on I-45 will likely emit less emissions than that same vehicle in slower moving stop-and-go traffic under acceleration and deceleration due to variable engine loads.
- Hot soak emissions might be a source of elevated VOCs in and around parking lots.
- Roadside gas filling stations and certain commercial facilities such as drycleaners emit VOCs.

The mobile air monitoring van used on the project was not set up to monitor 1,3-butadiene, acetaldehyde, acrolein, formaldehyde, or polycyclic organic matter. Therefore, the project was not able to measure these pollutants. See below for a discussion of black carbon and $PM_{2.5}$, which was used as a proxy for diesel particulate matter.

- NOx and Ozone: The project was unsuccessful at obtaining a mobile NOx sensor. Only one stationary NOx sensor is located within the project area (at the intersection of 610 and I-45). As a result, NO_x concentrations were not included in the project. Ozone was not included in the study.
- Black Carbon and $PM_{2.5}$: The mobile air monitoring van was not yet equipped to measure Black Carbon or $PM_{2.5}$ concentrations. As a result, we installed Purple Air sensors and Minivol sensors (EPA equivalent method)) for five school days at two schools, Bruce Elementary and the Joint Aldine campus, to measure current concentrations at those locations. However, due to time constraints, the data have not yet been fully analyzed and interpreted.

The EPA has standards for PM2.5 – a 24-hour standard which is 35 ug/m3 and an annual standard of 12 ug/m3. However, the World Health Organization recommends that PM2.5 not exceed 10 ug/m3 for the annual average or 25 ug/m3 for the 24-hour average. The data from actual (versus C-Line modeled) PM readings from the Purple Air sensor at Bruce ES ranged from 3.83 ug/m3 to 54.46 ug/m3 (exceeding the EPA and WHO 24-hour thresholds). However, the Purple Air data between January 9 and January 16 averaged 18.6 ug/m3.

Dispersion of the emissions from the high-traffic roadways to down-wind streets and neighborhoods.

- Data provide by HARC was not cleaned up to remove "noisy" readings (such as a spike in concentrations when the mobile lab was following a highly polluting truck).

Furthermore, there are no regulatory standards for the MSAT air pollutants that were monitored in this study. Table 1 gives a framework for understanding the results of the mobile air monitoring conducted for the NHHIP HIA, laying out short-term and long-term ambient exposure guidelines set by the Texas Commission on Environmental Quality (TCEQ). However, it is important to note that there is concern about the TCEQ "safe" levels and local air quality researchers contend that much lower and more protective thresholds should be established. For example, there is no known safe level of exposure to benzene and a general guideline that has been applied is that readings above 10 ppb should be examined and anything above 20 ppb is a concern. Due to our time constraints and limited budget, the mobile air monitoring was not conducted at intervals throughout the HIA. However, future HIAs should consider budgeting for adequate mobile air monitoring sampling to gain greater insight into exposure levels in communities surrounding roads and highways, particularly if there is no stationary air monitor nearby.

Table 1. TCEQ Short Term and Long Term Effect Screening Levels.

Species	Short Term (1-Hour)	Long Term (24-Hour)
Benzene	180 ppb	1.4 ppb
Toluene	4,000 ppb	1100 ppb
C2-Benzene (ethyl benzene & zylenes)	58-380 ppb (depending on isomers)	42 ppb

Source: TCEQ.

Data Visualization

The data collected by HARC's mobile air monitoring lab produced a .csv file that includes the measured pollutant concentrations values, a timestamp, and latitude and longitude coordinates. This information allows the data to be spatially visualized with a GIS program. During the monitoring period, over 180,000 unique sample readings were captured for each pollutant. The monitoring lab was asked to follow fixed routes over the course of the study period with the intent of collecting enough samples along the route to determine the aggregated average reading for equally sized, non-overlapping zones. A hexagonal tessellation of 1,000 m² was applied to the extent of the monitored route and the readings that fell within each hexagon were averaged to provide a representative value. The average values were then displayed as choropleth symbols according to their relative concentration value

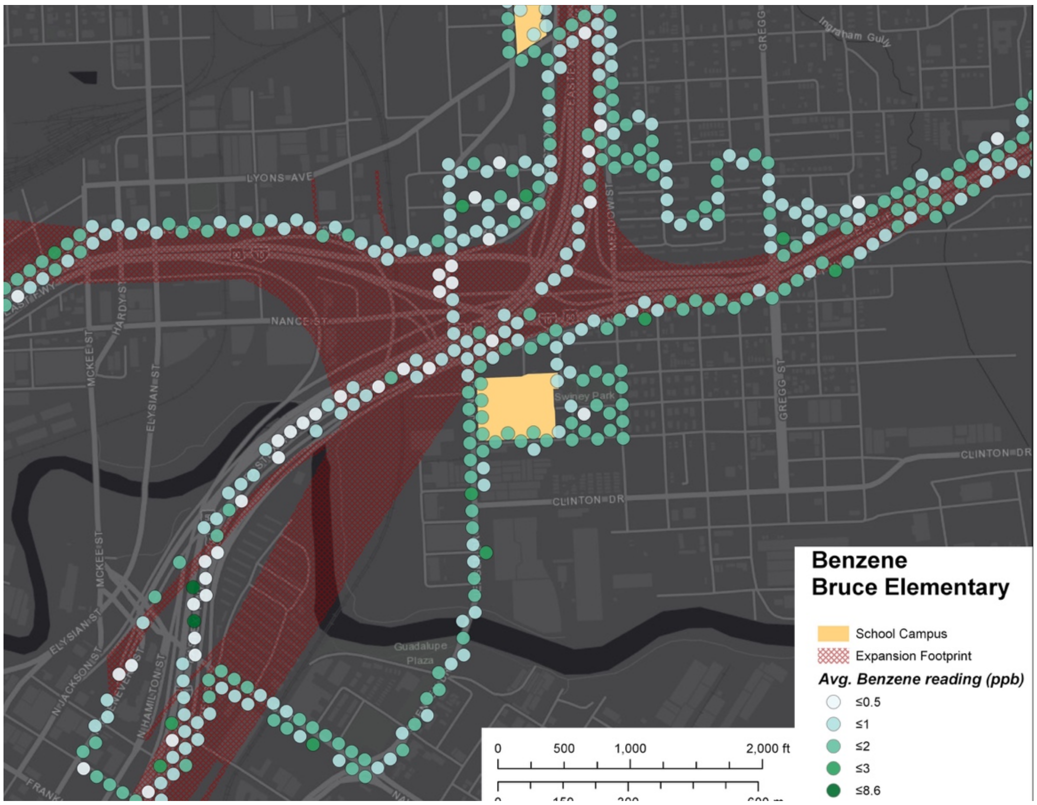


Figure 1. Mobile air monitoring results for benzene at Bruce Elementary.

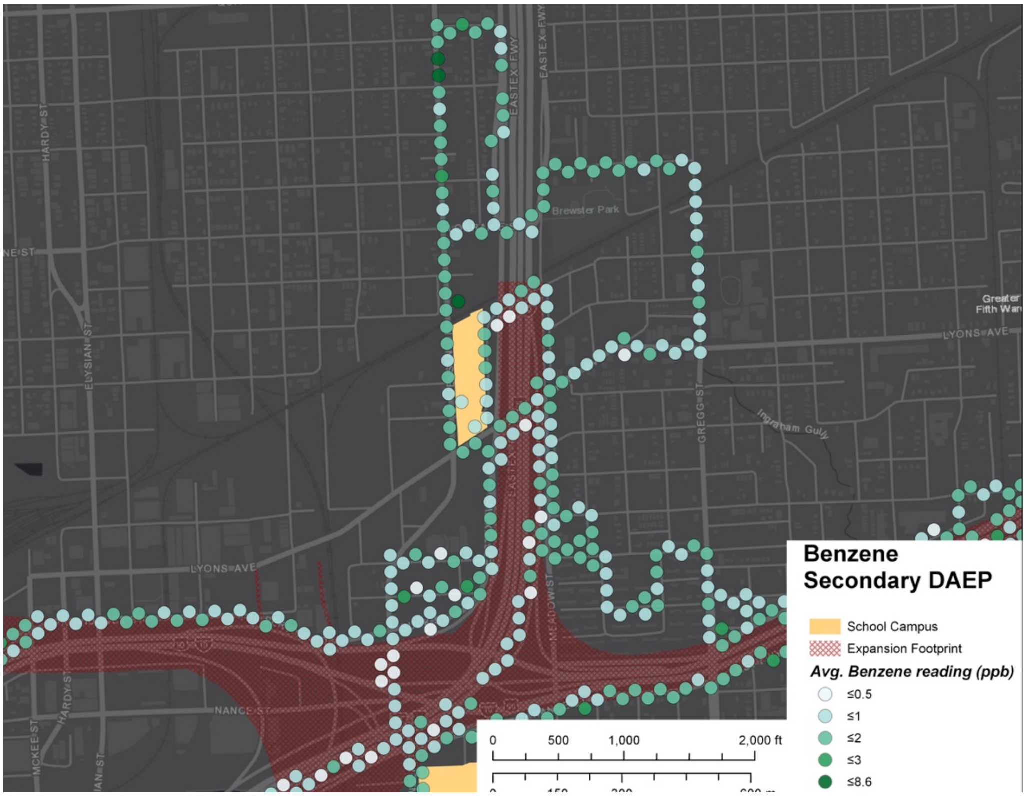


Figure 2. Mobile air monitoring results for benzene at Secondary DAEP.

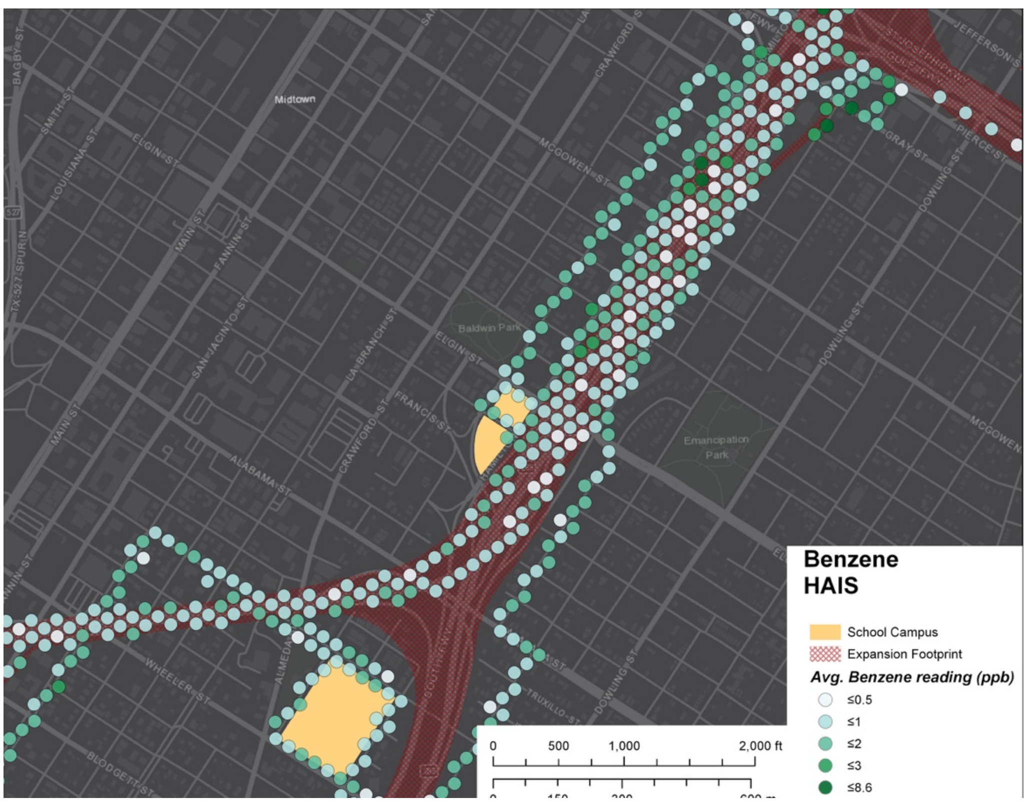


Figure 3. Mobile air monitoring results for benzene at HAIS.

Figure 4. Mobile air monitoring results for benzene at Jefferson Elementary.

Figure 5. Mobile air monitoring results for benzene at Roosevelt Elementary.

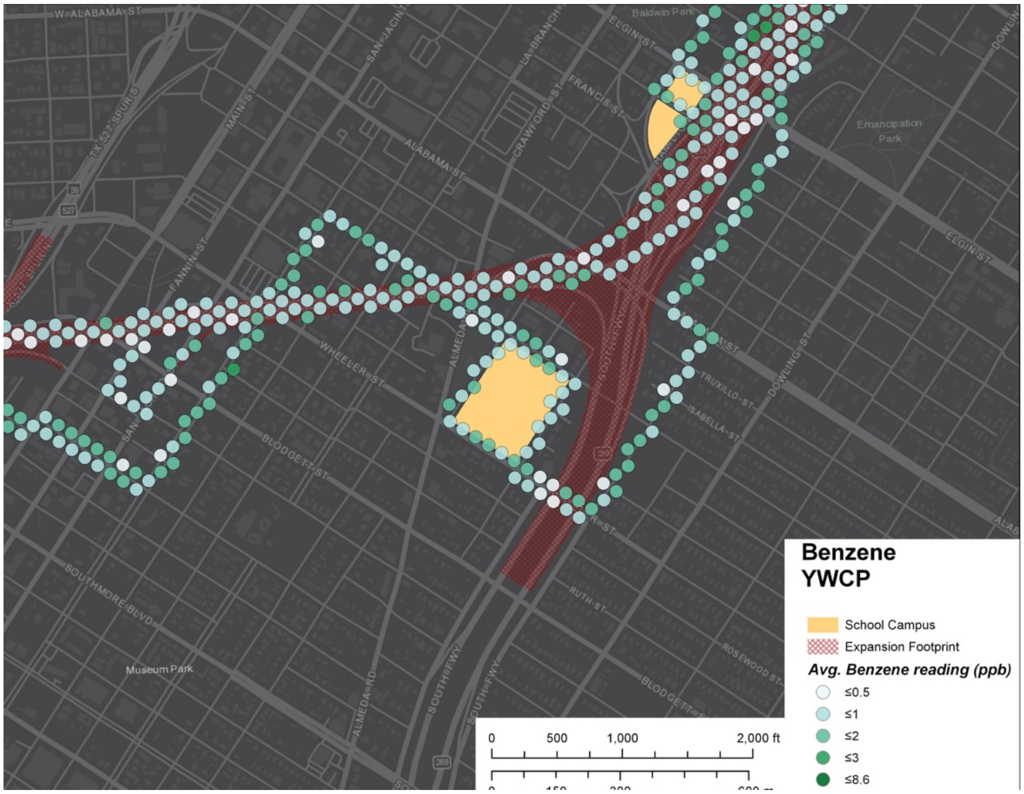


Figure 6. Mobile air monitoring results for benzene at YWCP.

Figure 7. Mobile air monitoring results for benzene at Aldine schools.