WJHW

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Designers and Planners for Sound, Video, Multi-Media
Telecommunications, Broadcast, Theatre & Acoustics

Dallas • San Antonio • Denver

September 18, 2023

Mr. Darren Nielsen
Vice President/KC Studio Leader
HNTB
715 Kirk Drive
Kansas City, MO 64105

Subject: Ryan Field Redevelopment at Northwestern University
Rebuttal to Arup report

Dear Mr. Nielson,

WJHW has been involved in the sports and entertainment venue industry for over 30 years, having completed extensive work on professional and collegiate projects, and it is this expertise that we bring to the Northwestern University project. WJHW was founded in 1991 and has been an industry leader in acoustics and sound system design for the vast majority of professional arenas and stadia since. Our resume includes all 32 current NFL stadia, all 30 NBA arenas, 24 of 32 NHL arenas (75%), 28 of 30 MLB stadia (93%), and 19 of 29 MLS stadia (66%). Additionally, WJHW has completed numerous collegiate stadia and arenas for Power 5 conference teams including:

- **SEC:** U of Arkansas, U of Alabama, U of Tennessee, Louisiana State, Mississippi, Mississippi State, Texas A&M, U of Texas, U of Missouri, U of Georgia, Auburn, U of Florida, and U of Kentucky
- **ACC:** North Carolina, Duke, Georgia Tech, Wake Forest, Florida State, U of Virginia, Louisville, Boston College, North Carolina State, Notre Dame, and Virginia Tech
- **BIG12:** U of Houston, Iowa State, U of Kansas, Kansas State, TCU, Oklahoma, Texas Tech, U of Cincinnati, and West Virginia
- **PAC12:** Arizona State, U of California, U of Colorado, U of Oregon, Oregon State, Stanford, and U of Utah
- **BIG10:** Iowa, Minnesota, Northwestern, Purdue, Michigan, Ohio State, Penn State, Rutgers, and Nebraska

Our efforts in these projects include sound system design and acoustics analysis as well as many of the technologies utilized in these facilities (e.g. broadcast, audio-video, security). Further, WJHW provides concert support in numerous large stadia including Levi's Stadium (Santa Clara, CA), AT&T Stadium (Arlington, TX), US Bank Stadium (Minneapolis, MN), Globe Life Field (Arlington, TX), and NRG Stadium (Houston, TX) for a variety of acts. Our expertise in these venues is substantial and is unrivalled in the industry.

This extensive experience allows us to speak with unique authority on the subjects of interest to the Evanston and surrounding communities, and we offer the following responses to the Arup report dated August 11, 2023 and revised comments dated August 15, 2023.

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General Comments

The ARUP Report states at its outset that:

"This memo provides comments and questions on the documents provided to Arup for our review. No additional analysis of the information presented in the WJHW reports was conducted."

The ARUP Report does not provide any evidence for the Land Use Commission to consider that refutes the findings of Henderson or WJHW regarding sound propagation. It does not provide any indication of SPLs above those levels modeled by Henderson nor does it opine on whether those levels would have an adverse impact on the health, safety, and welfare of nearby neighbors or the community.

The following general comments were raised in the Arup Report:

- **Arup Comment:** General description of sound mitigation strategies could help limit noise impact to the community; however, they need to be developed in detail and assessed (in terms of both feasibility and effectiveness). No definitive design solutions or proposed operational limits or criteria are proposed. [See Section 4.2.1, Item 14 and Section 4.2.2, Item 21]

  WJHW Response: *The report describes noise mitigation elements starting on page 5; notably there are multiple permanent items included in the stadium design that are intended to lower community sound levels for football games and other events, in comparison with the existing stadium, including:*

  - *The event level/field being set 20+ ft below grade which reduces total building openings through which sound can escape to the community.*
  - *A distributed house sound system within the seating bowl which reduces sound output of the house system compared to the current end zone cluster.*
  - *A canopy above the seating areas provides adequate sound reduction characteristics and reduces the bowl opening through which sound can transmit to the community.*
  - *Enclosures and walls around the seating bowl that further reduces openings in the building and reduces sound emissions to the community.*

  Temporary sound mitigation strategies focusing on the northwest corner of the stadium are being analyzed, including sound curtains and moveable partitions which will have a minimum sound reduction performance of 20 dBA.

  In addition to the permanent architectural elements and temporary measures noted above, multiple operational parameters have been proposed such as:

  - *Ending concerts at 10:00 pm Sunday – Thursday and 10:15 pm Friday – Saturday notwithstanding local ordinances allowing sound until 11:00 on weekend evenings.*
  - *Installation of sound monitoring devices in and/or around the stadium.*

- *Limiting maximum sound levels at the sound board.*

- **Arup Comment:** There is a limited representation of the community through the measured and modeled sound levels. Comparisons are made against only three long-term measurement locations in Evanston, and no locations in Wilmette or potentially impacted areas farther from the Ryan Field site. [See Section 3.1, Items 1-4]

  WJHW Response: *Measurement locations are representative of the areas near the stadium that likely have the greatest (worst case) acoustic impact in the community. As these areas likely have the greatest sound exposure, it is proper to focus on these areas specifically. We note that Arup completed sound measurements in Wilmette indicating ambient LAeq values are between 46 and 52 dBA (which are in excess of the statutory limit of 45 dBA for evening/nighttime) and 58 to 65 dBC.*

- **Arup Comment:** Short-term gameday measurements at additional receptors (9 locations in Evanston, 1 in Wilmette) were conducted for between 30-seconds and 2-minutes each. Gameday activities occurring during these short intervals are not documented (e.g. sound generated by crowd activities or public address announcements), so it is not clear if this measurement period was long enough to accurately represent gameday activity sound. [See Section 3.1, Items 5-6]

  WJHW Response: *All short-term gameday measurements included activity noise from the stadium which was primary public address announcements or fan noise, as noted on page 4 of the report.*

- **Arup Comment:** 3D acoustic / electroacoustic computer modeling of concerts does not include pertinent information including assumptions on the sound system including the number of loudspeaker clusters, music genre which can vary in frequency spectra, and parameters of the modeling inputs including applicable standards if meteorological affects have been considered. [See Section 4.2.1, Item 13]

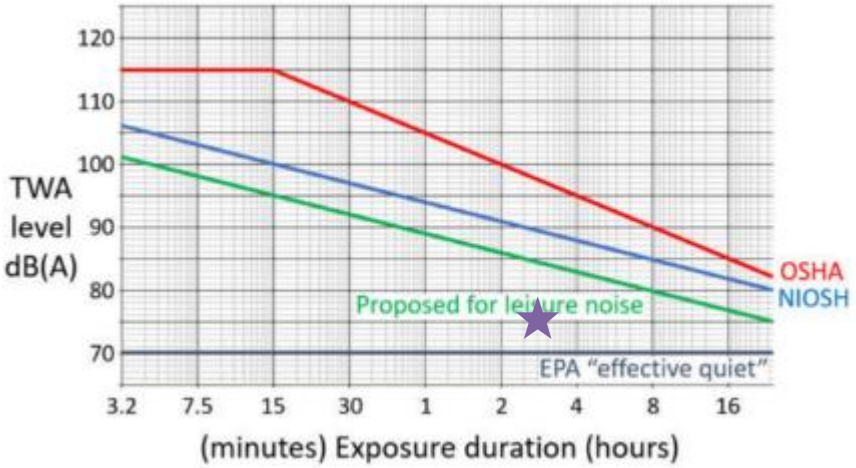
  WJHW Response: *Specifics regarding the concert system/stage setup modeled are listed on page 7 of the report. These include stage set on south end of stadium, line array loudspeakers (4 total), pop/rock music frequency spectrum, and sound level set at 101 dBA at the mix position (100 ft from front of stage). Regarding meteorological affects, the analysis is based on ISO 9613 which describes conditions including an outward wind direction from the noise source(s) - in this instance the stage sound system modelled and "moderate" temperature inversion. ISO 9613 (stated on page 6) is an industry standard for predicting environmental sound and provides a conservative (not extreme) condition for sound propagation. Per ISO 9613, the method describes "the sound propagation from known sound sources under meteorological conditions favorable to sound propagation." Additionally, the distances to the nearest residences are such that the wind and inversion conditions will have a minimal impact at those locations.*

- **Arup Comment:** Other than commentary that gameday and concert sound would be audible, there is no other assessment of noise impact provided beyond general ambient sound level comparisons. Impact on the community in terms of annoyance, or other adverse health effects of noise should be considered. [See Section 4.2.2, Item 21]

  WJHW Response: *The report does not speculate on the perceived discomfort of any particular resident, but rather compares the existing noise environment at the potentially most affected residences and against the quantitative noise regulations, where appliable. Regarding adverse health effects, community sound levels will not create dangerous conditions or result in hearing damage/loss (per OSHA standards for noise exposure). Interference with speech communication may occur in close proximity to the stadium (with the possibility that this may only occur on the University property) and can be further mitigated to the north by the implementation of temporary noise mitigation solutions. Sleep disturbance is limited – if not eliminated – by the agreed event end time of 10:00 pm or 10:15 pm. Cardio vascular, physiological, and mental health issues are related to long term noise exposure which is vastly different than the amount of exposure proposed for concert events (approximately 3 hours per event, 6 days of the year). Annoyance is subjective as, indeed, some in the community have indicated they anticipate deriving a positive experience from the concert count, but it may occur with levels of 55 dBC or greater, and the duration of events limit this impact to a few hours across 6 days a year.*

  Additionally, it should be noted the upper sound limit as shown in the model is representative of a peak condition, and is not anticipated to be consistent.

  It is noted the comparisons to game day events show these impacts are already known/experienced in the neighborhoods and efforts to minimize the sound levels will likely improve the conditions for game days and limit overall impact during concert events.



From International Journal of Environmental Research and Public Health, article "Loud Music and Leisure Noise Isa Common Cause of Chronic Hearing Loss, Tinnitus and Hyperacusis", Pienkowski, 2021

The above graphic indicates sound level limits versus exposure time which result in risk to the community regarding noise exposure. The higher end of predicted sound levels outside the stadium from concerts are up to 75 dBA. These levels at an approximate exposure of 3 hours, as indicated by the ★ above, are substantially below the levels required by OSHA, NIOSH, and the proposed leisure noise levels. Levels below 70 dBA – which encompass the vast majority of the surrounding community – are "EPA Effective Quiet" related to community noise exposure.

- **Arup Comment:** Ambient sound level comparisons are based on broadband dBA levels only. The frequency spectrum of amplified music concerts is significantly different than other ambient sound sources and typically include substantial low-frequency sound energy (125Hz and below) which can be particularly disturbing to the community. Comparisons of predicted music levels with ambient sound should include a more detailed frequency analysis, at a minimum comparing low- frequency sound levels. [See Section 4.2.2, Items 15, 16, & 21]

  WJHW Response: *Anticipated dBC levels were provided in the report on page 9 at the request of the City of Evanston, which include low-frequency sound impact. dBA is specifically used for comparisons as this value is commonly used to describe the relative loudness of sound as perceived by the human ear, and is the most common metric for statutory noise control including the Village of Wilmette and State of Illinois, and many Federal (FHA, FAA, DOT, etc.) agencies. WJHW acknowledges the difference in frequency content between concerts and University football games will be perceptible and reiterates the short duration of the potential impacts.*

- **Arup Comment:** There is no description of planned scheduling and timing of noise-producing concert activities including event setup, soundchecks, the concert event, and teardown. [See Section 4.2.2, Item 22]

  WJHW Response: *Setup of the stage, sound system, lighting and supplemental equipment will typically occur the day before a concert event. Members of the community will observe trucks and buses entering and leaving the underground loading area. The day of the concert will involve completion of setup activities, sound system tuning and sound check activities in the afternoon occurring for 45-60 minutes, and the concert event in the evening. Immediately following the concert event, dismantling of the stage, sound system, lighting and supplemental equipment will commence, and wrap up the following day. Each event is unique in terms of show elements as well as requirements and limitations stated by the venue. All applicable regulations regarding noise and on-site activities/hours will be complied with.*

- **Arup Comment:** Arup observed that ambient sound levels at each location were mostly continuous, with some intermittent road traffic. This means that for the majority of the time, residents perceive a lower ambient sound level than is represented by a time-average metric like L_{eq} used as the basis in WJHW letters. This may be quantified by statistical percentile sound levels.

  WJHW Response: *Leq is used in the establishment of most noise ordinances and Federal regulations. It is the most commonly applied metric for community noise evaluation and regulation. The University team understands sound levels fluctuate across time and realize sound levels will occasionally be above or below the Leq (average) sound level. Additionally, Leq is the industry standard method for determining compliance with statutory requirements for community sound levels, such as the State of Illinois requirements for 1-hour Leq (Illinois Administrative Code, Title 35, Section 900.103 - Measurement Procedures). It is noted that Arup acknowledges that most ambient sound levels are "mostly continuous" and observed average sound levels of 46-52 dBA in the Wilmette neighborhoods. These average levels are above the statutory limits set by Wilmette (45 dBA) and further negate the proposed statistical metrics (percentiles) for base ambient sound levels.*

- **Arup Comment**: Given the concert music sound would be relatively continuous during each set piece, evaluation of concert sound levels within the Wilmette community would be better gauged by comparing the ambient sound levels using a statistical percentile level (e.g. L_{90} – the sound levels exceeded for 90% of the measurement interval) rather than the time-averaged L_{eq} sound level used in the WJHW letters. [See Section 4.2.1]

  WJHW Response: *L90 essentially sets the lower limit of the of the ambient sound field and does not realistically represent the expectation for sound levels within the community. Sound levels exceed these values 90% of the time (54 minutes out of every hour). We understand that there may be particularly quiet moments during a day/evening, but the Leq represents the average and sound level may be at, above, or below this value as sound fluctuates. Further, Leq is the most common metric used by municipalities to describe adverse or disagreeable sound levels within the community and has been found to correlate well with annoyance (Kryter, The Effects of Noise on Man, 1970, pg 310).*

  Arup's contention that concert music is "relatively continuous" is an inaccurate assumption as they contend sound levels should be compared to the lowest sound level perceived in the community, but make no comment on the average sound level perceived (to which, some period of time would exceed these average/Leq values) and presume to argue the community will perceive annoyance based on levels observed only 6 minutes of every hour. While these brief moments may allow sound to be heard more clearly, it is not representative of the entirety of time the concerts will occur.

- **Arup Comment**: From our sound survey of Wilmette locations, L90 ranged from 38-40dBA. The time-averaged sound levels (LAeq) ranged from 46-52dBA which is generally lower than the range quoted in the WJHW letter conclusions ("50-65 dBA" from page 8, paragraph 4). [See Table 1]

  WJHW Response: *Northwestern acknowledges the measurements conducted by Arup on the Village of Wilmette. Henderson did not conduct long term measurements in Wilmette in order to compare directly to the data collected from Arup. The neighborhood noise study conducted by Henderson was continuous from Friday to Sunday at three locations in Evanston in order to capture typical game day sound. It should also be noted that Arup's measurements were taken on a Thursday evening, which is presumably quieter than a weekend with no gameday activity.*

- **Arup Comment**: Based on our observations, we recommend that L90 levels are utilized as the baseline for community ambient sound levels within the residential areas in Wilmette.

  WJHW Response: *L90 describes the lower limit of ambient sound levels. While this may be how low sound could get, it sets an expectation for community sound level that is lower than what is actually perceived on site. Noise fluctuates and expecting community noise sources to occur at levels below 90% of the other/existing community noise sources is unrealistic which is why Leq is also the common standard for statutory requirements and is more appropriate to describe whether an exceedance or violation occurs. WJHW disagrees with this as the only method for comparing concert sound levels to neighborhood ambient levels. Leq is also descriptive of the perceived noise environment.*

- **Arup Comment**: The WJHW letters do not reference any local or regional noise codes or ordinances. Noise ordinances exist for Wilmette, Evanston, and the State of Illinois. Furthermore, the WJHW letters do not propose any criteria to quantitatively assess noise impact. [see Appendix A]

  WJHW Response: *Noted. The noise ordinance for Evanston is a nuisance ordinance (i.e. no set noise level limits) and Wilmette and Illinois include specific dBA or octave band noise limits. The Wilmette sound level limits are 45 dBA and the average ambient – per Arup's measurements – exceed the level limits during the time concerts would occur already. WJHW also notes the State of Illinois limits are based on 1-hour Leqs (further reinforcing the argument to use Leq as the baseline for ambient sound level comparison). It is also noted the levels predicted in the Henderson model are the upper limit of sound level transmitted to the community, meaning the Leq values are likely to fall below the values indicated in the Henderson model.*

- **Arup Comment:** A summary table comparing predicted concert sound levels (according to the WJHW letters) against ambient sound levels surveyed by Arup is presented in Table 1.

Location	Sound Level Measured[9]		Wilmette noise ordinance[10]	Illinois State noise limits[11]	Henderson predicted concert sound level ("with Additional Sound Mitigation" scenario)[12]	Noise codes exceeded? (Y/N)	Ambient sound levels exceeded? (Y/N)
	L_{90}	L_{eq}					
640 Gregory Ave	39 dBA 53 dBC	47 dBA 60 dBC	45 dBA	55 dBA 73 dBC	60-65 dBA 75-80 dBC	Y	Y
624 Isabella Ave	40 dBA 53 dBC	52 dBA 65 dBC	45 dBA	55 dBA 73 dBC	60-65 dBA 75-80 dBC	Y	Y
128 5th St	39 dBA 53 dBC	47 dBA 58 dBC	45 dBA	55 dBA 73 dBC	60-65 dBA 75-80 dBC	Y	Y
6th & Maple	38 dBA 52 dBC	46 dBA 59 dBC	45 dBA	55 dBA 73 dBC	60-65 dBA 75-80 dBC	Y	Y

Table 1: Comparison of predicted concert sound with surveyed ambient sound at Wilmette locations

WJHW Response: *WJHW notes the LAeq values measured by Arup are all above the statutory requirements for the Village of Wilmette. Statute requires sound emissions to not exceed 45 dBA; all ambient Leq values are 46 dBA or above. Statutory limits noted for the State of Illinois are based on 1-hour Leqs (per staff Mr. Anand Rao, 312.814.3956). We reiterate the Henderson model indicates the "worst case" - the upper limit generated from the modelled sound system – for sound levels generated at the stadium and the Leq values will be lower.*

It should be noted that none of the SPLs referenced in this chart exceed any threshold that would be considered harmful or result in a negative impact on health, safety or welfare for an exposure over a three-hour duration, six times per year.

Detailed Comments

Item 1	
Document	WJHW letter 1, Henderson Exhibit, pages 3 and 7
	Henderson Exhibit Tables 1 and 4 include weather conditions during the gameday and non-gameday measurements, based on an internet source. The tabulated "Max Wind Speed" for 5 out of 7 measurements periods is greater than typical 12 mph maximum speed recommended in measurement procedure standards[13,14]. The Henderson exhibit states "Overall, weather had negligible effects on the measurements."
Arup Comment	Provide explanation and additional observations to support the statement that weather conditions had negligible effect on measurements.
WJHW Response	The max wind speed included in the report was the maximum for the day and was not the continuous wind speed. Measured sound levels exceeded the wind induced noise levels reported utilizing the Larson Davis Model EPS2116 Outdoor Microphone Protection, therefore wind was assumed to have a negligible effect. Link to Larson Davis information follows. https://www.larsondavis.com/docs/librariesprovider2/datasheets/ld-eps2116-outdoor-noise-monitoring-microphone-protection-ds-0240.pdf?sfvrsn=c2e4e3c5_18. Additional wind speed and gust information can be accessed from www.wunderground.com for additional context, however, these measurements are not at the specific meter locations.

Item 2	
Document	WJHW letter 1, Henderson Exhibit, page 6
	Long-term ambient sound survey locations do not include receivers in Wilmette, or generally beyond 3 or 4 blocks from Ryan Field
Arup Comment	Supplementary ambient sound surveys including additional neighborhoods to provide better representation of potentially impacted areas.
WJHW Response	The neighborhood noise study locations aligned with the original gameday noise study locations near the stadium.

Item 3	
Document	WJHW letter 1, Henderson Exhibit, page 7
	The non-gameday weekend measurement results in Table 5 are a duplicate of gameday measurements results in Table 2.
Arup Comment	Clarify which table is gameday or non-gameday noise results. Provide the missing table of information.
WJHW Response	Results table was mistakenly duplicated. Table 5 in the Henderson survey has been updated, and attached.

Item 4	
Document	WJHW letter 1, Henderson Exhibit, page 2
	Henderson Exhibit: Long-term measurements of gameday sound levels were conducted in/around Ryan Field parking lots only.
Arup Comment	Conduct gameday measurements at neighborhood locations to document typical gameday activity sound (crowd cheers, public address announcements, etc.).
WJHW Response	Short duration measurements were collected during the gameday noise study at various locations in the surrounding neighborhoods. These measurements included activities described by Arup.

Item 5	
Document	WJHW letter 1, Henderson Exhibit, page 4
	Gameday measurements in neighborhoods were short-duration 30-120s at each location. This measurement duration may be too short to represent gameday activity sound levels.
Arup Comment	Measurements of existing gameday sound in surrounding community should capture range of gameday activity sound (crowd cheers, public address announcements, etc.). Document the gameday activities occurring during measurement intervals. Conduct longer or multiple measurements at each location as required to capture typical range of gameday activity levels.
WJHW Response	Short duration measurements were collected during the gameday noise study. All measurements included activity noise from the stadium which was primarily public address announcements and fan noise.

Item 6	
Document	WJHW letter 1, Henderson Exhibit, pages 4-5
	Only one gameday measurement (30-120 seconds in duration) was conducted in Wilmette. Results for gameday measurements are presented as an aggregate range with no results at individual receptors presented.
Arup Comment	Provide a supplementary gameday activity sound survey which includes additional neighborhoods to provide better representation of impacted areas. Include measurement results for each receiver location.
WJHW Response	Measurements were conducted in neighborhoods with close proximity to the stadium and are representative of those areas which may have the greatest impact from stadium activities.

Item 7	
Document	WJHW letters, pages 2-3
	The comparison of gameday vs. non-gameday activity sound in neighborhoods is based on a mix of different receivers and mix of long-term and short term (60-120 second acquisitions) and comparing broad ranges over multiple receivers.
Arup Comment	To quantify community sound levels due to gameday activities and compare to typical ambient (non- gameday) metrics, measurements of similar duration (longer than the 30-120s duration measurements measured by Henderson), time-of-day, and location could provide a more clear and meaningful comparison. Comparisons should be documented at each position rather than presenting overall aggregate range across all receivers.
WJHW Response	Figures 1 (page 3) and 2 (page 4) show long term measured sound levels during gameday and non-gameday weekends. Measurements are at the same location, have the same time period, and indicate sound levels across the entirety of the day (daytime and nighttime). Gameday and neighborhood noise studies utilized different locations. Studies occurred at different times during the year, but both occurred over the weekend.

Item 8	
Document	WJHW letters, page 3
	WJHW compares surveyed gameday activity sound levels with ambient Leq dBA levels. Figures 1 and 2 also show logged LA90 levels, though these are not referenced or discussed in WJHW's analysis.
Arup Comment	For neighborhoods with intermittent traffic, measured L90 sound levels are a more appropriate representation of the ambient sound conditions. The L90 levels should also be compared against gameday activity sound levels when considering noise impact.
WJHW Response	L90 is the lower limit of the ambient sound level and sets an unrealistic expectation for the fluctuating nature of ambient sound. A full 90% of the sound experienced is above the limit set by L90. Leq is the standard statutory representation of measured sound level in community noise standards, including the State of Illinois.

Item 9	
Document	WJHW letters, pages 3-4
	A description of new stadium design elements is included and is argued that the new build design elements will "be helpful in reducing sound…". There is not sufficient analysis or modeling to demonstrate the gameday sound impact of the new stadium design and the outcomes of each individual and/or combination of elements. There is also no description of the proposed "canopy" with information about the design parameters (e.g. materiality, extent of coverage, etc.).
Arup Comment	Provide additional analysis each of these design elements can offer individually and collectively to clearly illustrate a more quantifiable estimate of outcomes related to sound levels in the surrounding communities. Clarify which of the listed elements (canopy, barriers, absorptive material, etc.) will be included in the stadium design.
Item 9 (revision A)	
Updated Document	WJHW letter 3, pages 5-6
	An additional description has been included (#3, page 6) that describes enclosures and walls around the seating bowl using vertical barriers. It is unclear if this is only a descriptor of elements that had already been included in analysis presented later in the document or a new/updated element of the design that has been incorporated in updated analysis.
Arup Comment	Provide additional analysis each of these design elements can offer individually and collectively to clearly illustrate a more quantifiable estimate of outcomes related to sound levels in the surrounding communities. Clarify which of the listed elements (canopy, barriers, absorptive material, etc.) will be included in the stadium design. Clarify if item #3 – enclosures and walls around the seating bowl – had previously been included in the presented 3D acoustic / electroacoustic modeled results.
WJHW Response	Comparing the individual contribution of each noise isolation element is unnecessary. It is the collective result of all noise mitigation elements which is relevant to the community. The noise mitigation outline in the report (pages 5, 10, and 14) are included in the modelling and the results are representative of the community noise levels anticipated with these items included in the design. Enclosures and walls around the seating bowl have remained consistent throughout the modeling exercise.

Item 10	
Document	WJHW letters, pages 2-3
	Surveyed gameday sound levels are compared with ambient Leq dBA levels. Figures 1 and 2 also show logged L90 dBA levels, though these are not referenced or discussed in the narrative.
Arup Comment	For neighborhoods with intermittent traffic, measured L90 percentile levels are a more appropriate representation of the ambient sound conditions perceived by residents. The L90 levels should also be compared against gameday sound levels when considering noise impact.
WJHW Response	L90 is the lower limit of the ambient sound level and sets an unrealistic expectation for the fluctuating nature of ambient sound. A full 90% of the sound experienced is above the limit set by L90. Leq is the standard statutory representation of measured sound level in community noise standards, including the State of Illinois.

Item 11	
Document	WJHW letters, page 3
	A distributed sound system is described as an element that will be included in the design. The benefits cited with regards to community noise are not unreasonable but are not quantified. No clear statement is made about the use of this system for other events (e.g. concerts).
Arup Comment	Provide analysis that illustrates the benefits of the distributed sound system for gameday community noise. Clarify if this distributed sound system will be used for other events. In our experience, a distributed sound system is likely not viable for large concert sound reinforcement.
WJHW Response	Regarding the concert experience using the distributed system, WJHW's experience shows this can be used - though, often they are not. Should a distributed system be used during a concert, it would be used as fill (as in, filling in the gaps that the stage/main system does not cover). The primary/directional sound would still come from the stage. WJHW has seen house sound systems used in conjunction with the touring rig, specifically in AT&T Stadium (Dallas) and US Bank (Minneapolis).

Item 12	
Document	WJHW letters page 4
	The letter states "We would expect that these design features, combined with lower capacity, will ultimately result in less sound exposure to the residential properties surrounding the stadium compared to the current experience." The argument that lower stadium capacity will not necessarily result in less sound exposure is not correlated with sound level measurements or modeled results. We note that the listed game attendance during the weekend surveyed by Henderson was recorded as 32,123. (https://nusports.com/sports/football/stats/2022/wisconsin/boxscore/19987) which is slightly below the maximum game capacity of the new stadium design of 35,000.
Arup Comment	Statements of sound exposure based on lower stadium capacity design should be made in the context of actual crowd sizes of Ryan Field games in recent years.
WJHW Response	This is a general reference for stadium size (i.e. capacity). WJHW stands by the comment that the design features will result in less sound exposure to the community. The stadium design features provide improvement in noise reduction to the community – regardless of crowd size – as they provide additional barriers to sound transmission. The existing, on grade stadium is essentially wide open. The proposed new stadium includes numerous barriers around the perimeter of the seating bowl, is partially below grade and will have a canopy to limit sound transmission.

Item 13	
Document	WJHW letters, pages 4-7
	Details on input data or methodology for the 3D acoustic / electroacoustic modeled concert sound predictions are not provided. Relevant details include: • Stadium reference design (only 2D plan view shown) • Sound system design and configuration • Frequency spectrum of sound source levels (only overall dBA level at sound mix position is presented). Assumed frequency spectrum has a significant impact on audibility and disturbance in neighborhoods (e.g. whether a reasonable pop/rock, dance/EDM, r&b/hip hop, or other musical genre spectrums are considered) • Modeling standards used (user options within the modeling software). For example, is the 3D acoustic / electroacoustic model based on Cadna's implementation of ISO 9613? Is full 3D sound diffraction implemented? What ground effects are assumed? Does it account for meteorological (atmospheric) effects?
Arup Comment	Provide 3D acoustic / electroacoustic modeling input data and details listed above.
Item 13 (revision A)	
Updated Document	WJHW letter 3, pages 6-7
	Additional details are provided on input data and methodology for the 3D acoustic / electroacoustic modeled concert sound predictions including: • The 3D acoustic / electroacoustic model is based on Cadna's implementation of ISO 9613. It is noted that 'adverse wind conditions in all directions related to the sound source per ISO 9613' have been included. Other environmental factors (e.g. air temperature, humidity, temperature inversions, etc.) have not been included in the model. Have other standards been considered for implementation in the model? • The amplified sound source is noted to be a 'pop music' frequency spectrum. No details of the frequency spectrum are provided in relation to the sound levels set at the sound board location. • Use of a line array sound system is noted as the amplified sound source positioned at 56 ft above the field. Further details of the sound system design and configuration are not provided – just a photograph of an example of a line array loudspeaker – nor any details how Cadna incorporates a amplified sound system into its modeling input. While these details clarify portions of our previous comments, further clarifications would help evaluate the results and conclusions and what limitations of the 3D acoustic / electroacoustic remain.
Arup Comment	Provide additional 3D acoustic / electroacoustic modeling input data and details listed above.
WJHW Response	Stadium is based on the architectural model. Sound system design is based on a generic touring concert sound system and specific inputs are indicated on page 7 of the report. Frequency spectrum is based on a typical pop music concert spectrum. Modeling standards include: • Frequency spectrum utilized was from a previously measured rock concert.

	• Industry Standard: ISO 9613 • Meteorology was not accounted for in calculations. • Ground absorption was not accounted for in calculations. • Lateral Diffraction Setting: some Obj This modelling approach was intentionally conservative as it does not include any event attendees (empty seats included in the model), trees and additional landscaping which will further assist in the attenuation of sound.

Item 14	
Document	WJHW letter 2, pages 5-7
	Concert sound prediction maps are included for two scenarios: A baseline design and a design "with Additional Sound Mitigation" (figures 3-6). While WJHW's narrative describes various noise mitigation options in general, details of noise mitigation design included in Henderson's "Additional Sound Mitigation" scenario are not presented.
Arup Comment	Provide design details for "mitigated scenario" to clarify what each of these design elements can offer individually and collectively. Clarify which of the listed elements will be included in the stadium design to clearly illustrate a more quantifiable estimate of outcomes related to noise.
WJHW Response	The mitigated scenario is the result of closing in locations of the north elevation openings. As the design of the structure continues to evolve, the University is committed to finalizing the investigation of mitigation options which will provide the most benefit to the surrounding community.

Item 15	
Document	WJHW letter 2, pages 5-7
	Concert sound predictions are presented as broadband dBA and dBC results only. No frequency band results, or indication of low-frequency results are provided.
Arup Comment	Consider frequency spectrum of predictions results, especially low-frequency (125Hz and below) impact.
WJHW Response	dBA is the standard to which most municipalities determine acceptability of community noise, including the Village of Wilmette and the State of Illinois. Low frequency sound impact is represented by dBC and was included in the report at the request of the City of Evanston.

Item 16	
Document	WJHW letters, pages 8-10
	The specific nature of concert sound compared to typical or existing ambient sound sources in the environment are not addressed. Amplified concerts typically contain prevalent low-frequency (bass) energy that is often rhythmic. Characterizing concert sound in terms of single broadband dBA sound levels is not sufficient, and sound pressure levels at lower frequencies should be specifically considered. Considerations appropriate for an impact assessment are referenced in environmental noise survey standards, and there is precedent in other noise codes, agreements, and guidance documents.
Arup Comment	Provide a noise impact study that contains specific consideration of characteristics of concert music sounds compared to other existing ambient sound in the community.
WJHW Response	Model images of the dBA and dBC contour maps have been provided to represent noise from concert events.

Item 17	
Document	WJHW letters, pages 5-6
	An argument is made for the shielding effect of Northwestern University buildings to the North as partial justification of North-facing orientation of sound system. However, building shielding appears to benefit a small percentage of Wilmette residential land area as demonstrated in Henderson's 3D acoustic / electroacoustic modeling output.
Arup Comment	Provide further clarification on the level of benefit shielding is providing for community noise from concert events.
Item 17 (revision A)	
Updated Document	WJHW letter 3, page 9
	An argument is made that alternative stage locations do not realize the sound reduction benefits of the building barrier effect of structures to the North of Ryan Field in comparison to those to the South. However, 3D acoustic / electroacoustic modeling is not presented to qualify this conclusion and provide numerical and statistical comparison of the predicted sound levels and the population affected.
Arup Comment	Provide further clarification on the level of benefit shielding is providing for community noise from concert events.
WJHW Response	The benefit of shielding from the University buildings is noted in the report on page 9. In addition to the shielding effect of the buildings to the north, reference Appendix C North Stage Analysis for additional factors which warrant the final stage orientation.

Item 18	
Document	WJHW letters, page 6
	An argument is made that the effects of including structures beyond the Northwestern University property (not included in Henderson's 3D acoustic / electroacoustic model) would result in lower noise levels: "…would limit how far into the residential area sound travels before it reaches ambient levels. The sound levels in the residential community will be lower than at the property line, when factoring in the impact of other structures, distance, directivity, and other factors." There is no analysis or estimate of the difference or at what distance the sound is estimated to be attenuated to ambient (or code required) levels. Buildings also reflect sound and may cause local increases in sound level. Meteorological effects, depending on weather conditions, can result in less attenuation with distance.
Arup Comment	Additional enhancements to the 3D acoustic / electroacoustic model to include residential structures and meteorological conditions should be included to analyze and accurately quantify the predicted sound attenuation with distance.
Item 18 (revision A)	
Updated Document	WJHW letter 3, page 9
	The updated figures illustrate sound levels that differ from previous results, but no discussion is provided why there may be differences. Reviewing the mitigated option (figure 7), items of note include: • Sound levels at various properties to the north have increased from 80 dBC in previous results to 85 dBC • Sound levels to the north within the residential areas are 75 dBC – 80 dBC along the south facing portion of the property. The north side of the property appears to benefit from some 'sound shadowing' with levels typically at 70 dBC *or* 5 dBC lower than the south portion of the property. No discussion is provided on the effects of the meteorological conditions included, what effects additional meteorological conditions may have which have not been modeled, or a statistical analysis of sound levels from the updated model results with the residential structures included.
Arup Comment	Additional enhancements to the 3D acoustic / electroacoustic model to include meteorological conditions should be included to analyze and accurately quantify the predicted sound attenuation with distance in varying conditions. Statistical analysis of the sound levels with/without the inclusion of the 3D modeled structures should be provided to evaluate the outcomes of their inclusion in the 3D acoustic / electroacoustic model.
WJHW Response	Additional residential and community buildings were included in the model per a previous response. Weather conditions can vary substantially - day to day, time of year, and even over an evening. While these conditions can impact sound transmission, the sheer number of combinations would be impossible to model. At this time, ISO 9613 has been used as the baseline as this is the industry standard to utilize when modelling anticipated sound levels.

Item 19	
Document	WJHW letters, pages 4-8)
	There is no description of planned scheduling and timing of sound from concert activities including event setup, soundchecks, the concert event, and teardown.
Arup Comment	Timing of concerts and other sound generating activities associated with concert production should be considered in a noise impact assessment.
WJHW Response	Setup of the stage, sound system, lighting and supplemental equipment will typically occur the day before a concert event. Members of the community will observe trucks and buses entering and leaving the underground loading area. The day of the concert will involve completion of setup activities, sound check activities in the afternoon occurring for 45-60 minutes, and the concert event in the evening. Immediately following the concert event, dismantling of the stage, sound system, lighting and supplemental equipment will commence, and wrap up the following day. Each event is unique in terms of show elements as well as requirements and limitations stated by the venue.

Item 20	
Document	WJHW letters, pages 1,3,4,6, & 8
	The focus of the document is the sound impact of residential properties, but does not address other building and land uses in the community.
Arup Comment	A noise impact study should consider all noise-sensitive uses, including but not limited to, residential, worship, healthcare facilities, education (schools), and outdoor parks and recreation spaces that would potentially be impacted.
WJHW Response	The closest sensitive receivers to the stadium are residential neighborhoods and the majority of our effort has been related to them. There are other sensitive spaces within Evanston and Wilmette that may experience sound impact, but our assessment shows these to have lower overall impact. We have not forgotten about these potential receivers, but the overwhelming concern is with the residential properties closest to the stadium.

Item 21	
Document	WJHW letters, page 1
	The introduction states that the memo "includes comments on the potential impact of sport and concert activities at the stadium on the surrounding communities". The WJHW letter does not make clear statements on noise impact to the community. General statements concerning the audibility of concert and gameday activity sound (that they will be audible) are given. The letter compares limited modeled and measured broadband sound pressure levels without reference to local or regional noise codes, and without interpretation of impact on the community these sound levels may have. The geographical extents of the area studied (measured and modeled) are limited and do not address all neighborhoods that may be impacted.
Arup Comment	A noise impact assessment has not been provided and is recommended.
WJHW Response	The report outlines the study completed for this project. Statements made are representative of the results.

Item 22	
Document	WJHW letters, pages 9-10
	Recommendations for concert sound mitigation include limiting sound levels by implementing sound level limits, noise level monitoring, and limiting hours of concerts. No specific limits are proposed or details of concert event management approaches for activities such as soundcheck, event start, curfew times, and teardown.
Arup Comment	The concert sound mitigation strategies should be developed in more detail and assessed in terms of both feasibility and effectiveness including event management approaches.
WJHW Response	The report describes noise mitigation elements starting on page 5; notably there are multiple permanent items included in the stadium design that are intended to lower community sound levels for football games and other events, in comparison with the existing stadium, including: • The event level/field being set 20+ ft below grade which reduces total building openings through which sound can escape to the community. • A distributed house sound system within the seating bowl which reduces sound output of the house system compared to the current end zone cluster. • A canopy above the seating areas provides adequate sound reduction characteristics and reduces the bowl opening through which sound can transmit to the community. • Enclosures and walls around the seating bowl that further reduces openings in the building and reduces sound emissions to the community. Temporary sound mitigation strategies focusing on the northwest corner of the stadium are being analyzed, including sound curtains and moveable partitions which will have a minimum sound reduction performance of 20 dBA. In addition to the permanent architectural elements and temporary measures noted above, multiple operational parameters have been proposed such as: • Ending concerts at 10:00 pm Sunday – Thursday and 10:15 pm Friday – Saturday notwithstanding local ordinances allowing sound until 11:00 on weekend evenings. • Installation of sound monitoring devices in and/or around the stadium. Limiting maximum sound levels at the sound board.

Item 23 (new item)	
Document	WJHW letter 2, pages 5-7
	Concert sound prediction maps are included for two scenarios: A baseline design and a design "with Additional Sound Mitigation" (figures 3-6).
Updated Document	WJHW letter 3, pages 8-12
	Concert sound prediction maps are included for two scenarios: A baseline design and a design "with Additional Sound Mitigation" (figures 4-7). 3D modelled structures beyond the property line of Northwestern University two to three blocks away have been included. However, no information on the source and currency of the 3D GIS data is noted. A different false color scale step is used in these figures which makes it difficult to compare to the previously published results.
Arup Comment	Provide details for 3D GIS information used. Provide figures with false color map scales equivalent to the previous presented figures (or update previous figures) to allow for direct comparison between modeled results.
WJHW Response	Structures beyond the University's property line were modelled to the following boundaries: Maple Avenue (North), Bryant Avenue (East), Lincoln Street (South) and Broadway Avenue (West). dBA and dBC scale was adjusted to focus on the levels encountered in the model in an effort to minimize confusion caused by the use of similar colors on the previous scale. dBA and dBC data shown in the modeling images can be directly compared as the only adjustment between the two reports was to include the structures outside of the University's property line to the extents noted above.

We appreciate the opportunity to provide the above responses to the comments and concerns raised by Arup.
Regards,

Greg Hughes
Principal

HENDERSON ENGINEERS

Exhibit - Noise Surveys

Two noise surveys were completed on separate occasions in order to assess the existing ambient noise levels during a gameday weekend and non-gameday weekend. The noise surveys were conducted with field calibrated Larson Davis Model 831 Type 1 sound level meters (SLM), each placed inside a weather-tight environmental enclosure. The microphone for each SLM was located in an environmental enclosure with a windscreen. The complete sound measuring apparatus was attached to an arm mount which was installed on a light pole or column along with the environmental kit approximately 10 – 12 feet above the ground.

1. Gameday Weekend

   An environmental noise survey was conducted for a continuous 67-hour period on October 7-10, 2022. See figures below for measurement locations.

Figure 1: Site Map of Measurement Location (Google Maps)

Figure 2: Measurement Equipment Photos

Below is a summary of the weather conditions during the measurement period.

Table 1: Weather Conditions (wunderground.com)

	Weather	Temperature (high / low)	Max Wind Speed
October 7, 2022	Fair	56° / 42°	17 mph
October 8, 2022	Fair	58° / 38°	17 mph
October 9, 2022	Fair	68° / 42°	12 mph
October 10, 2022	Fair	73° / 47°	13 mph

Overall, weather had negligible effects on the measurements.

The following table provides the overall measurement summary. See appendix for definitions.

Table 2: Overall Measurement Summary Results

	Date	Timeframe	L_{eq} "Average" (dBA)	$L_{max,slow}$ "Maximum" (dBA)	$L_{min,slow}$ "Minimum" (dBA)	L10 (dBA)	L90 (dBA)
Meter 1	10/7/2022	2pm - 12am	57.6	97.7	43.6	58.9	46.4
	10/8/2022	12am - 12am	71.8	90.0	42.5	77.4	44.4
	10/9/2022	12 am -12am	55.8	79.3	42.1	59.8	44.3
	10/10/2022	12am - 9am	55.4	85.2	35.8	55.6	44.3
Meter 2	10/7/2022	2pm - 12am	68.5	98.8	47.0	67.3	51.2
	10/8/2022	12am - 12am	71.4	99.1	46.5	76.7	47.4
	10/9/2022	12 am -12am	63.0	99.0	46.4	63.2	47.4
	10/10/2022	12am - 9am	60.2	88.9	40.0	63.8	47.9
Meter 3	10/7/2022	2pm - 12am	60.3	90.3	43.2	60.9	49.7
	10/8/2022	12am - 12am	74.2	89.4	42.2	79.8	44.5
	10/9/2022	12 am -12am	57.3	87.7	41.5	57.7	44.1
	10/10/2022	12am - 9am	58.7	91.3	41.8	60.0	43.0

A. Gameday Noise

1) There were tailgates/parties consisting of amplified music and large groups of people near the location of each sound level meter. The sound levels measured during the game in these locations is inflated when considering the sound level in the neighborhood during gamedays.

Figure 4: Tailgate/Party at South End of West Parking Lot October 8, 2022

2) In addition to the long duration measurements, short duration sound measurements were collected in the surrounding neighborhood to determine the sound level at different locations around the site during the football game. The short duration measurements were collected with a Larson Davis Model 831 Type 1 sound level meter with windscreen and ranged in duration from 30 – 120 seconds. Refer to the following figure for short duration sound measurement locations.

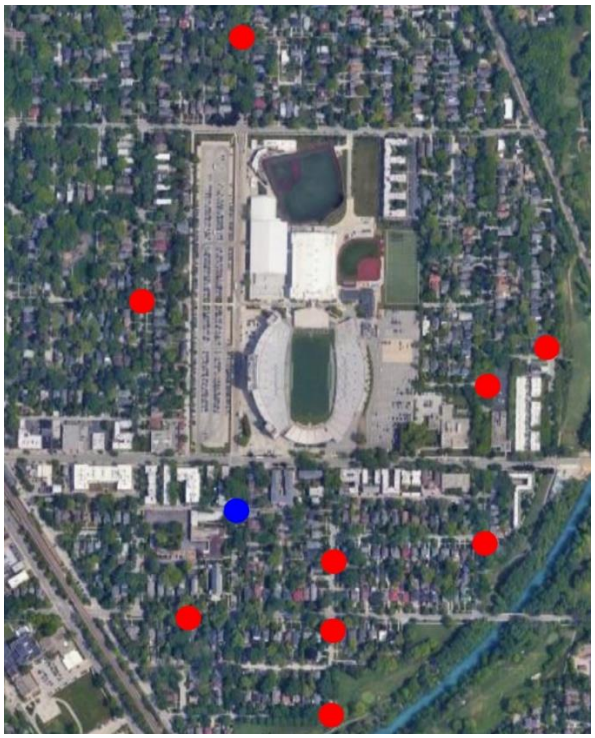


Figure 5: Short Duration Sound Measurement Locations October 8, 2022

3) The LAeq sound levels ranged from 50-65 dBA for the locations shown in red. The LAeq sound level at the blue location was 84 dBA primarily due to the large party at the south end of west parking lot shown in Figure 4.

4) The primary noise source from the football stadium was the sound system, and it was audible at all of the short duration sound measurement locations. Since this is not a consistent noise source, it is not possible to isolate that sound from the other ambient noise such as cars, people, trains, and birds.

5) The main loudspeaker cluster is located at the north endzone and directed to the south. Based on subjective listening and sound levels measured, the sound levels are higher in the neighborhoods to the south than to the north from the stadium sound system. The sound levels from stadium sound system are higher in the neighborhoods to the east than to the west due to the east side of the stadium having a lower height since the pressbox is located on the west side.

2. Non-Gameday Weekend

An environmental noise survey was conducted for a continuous 57-hour period on December 2-4, 2022 during a non-gameday weekend. The sound level meter locations differed from the gameday noise survey, as they were placed in the surrounding neighborhoods. See figures below for measurement location.

Figure 6: Site Map of Measurement Location (Google Maps)

Figure 7: Measurement Equipment Photos

Table 3: Sound Level Meter Locations

	Intersection	
Meter 1	Chancellor St.	Asbury Av.
Meter 2	Lincoln St.	Jackson Av.
Meter 3	Chancellor St.	Eastwood Av.

Below is a summary of the weather conditions during the measurement period.

Table 4: Weather Conditions (wunderground.com)

	Weather	Temperature (high / low)	Max Wind Speed
December 2, 2022	Fair	53° / 36°	23 mph
December 3, 2022	Fair	51° / 21°	26 mph
December 4, 2022	Early Morning Rain	40° / 19°	16 mph

Overall, weather had negligible effects on the measurements.

The following table provides the overall measurement summary. See appendix for definitions.

Table 5: Overall Measurement Summary Results

	Date	Timeframe	L_{eq} "Average" (dBA)	$L_{max,slow}$ "Maximum" (dBA)	$L_{min,slow}$ "Minimum" (dBA)	L10 (dBA)	L90 (dBA)
Meter 1	12/2/2022	10am - 12am	56.4	79.8	45.4	59.1	48.8
	12/3/2022	12am - 12am	53.6	77.4	41.7	56.6	44.4
	12/4/2022	12 am -7pm	65.2	104.3	33.3	56.4	43.1
Meter 2	12/2/2022	10am - 12am	62.3	86.5	41.7	66.7	47.4
	12/3/2022	12am - 12am	60.5	83.0	36.3	65.7	41.6
	12/4/2022	12 am -7pm	66.7	106.5	32.8	66.5	36.0
Meter 3	12/2/2022	10am - 12am	56.5	87.7	40.8	58.4	46.1
	12/3/2022	12am - 12am	52.8	83.9	37.5	55.4	41.4
	12/4/2022	12 am -7pm	64.9	106.3	32.6	55.3	37.4