NORTH PORTLAND
2ND DRAFT NOISE STUDY

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1.0 INTRODUCTION

1.1 Purpose

The North Portland area is a vibrant community, supporting residential populations, a wildlife reserve, and an active commerce. As Portland continues to attract new residents and residential areas expand in North Portland, the conflict between the residential desire for a peaceful environment and the commercial requirement to efficiently conduct business become more critical. The City of Portland chose to study North Portland to better understand noise within its boundaries. The sustainability of the North Portland residential community relies on planning decisions based on a well-defined understanding of the sound characteristics of the community.

The intent of the North Portland Environmental Noise Data Collection and Abatement Recommendation Project was to document the dominant sources of sound and to quantify the levels of sound in the North Portland neighborhood. The resulting noise mapping will serve as a tool for future planning.

1.2 Study Area

The North Portland Environmental Noise Project was a two-year study of community noise in the North Portland area. The geographical area identified for this study is shown in Figure 1 below and is defined as follows:

- Northern boundary: State line
- Northeastern boundary: The Peninsula Slough
- Eastern boundary: North Williams Avenue
- Southern boundary: Northeast Oregon Street
- Western boundary: The Willamette River

Neighborhoods within the North Portland area are diverse, each with unique characteristics forming that community. The study area included the following neighborhoods:

1.2.1 Arbor Lodge

Arbor Lodge is a neighborhood with the eastern boundary formed by I-5. North Lombard Transit Center and North Portland Boulevard stations on the MAX yellow line provide light rail service to the neighborhood, which has encouraged new development in the neighborhood.

1.2.2 Bridgeton

Bridgeton is a neighborhood on a small levee between the Columbia River (North Portland Harbor) and Bridgeton Slough. The community is small and primarily residential including traditional single family homes, townhouses, apartment and condominium complexes. Houseboat moorages line the shore. Bridgeton also has many marinas and marina related businesses. The forty-mile loop bike trail runs through Bridgeton making walking and biking popular activities.

1.2.3 Cathedral Park

Cathedral Park is a neighborhood on the East shore of the Willamette River. St Johns on the northeast and University Park on the southeast border Cathedral Park. A park with the same name is the neighborhood landmark.

1.2.4 East Columbia

East Columbia is a neighborhood in the Northeast section of Portland consisting of a main area west and north of the Sunderland neighborhood and a smaller disconnected section along the Columbia River shore south of Hayden Island and east of Bridgeton. The Columbia Children's Arboretum is located within the community.

1.2.5 Hayden Island

Hayden Island is an island in the Columbia River between Vancouver, Washington and Portland, Oregon. The Washington/Oregon state line bisects the island, the west half in Washington and the eastern portion in Oregon. I-5 connects Hayden Island to the rest of Portland. The east end of the island, often called Jantzen Beach, is a highly developed retail area near the freeway. The east end also includes hotels, offices and condominium complexes. Further east are several houseboat moorages and marinas. West of the retail core are two residential area, additional houseboat moorage and undeveloped land purchased by the Port of Portland in 1983.

1.2.6 Kenton

Kenton is one of Portland's historic neighborhoods. Built by the Swift Meat Packing Company with major development in 1911, the area was annexed by the City of Portland and became the center of West Coast cattle trading. In 1959 Oregon Centennial Celebrations were held in Kenton. A large statue of Paul Bunyon remains as a reminder of this Celebration and is now considered a symbol of the neighborhood.

The channel of the Columbia River that separates this region from Hayden Island forms Kenton's northern border. I-5 forms the eastern boundary and Lombard forms the southern boundary. Portland International Raceway (PIR) and Portland Metropolitan Expo Center are within Kenton boundaries.

The northern section of Kenton between N. Columbia and the Columbia River is zoned industrial. The southern section of Kenton is zoned residential.

1.2.7 Overlook

Overlook neighborhood is located on the eastern shore of the Willamette River. Over half of the land within Overlook is zoned industrial, Swan Island, the Mock's Bottom industrial areas, and Union Pacific rail yards are all technically within Overlook. The residential section of Overlook is a neighborhood of stately homes on the bluff overlooking the Swan Island industrial area and the Willamette and West Hills.

The neighborhood includes the Overlook House, a Tudor residence built in 1927 which sits on more than one acre. The house serves as a community center. The Interstate Firehouse built in 1910 today serves the community with arts education, exhibits and theatre.

1.2.8 Piedmont

Piedmont was originally platted in 1889 and promoted in early marketing flyers as " The Emerald, Portland's Evergreen Suburb, Devoted Exclusively to Dwellings, a Place of Homes." Today Piedmont remains primarily residential.

1.2.9 Portsmouth

Portsmouth is located in North Portland. St. Johns, University Park, and Kenton neighborhoods border it. The community has a charming, small town feel and an active Neighborhood Association.

1.2.10 St. Johns

St. Johns is the largest and most diverse of the studied neighborhoods. It is located on the tip of the peninsula formed by the confluence of the Willamette River and the Columbia River. The western section of St Johns is largely industrial, supporting much of the freight and shipping activity through North Portland. Smith Bybee Lakes and a Wildlife Reserve occupy much of the north section. The south and east section support the residential community. A vibrant commercial corridor is located at the intersection of Lombard and Philadelphia and is referred to as "Downtown St Johns".

St johns is named in honor of one of the first settlers, James John, who is credited with laying out the original 8 block town site in 1865.

The St Johns Bridge is a prominent landmark for the community.

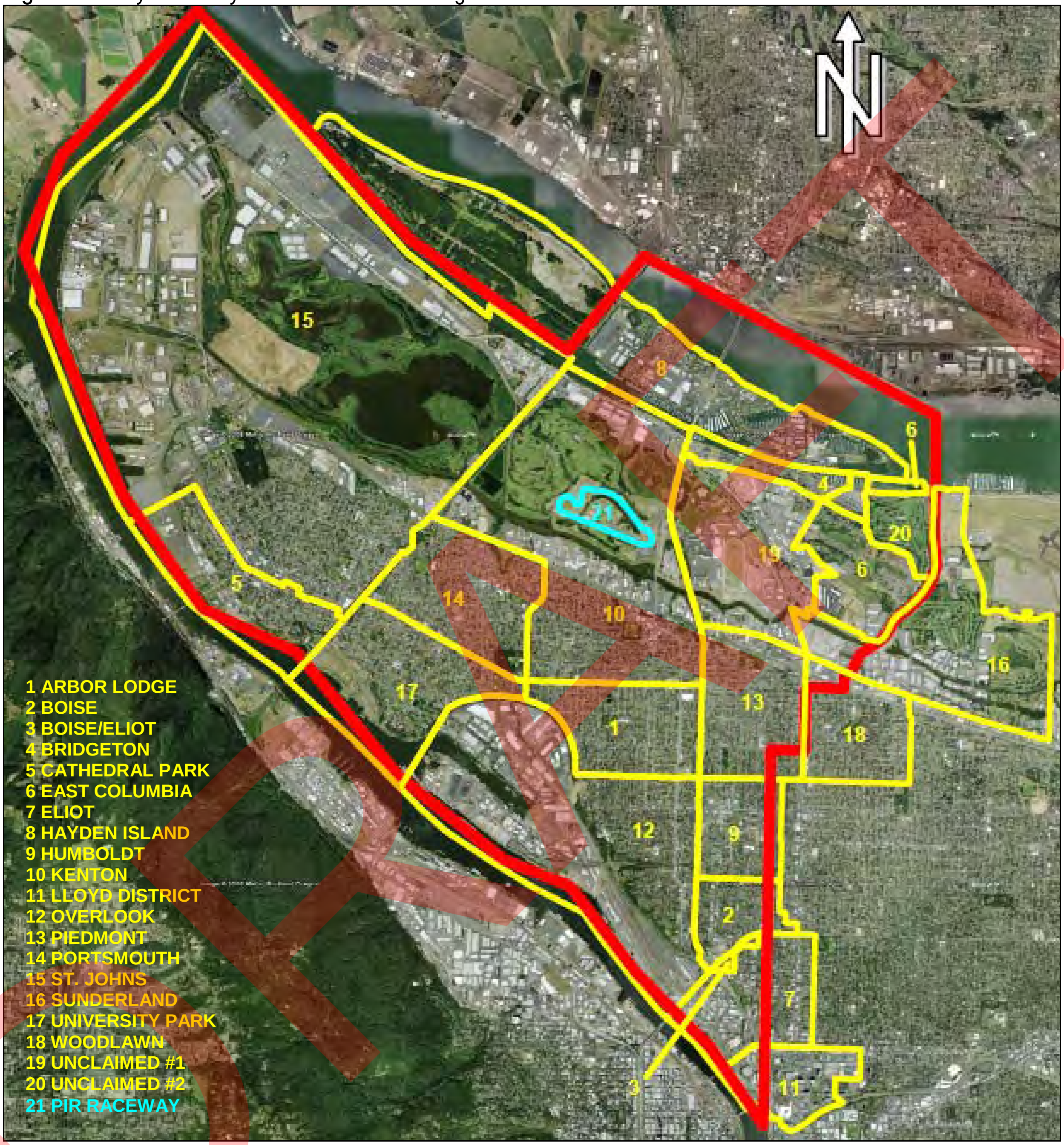
1.2.11 University Park

University Park is a neighborhood on the East Shore of the Willamette River. University Park is home to University of Portland. However, the community was named not for the University of Portland but for its once close proximity to Portland University, a Methodist College in existence in the 1890s.

The study area also encompasses portions of the following Northeast Portland communities:

- Boise
- Eliot
- Humboldt
- Lloyd District
- Sunderland
- Woodlawn

Figure 1. Study Boundary and North Portland Neighborhoods



Source: Google Earth™, City of Portland

Table 1. North Portland Neighborhood Details

Neighborhood	Area (square miles)	Population	Population Density (persons per square mile)	Households	Average Household (persons)
Arbor Lodge	0.87	6,065	6,981	2,573	2.36
Boise	0.43	3,119	7,253	1,168	2.67
Bridgeton	0.28	593	2,133	306	1.94
Cathedral Park	1.02	3,033	2,964	1,361	2.23
East Columbia	0.69	753	1,090	282	2.67
Eliot	0.84	3,299	3,927	1,500	2.2
Hayden Island	1.69	2,130	1,260	1,224	1.74
Humboldt	0.55	5,061	9,202	1,921	2.63
Kenton	3.42	6,934	2,025	2,707	2.56
Lloyd District	0.16	-	-	-	-
Overlook	3.31	6,093	1,839	2,462	2.47
Piedmont	0.96	6,427	6,685	2,518	2.55
Portsmouth	1.09	8,304	7,627	2,866	2.9
St. Johns	11.02	11,346	1,029	4,147	2.74
Sunderland	1.88	607	323	62	9.79
University Park	1.20	5,250	4,386	1,692	3.1
Woodlawn	0.73	4,889	6,697	1,854	2.64
Unclaimed #1	0.44	-	-	-	-
Unclaimed #2	0.09	-	-	-	-

Source: City of Portland (Census 2000)

1.3 Scope

North Portland residents and City officials previously identified the following as primary sound sources in the community:

- Portland International Raceway (PIR)
- Railways
- Arterial cargo truck noise in residential neighborhoods
- I-5 traffic
- Airplane activity at Portland International Airport (PDX)

PIR is a unique source of sound within this community due to the seasonal events and the wide variety of vehicles and types of races each with unique sound signatures. Sound levels also vary throughout the race depending on the vehicle location on the track. Noise complaints are more frequent for PIR events when compared to other community sound sources. Therefore, a major focus of this study was on sound associated with PIR events in an attempt to correlate data from track-side monitoring positions with resulting community sound levels.

Many hours of sound level measurements were taken to document sound levels associated with various events throughout the community. These measurements established that the multiple noise sources in North Portland and the interaction of sources, often one masking another, made study of any one source difficult and directed the study toward computer noise mapping for this community. Each sound source was analyzed without influence from other sources through a computer noise model. The results of model show predicted sound level contours for each sound source in a variety of conditions. The measured data was used as the ground truth sampling for model calibration.

2.0 SUMMARY

Community noise is defined by the World Health Organization (WHO) as "noise emitted from all sources except noise at the industrial workplace. Main sources of community noise include road, rail and air traffic, industries, construction and public work, and the neighborhood."

In 1999, WHO developed guidelines for community sound levels. WHO reported that in outdoor living areas, average daytime sound levels of 50-55 dBA were considered moderately to seriously annoying, and average exterior nighttime sound levels over 45 dBA contributed to sleep disturbance.

The acoustical environment of any residential neighborhood is a complex blend of sounds, not only in level but also in frequency content and tonal character. The audible range of human hearing is between 20 Hz and 20,000 Hz for young, unimpaired listeners. However, the human ear is less sensitive to higher and lower frequency sounds falling outside the range of speech and has a frequency response that is dependent on the overall level of the listening environment. A filtering system which discounts the low frequency bands and the very high frequency bands was developed and is typically applied to spectral data to simulate the human response to the sound levels. The filter is typically referred to as A-weighting. Sound levels with the filter or weighting system applied are referred to as dBA. All levels in this report assume an A-weighting unless otherwise noted.

Adverse health effects have been noted with individuals exposed to high levels of noise. However, hearing damage is not likely unless exposure to levels over 75 dBA occur with prolonged daily noise exposure.

The typical social consequences of a noisier environment are:

- Speech intelligibility
- Sleep disturbance

Speech interference is influenced by the signal to noise ratio, or the level of the voice of the talker compared to the level of the background sounds. For good speech intelligibility, the speech should be 15-dBA louder than the background. Environmental sounds may also mask other important signals such as doorbells, telephone conversations, alarm clocks, and safety warning devices.

Sleep disturbance is another major environmental effect. The difference in sound level between the ambient condition and the noise event will determine the level of disturbance. Although, as a general rule, assuming typical nighttime background sound levels in a bedroom of around 30 dBA (interior), a noise event with a resulting level of 45 dBA (interior) would begin to cause a disturbance in sleep patterns. The probability of a disturbance increases with the number of events during the sleep period.

Sound levels vary widely throughout the North Portland Study area depending on the proximity of the neighborhood to the noise source. Wind and other atmospheric conditions also influence noise levels, increasing the noise levels in some communities and decreasing it in others.

This study has attempted to delineate the noise characteristics associated with the various sources present.

2.1 Portland International Raceway (PIR)

Race activity from PIR is audible, at some level, throughout North Portland. It is interesting to note, however, that in the communities of Kenton, Portsmouth and northeast St. Johns, where the actual sound levels from the race activity are highest, sounds from traffic along the freight corridor of North Columbia Boulevard mask much of the race sound at locations near the roadway. However, the study found, through measurement and modeling, that sound levels from PIR race activity were occasionally over Code limits for both drag and open wheel formula one style cars in sections of Kenton. No Code exceedances were identified for drag events that were within with the nighttime trackside limit of 90 dBA.

Figure 2. PIR Late Night Drag Nighttime Broadband Residential Code Exceedance Areas for 90-dBA Trackside Event, No Meteorology

Source: The Greenbusch Group, Cadna/A

Figure 3. PIR Late Night Drag Daytime Broadband Residential Code Exceedance Areas for 105-dBA Trackside Event, No Meteorology

Source: The Greenbusch Group, Cadna/A

The general differences between the Wednesday and the Friday night drag races are the vehicle type. Wednesday night races tend to offer a mix of classic 1960's and 70's muscle cars, while the Friday night drag focuses on smaller 4 cylinder foreign import cars. These smaller displacement engines are notably quieter than the larger 8 cylinder engines found more prevalent on a Wednesday night.

The reduced sound levels of the smaller type of vehicle have permitted the Friday Drag races to operate past 10 p.m. and still meet the more restrictive permissible nighttime decibel levels as defined in Title 18.10.010 of the City Code. The Noise Control Office has noted that the drag races on Fridays have been able to operate with a minimal number of concerns or complaints from the public. As a matter of clarification, the Friday night drags were created to help get young people off of public with unsanctioned and illegal drag racing and the resulting accidents. The innovative program has not appeared to be a problem for the North Portland communities because the smaller engines are quieter than the with larger size engines traditional at racetracks.

General non-varianced full race track modeling identified City Code exceedances in Kenton, Portsmouth and Bridgeton.

Figure 4. PIR Full Track Race Daytime Broadband Residential Code Exceedance Areas for 103-dBA Trackside Event (10 vehicles), No Meteorology

Source: The Greenbusch Group, Cadna/A

Considering the absolute worst case condition of a 115 dB varianced race (113 dB black flag) and assuming that every car on the track took advantage of the variance, City Code exceedance is possible in Kenton, Portsmouth, St Johns, Arbor Lodge, Piedmont, University Park, Bridgeton, East Columbia and Hayden Island neighborhoods.

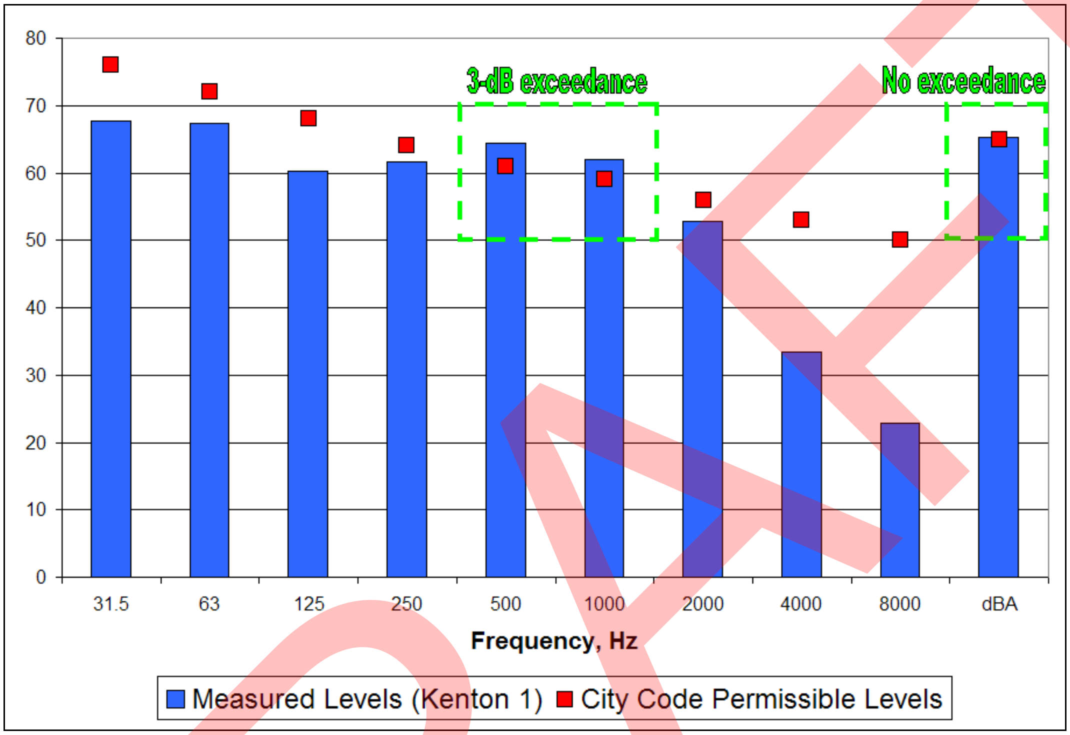
Wind and atmospheric conditions will also alter and shift the noise footprint. This shift may expand the number of homes and neighborhoods experiencing sound levels above City Code limits.

Figure 5. PIR Full Track Race Daytime Broadband Residential Code Exceedance Areas for 113-dBA Trackside Event (10 vehicles), No Meteorology

Source: The Greenbusch Group, Cadna/A

It was also discovered, through measurement of the spectral content, that in some cases where the overall A-weighted value was within City Code limits, the octave band sound levels exceeded octave band City Code limits in some mid frequency bands. The most common range for the exceedance was between 500 Hz and 1000 Hz. An example of this measured condition is presented in Chart 1 below.

Chart 1. NHRA Late Night Drag Event (09/01/07 7:48:56 p.m.), Broadband and Octave Band Code Compliance Assessment, L_{max} dBA re: 20 μPa



Source: The Greenbusch Group, City of Portland

2.2 Railways

The train whistle was documented as the most intrusive sound source in the residential neighborhoods of Kenton, Portsmouth and Cathedral Park. It was also the source most likely to cause sleep disturbance.

According to a recent environmental noise publication by the World Health Organization (WHO), "Guidelines for Community Noise," sleep is generally disturbed when more than 10-15 events cause the interior maximum sound level to exceed 45 dBA during one nighttime period. Typical residential construction affords approximately 25 dB of noise reduction for exterior noise sources. Therefore, the threshold for sleep disturbance could be extrapolated to 15 events exceeding 70 dBA at the exterior of the residence. This extrapolation assumes that the interior ambient sound level in the home is much less than 45 dBA. In warmer weather, the potential for open bedroom windows reduces the noise reduction afforded by the structure to approximately 15 dBA. This reduces the allowable exterior level to 60 dBA in order to maintain the interior 45-dBA maximum.

Measured sound pressure levels of the train horn event in Kenton were over 103 dBA. This would likely result in levels in the high 70s dBA inside the residence assuming that the windows were closed. With windows open the interior level would increase to the high 80's dBA.

Sound levels measured in a Cathedral Park residence with the windows open, resulted in levels in the mid 70's dBA. Closing the windows would likely reduce the level to within the mid 60's dBA, still far above the WHO identified criteria of 45 dBA.

2.3 Freight Corridors

Sound levels associated with the traffic noise along the freight corridors of N. Columbia Boulevard, North Lombard and North Going exceed Federal Highway Administration (FHWA) criteria of L_{eq} 67 for Noise Abatement and the US Department of Housing and Urban development (HUD) criteria of L_{dn} 65 for Site Acceptability.

Along North Columbia Boulevard, in the St. Johns neighborhood, 76 residences (76%) exceed the L_{eq} 67 criterion. In Portsmouth and Kenton, 30 residences (34%) exceed criteria. Along North Lombard Street, in Cathedral Park and St. Johns, 72 residences (98%) exceed criteria, and in University park and Portsmouth, 29 residences (100%) exceed criteria. Along North Going Street in Overlook, 17 residences (26%) exceed criteria. See Section 7.2.3 for expanded analysis results.

For planning purposes, new development along these corridors should be carefully considered.

2.4 I-5 Traffic

The I-5 corridor passing through North Portland is currently undergoing renovation. The Oregon Department of Transportation (ODOT) is addressing noise issues. No further study of the source was undertaken.

2.5 Portland International Airport (PDX)

Noise issues surrounding flight activity from PDX have been studied exhaustively under other contracts. The flight patterns are concentrated along the Columbia River where direct overflights of occupied areas are minimized. The Federal Aviation Administration (FAA) considers lands in the DNL 65 or greater noise zones to be impacted and eligible for mitigation. Reviewing the predicted noise contours published by PDX, no community within North Portland falls within this zone. No further study was undertaken.

3.0 TERMINOLOGY

The auditory response to sound is a complex process that occurs over a wide range of frequencies and intensities. Decibel levels, or “dB,” are a form of shorthand that compress this broad range of intensities with a convenient numerical scale. The decibel scale is logarithmic. For example, using the decibel scale, a doubling or halving of energy causes the sound level to change by 3 dB; it does not double or halve the sound loudness as might be expected.

The minimum sound level variation perceptible to a human observer is generally around 3 dB. A 5-dB change is clearly perceptible, and an 8 to 10 dB change is associated with a perceived doubling or halving of loudness. Common sound pressure levels are reported below in Table 2.

3.1 Definitions

- ***Inequality, < or >***

  A mathematical inequality is a symbolic representation of the relative size of two values. In the statement “a < b”, the value of “a” is less than the value of “b.” In the statement “a > b”, the value of “a” is greater than the value of “b.”

- ***Sound Power Level, PWL***

  The term sound power is the amount of energy per second generated by a source, measured in watts. Sound power is independent of distance, path or influence from any nearby surfaces.

- ***Sound Pressure Level, SPL***

  Sound pressure level correlates with what is heard by the human ear. SPL is defined as the squared ratio of the sound pressure with reference to 20 μPa (noted “dB re: 20 μPa). Sound pressure is affected by distance, path, barriers, directivity, etc.

- ***A-weighted Sound Pressure Level, dBA***

  The human ear is less sensitive to higher and lower frequency sounds falling outside the range of speech and has a frequency response that is dependent on the overall level of the listening environment. Sound level meters and monitors utilize weighting systems to approximate human perception of sound. Measurements made utilizing the weighting system designed to simulate the perception of human hearing at medium to high levels are referred to as “A weighted” and are called “dBA”.

- ***Equivalent Sound Pressure Level, L_{eq}***

  Leq is the A-weighted level of a constant sound having the same energy content as the actual time-varying level during a specified interval. L_{eq} is used to characterize complex, fluctuating sound levels with a single number. Typical intervals for L_{eq} are hourly, daily and annually.

- ***Percentage Sound Level, L_n***

  L_n is the sound level that is exceeded n percent of the time; for example, L_{08} is the level exceeded 8% of the time. L_{25} is the sound level exceeded 25% of the time.

- ***Minimum Sound Level, L_{min}***

  L_{min} is the minimum recorded root mean square (rms) A-weighted sound level for a given time interval or event.

- ***Maximum Sound Level, L_{max}***

  L_{max} is the maximum recorded rms A-weighted sound level for a given time interval or event.

- ***Day-Night Sound Level, L_{dn} or DNL***

  L_{dn} is the L_{eq} measured over a 24-hour interval, with sound levels occurring between 10:00 p.m. and 7:00 a.m. penalized by 10 dBA to reflect greater potential for disturbance. The nighttime penalty is imposed where sleep interference is a consideration. The L_{dn} has been found to have a close correlation with community response to noise.

- ***Ambient Sound Pressure Level***

  A sound pressure level that describes the average sound environment at a specified location during a specified time period including contributions from all sound sources, both local and distant, excluding specific sources of interest or under investigation. The L_{eq} descriptor is often accepted by jurisdictions as representative of the ambient sound level.

- ***Background Sound Pressure Level***

  A sound pressure level that describes the average sound environment at a specified location during a specified time period including contributions from all continuous sound sources, both local and distant, exclusive of extraneous events, such as aircraft, intermittent traffic, animals, people, etc. The L_{90} descriptor is often accepted by jurisdictions as representative of the background sound level.

- ***Signal to Noise Ratio, S/N***

  The Signal to Noise Ratio is the difference in sound pressure level, in dBA, between the source under investigation and the ambient noise level. The difference between these levels is useful for determining contributions of ambient noise level during a measurement period. The larger the S/N, the more prominent the sound source becomes.

Table 2. A-weighted Levels of Common Sounds

Sound	Sound Pressure Level[1]	Approximate Relative Loudness[2]
Jet Plane @ 100 feet	130	128
Rock Music with Amplifier	120	64
Thunder, Danger of Permanent Hearing Loss	110	32
Boiler Shop, Power Mower	100	16
Orchestral Crescendo at 25 feet	90	8
Busy Street	80	4
Interior of Department Store	70	2
City of Portland Daytime Permissible Level (Industrial to Residential)[3]	65	1-1/2
City of Portland Nighttime Permissible Level (Industrial to Residential)[3]	60	1
Ordinary Conversation @ 3 feet	60	1
Quiet Car at Low Speed	50	½
Average Office	40	¼
City Residence, Interior	30	1/8
Quiet Country Residence, Interior	20	1/32
Rustle of Leaves	10	1/64
Threshold of Hearing	0	1/128

Source: US Department of Housing and Urban Development, Aircraft Noise Impact Planning Guidelines for Local Agencies, November 1972.

1. dBA re: 20 μPa
2. As compared to ordinary conversation at 3 feet.
3. City of Portland Code Section 18.10.010 – Land Use Zones

4.0 APPROACH

4.1 Noise Surveys

Grove Insight, under the direction of the City of Portland's Office of Neighborhood Involvement, conducted two community surveys in an attempt to identify and characterize community opinion related to current environmental noise conditions in the North Portland area.

The initial survey, "Views of Noise Sources in North Portland Neighborhoods" polled 300 North Portland residents in May 2006. A follow-up survey, "Identifying and Addressing Noise Problems in North Portland Neighborhoods" polled 300 additional residents in September 2006.

The goal of the surveys was to gauge community response to each of the study sound sources within the various neighborhoods. The survey results were intended to identify study focus areas by correlating study sound sources and affected neighborhoods. The first survey resulted in fairly global opinions from North Portland as a whole. It was agreed that standard surveying methodology did not lend itself well to the level of data resolution needed to be useful for this study.

A second set of survey questions was generated with input from the City and Greenbusch. The second survey attempted to correlate the level of concern for each of the study sources with a more precise geographic location identified by cross streets of the respondent. The results of the second survey offered more useful information. However, the useable sample set was reduced significantly, as only 52% of the respondents were willing to report their geographic location. The survey results were still considered too broad and in some cases the conclusions seem unrealistic. For example, Kenton showed a lower percentage of those who consider truck noise a serious issue even though the Columbia freight corridor runs along the perimeter of this neighborhood. Further review of the survey participants revealed that no resident living along the trucking corridor was included in the survey sample set.

The survey data was to have been a vital component to guiding the study and determining noise measurement focus areas. Unfortunately, neither survey clearly correlated specific noise sources with neighborhood impact.

In response to the lack of guidance provided by the surveys, the noise study continued to include all of the previously identified noise sources with an emphasis on PIR. The extent of potential noise impacts for each neighborhood were assessed based on sound exposure levels for the various sources compared with ambient levels.

4.2 Data Collection

The data collection period took place between June 2006 and September 2007. Each source was documented in a variety of scenarios and geographic locations to provide a meaningful baseline to ground-truth and calibrate the computer noise modeling. Ambient sound levels were also documented for community impact assessment.

4.3 Historical Data

The North Portland Noise Data Collection Project and Study was the result of concerns from the Portland City Council, and in particular from City Council person Sam Adams that residents in North Portland may have a disproportional number of excessive noise sources located in this section of the City. It appears that like many socio-economically middle class or rapidly gentrifying areas of the United States that the North Portland region the City does in fact have many noise pollution sources to discuss. Another portion of this discussion on sources in North Portland also needs to recognize the improvements in the sources of noise that have disappeared over the last few years.

In terms of a few sources that we learned are no longer impacting the community, the following should be recognized as past sources that inform the concerns of North Portland residents. Historically, citizens have raised the issue that projects with noise as a primary function are located or considered for location in their section of the City.

A few years ago the Portland Meadows horse racetrack was a source of loud rock concerts for tens of thousands of fans throughout the summer. The concerts were a source of complaints throughout the North Portland area radiating in all directions from the concerts. Complaints were received from surrounding neighborhoods and Hayden Island. The Noise Control Office reports that the concerts included heavy bass radiating in all directions from the main stage and monitor speakers.

In recent years, a case was brought before a City of Portland Code Hearings Officer to evaluate the legality of the concerts. The review from the Code Hearings Office determined that the property owner and the promoter had a historic record of approval to continue with one concert a year. Over the last 5 or 6 years virtually all activities related to concerts at the venue have ceased. The impact and series of complaints from this particular concert based source of complaints disappeared with the findings and determination from the City's Code Hearings Officer that put limits on the use of the property as a concert venue.

There were also two other proposals on the table over the last 8 years to build additional concert venues in North Portland. One came from Paul Allen and his development entities in the Northwest. Mr. Allen and his associates were seeking to build an outdoor amphitheater in the center of the Portland International Raceway track. The venue was planned to be at 18,000 seats or larger. The project did not receive approval from the Portland City Council and was not built.

In a similar time frame that the PIR amphitheater project was explored, the METRO Council was contemplating changes to their Expo Center property. The Metro Councilors were interested in developing their own amphitheater project at the Expo Center. The project was received by North Portland residents as poorly as the PIR amphitheater project was and did not get far enough for METRO Councilors to approve any specific development plans.

One other automotive raceway previously existed in the North Portland region on the Northeastern edge of the Portland Meadows horse racetrack. This smaller regional race facility was called the Portland Speedway. It operated for 77 years and closed officially in January 2002. The Portland Speedway operators did not receive a renewed lease from the property owner. The Noise Control Officer reports that over the years the community had been confused as to exactly which track was creating the raceway noise they were experiencing. The loss of the Portland Speedway makes dealing with complaints from automotive raceways easier for the City to address any changes.

While several of the past concerns of noise sources have improved over the years the North Portland area today has a list of ongoing and significant sources. A few of the sources overlap each other creating a complex array of noise emanating to households in the community.

The study offers more information on the following: noise from the Portland International Airport, rail corridor noise in the study area with a focus on train whistle concerns, roadway cargo vehicle or truck related impacts from the Rivergate industrial region, a variety of sources at Portland International Raceway; and noise from the regional highways in the study area. A strong focus has been placed on the issues that have received limited study in the past, as well as a focus on the issues that the City has the greatest ability to make changes to through legal and/or long term planning approaches.

4.4 Noise Model

In large areas such as the region defined in the North Portland Noise Data Collection Project, computer modeling is a necessary approach to help predict the anticipated sound levels. It would be cost prohibitive to collect actual sound level readings throughout the entire study area. “Ground Truthing” is the concept of collecting measured sound level data and comparing it to the predicted sound levels from the model. Using “Ground Truthing” the outcome of a given modeling approach can be tested for accuracy. Corrections can be made to calibrate the model to agree with measured data points.

Modeling has been used successfully for many years for a variety of forms of pollution. For over twenty years, air pollution models have allowed environmental scientists to predict the exposure to the public. In the case of a hazardous materials, it has allowed emergency response professionals to accurately predict the direction an air pollution plume is travelling. Regions in the path of exposure can be evacuated, protecting the public. Noise modeling is an emerging technology and will improve in the coming years as more US cites adopt the system for their long range planning efforts. In large cities in the European Union, noise mapping is a mandated planning tool and approach.

5.0 SOURCES

5.1 Portland International Raceway



5.1.1 Variety of Races

There are wide arrays of races that occur at the Portland International Raceway. The races range broadly including:

- Drag racing
- Motocross motorcycle racing
- Open wheel formula one style cars

5.1.1.1 Drag Races

There are general differences between the Wednesday and Friday night drag races. Generally, the Wednesday night races tend to offer a mix of classic 1960's and 70's muscle cars, while the Friday night drag races attract a younger crowd that focuses on tuning smaller 4 cylinder foreign import cars. These smaller displacement engines are notably quieter than the larger 8 cylinder engines found more prevalent on a Wednesday night.

The sound levels of the 4 cylinder engines have characteristic sound signatures with a dominant higher frequency or "pitch" to their sound. The higher frequency sounds degrade more rapidly before reaching the residences in the area.

5.1.1.2 Motorcycles

There are differences in sound characteristics between individual motorcycles that race at the track. The Noise Control Officer, Paul van Orden, has noted that in the past he has listened to and evaluated a variety of motorcycles race types in the community. His observations have shown that in the Kenton neighborhood, motorcycles produce higher pitched sounds that have a tonal quality that one might compare to the buzzing of bees or to a leaf blower. The tonal quality of these vehicles is frequently perceived as irritating and helps to support one of the community concerns that neighbors have raised in past public meetings. The comments that the problem is not solely about decibel levels but also includes the tonal qualities of the sounds from the raceway emanating to residences in the community is supported by this finding.

This study has collected data to begin exploring spectral (specific pitch) sound levels to define the tonal characteristics of a variety of races at PIR. It is important to note that each race type offers its own unique sound signature in the same sense as a fingerprint has its unique characteristics. The goal of this study was to better understand the individual characteristics of the races at the track and to prepare any recommendations for future abatement that will best address the greatest number of race types at the facility.

5.1.2 Regulations

The Oregon Department of Environmental Quality (DEQ) defined maximum allowable noise levels for motor sports racing vehicles within Oregon State as follows:

> *"(c) Sports Car Racing Vehicle. No motor sports facility owner and no person owning or controlling a sports car racing vehicle shall cause or permit its operation at any motor sports facility unless the vehicle is equipped with a properly installed and well-maintained muffler and noise emissions from its operation do* ***not exceed 105 dBA at trackside****;*
>
> *(d) Closed Course Motorcycle Racing Vehicle. No motor sports facility owner and no person owning or controlling a closed course motorcycle racing vehicle shall cause or permit its operation at any motor sports facility unless the vehicle is equipped with a properly installed and well-maintained muffler and noise emissions from its operation do* ***not exceed 105 dBA*** *at trackside or 105 dBA at 20 inches (.5 meter) from the exhaust outlet during the stationary measurement procedure;"*
>
> *Oregon Administrative Rules Chapter 340 Division 35 Section 40*

Noise exposure from Portland International Raceway (PIR) is governed by the City of Portland Noise Code as follows:

> *"For purposes of determining permissible sound levels of motor vehicle racing only, the Portland International Raceway shall be deemed an industrial land use zone of source, which use was in operation before January 1, 1977. Sound levels generated by any other use of the Portland International Raceway shall meet the standards defined in 18.10.010 A., Figure 1."*
>
> *City of Portland Code Section 18.10.050 – Motor Vehicle Racing Events*

Generally, permissible sound levels are determined by the land use zoning of the parcel generating the sound exposure and the parcel receiving the sound. Permissible code levels are shown in Table 3 below.

Table 3. City of Portland Permissible Daytime Sound Levels, dBA re: 20 μPa

Zone Category of Source	Zone Category of Receiver (measured at property line)			
	Residential	Open Space	Commercial	Industrial
Residential	55	55	60	65
Open Space	55	55	60	65
Commercial	60	60	70	70
Industrial	65	65	70	75

Source: City of Portland Code Section 18.10.010 – Land Use Zones

Adjustments are applied for various conditions as follows:

> *"1) During night hours, the sound levels of [Table 3 above] shall be reduced by 5 dBA.*
>
> *2) During all hours, the sound levels of [Table 3 above] shall be decreased 5 dBA for narrow band or steady sound (apply 1 only).*
>
> *3) The adjustments provided herein are cumulative."*
>
> *City of Portland Code Section 18.10.010 – Land Use Zones*

Corresponding nighttime permissible levels between the hours of 10 p.m. and 7 a.m. are shown in Table 4 below.

Table 4. City of Portland Permissible Nighttime Sound Levels, dBA re: 20 μPa

Zone Category of Source	Zone Category of Receiver (measured at property line)			
	Residential	Open Space	Commercial	Industrial
Residential	50	50	55	60
Open Space	50	50	55	60
Commercial	55	55	65	65
Industrial	60	60	65	70

Source: City of Portland Code Section 18.10.010 – Land Use Zones

In addition to broadband permissible levels defined above, the City of Portland Code has assigned permissible octave band sound levels correlating with permissible broadband sound levels. Satisfaction of both broadband and octave band permissible sound levels are required by Code as follows:

> *"Octave-band measurements shall be compared to the appropriate values indicated in Figure 2 for equivalent permissible dBA land use values; octave-band sound pressure in excess of these standards shall be considered evidence of a violation of this Title."*
>
> *City of Portland Code Section 18.10.010 – Land Use Zones*

City of Portland permissible octave-band sound levels are shown in Table 5 below.

Table 5. City of Portland Permissible Octave Band Sound Pressure Levels, dB re: 20 μPa

Permissible dBA Sound Level	Octave Band Center Frequency, Hz								
	31.5	63	125	250	500	1000	2000	4000	8000
45	64	58	51	46	42	39	36	33	30
50	65	62	56	50	46	43	40	37	34
55	68	65	61	55	52	49	46	43	40
60	72	68	64	60	56	54	51	48	45
65	76	72	68	64	61	59	56	53	50
70	79	76	72	69	66	64	61	58	55
75	82	79	76	73	71	69	66	63	60

Source: City of Portland Code Section 18.10.010 – Land Use Zones

Given that the City of Portland Code considers PIR an industrial zone of source, permissible residential sound exposure levels would be **65 dBA** during daytime hours and **60 dBA** during nighttime hours.

To aid in compliance monitoring for both City and State regulations, general trackside noise level limits were established. A permanent sound monitor was installed 50 feet from the southern track straightaway and is maintained by the City of Portland. General noise level limits at this location are presented in Table 6 below.

Table 6. General PIR Sound Pressure Level Limits, dBA re: 20 μPa

Time Period	SPL @ 50 feet
Weekdays, 7:00 – 22:00 (daytime hours)	103
Weekdays, 22:00 – 7:00 (nighttime hours)	90
Sundays, 7:00 – 10:00 (early daytime hours)	90
Sundays, 10:00 – 22:00 (daytime hours)	103
Sundays, 22:00 – 7:00 (nighttime hours)	90

Source: City of Portland

While the trackside sound limits described in Table 6 above are intended to meet permissible City Code levels, City Code compliance is not always attained in residential districts near PIR. City Code limits are based on zoning, residential zones are associated with the lowest permissible levels. As the population of North Portland increases, residential districts are migrating progressively nearer to PIR. The expansion of residential districts nearer to PIR, will continue to make City Code compliance challenging, even though State regulations may be met 50 feet from the track.

5.1.3 Major Race Events and Variance Agreements

There are four separate variances that promoters can request from the City of Portland's Noise Review Board to operate over a 103 dBA sound level measured at 50 feet from the track side. Each varianced race weekend may have several different types of race vehicles. The mix of vehicles may include both vehicles that require the variance to operate, as well as race groups that occur on a variance race weekend that actually operate in compliance with 103 dBA level used for general compliance checks. The study has made attempts to review a representative body of different vehicles, but can by no means include a study of every race type that occurs at the racetrack. Historical data has been collected over the years on the varianced races which helped to direct the work in this study toward the concept of focusing on a separate body of information not previously collected.

Further discussion is offered in section 5.1.2 on the permitted sound levels and the overlaying State and local noise standards compared to a general approach tied to a 103 dBA daytime sound level used for races with no noise variance.

In reviewing the schedule of racing at PIR noted on their web site at www.portlandraceway.com, one can get picture of the frequency with which particular races types occur at the facility. The study notes in other sections that the data collected has started to demonstrate that drag racing events, at times, are in excess of the permitted sound levels established in Title 18 of the Portland City Code. This concern has been raised for years by the Noise Review Board member Kerrie Standlee and can be seen as a notable issue when one tallies the number of drag races anticipated for the 2008 drag racing schedule. From March 7th to November 1 there are approximately 60 evenings of drag racing planned for the raceway. These 60 nights of drag racing only represent one type of race vehicle. The 4 race weekends that include varianced race vehicles are anticipated to be in excess of the normal permitted sound levels of Title 18 of the City Code. This adds approximately 12 additional dates of racing in excess of Title 18 permissible levels. The 2008 racing schedule includes many other races that are listed in the Appendix.

In response to several large race events often scheduled at PIR, four noise variances are issued each year in accordance with City Council Resolution No. 34626 (1989) as follows:

> *"An upper dBA limit for the four events shall be established as follows:*
>
> *1 event at 115 dBA at 50'*
>
> *2 events at 112 dBA at 50'*
>
> *1 event at 110 dBA at 50'*
>
> *These limits are established to provide flexibility yet, the overall intent is to continue to encourage a reduction in noise levels."*
>
> *City Council Resolution No. 34626 – October 25, 1989*

The variance process for PIR events is as follows:

- Race promoter submits a noise variance application to the Noise Review Board.
- Noise Review Board reviews the variance application and provides a public forum for community feedback.
- Noise Review board approves or denies the noise variance in whole or in part based on their review of the application and community feedback.
- Upon variance approval, the race promoter is required to provide a complaint hotline for community members during the event along with any other conditional requirements outlined in the variance approval document.
- Upon variance denial, an appeal process is available to the applicant.

Noise variances approved during the study period are shown in Table 7 below.

Table 7. PIR Daytime Noise Variance Limits (06/2006 – 09/2007), L_{max} dBA re: 20 μPa

Variance Dates	Race Event	SPL @ 50 feet[1]
06/15/06 – 06/18/06	Champ Car Grand Prix Auto Race	No limit
	Toyota Atlantic Series	No limit
	Trans-Am Championship Series	112
07/06/06 – 07/09/06	Portland Historic Races Main Event	115
	Portland Historic Races	110
07/20/06 – 07/23/06	American Le Mans Series	115
09/02/06 – 09/04/06	ABFM / SOVREN Historic Races	112
06/07/07 – 06/10/07	Champ Car Grand Prix Auto Race	112
07/06/07 – 07/08/07	Portland Historic Races	112
08/31/07 – 09/03/07	ABFM / SOVREN Historic Races	112

Source: City of Portland

5.1.4 Trackside Measurements for General Compliance Checks

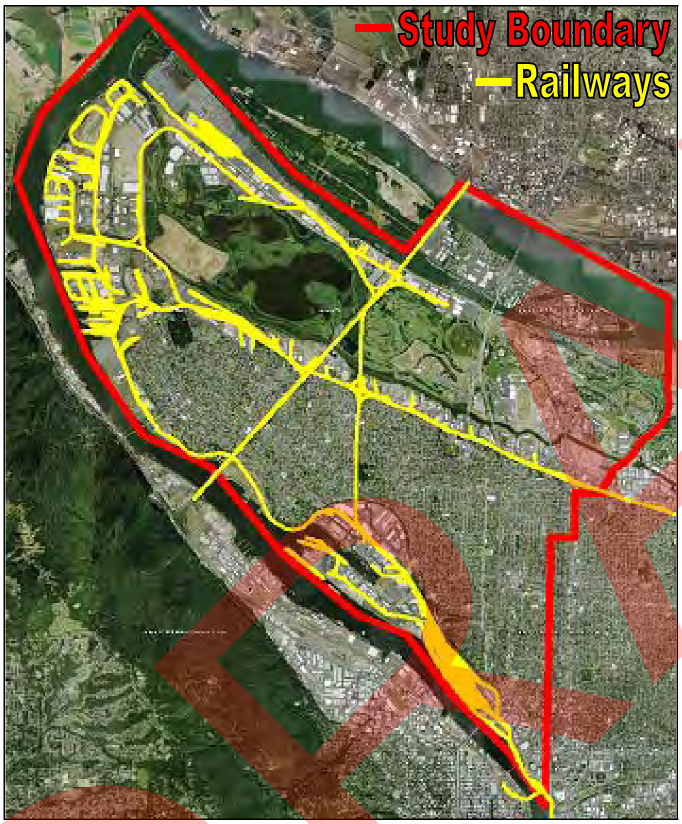
In addition the trackside computerized automated data collection meter on the South straightaway section of the track, the racetrack also utilizes a location on the opposite end of the track. The additional location is staffed by a race judge that monitors a handheld noise meter to report if any of the race cars exceed the permitted levels for the given race.

These two trackside measurement locations use the perspective that a 103-dBA FAST sound level is in compliance with City Noise Code limits in the neighborhood. This perspective was based on a series of early sound level tests taken in the late 1980's and early 1990's. Historically, there has been a concern that the limited testing that was used to establish the use of the 103 dBA level is not the correct level to establish full compliance with City's Noise regulations of Title 18 of the City Code. The 103 level that is used by the race community and referred to by some members of the neighborhood should not be seen as a specific compliance regulation level. As a result of this new study, the trackside level may need to be refined and reduced to assure the community full compliance with the legal expectations of Title 18 to control noise pollution emanating from the raceway at healthy levels.

5.2 Railways

Approximately 21 miles of railroad tracks are distributed throughout North Portland. A graphical representation of all railroad tracks in North Portland is shown in Figure 6 below.

Figure 6. North Portland Railways



Source: Google Earth™, City of Portland, The Greenbusch Group

Many of these rail lines run near residential communities. Train horn soundings at public grade crossings in these residential areas have been a frequent source of community complaint. Train horns typically occur at all hours of the day and night and can reach very high sound levels. When the train horn is sounded near a residential community, the level of disturbance increases at night as the horns may interfere with sleep. Particular areas of community complaint have been the St. Johns, Cathedral Park, and Kenton neighborhoods. Historically, sound level requirements for the train horns related to minimum acceptable sound levels only, to ensure adequate warning identification. In 2005, the Federal Railroad Administration (FRA) established maximum permissible sound levels for train horns. Railroad operators will not be required to meet the newly-defined permissible sound levels until 2010. Minimum acceptable and maximum permissible sound levels for train horn soundings are shown in Table 8 below.

Table 8. FRA Permissible Train Horn Sound Levels @ 100 feet

Condition	Sound Level, dBA[1]
Minimum acceptable sound level	96
Maximum permissible sound level	110[2]

1. No weighting specified, A-weighting was assumed.
2. Railroad operators are not required to meet this level until 2010.

Source: Federal Railroad Administration, "Train Horn Rule Fact Sheet" December 2006

In addition to maximum and minimum sound levels, the FRA has established a consistent method for sounding train horns at public grade crossings as follows:

> *"… locomotive engineers must sound train horns for a minimum of 15 seconds, and a maximum of 20 seconds, in advance of all public grade crossings, except:*
>
> - *If a train is traveling faster than 45 mph, engineers will not sound the horn until it is within ¼ mile of the crossing, even if the advance warning is less than 15 seconds.*
> - *If a train stops in close proximity to a crossing, the horn does not have to be sounded when the train begins to move again.*
> - *There is a "good faith" exception for locations where engineers can't precisely estimate their arrival at a crossing.*
>
> *Wherever feasible, train horns must be sounded in a standardized pattern of 2 long, 1 short and 1 long. The horn must continue to sound until the lead locomotive or train car occupies the grade crossing."*
>
> *Federal Railroad Administration, "Train Horn Rule Fact Sheet" - December 2006*

Along the North Columbia Boulevard Corridor, there are several public grade crossings in close proximity. It was observed that after the initial 2 long, 1 short, and 1 long pattern, the last horn blast continued in duration along the entire length of the corridor. This area is also densely populated with residential buildings located near the railway lines.

Additional information will be added on the implications for the sound levels from train whistle noise once we have acquired current train counts in any available corridors in the study area.

5.3 Freight Corridors

Vehicle traffic can be a major contributor to the noise character of a neighborhood. When the vehicle mix includes freight haul trucks, buses, and motorcycles, the intermittent increases in broadband sound levels of general traffic flow can be a source of disturbance. Federal, State and City jurisdictions have adopted regulations, standards, and permissible levels for various types of vehicles to control sound levels associated with public road use.

At the Federal level, the Environmental Protection Agency (EPA) has established permissible levels for freight transportation on public roads. The EPA levels correspond to freight transport vehicles with Gross Combination Weight Rating (GCWR) in excess of 10,000 lbs, as shown in Table 9 below.

Table 9. EPA Regulations for Freight Transport Vehicles over 10,000 GCWR

Model Year	Maximum Sound Level, dBA[1]		Minimum Measurement Distance
	< 35 MPH	> 35 MPH	
< 1986	86	90	50 feet from centerline
> 1986	83	87	50 feet from centerline

1. When measured on an open site with fast meter response.
Source: 40 CFR Part 202

At the State level, the Oregon Department of Environmental Quality (DEQ) has delineated permissible levels for motor vehicles operating on public roadways. These limits are shown in Table 10 below.

Table 10. DEQ Road Vehicle Standards

Vehicle Type	Model Year	Maximum Sound Level, dBA	Minimum Measurement Distance
All vehicles described in ORS 481.205(2)(a)	< 1976	94	25 feet
	> 1976	91	25 feet
All other trucks in excess of 8,000 pounds (3629 kg) GVWR[1]	< 1976	94	25 feet
	1976-1981	91	25 feet
	> 1981	88	25 feet
Motorcycles	< 1975	102	20 inches
	> 1975	99	20 inches
Front-engine automobiles, Light trucks and all other front engine road vehicles	All	95	20 inches
Rear-engine automobiles and light trucks and mid-engine automobiles and light trucks	All	97	20 inches
Buses as defined under ORS 481.030	< 1976	94	25 feet
	> 1976	91	25 feet

1. Gross Vehicle Weight Rating
Source: DEQ OAR Chapter 340, Division 35

At the city level, the City of Portland Code adopts Federal EPA levels for interstate freight transport vehicles of 10,000 pounds GCWR or more. All other vehicles are required to comply with State DEQ levels. In addition, the City of Portland Code also provides additional restrictions to reduce freight transport sound levels within the community, as follows:

> *"B. No person shall operate, and no owner of any motor vehicle shall permit to be operated upon any public road, street, or highway, any motor vehicle so as to cause any greater noise or sound than is reasonably necessary for the proper operation of such motor vehicle.*
>
> > *1. No person shall operate a motor vehicle on a street or highway with an exhaust system utilizing a cutout, bypass or similar device.*

2. No person shall operate a motor vehicle in such a manner as to cause or allow to be emitted squealing, screeching, or other such noise from the tires in contact with the ground because of rapid acceleration or excessive speed around corners or other such reason, except that noise resulting from emergency action to avoid imminent danger shall be exempt from this provision.

3. No person shall operate any motor vehicle in excess of 10,000 pounds GCWR, in any residential zone of the City or within 200 feet of any dwelling unit, school, hospital or library, with a dynamic braking device engaged except to avoid imminent danger."

- City of Portland Code Section 18.10.020B

In general, permissible levels established by the Federal EPA and State DEQ are not often exceeded by motorized vehicles when properly muffled and no compression (jake) braking devices are used. In application, these permissible levels could be met and still present a significant increase in noise level in a residential community. To address community traffic noise levels and identify potential impacts, several criteria have been developed. For the purposes of this study Federal Highway Administration (FHWA) and US Department of Urban Development (HUD) criteria were used as the basis for identifying potential noise impacts related to freight vehicle traffic.

The Federal Highway Administration (FHWA) has developed criteria for relating traffic sound levels with community impact. Typically, these levels will be used to determine whether or not noise mitigation is required for a highway or transit project. However, these values also serve as useful indicators for community response to traffic noise. FHWA impact criteria as designated by various land uses is shown in Table 11 below.

Table 11. FHWA Noise Abatement Criteria

Activity Category	Description	Hourly L_{eq}
A	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.	57 Exterior
B	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.	67 Exterior
C	Developed lands, properties, or activities not included in Categories A or B above.	72 Exterior
D	Undeveloped lands.	--
E	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.	52 Interior

Source: Federal Transit Administration, "Transit Noise and Vibration Impact Assessment" May 2006

In addition to the FHWA criteria, the US Department of Urban Housing and Development (HUD) has developed criteria for evaluating the acceptability of a residential development site based on existing environmental sound levels. While this study is evaluating existing residential dwellings, the HUD critieria serves as a useful indicator for excessive environmental noise levels. HUD environmental noise limits, described in day-night sound levels, are shown in Table 12 below.

Table 12. HUD Standards For Acceptable Exterior Noise

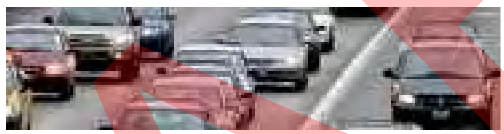
Exterior Noise Level, L_{dn}	Noise Impact
Less than 65 dBA	Levels are generally acceptable
65 to 75 dBA	Normally unacceptable to HUD[1]
Greater than 75 dBA	Unacceptable

1. Appropriate sound attenuation measures must be provided: 5 dB attenuation above the attenuation provided by standard construction required in 65-70 L_{dn} zone; 10 dB additional attenuation in 70-75 L_{dn} zone.

Source: U.S. Department of Housing and Urban Development, 1985

Many heavy trucks utilize residential streets in North Portland while traveling between Port of Portland terminals and major freight arterials to transport freight out of the North Portland area. The three major freight corridors identified for inclusion in the study were North Columbia Boulevard, North Lombard Street, and North Going Street.

5.4 I-5 Traffic



The I-5 corridor runs through Hayden Island, along the eastern boundary of Kenton, Arbor Lodge, and Overlook, and along the western boundary of Piedmont. Oregon Department of Transportation (ODOT) installed noise walls along this corridor.

5.5 Portland International Airport

Flight patterns at Portland International Airport (PDX) are concentrated along the Columbia River, and industrial and commercial land use zones, avoiding residential areas.

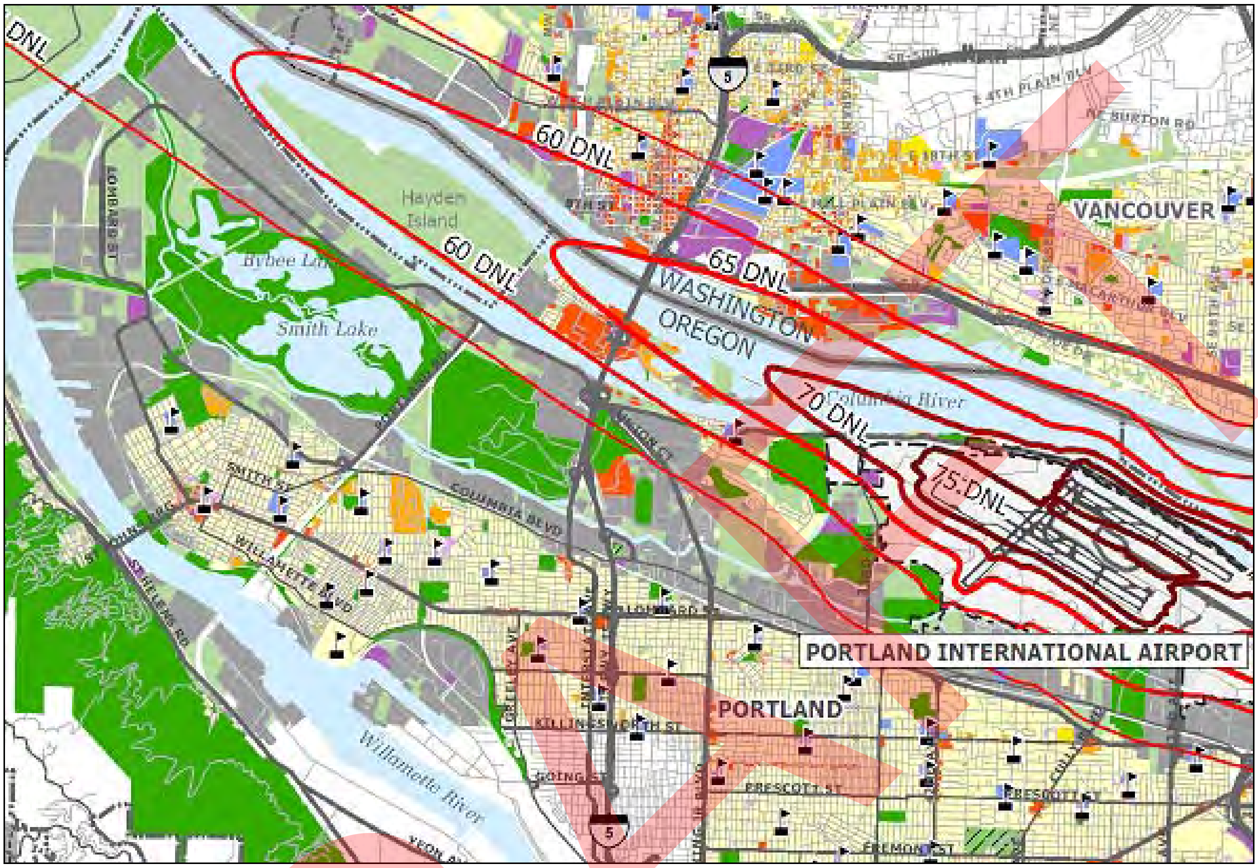
Sound levels generated by aircraft activity at PDX have been thoroughly studied outside of this contract.

Our analysis was based on compliance with FAA Order 5100.38B Chapter 8 Par 812, Noise Insulation Projects. This order stipulates eligibility for the program as follows:

- A Facility must be located within a minimum DNL 65 zone
- Interior DNL levels exceed 45
- In facilities where interior noise levels exceed DNL 45 by 1 - 4 dB, an improvement of 5 dB is considered minimum.

Contours of predicted sound exposure levels for the airport are shown in Figure 7 below.

Figure 7. Portland International Airport Sound Level Contours



Source: Portland International Airport Noise Compatibility Study, Figure D23, Port of Portland

6.0 MEASUREMENTS

6.1 Protocol

Measurements were performed to validate and calibrate noise model results. All field measurements were performed in general accordance with ASTM E1503 “Standard Test Method for Conducting Outdoor Sound Measurements Using a Digital Statistical Analysis System (2006).” Meteorological effects were assessed using local weather reports during the computer modeling process.

6.2 Equipment Used

All digital sound level meters used during field measurements and some of their classifications are listed below in Table 13.

Table 13. Digital Sound Level Meter Classifications

Sound Level Meter	Serial Number	Classification	Standard
Brüel & Kjær (B&K) Type 2250	2551241	Class 1	IEC 61672
		Band Class 0	IEC 61260
Rion NL-32	161680	Class 1	IEC 61672
Rion NL-32	161681	Class 1	IEC 61672
Larson Davis LD3200	0272	Type 1	ANSI S1.4
Larson Davis LD2900	0386	Type 1	ANSI S1.4
Larson Davis LD812	0142	Type 1	ANSI S1.4
Larson Davis LD700	1436	Type 2	ANSI S1.4

Source: The Greenbusch Group

6.3 Measurement Locations Selection

The Greenbusch Group has worked with City of Portland Noise Office to select several testing locations based on the observations the Noise Control Office has been making over the last ten years or longer. The intent was to establish a few consistent locations through out the study and expand out from the primary test locations to “ground truth” the outcome of the noise modeling and mapping.

The project had a limited amount of funding. Testing in every single neighborhood prescribed in the confines of the North Portland Noise Study area was not feasible within the contracted scope. It is important to consider that the goal of the study was to establish a current level of baseline information that can be further expanded in the future. The City of Portland will move forward as the first major City in the United States to use noise maps to direct future development decisions and long range planning. It is understood that in breaking ground in helping to establish noise mapping in the United States, that future improvements to the approach are inevitable.

In the case of train whistle noise, a few locations were selected that offered a clear picture of the potential impact to representative residential locations in close proximity to rail corridors. The impacts of train whistle noise are a relatively straightforward modeling exercise.

In the case of PIR, two primary locations were visited for the major race types and for most of the varianced race weekends. The primary location was at the northern end of North Delaware at the dead end that's in the vicinity of 8761 N. Delaware. The second primary test location was in the grandstands along the Southern straightaway on the PIR property. These two measurement locations were selected to allow validation and calibration of the model, which permitted the project to extrapolate the emanation of noise to the greater North Portland community. Support for the model and mapping was completed with additional short-term test locations to help ensure accuracy.

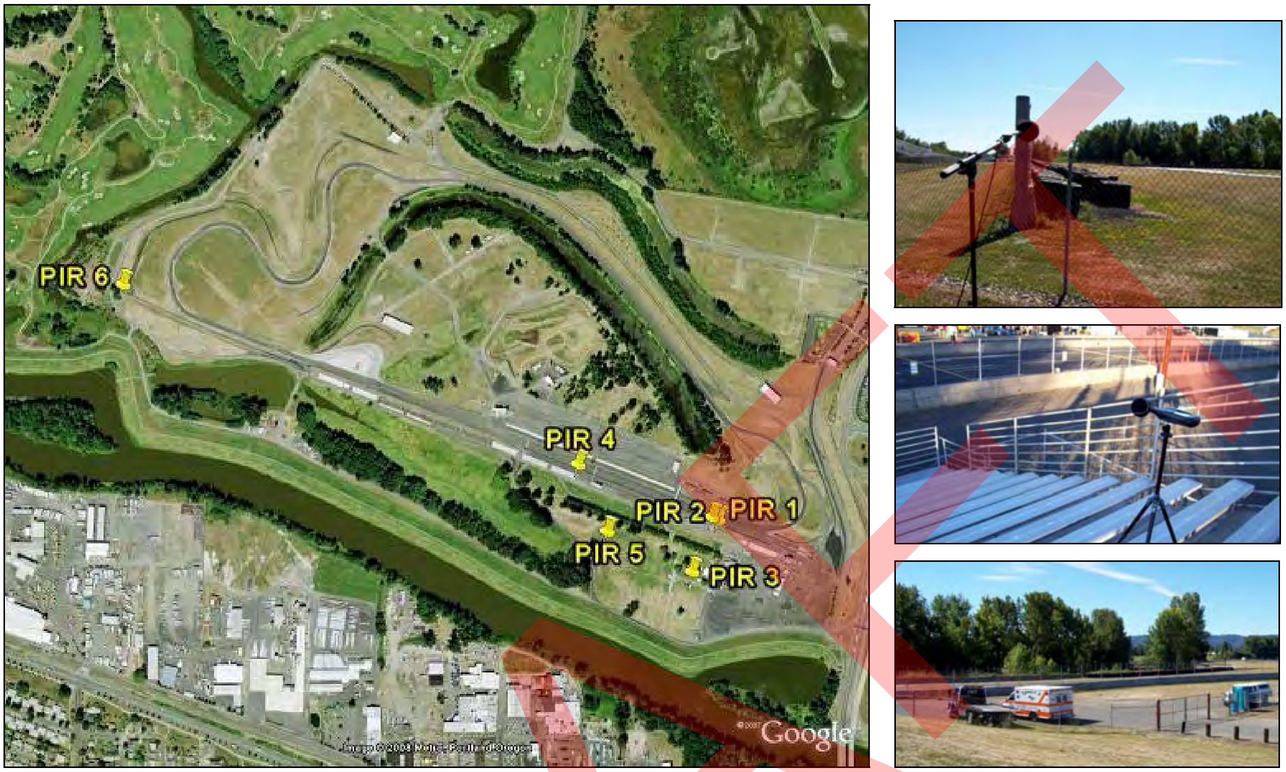
6.4 Measurement Locations

Each measurement location was documented by either Global Positioning System (GPS) coordinates or a nearby street address or intersection. A complete list of measurement locations is provided in the Appendix.

Figure 8. Northern Measurement Locations

Source: Google Earth™, City of Portland, The Greenbusch Group

Figure 9. PIR Measurement Locations



Source: Google Earth™, City of Portland, The Greenbusch Group

Figure 10. Central Measurement Locations

Source: Google Earth™, City of Portland, The Greenbusch Group

Figure 11. Southern Measurement Locations

Source: Google Earth™, City of Portland, The Greenbusch Group

6.5 Measurements Performed

Noise levels are varied and complex throughout the North Portland area. Typically sound from several sources is overlaid one on top of another to create the neighborhood background levels. Sound from the races at PIR is audible under some conditions for most of the neighborhoods within the study area. It must be noted, though, that audibility does not constitute a Code exceedance. In the Kenton and Portsmouth areas where sound from PIR should have been most noticeable, frequently train events and freight hauling activity masked it. The sounds from PIR seemed more of an annoyance to the most distant neighborhoods, where the ambient conditions were quieter and the sound from the race activity became more of an intrusion.

Many, many hours of measurements were performed for this study. Shown below are several snapshots of the measured noise levels in various neighborhoods. A complete record of all measured data sets is included in the Appendix.

6.5.1 Cathedral Park

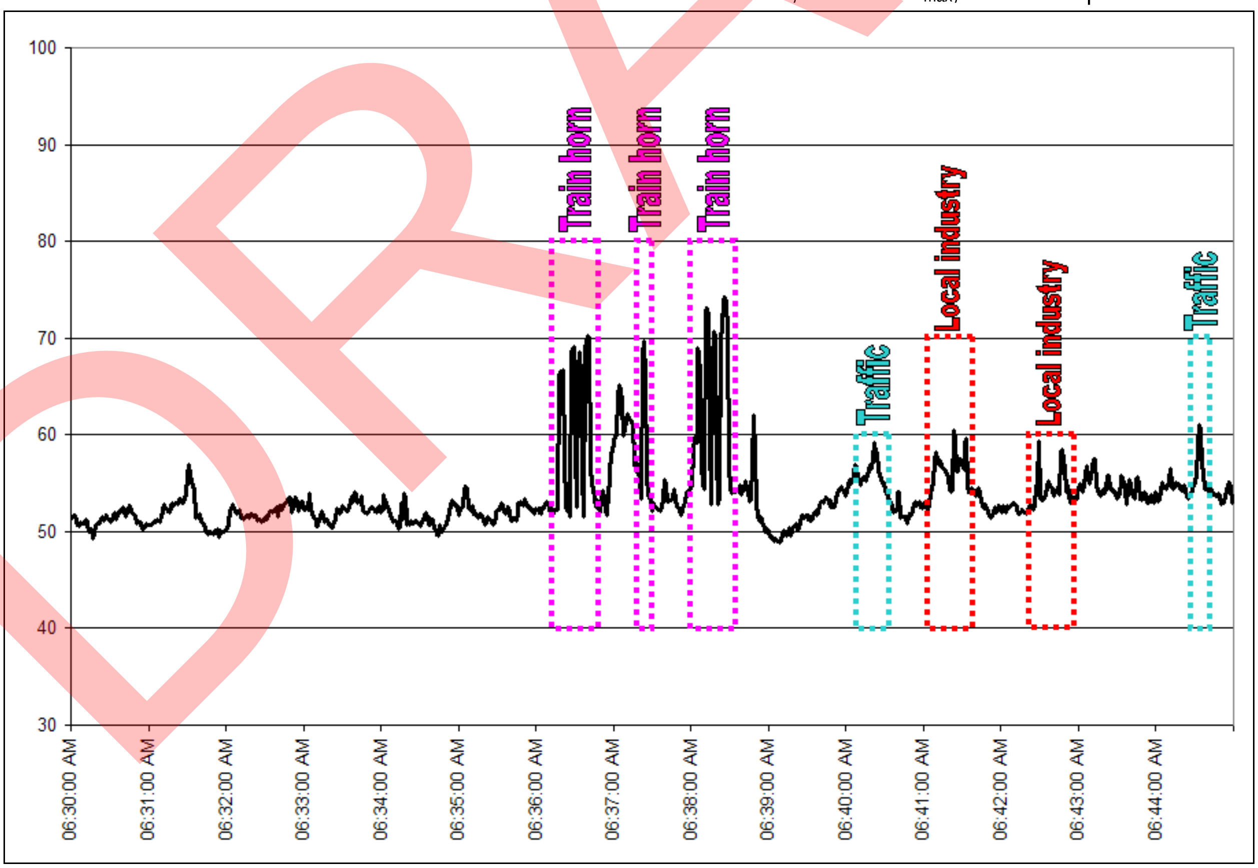
Train horns were the dominant sound in the Cathedral Park neighborhood. Train horn sound levels were documented inside a bedroom at a Cathedral Park residence at measurement location Cathedral Park 1. The bedroom window was left closed during the nighttime hours and remained open during the daytime hours. While train events were likely logged during the nighttime hours, sound levels were below the recording threshold when the window was closed. Therefore, most of the likely train horn evens were not documented with a sound recording. In addition, it is very likely that more train events occurred than those shown in Table 14 below, as only train horn events loud enough to trigger a sound recording are shown below.

Table 14. Measured Cathedral Park Train Horn Sound Levels, 1-second L_{max} dBA re: 20 µPa

Period	Train Events	Loudest Event Sound Level
11/26/07 15:54-14:60	3	72
11/27/07 05:43-16:41	6	77
11/28/07 06:48-18:45	4	77
11/29/07 06:27-21:00	14	77
11/30/07 08:21-18:37	12	75

Source: The Greenbusch Group

Chart 2. 11/27/07 Train Horns at Measurement Location Cathedral Park 1, 1-second L_{max}, dBA re: 20 µPa

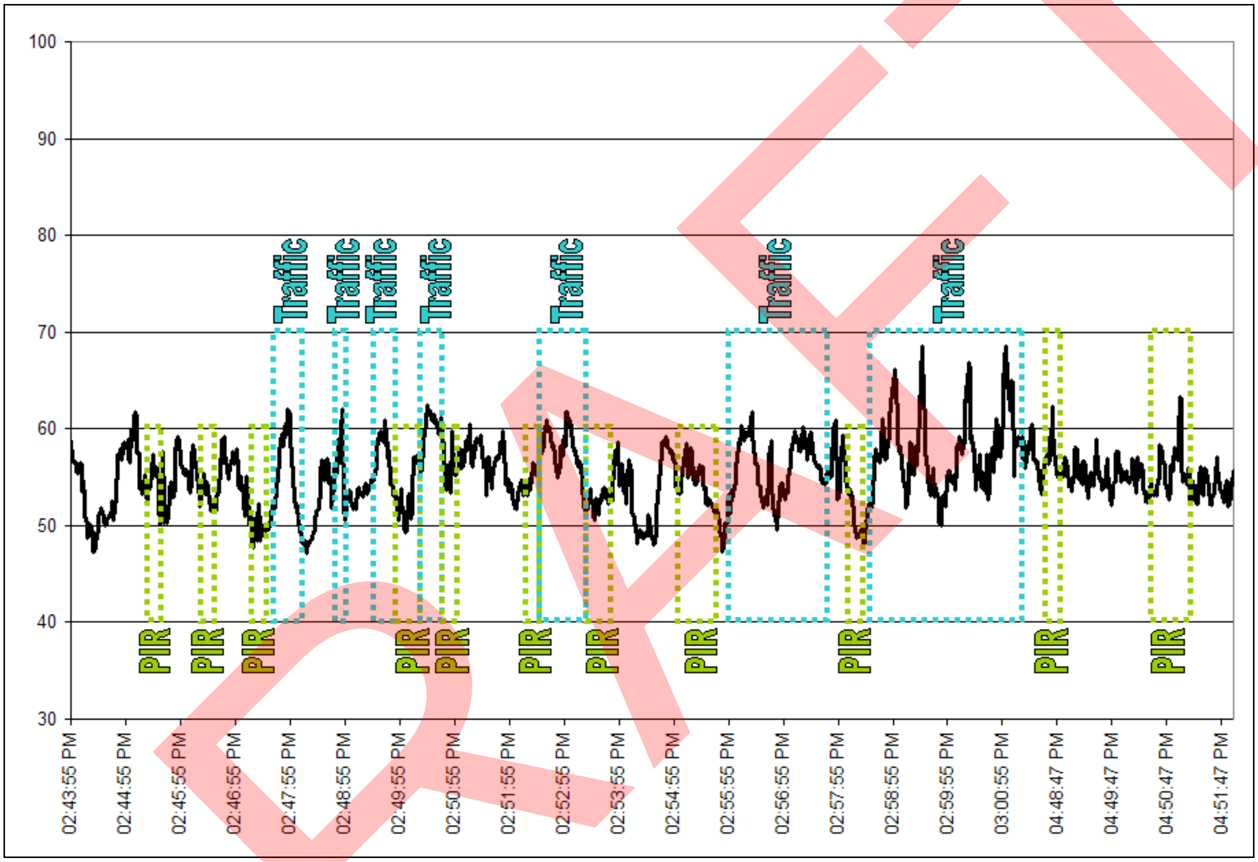


Source: The City of Portland, The Greenbusch Group

6.5.2 Kenton

Kenton was one of the most impacted neighborhoods, with close proximity to a rail line with numerous crossings, a freight corridor along N. Columbia and PIR. Kenton 1 corresponds with our key measurement point on Delaware. This location was on a slight hill at the end of a dead end street overlooking Columbia. Note that the sound energy from the race and the traffic are similar.

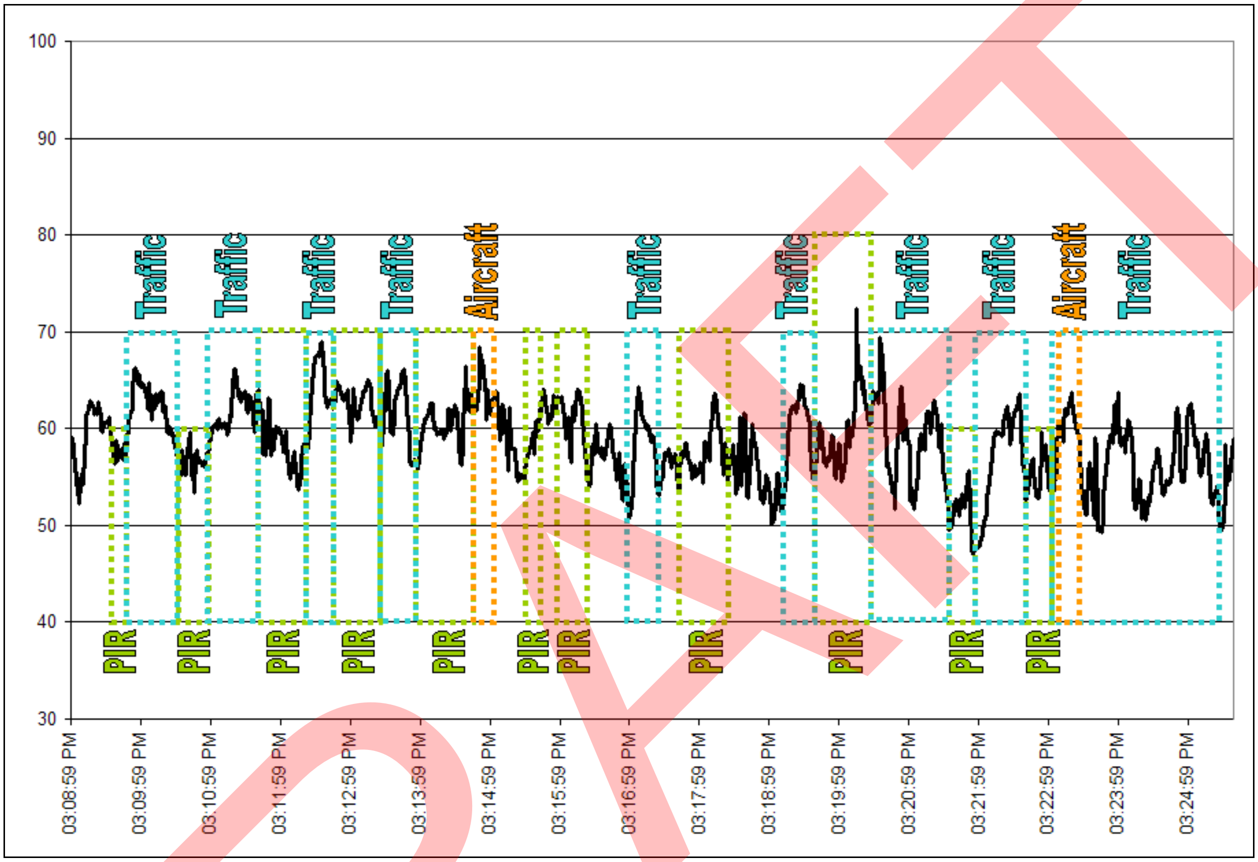
Chart 3. 09/01/07 PIR SOVREN Race at Measurement Location Kenton 1, 1-second L_{max}, dBA re: 20 μPa



Source: The Greenbusch Group

Chart 4 below shows a location in Kenton that is at the same elevation and within 20 feet of N. Columbia Boulevard. Again, the traffic effectively masks the race much of the time.

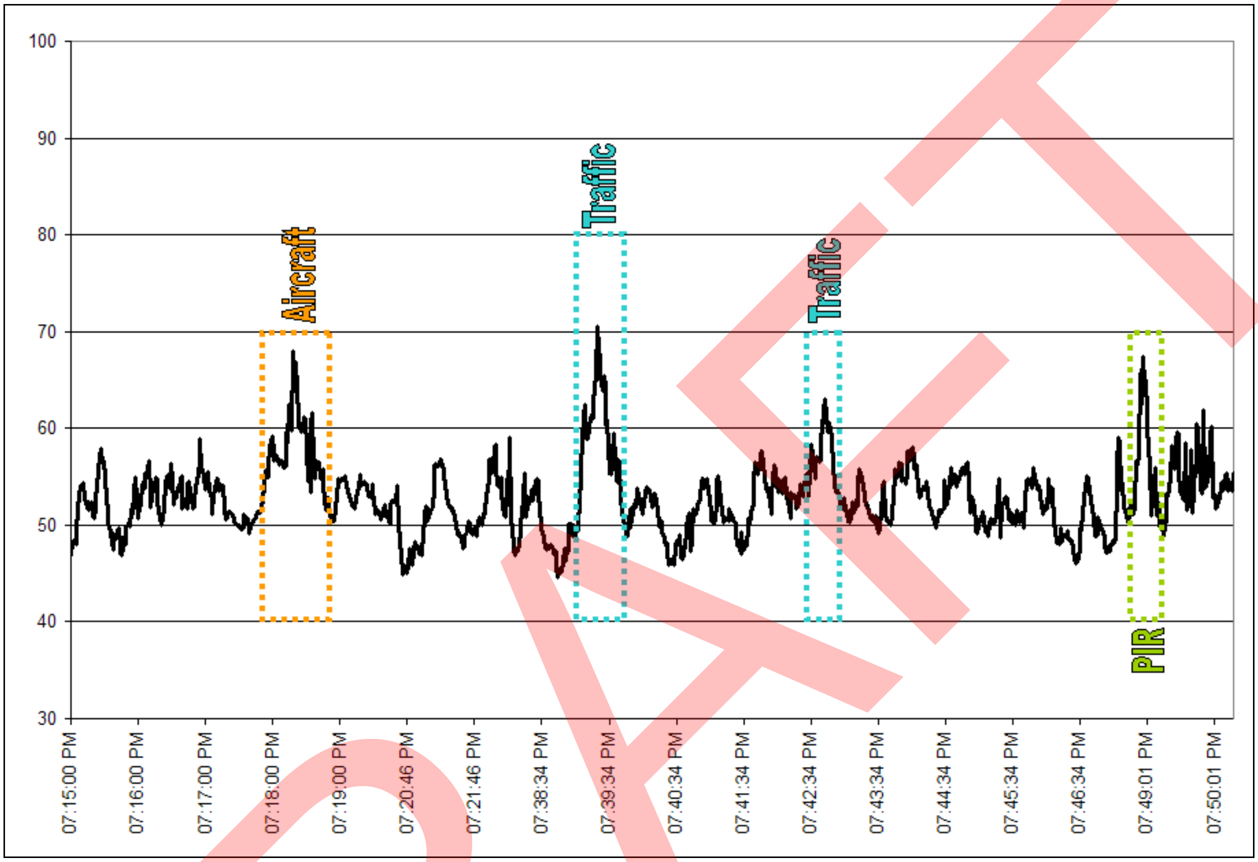
Chart 4. 09/01/07 PIR SOVREN Race at Measurement Location Kenton 5, 1-second L_{max}, dBA re: 20 μPa



Source: The Greenbusch Group

Chart 5 below shows sound levels from a Late Night Drag at the key position along Delaware. Note the Code exceedance for the race.

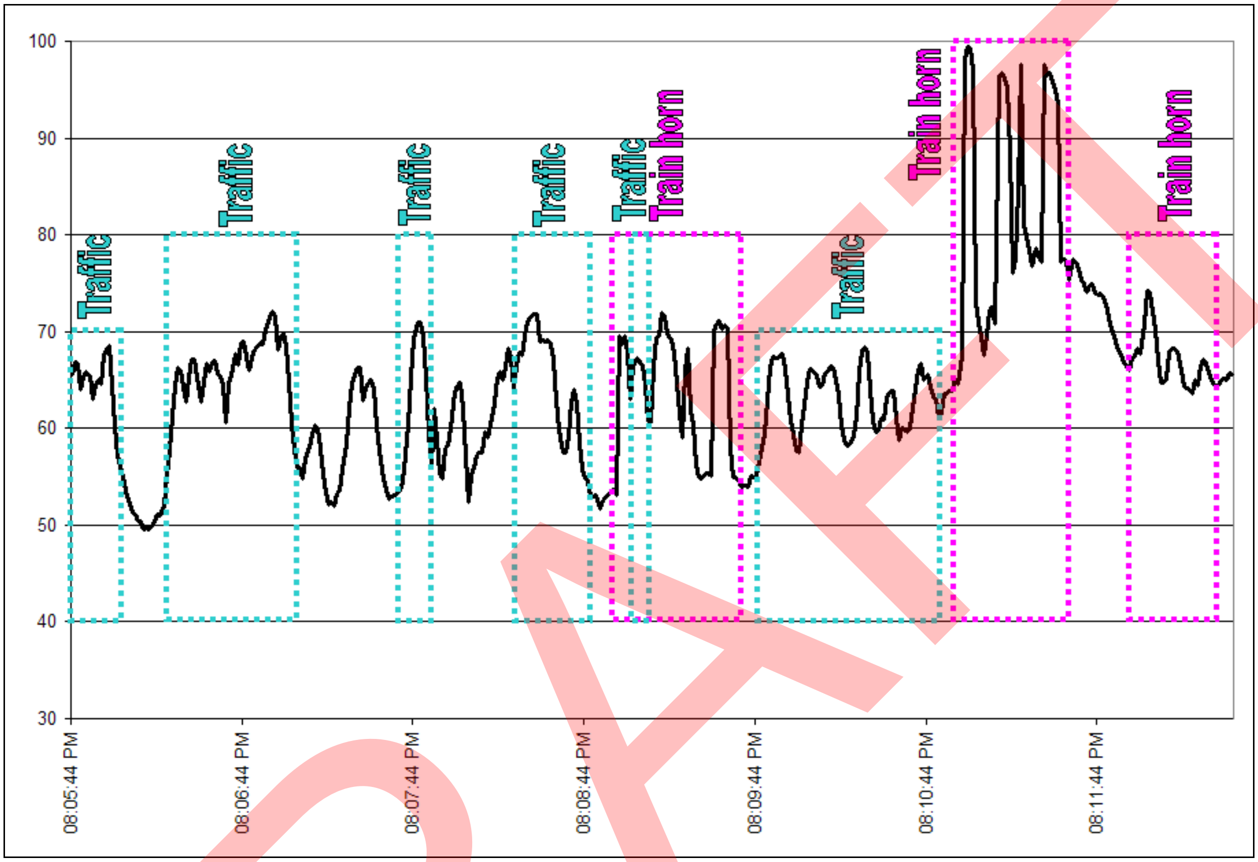
Chart 5. 09/01/07 PIR LND at Measurement Location Kenton 1, 1-second L_{max}, dBA re: 20 μPa



Source: The Greenbusch Group

Chart 6 below depicts the level of the train horns at a location near N. Columbia Boulevard.

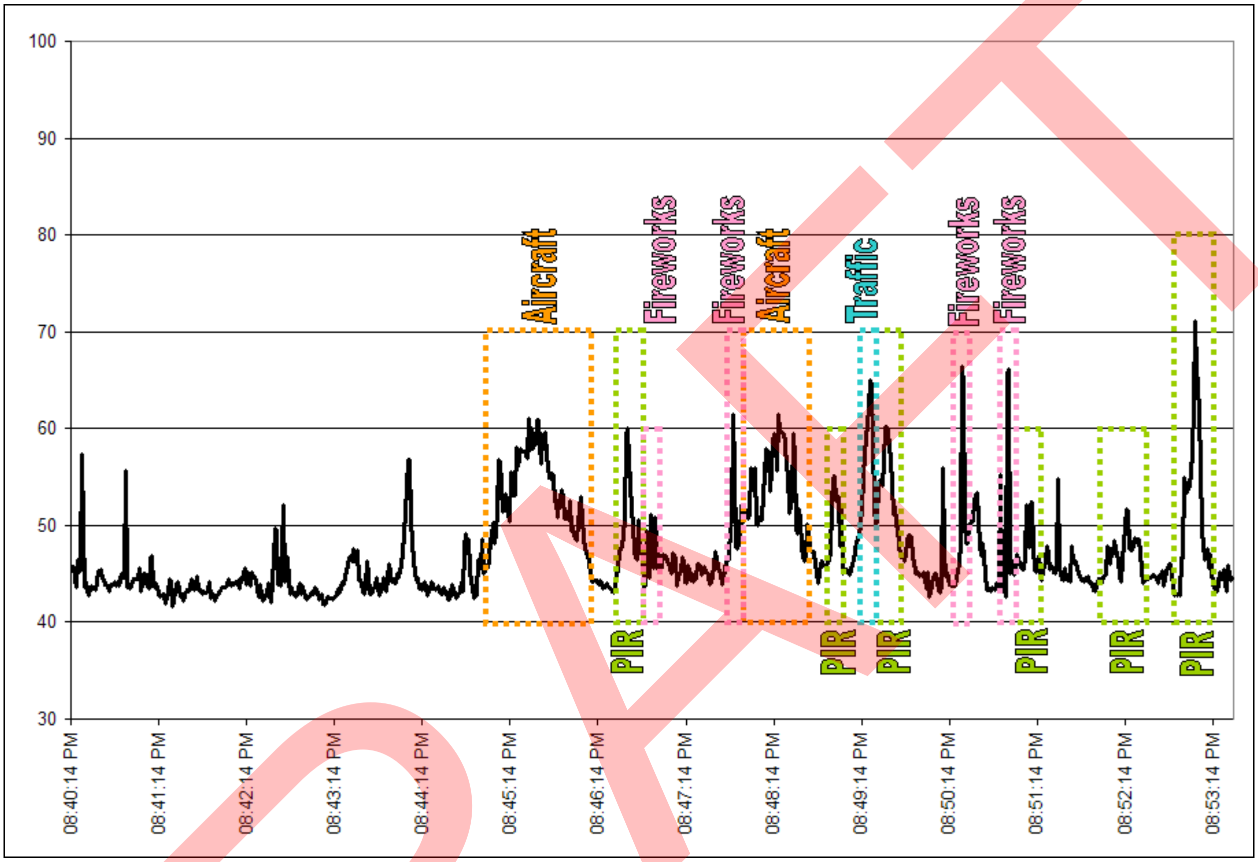
Chart 6. 09/01/07 PIR LND at Measurement Location Kenton 4, 1-second L_{max}, dBA re: 20 μPa



Source: The Greenbusch Group

Chart 7 below shows a position in Kenton at the intersection of Emerald and Halleck, a significant distance from Columbia Blvd. Note the Code exceedance for the Late Night drag is greater than aircraft, neighborhood fireworks or local traffic.

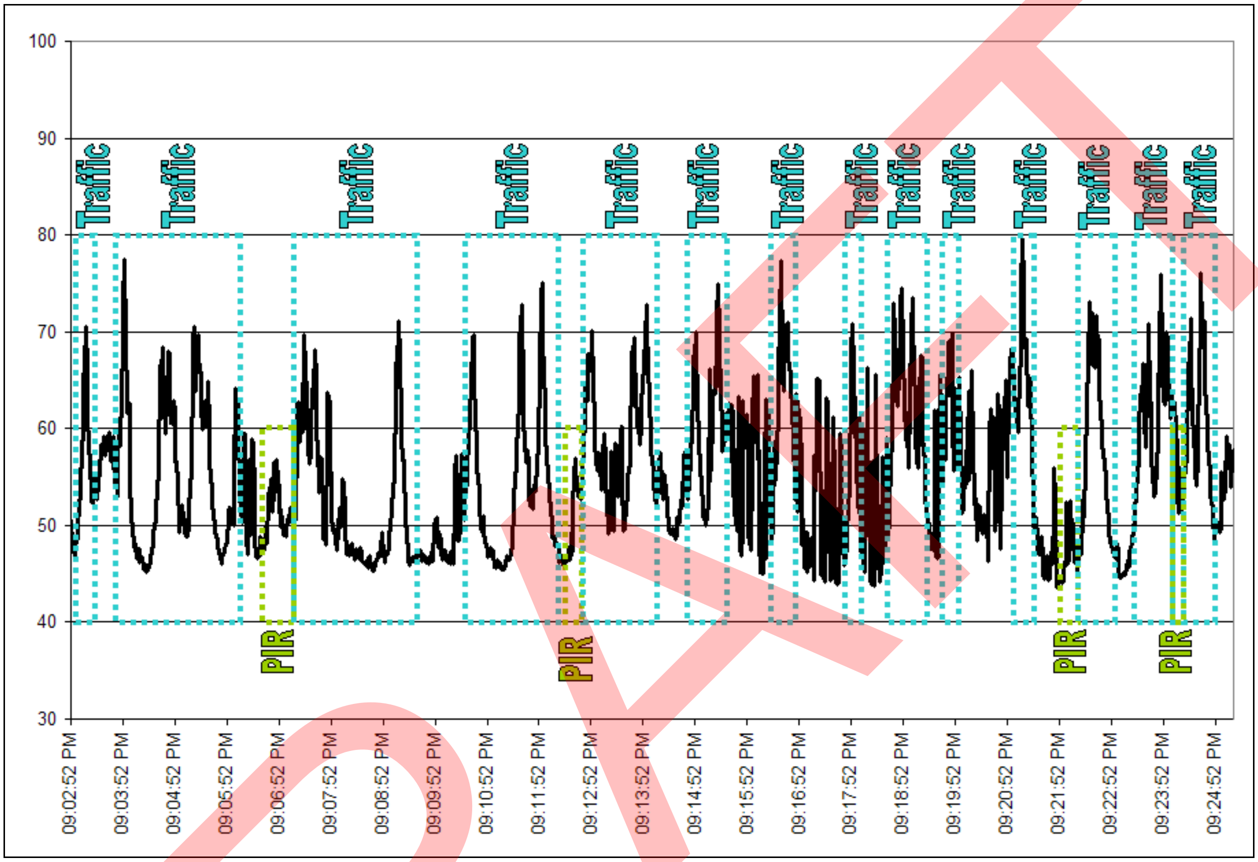
Chart 7. 09/01/07 PIR LND at Measurement Location Kenton 6, 1-second L_{max}, dBA re: 20 μPa



Source: The Greenbusch Group

Chart 8 shows a Kenton location near Columbia Park. Local traffic and more distance traffic on Lombard dominated the sound environment. Race activity was barely audible as traffic movement subsided.

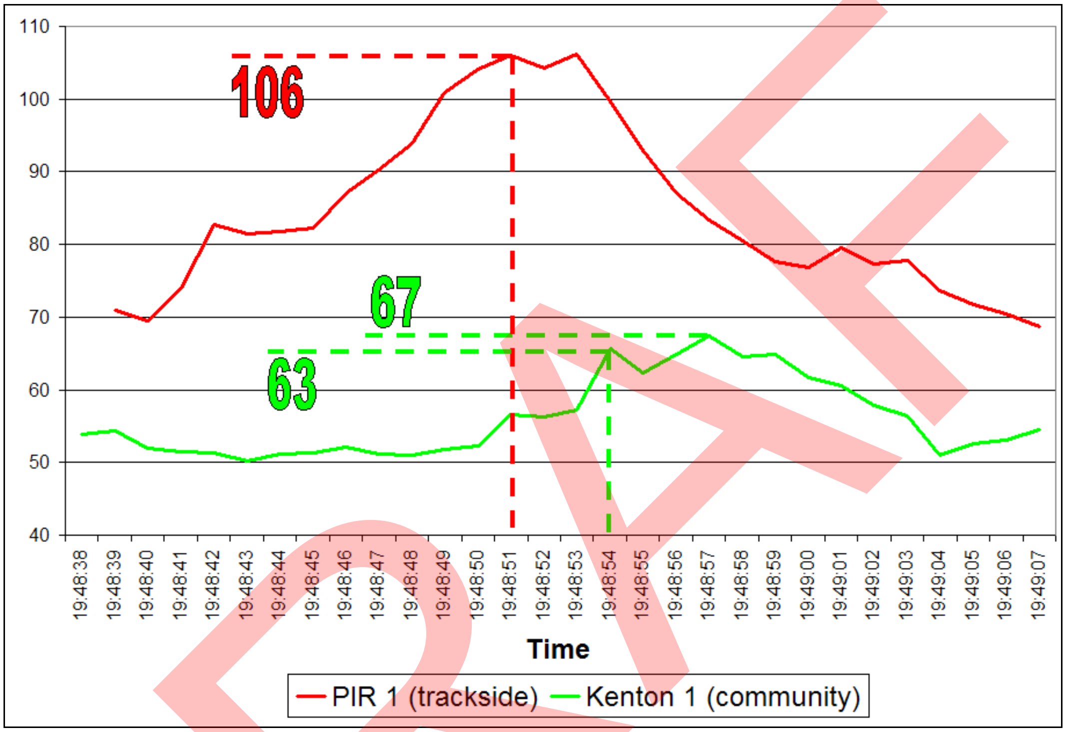
Chart 8. 09/01/07 PIR LND at Measurement Location Kenton 7, 1-second L_{max}, dBA re: 20 μPa



Source: The Greenbusch Group

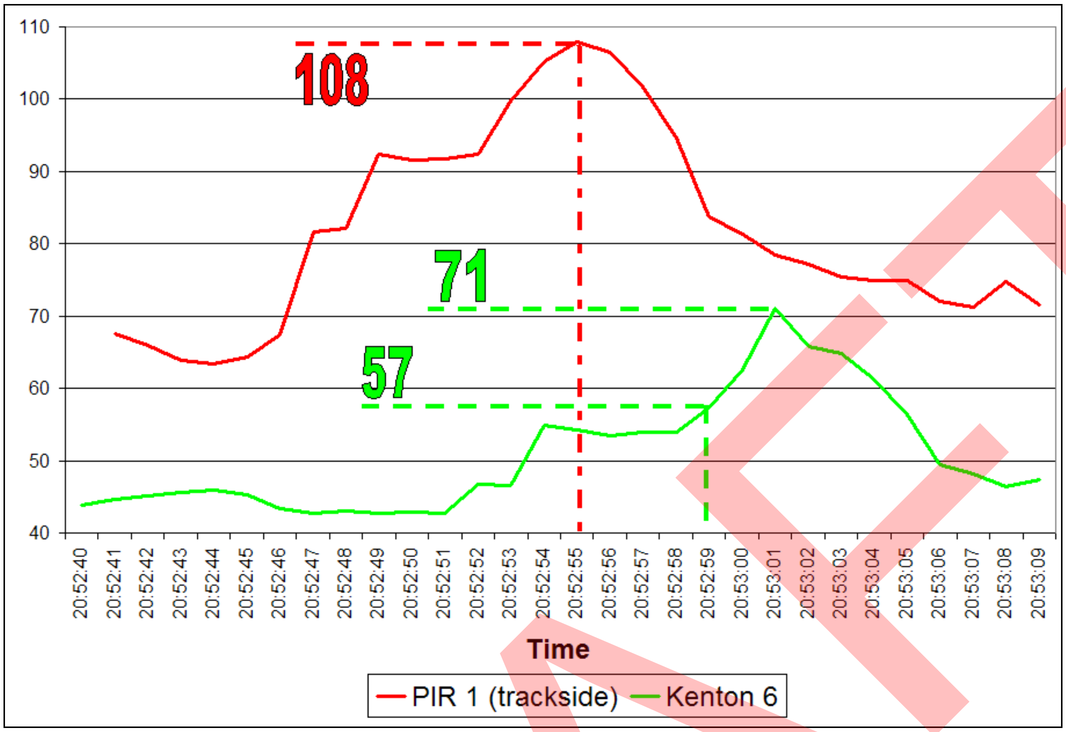
Charts 9-11 below demonstrate the propagation pattern of sound from PIR. The 106 dBA, 108 dBA and 107 dBA levels respectively were measured trackside and the corresponding levels of 67 dBA, 71 dBA, and 57 dBA were measured of the same event in the neighborhood. You will note that the model calculated a lower dBA level. The level and arrival time of the sound from the race event did not correspond with the model. The discrepancy may be due to the positioning of the trackside monitor for the drag events. It appears that the trackside monitor may not be recording the point of maximum sound.

Chart 9. NHRA Late Night Drags Event 1 Time-Domain Comparison, 1-second L_{max} dBA re: 20 µPa



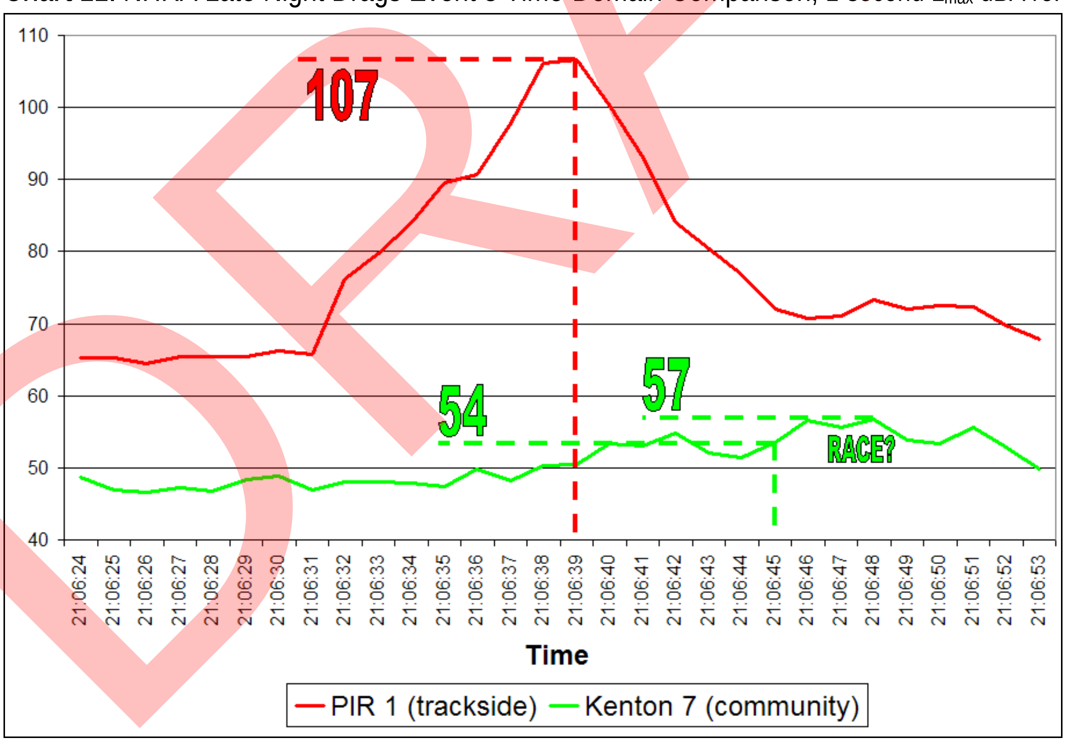
Source: City of Portland, The Greenbusch Group

Chart 10. NHRA Late Night Drags Event 2 Time-Domain Comparison, 1-second L_{max} dBA re: 20 µPa



Source: City of Portland, The Greenbusch Group

Chart 11. NHRA Late Night Drags Event 3 Time-Domain Comparison, 1-second L_{max} dBA re: 20 µPa



Source: City of Portland, The Greenbusch Group

Nighttime sound levels were also documented in the Kenton neighborhood at measurement location Kenton 4. Sound recording for source identifications was not performed at this measurement location. However, it is very likely that sound levels in excess of 90 dBA were caused by train horn soundings at the nearby public grade crossings. A summary of probable nighttime train horn events at this measurement location is presented in Table 15 below.

Table 15. Measured Kenton Sound Levels, 1-second L_{eq} dBA re: 20 μPa

Period	Probable Train Horn Events (> 90 dBA)	Loudest Exterior Event Sound Level	Loudest Likely Interior Sound Level	Sleep Disturbance Threshold
08/31/07 22:00 – 09/01/07 07:00	7	103	78	45
09/01/07 22:00 – 09/02/07 07:00	20	104	79	45

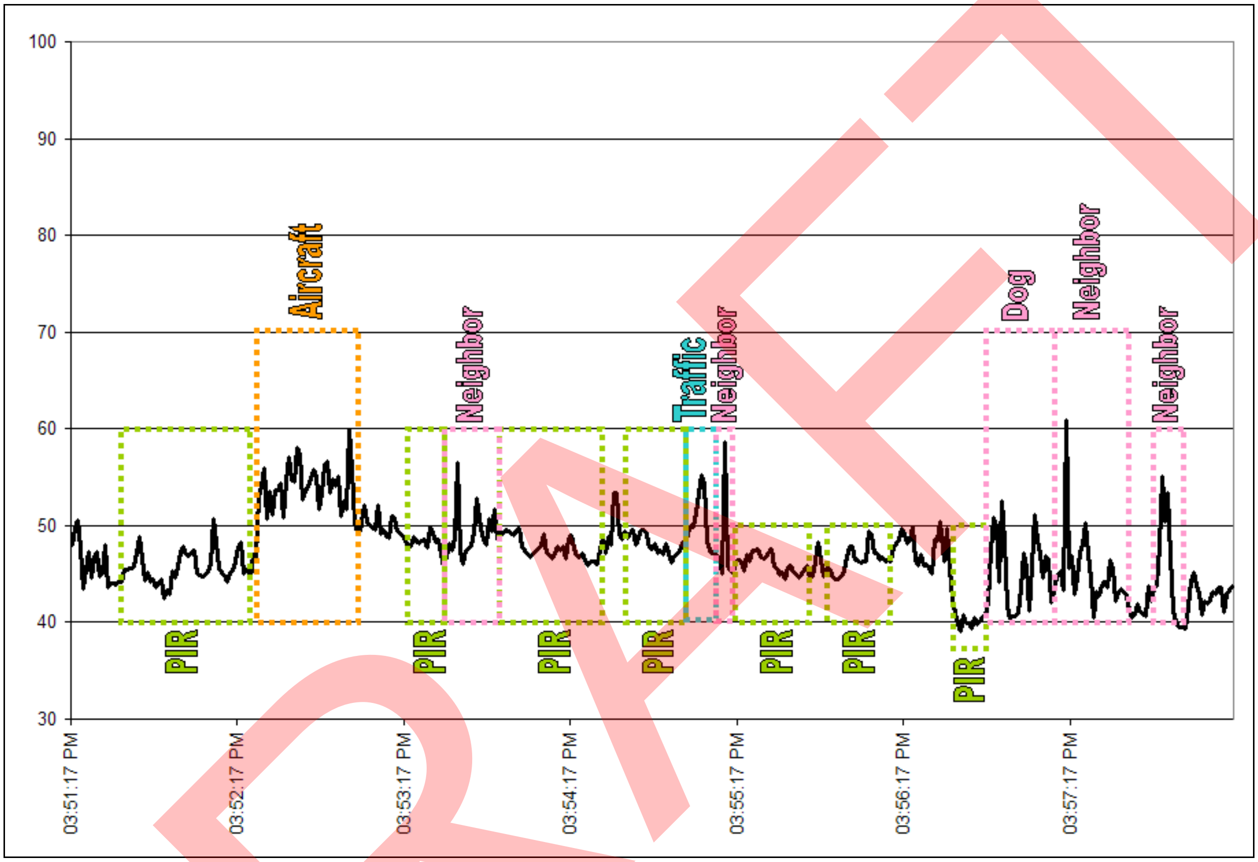
Source: The Greenbusch Group, World Health Organization "Guidelines for Community Noise"

These two nighttime periods document severe exceedances of sleep disturbance thresholds. It is very likely that Kenton residences near the railway are frequently disturbed during nighttime hours due to train horn soundings.

6.5.3 Portsmouth

Chart 12 demonstrates that, for a position such as this Portsmouth location near University Park, the sound levels from the race become a much more dominant component to the neighborhood sound, even though the Code has not been exceeded.

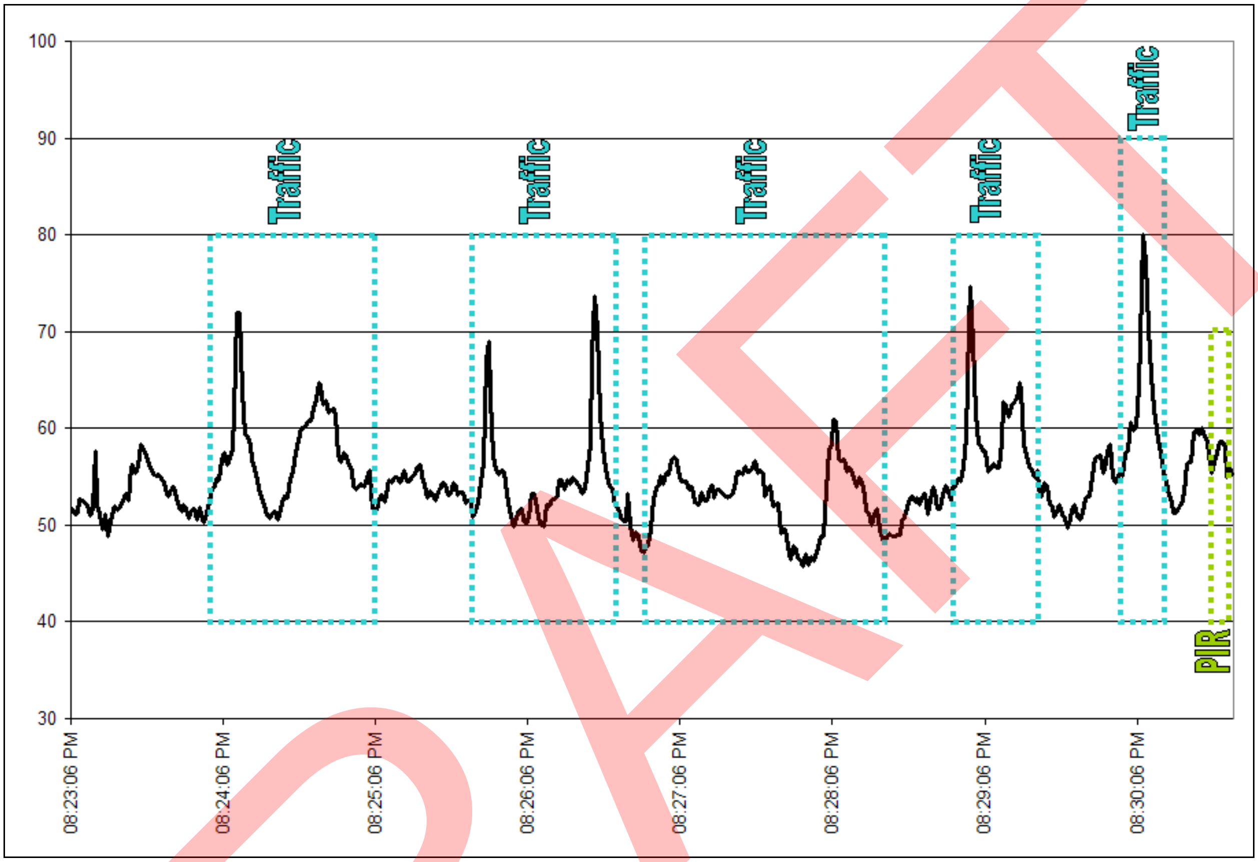
Chart 12. 09/01/07 PIR SOVREN Race at Measurement Location Portsmouth 2, 1-second L_{max}, dBA re: 20 μPa



Source: The Greenbusch Group

Chart 13 shows a position in Portsmouth near Columbia Park. Note that noise levels from traffic on Lombard begin to dominate the neighborhood ambient levels. Race activity was only audible as the traffic died down.

Chart 13. 09/01/07 PIR LND at Measurement Location Portsmouth 1, 1-second L_{max}, dBA re: 20 µPa

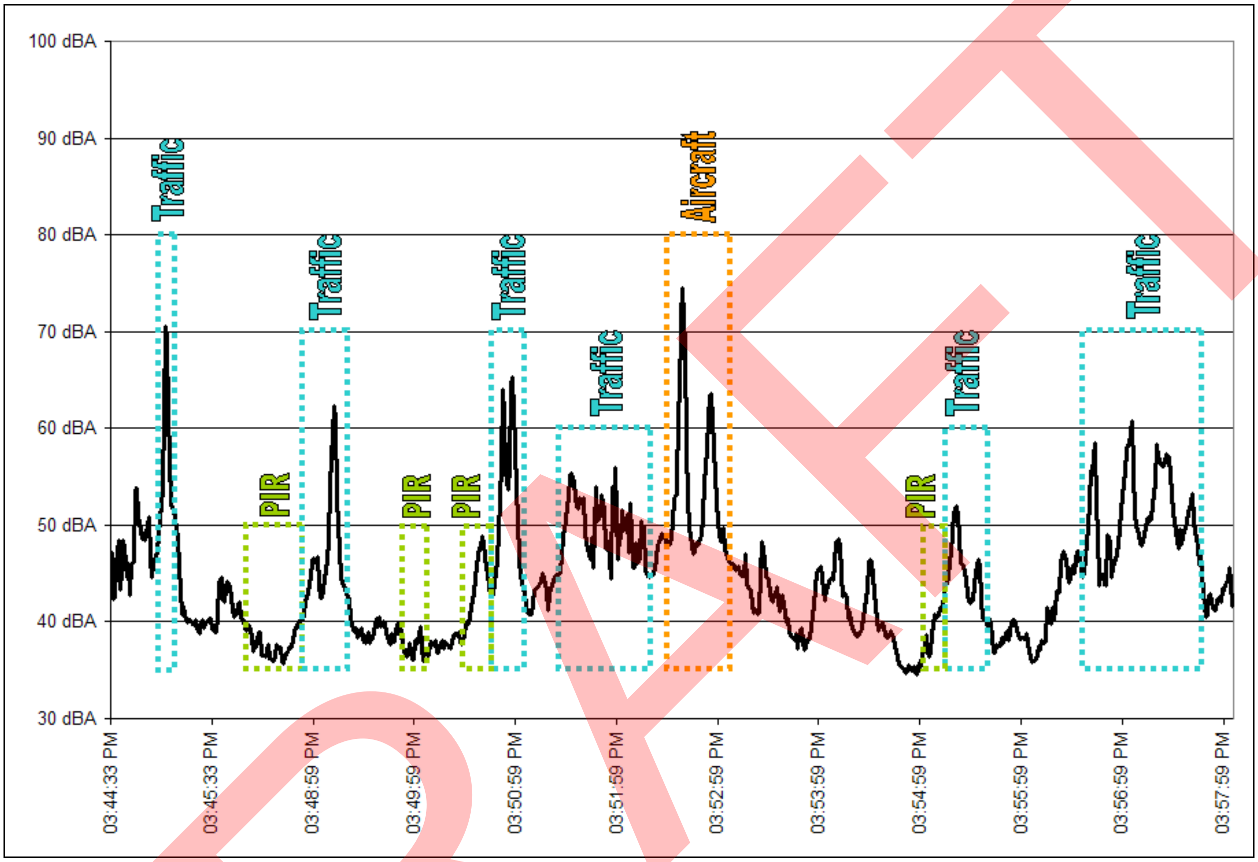


Source: The Greenbusch Group

6.5.4 St. Johns

This location in the Smith Bybee Lakes Wildlife Park shows race activity is slightly audible only as traffic from N. Marine subsides.

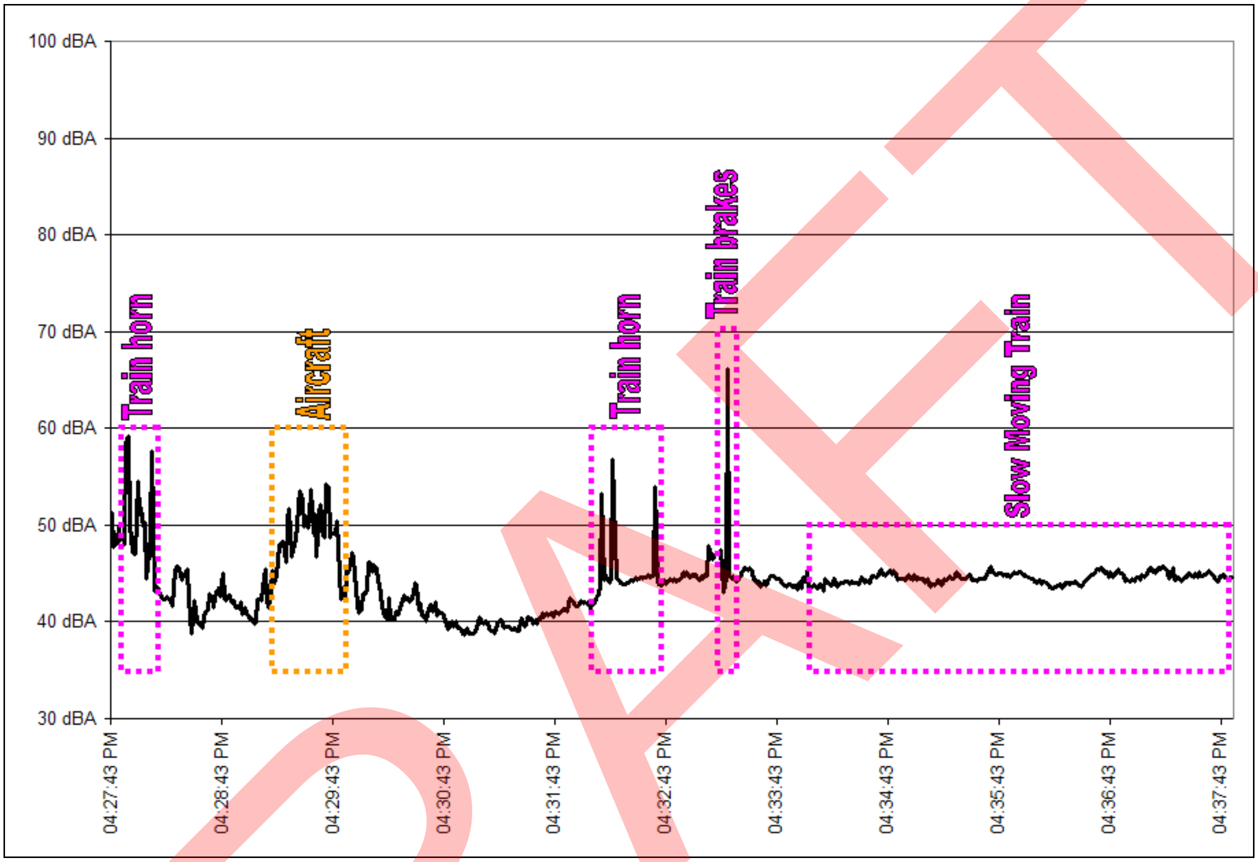
Chart 14. 09/01/07 PIR SOVREN Race at Measurement Location St. Johns 1, L_p, dBA re: 20 μPa



Source: The Greenbusch Group

This location along the waterfront marsh at Smith Bybee Wildlife Park shows train activity dominates during a race. Race activity was only slightly audible and was largely masked by the train movement.

Chart 15. 09/01/07 PIR SOVREN Race at Measurement Location St. Johns 2, L_p, dBA re: 20 μPa

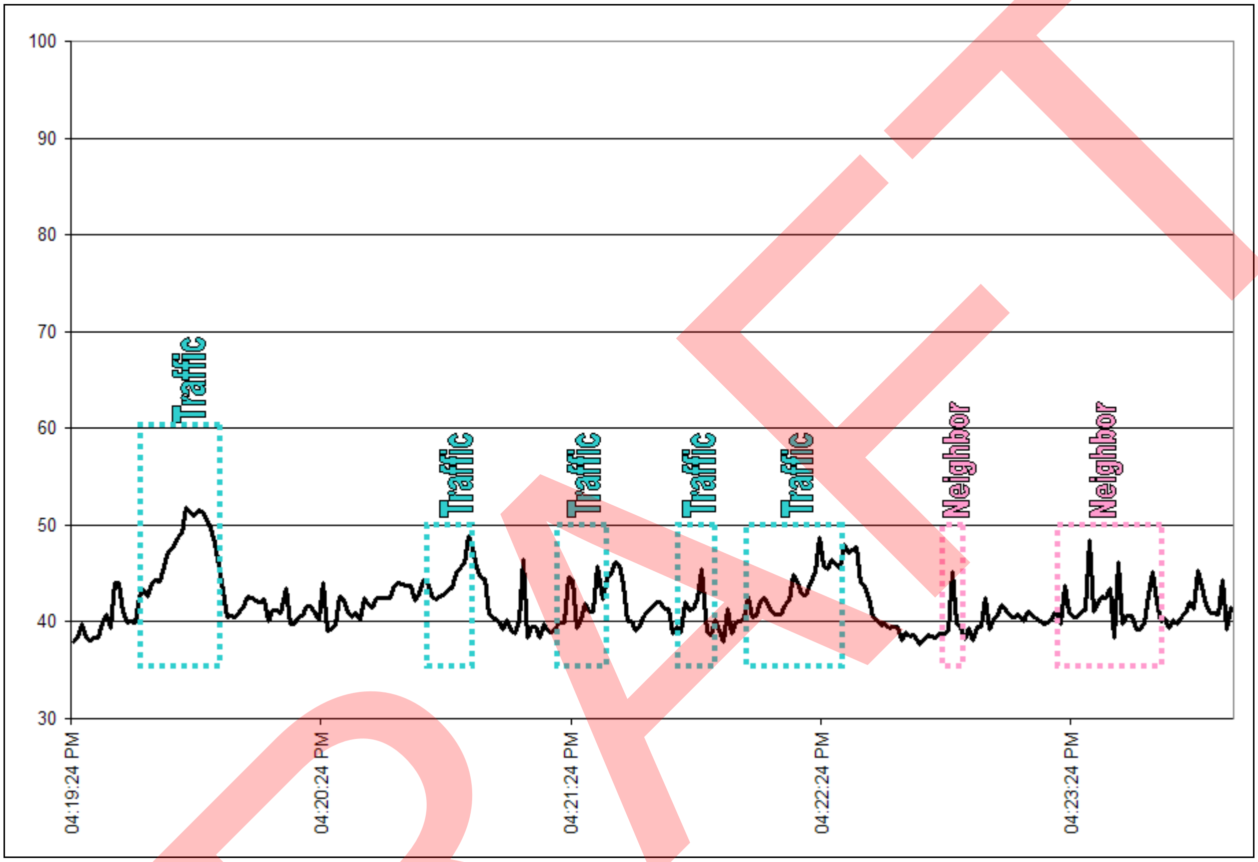


Source: The Greenbusch Group

6.5.5 University Park

Sound levels from the SOVREN race were barely audible at this University Park location. The race was effectively masked by local traffic and neighborhood sounds.

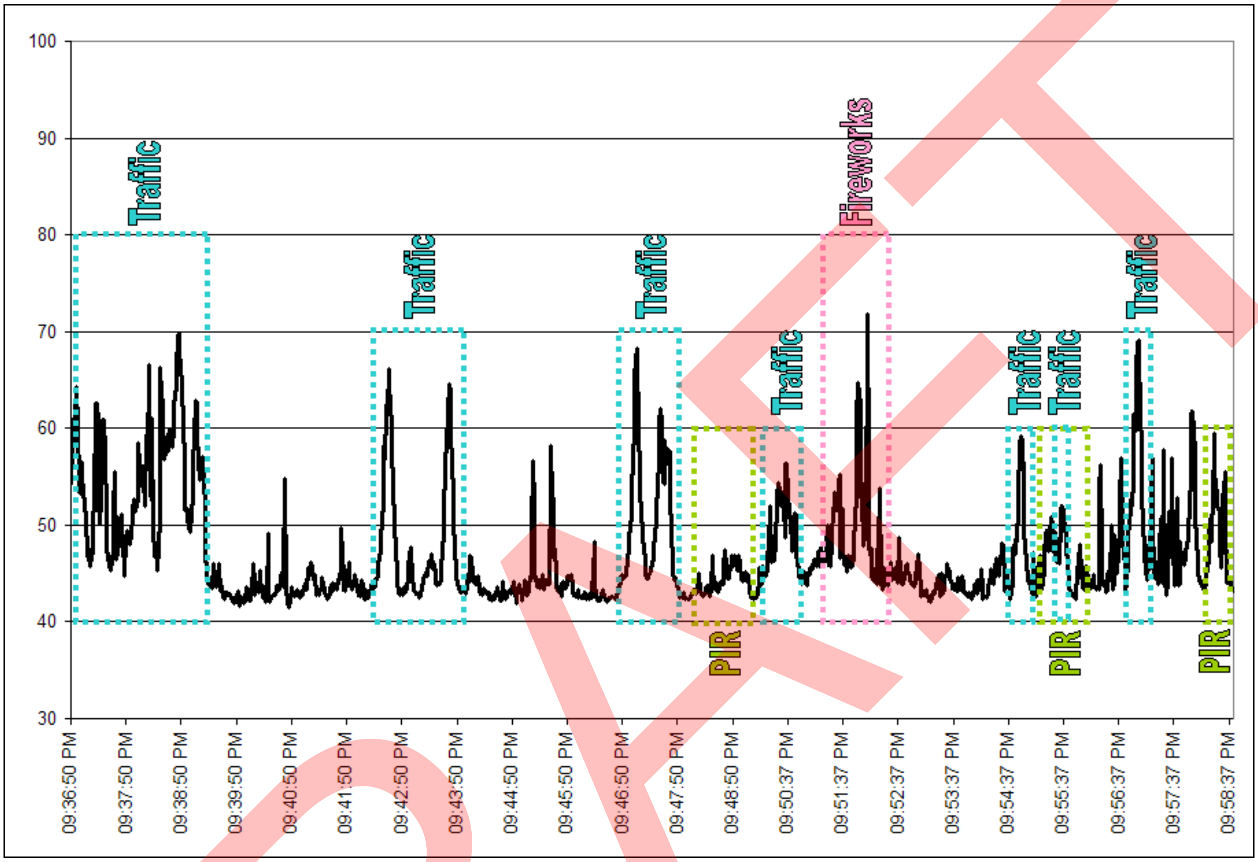
Chart 16. 09/01/07 PIR SOVREN Race at Measurement Location University Park 1, 1-second L_{max}, dBA re: 20 μPa



Source: The Greenbusch Group

Sound levels from the Late Night Drags were audible at this University Park location, although quickly masked by local traffic.

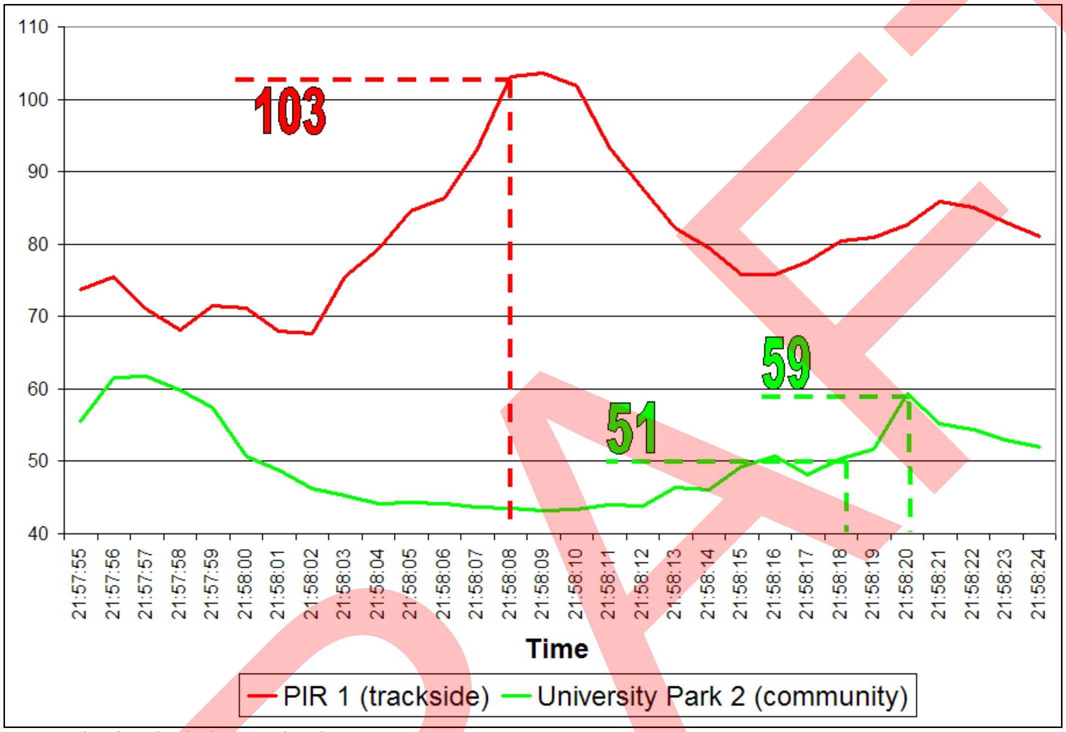
Chart 17. 09/01/07 PIR LND at Measurement Location University Park 2, 1-second L_{max}, dBA re: 20 µPa



Source: The Greenbusch Group

Chart 18 below demonstrates the propagation pattern of sound from PIR. The 103 dBA level was measured trackside and the 59 dBA level was measured of the same event in the neighborhood. This event corresponds to the race event to the far right of Chart X above. You will note that the model calculated the 51 dBA level. The level and arrival time of the sound from the race event did not correspond with the model. Modifications were made as discussed above.

Chart 18. NHRA Late Night Drags Event 4 Time-Domain Comparison, 1-second L_{max} dBA re: 20 µPa



Source: City of Portland, The Greenbusch Group

7.0 NOISE MODEL

7.1 Background

The primary methodology used for the noise exposure level analysis and prediction was a computer noise model. This model was created with the acoustic modeling software Cadna/A. Cadna/A uses the CADNA (Control of Accuracy and Debugging for Numerical Applications) computation engine developed by the Pierre et Marie Curie University of Paris.

The Cadna/A model was built from Geographic Information System (GIS) data supplied by the City of Portland's Bureau of Technology Services department. The data contained within the noise model included: topography, public streets, railways, water bodies, neighborhood boundaries, public parks, land zoning, building footprints and the PIR raceway.

The Cadna/A model utilized the following standards for predicting sound levels:

- Propagation calculations: International Standards Organization (ISO) 9613
- Traffic calculations: Germany Federal Ministry of Transport Standard RLS-90

Sound propagation over large distances is strongly influenced by meteorological conditions. Air temperature, relative humidity, wind speed, wind direction, and wind stability are factors than can affect the manner in which sound propagates. Cadna/A has the ability to predict sound propagation patterns that include the effects of these various meteorological conditions. More detailed explanations of Cadna/A modeling functionality, approaches, and measurement verification are included in the Appendix.

7.2 Source Modeling and Predictions

7.2.1 Portland International Raceway

There are two major types of race uses at PIR that justify two separate modeling approaches: drag racing and full race track events.

7.2.1.1 NHRA Late Night Drags

The most popular drag racing event at PIR is the National Hot Rod Association (NHRA) Late Night Drags (LND). During these events, racing can continue until midnight. Sound level limits in effect during NHRA LND events are listed in Table 16 below. These limits were set, intending to correlate with City Code compliance at nearby residential properties. The 105-dBA level was derived from the 105 dBA State permissible trackside level.

Table 16. Permissible Levels during NHRA LND Events

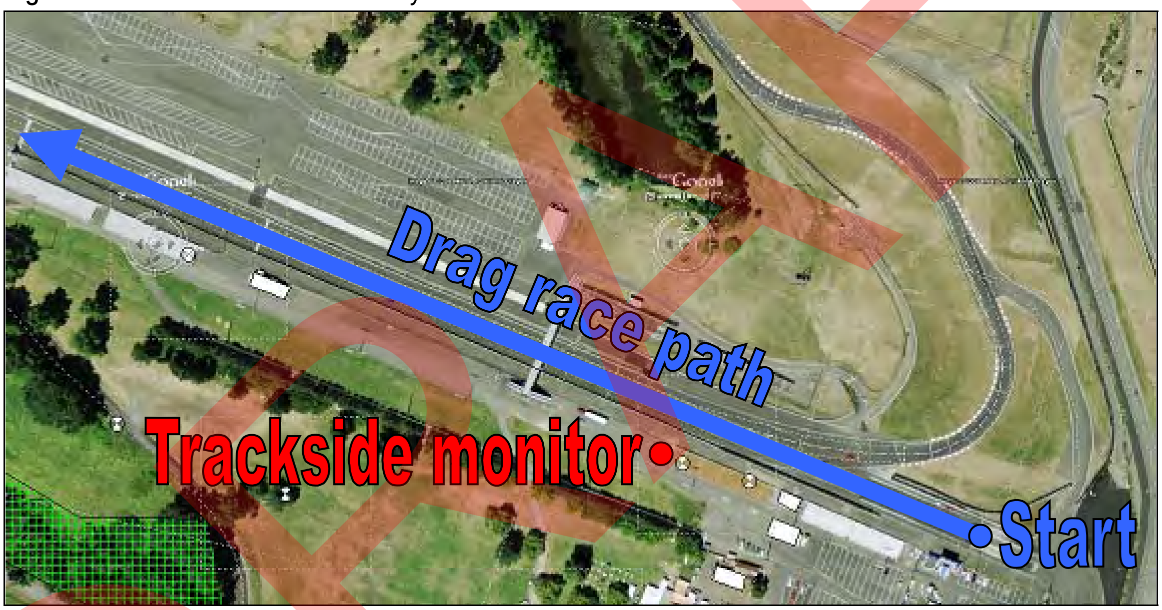
Time Period	Permissible Trackside Sound Level
Before 10:00 pm	105 dBA
After 10:00 pm	90 dBA

Source: The Greenbusch Group

The City's trackside monitor is located within the first third of the active portion of the southern straight away. The trackside monitor is used by the City to track exceedances of permissible sound levels during the drag racing events.

During a single drag racing event, trackside sound levels vary significantly due to the short 50-foot distance between the trackside monitor and the raceway. Sound levels at the start and finish or the race are generally significantly less than the maximum recorded trackside sound level, which occurs as the car passes by the trackside monitor. Race and trackside monitor geometry is shown in Figure 12 below.

Figure 12. NHRA LND Race Geometry



Source: Google Earth™, City of Portland, The Greenbusch Group

Sound level predictions were calculated for several meteorological conditions. Predicted levels are listed in Tables 17 and 18 below.

Table 17. Predicted Community Sound Levels for 105-dBA NHRA Drag Race, Single Vehicle or Two Vehicles Traveling at Similar Speed, L_{max} dBA re: 20 μPa

Location	Meteorological Conditions[1]					
	None – baseline	Annual average	Spring evening	Early summer evening	Late summer evening	Code Limit
Hayden 3	53	51	60	49	49	65
Kenton 1	65	63	57	70*	70*	65
Kenton 4	66	64	58	61	66*	65
Kenton 6	57	56	50	53	63	65
Kenton 7	54	52	47	50	54	65
Portsmouth 1	51	50	44	47	51	65
University Park 2	48	46	41	44	48	65

*Exceeds City Code permissible broadband levels
1. See Appendix for meteorological evaluation definitions
Source: Cadna/A, The Greenbusch Group

Table 18. Predicted Community Sound Levels for 90-dBA NHRA Drag Race, Single Vehicle or Two Vehicles Traveling at Similar Speed, L_{max} dBA re: 20 μPa

Location	Meteorological Conditions[1]					
	None – baseline	Annual average	Spring night	Early summer night	Late summer night	Code Limit
Hayden 3	40	37	46	40	40	60
Kenton 1	51	49	46	57	57	60
Kenton 4	51	49	47	51	56	60
Kenton 6	44	42	39	44	50	60
Kenton 7	41	39	36	41	47	60
Portsmouth 1	38	36	34	38	45	60
University Park 2	35	33	31	35	42	60

*Exceeds City Code permissible broadband levels
1. See Appendix for meteorological evaluation definitions
Source: Cadna/A, The Greenbusch Group

7.2.1.2 Full Race Track Events

Many race events take place at PIR where the full race track is used. The types of racing vehicles used during these events include various types of race cars, motorcycles, and go-karts. Permissible sound levels 50-feet from the track edge for non-variance race events are listed in Table 19 below.

Table 19. Permissible TracksideLevels during Non-Variance Race Events

Time Period	Permissible Trackside Sound Level
Before 10:00 pm	103 dBA
After 10:00 pm	90 dBA

Source: The Greenbusch Group

The City's trackside monitor is used to track exceedances of permissible sound levels during the full track racing events.

During a full track racing event, trackside sound levels vary significantly due to short 50-foot distance between the trackside monitor and the raceway. Sound levels measured when a race vehicle is not passing directly in front of the trackside are generally significantly less than the maximum recorded trackside sound level, which occurs as the race vehicle passes by the trackside monitor. Race and trackside monitor geometry is shown in Figure 13 below.

Figure 13. Full Rack Track Geometry

Source: Google Earth™, City of Portland, The Greenbusch Group

Sound level predictions were calculated for several meteorological conditions. Predicted levels are listed in Tables 20-23 below.

Table 20. Modeled Maximum Community Sound Levels for 103-dBA Full Track Race Event, 10 Similar Vehicles, 1-second L_{max} dBA re: 20 µPa

Location	Meteorological Conditions[1]							
	None – baseline	Annual average	Spring daytime	Spring evening	Early summer daytime	Early summer evening	Late summer daytime	Late summer evening
Hayden 3	63	61	69*	70*	58	62	56	59
Kenton 1	70*	68*	64	65*	69*	74*	70*	75*
Kenton 4	72*	70*	66*	68*	69*	74*	71*	75*
Kenton 6	64	63	55	57	63	68*	64	70*
Kenton 7	61	59	51	53	55	59	60	66*
Portsmouth 1	59	57	50	52	54	58	58	65
University Park 2	56	54	47	49	50	53	53	59

*Exceeds City Code permissible broadband levels
1. See Appendix for meteorological evaluation definitions
Source: Cadna/A, The Greenbusch Group

Table 21. Modeled Maximum Community Sound Levels for Varianced 108-dBA Full Track Race Event, 10 Similar Vehicles, 1-second L_{max} dBA re: 20 µPa

Location	Meteorological Conditions[1]							
	None – baseline	Annual average	Spring daytime	Spring evening	Early summer daytime	Early summer evening	Late summer daytime	Late summer evening
Hayden 3	68*	66*	74*	75*	63	67*	61	64
Kenton 1	75*	73*	69*	70*	74*	79*	75*	80*
Kenton 4	77*	75*	71*	73*	74*	79*	76*	80*
Kenton 6	69*	68*	60	62	68*	73*	69*	75*
Kenton 7	66*	64	56	58	60	64	65*	71*
Portsmouth 1	64	62	55	57	59	63	63	70*
University Park 2	61	59	52	54	55	58	58	64

*Exceeds City Code permissible broadband levels
1. See Appendix for meteorological evaluation definitions
Source: Cadna/A, The Greenbusch Group

Table 22. Modeled Maximum Community Sound Levels for Varianced 110-dBA Full Track Race Event, 10 Similar Vehicles, 1-second L_{max} dBA re: 20 μPa

Location	Meteorological Conditions[1]							
	None – baseline	Annual average	Spring daytime	Spring evening	Early summer daytime	Early summer evening	Late summer daytime	Late summer evening
Hayden 3	70*	68*	76*	77*	65	69*	63	66*
Kenton 1	77*	75*	71*	72*	76*	81*	77*	82*
Kenton 4	79*	77*	73*	75*	76*	81*	78*	82*
Kenton 6	71*	70*	62	64	70*	75*	71*	77*
Kenton 7	68*	66*	58	60	62	66*	67*	73*
Portsmouth 1	66*	64	57	59	61	65	65	72*
University Park 2	63	61	54	56	57	60	60	66*

1. See Appendix for meteorological evaluation definitions
Source: Cadna/A, The Greenbusch Group

Table 23. Modeled Maximum Community Sound Levels for Varianced 113-dBA Full Track Race Event, 10 Similar Vehicles, 1-second L_{max} dBA re: 20 μPa

Location	Meteorological Conditions[1]							
	None – baseline	Annual average	Spring daytime	Spring evening	Early summer daytime	Early summer evening	Late summer daytime	Late summer evening
Hayden 3	73*	71*	79*	80*	68*	72*	66*	69*
Kenton 1	80*	78*	74*	75*	79*	84*	80*	85*
Kenton 4	82*	80*	76*	78*	79*	84*	81*	85*
Kenton 6	74*	73*	65	67*	73*	78*	74*	80*
Kenton 7	71*	69*	61	63	65	69*	70*	76*
Portsmouth 1	69*	67*	60	62	64	68*	68*	75*
University Park 2	66*	64	57	59	60	63	63	69*

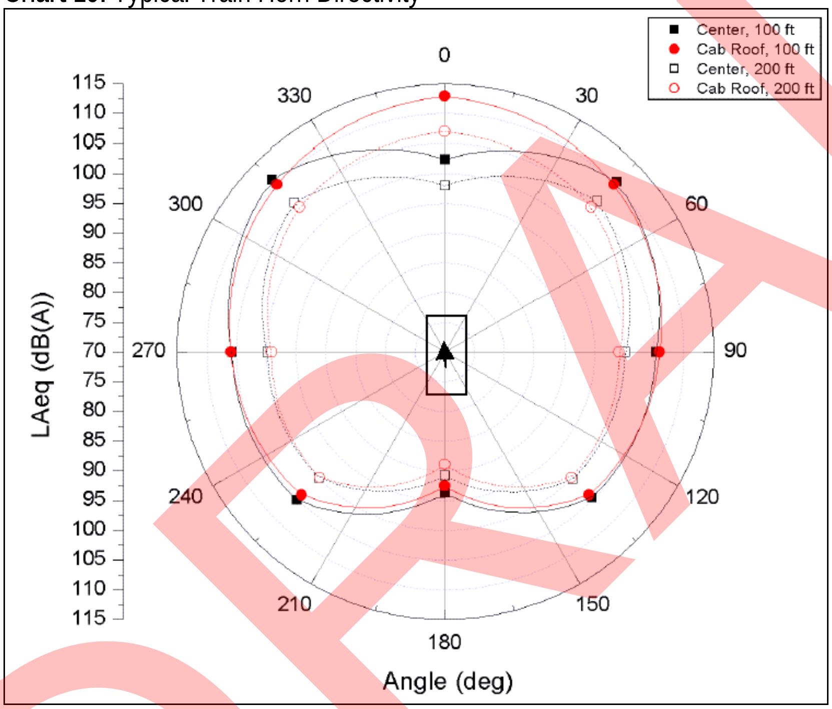
1. See Appendix for meteorological evaluation definitions
Source: Cadna/A, The Greenbusch Group

7.2.2 Railways

Railway horn soundings were modeled as point sources throughout the North Portland community. The point source sound level spectrum was based on field measurements and set to equal the new FRA regulation of 110 dB at 100 feet in front of the train in the direction of travel.

Train horn directivity played an important role in modeling community exposure. Train horns focus most of the sound emission directly in front of the train. However, the amount of acoustical energy produced during a sounding emanates a large amount of acoustical energy in all directions. In addition, the directivity of the train horn varies according to distance and mounting location of the horn. For the purposes of this study, the typical directivity pattern of a cab roof mounted train horn at 100 feet was used. Typical train horn directivities are shown in Chart 19 below.

Chart 19. Typical Train Horn Directivity



Source: Raposa and Fleming, IWRN 2001

Modeling was concentrated in the Kenton neighborhood, where there are a large number of public grade crossings and small distances between the railway and residential buildings. While the locations of public grade crossings are fixed, the location of the locomotive during actual train sounding events varies. Train horn sounding levels were modeled for three events in the Kenton neighborhood as described in Table 24 and Figure 14 below.

Table 24. Modeled Train Horn Events

Event	Neighborhood	Crossing Street
Event 1	Kenton/Portsmouth	North Columbia Boulevard Frontage Road
Event 2	Kenton	North Peninsular Avenue
Event 3	Kenton	North Tyndall Avenue
Event 4	Cathedral Park	North Baltimore Avenue

Source: The Greenbusch Group

Figure 14. Train Horn Modeling Event Locations

Source: Google Earth™, City of Portland, The Greenbusch Group

Community sound levels for the modeled train events are summarized in Table 25 below. Sound level contours are provided in the Appendix.

Table 25. Modeled Train Horn Event Sound Levels, 1-second L_{max} dBA re: 20 μPa

Event	Train Direction	Maximum Residential Building Sound Level
Event 1	Westbound	91
	Eastbound	97
Event 2	Westbound	94
	Eastbound	94
Event 3	Westbound	96
	Eastbound	86
Event 4	Westbound	87

Source: The Greenbusch Group

7.2.3 Freight Corridors

The Portland Department of Transportation (PDOT) provided all available classification traffic count data for the North Portland area. There are three general types of traffic count data: volume, velocity, and classification counts. Most of the traffic count data available for North Portland is volume data. Volume data is derived by taking the total number of vehicle axles counted during a specified time period, dividing by two, and averaging the value over a 24-hour time period. This approach assumes all of the counted vehicles have two axles. However, the roadways under investigation in this study carry a large number of freight vehicles, which generally have more than two axles. Velocity data provides a more accurate picture of total vehicle flow, while classification count data provides detailed information about the total number of vehicles and the percentage of each vehicle type. Given that the Cadna/A road noise model used in this study requires the input of traffic volume and the percentage of heavy vehicles, only classification data provided sufficient information for model input. Unfortunately, a limited amount of classification traffic count data was available for use in the study. While PDOT data was used when available, insufficient data was available to model all freight corridors according to PDOT traffic count data. In some cases, assumptions regarding traffic volume symmetry were made in order to model a specific roadway. In one case, no classification counts were available, short-term traffic counts taken during sound level measurements were used as the basis for model input.

RLS-90, the standard used by Cadna/A to model traffic noise, includes two primary input parameters: average hourly traffic volume and the percentage of "heavy vehicles." Cadna/A defines "heavy vehicles" as those with a gross vehicle weight of more than 2.8 tons. Model verification measurements revealed that all large vehicles, other than cars and motorcycles should be considered "heavy vehicles" in the noise model. Model verification measurements are presented in the Appendix.

Street geometry and nearby building outlines were included in the GIS data provided by the City of Portland. Satellite imagery was used to update some building locations. Building height information was acquired through the City of Portland parcel information database. Screening offered by fences was not included in the noise model.

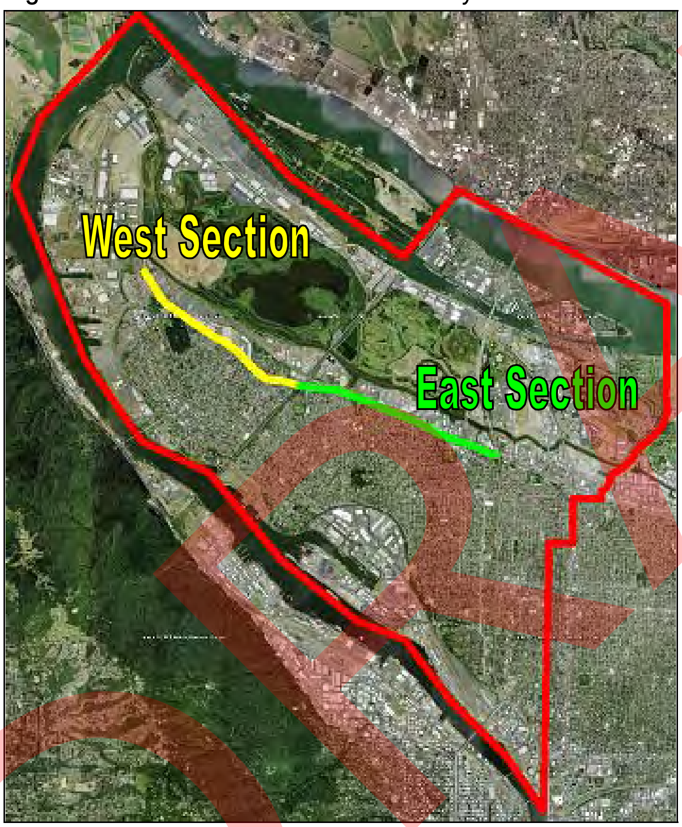
7.2.3.1 North Columbia Boulevard

North Columbia Boulevard is a major roadway in the northern area of North Portland. Freight vehicles utilize the roadway to transport freight out of the Rivergate Industrial District. The roadway is typically four lanes wide, two eastbound and westbound, with a speed limit of 40 miles per hour. For the purpose of study, two sections of the roadway with residential buildings site nearby were selected from the full stretch of roadway. The sections were defined as follows:

- West Section: between North Burgard Street and North Geneva Avenue
- East Section: between North Geneva Avenue and North Argyle Street

The geographic locations of these two roadway sections are shown in Figure 15 below.

Figure 15. North Columbia Boulevard Study Sections



Source: Google Earth™, City of Portland, The Greenbusch Group

Traffic count information provided by PDOT for North Columbia Boulevard is summarized in Table 26 below in terms of the average daily traffic (ADT).

Table 26. PDOT Traffic Counts for North Columbia Boulevard

Location	Start Date	Bound	Time Period	Average Hourly Volume	Percentage Heavy Vehicles
N Columbia Blvd & N Portsmouth Ave	01/07/03	East & West	Daytime	854[1]	34%
			Nighttime	326[1]	25%

1. Only west bound 24-hour ADT data was provided, total roadway traffic was estimated by doubling west bound counts.
Source: Portland Department of Transportation

PDOT traffic count information was entered into the Cadna/A model to evaluate expected sound exposure levels at residential buildings near North Columbia Boulevard. Each section was assumed to contain similar traffic volumes, based on traffic count data provided by PDOT. Corresponding modeled residential sound exposure levels for the nearest residential buildings are listed in Table 27 below.

Table 27. PDOT Traffic Sound Levels for North Columbia Boulevard

Section	Number of Buildings with Daytime Leq > 67	Number of Buildings with Ldn > 65	Number of Buildings with Ldn > 70	Number of Buildings with Ldn > 75
West section (99 buildings)	76 (77 %)	99 (100%)	68 (69%)	26 (26%)
East section (89 buildings)	30 (34%)	75 (84 %)	23 (26%)	7 (8%)

Source: Cadna/A, The Greenbusch Group

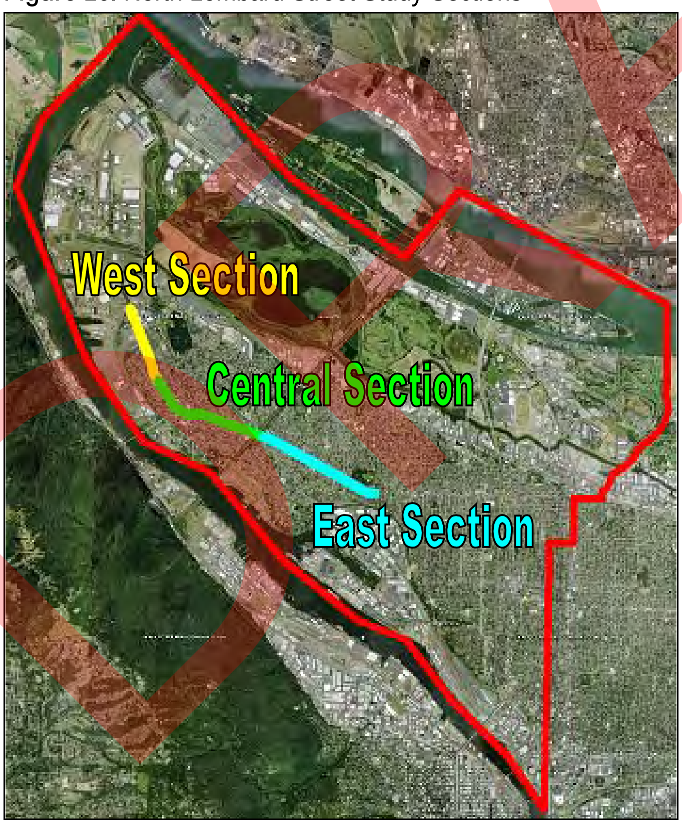
7.2.3.2 North Lombard Street

North Lombard Street is a major roadway in the southwestern area of North Portland. Freight vehicles utilize the roadway to transport freight out of the Rivergate Industrial District. The roadway is typically two lanes wide with a speed limit of 35 miles per hour. For the purpose of study, three sections of the roadway with residential buildings sited nearby were selected from the full stretch of roadway. The sections were divided at traffic count points and were defined as follows:

- West Section: between North Roberts Avenue and North Catlin Avenue
- Central Section: between Catlin Avenue and North Macrum Avenue
- East Section: between North Macrum Avenue and North Chautauqua Avenue

The geographic locations of the roadway study sections are shown in Figure 16 below.

Figure 16. North Lombard Street Study Sections



Source: Google Earth™, City of Portland, The Greenbusch Group

Traffic count information provided by PDOT and used in the noise modeling for North Lombard Street is summarized in Table 28 below.

Table 28. PDOT Traffic Counts for North Lombard Street

Location	Start Date	Bound	Time Period	Average Hourly Volume	Percentage Heavy Vehicles
N Lombard St & N Roberts Ave	10/04/04	North & South	Daytime	382	44%
			Nighttime	94	28%
N Lombard St & N Catlin Ave	5/22/02	East & West	Daytime	480	41%
			Nighttime	150	34%
N Lombard St & N Carey Blvd	5/21/02	East & West	Daytime	996	26%
			Nighttime	166	23%
N Lombard St & N Haven Ave	12/17/02	East & West	Daytime	913	26%
			Nighttime	181	23%

Source: Portland Department of Transportation

PDOT traffic count information was entered into the Cadna/A model to evaluate expected sound exposure levels at residential buildings near North Lombard Street. Corresponding modeled residential sound exposure levels for the nearest residential buildings are listed in Table 29 below.

Table 29. PDOT Traffic Sound Levels for North Lombard Street

Total Buildings Evaluated	Number of Buildings with Daytime Leq > 67	Number of Buildings with Ldn > 65	Number of Buildings with Ldn > 70	Number of Buildings with Ldn > 75
West section (64 buildings)	62 (97%)	64 (100%)	61 (95%)	25 (39%)
Central section (10 buildings)	10 (100%)	10 (100%)	10 (100%)	9 (90%)
East section (29 buildings)	29 (100%)	20 (100%)	29 (100%)	12 (41%)

Source: Cadna/A, The Greenbusch Group

7.2.3.3 North Going Street

North Going Street is a major roadway in the southeastern area of North Portland. Freight vehicles utilize the roadway to transport freight out of the Swan Island Industrial Park. The roadway is typically five lanes wide, two westbound and three eastbound, with a speed limit of 40 miles per hour. For the purpose of study, a section of the roadway with residential buildings sited nearby was selected from the full stretch of roadway. The section was defined as follows:

- Study Section: between North Port Center Way and North Interstate Avenue

The geographic location of the roadway study section is shown in Figure 17 below.

Figure 17. North Going Street Study Section

Source: Google Earth™, City of Portland, The Greenbusch Group

Classification traffic count data was not available for North Going Street. Traffic counts from short-term field measurements were used as a basis for estimating community sound exposure levels. These short-term traffic counts extrapolated for model input are shown in Table 30 below. Corresponding modeled residential sound exposure levels for the nearest residential buildings are listed in Table 31 below.

Table 30. Extrapolated Traffic Data for North Going Street

Location	Start Date	Bound	Time Period	Average Hourly Volume	Percentage Heavy Vehicles
N Port Center Way & N Going St	09/30/06	East & West	Daytime	588	42%
			Nighttime	78	21%

Source: The Greenbusch Group

Table 31. PDOT Traffic Sound Levels for North Going Street

Section	Number of Buildings with Daytime Leq > 67	Number of Buildings with Ldn > 65	Number of Buildings with Ldn > 70	Number of Buildings with Ldn > 75
Study section (65 buildings)	17 (26%)	24 (37%)	5 (7%)	1 (2%)

Source: Cadna/A, The Greenbusch Group

8.0 MITIGATION

This study has established that several corridors through residential communities in North Portland experience higher sound levels than are typical for an urban, residential location. Mitigation for the sources studied is not straightforward, and may have economic and/or operational implications. The mitigation treatments outlined below are intended as potential approaches for further discussion, rather than recommendations.

8.1 Portland International Raceway (PIR)

PIR is generally considered to be a positive element of the community, providing both recreation and advancing the economy. However, sound levels associated with the operation of PIR have been an issue in the residential communities for several years. Numerous studies have been conducted to further quantify neighborhood sound exposure levels during race activity. Some residents have lobbied to relocate the facility but this was determined to be not feasible.

State trackside sound limits were believed to be adequate for ensure compliance with the City Noise Code in the community, and continue to be a reference point for compliance issues. However, the existing permissible trackside sound levels were not adopted by the City Code, and the Portland Noise Review Board has expressed concerns of their adequacy. Sound levels at the track continue to be monitored during each race with a permanently located trackside monitor. The results of the measurements are periodically reviewed by the Noise Review Board. Variance agreements are in place for 4 major races, where the sound level is allowed to be increased to accommodate the race. Details of the variance requirements are outlined in Section 5.1.3.

Based on the measurements completed for this study and on our model predictions of community exposure levels for various race configurations, it is likely that sound levels in the community exceed City Code on occasion, during the races. Exceedance depends strongly upon the number of vehicles racing, the total sound emission from all the vehicles, the spectral content of the emission, and meteorological conditions. Potential additional mitigation measures include the following:

- Install a second, permanent monitor location near the quarter-mile mark on the southern straightaway to more accurately characterize the sound levels associated with the drags.
- Establish trackside octave band sound level limits to control mid-range frequency sound emissions from the racetrack and help achieve compliance with City Code permissible octave band sound levels at nearby properties.
- Install a 16-ft tall Plexiglas barrier along the edge of the track. A reduction of between 6 and 14 dBA could be realized in the Kenton and Portsmouth neighborhoods.
- Install a 9 ft tall Plexiglas barrier along the edge of the track. A reduction of between 1 and 10 dBA could be realized in the Kenton and Portsmouth neighborhoods.
- Install a 16-ft tall barrier behind the bleachers on the south side, extending the entire stretch of the southern straightaway. A reduction of between 1 and 9 could be realized in the Kenton and Portsmouth neighborhoods.

8.2 Railways

The horns from the trains are the most dominant sound source along the Columbia corridor. The maximum sound levels shown in Table 15 show the sound levels reach up to 104 dBA. The horns are a source of sleep disturbance in the Kenton and Portsmouth neighborhoods.

The Federal Railroad Administration (FRA) published the Final Rule on the Use of Locomotive Horns at Highway-Rail Grade Crossings, on April 27, 2005. The Final Rule preempts any state or local laws regarding the use of the train horn at public crossings.

The Final Rule provides public authorities the option to establish quiet zones provided certain safety measures are in place and the crossing accident rate meets FRA standards. A quiet zone is a segment of a rail line that contains public grade crossings at which locomotive horns are not normally sounded.

There are two types of quiet zones that may apply to North Portland are:

- Full Quiet Zone is a zone where the horn is silenced 24 hours per day.
- Partial Quiet Zone is a quiet zone where the horn is silenced for a specified period of the day, typically during the nighttime hours of 10 p.m. and 7 a.m.

In order to establish a quiet zone, the City must meet the following conditions:

- Show that the lack of the horn does not pose a significant safety risk.
- Implement safety measures such as Supplemental Safety Measures (SSMs) or wayside horns to reduce excess risk associated with no horn.

Supplementary Safety Measure (SSM)

Measures that may be an effective substitute in North Portland for the locomotive horn in the prevention of highway-rail casualties are:

- Four-Quadrant Gate System-a system of gates designed to provide a full closure of the crossing eliminating the opportunity to drive around a single lowered gate.
- Temporary Closure-for use in a Partial Quiet Zone by eliminating vehicular access to the crossing during certain hours of the day (10pm-7am) allowing train horns not to be silenced.

Wayside Horn

If a full quiet zone is not implemented, the use of a wayside horn would reduce the footprint of the noise impact. A wayside horn is a stationary horn located at a highway-rail grade crossing, designed to provide, upon the approach of a locomotive or train, audible warning to oncoming motorists of the approach of a train.

8.3 Freight Corridors

The freight corridors through North Portland communities increase the sound exposure levels for the residential structures in close proximity to North Columbia Blvd, North Lombard Street and North Going Street. The traditional approach to mitigating traffic noise is a noise wall. While this approach could be effective in these some locations, the height of the walls would need to be 12 feet or greater. The character of the residential neighborhoods would be signifcantly altered with the construction of these large barriers. View corridors would be disrupted and in areas where the residential stuctures are multiple stories, the upper units would have line of sight over the barrier, rendering it ineffective. No barriers are recommended along these corridors.

However, given the expansion of the residential properties in North Portland, the City may wish to consider resurfacing these corridors with a quiet pavement to reduce tire noise, or an addition to the Building Code for this area. This type of added permit requirement is not unusual for neighborhoods near airports. An outline of potential language is listed below:

8.3.1 Model Sound Transmission Control Ordinance Language

The City of Portland has imposed additional requirements for residential structures built after January 2009 in the following areas:

- North Columbia Blvd.
- North Lombard St.
- North Going St.

The requirements are outlined in the Sound Transmission Control Ordinance, Title XX. Section XX describes the construction requirements for buildings constructed along the freight corridors in North Portland.

Exterior Walls

1. Exterior walls, other than as described in this section shall have a laboratory sound transmission class rating of at least STC-50; (OR)
2. Masonry walls having a weight of at least one hundred twenty (120) pounds per square foot.
3. Wood frame walls at least six inches (5 1/4" in nominal depth) and finished on the outside with solid sheathing under an approved exterior wall finish. Butt all panels tightly. The interior surface shall be 2 layers of 5/8" gypsum board installed on a resilient clip such as Pac International RSIC. Insulate the cavity with batt insulation.

Exterior Windows

Windows shall have a laboratory sound transmission class rating of at least STC-40; compressed airtight when the window is closed so as to conform to an air infiltration test not to exceed one-half (1/2) cubic foot per minute per foot of crack length in accordance with ASTM E-283-65-T.3. Glass shall be sealed within the frame in an air-tight manner with a non-hardening sealant or a soft elastomer gasket or gasket tape. The perimeter of the window frames shall be sealed air-tight to the exterior wall construction with a sealant conforming to one of the following Federal Specifications: TT-S-00227, TT-S-00230, or TT-S-00153, or other materials approved by the Building Official, (listed).

Exterior Doors

Doors shall have a laboratory sound transmission class rating of at least STC-43, sealed airtight to the exterior wall construction.

Glass from any double glazed sliding doors shall be separated by a minimum one-half inch (1/2") airspace. Each sliding frame shall be provided with an efficiently airtight weather-stripping material as specified above. A third layer of glazing should be added as a “storm” door, sliding independently of the main door. This glazing shall be minimum ¼” laminated glass.

Glass, over two (2) square feet in area, of all doors, shall be rated STC 40 and shall be sealed in an airtight non-hardening sealant or in a soft elastomer

gasket or gasket tape.

Roofs

Combined roof and ceiling construction on other than as described in this section and the section on ceilings shall have a laboratory sound transmission class of STC-49; (OR)

With an attic or rafter space at least six inches (6") deep, and with a ceiling below, the roof shall consist of one-inch (1") composition board, plywood or gypsum board sheathing topped with an approved roofing material.

Window or dome skylights shall have a laboratory sound transmission class rating of at least STC-38. Skylight assemblies that consist of 1/4" tempered glass, 1/2" air space and a laminated panel consisting of 1/8" tempered glass, .03" (three mils) laminate and 1/8" tempered glass will be accepted in lieu of the tested assembly.

Ceilings

Ceilings on the upper level shall be gypsum board at least five-eighths inch (5/8") thick and shall be substantially airtight with a minimum of penetrations. The ceiling panels shall be mounted on resilient clips as described above for the walls.

Batt insulation rated not less than R-38 shall be provided above the ceiling between joist.

Ventilation

The Oregon State Code on Ventilation and Indoor Air Quality shall prevail. The following items shall be included:

The inlet and discharge openings shall be fitted with sheet metal transfer ducts of at least twenty (20) gauge steel, which shall be lined with one inch (1") thick coated glass fiber, and shall be at least ten feet (10') long with one (1) ninety degree bend. Gravity vent openings in attics shall be as close to code minimum in number and size, as practical. The openings shall be fitted with transfer ducts at least six feet (6') in length containing internal one inch (1") thick coated fiber glass sound-absorbing duct lining. Each duct shall have a lined ninety degree bend in the duct such that there is no direct line of sight from the exterior through the duct into the attic.

Bathroom, laundry and similar exhaust ducts connecting interior space to the outdoors shall be provided with a ninety degree bend in the duct such that there is no direct line of sight through the duct from the venting cross section to the room opening cross section. Duct lining shall be coated glass fiber duct liner at least one inch (1") thick.

Domestic range exhaust ducts connecting the interior space to the outdoors shall contain a self-closing damper across the exterior termination that allows for proper ventilation.

Air conditioning would potentially be required in some homes to ensure adequate cooling during warm periods without opening windows.

We would expect these construction modifications to reduce interior sound levels from traffic on the nearby freight corridors by approximately 8 dBA.

8.4 I-5 Traffic

The Delta Park Project, sponsored by ODOT is scheduled to begin constriction in the Spring of 2008. The project widens portions of I-5 between Victory Blvd to Lombard St. This project will be completed in two Stages:

Stage 1

- Widening I-5 southbound
- Constructing a new southbound entrance ramp bridge at Columbia Blvd.
- Widening the southbound Columbia Slough Bridge
- Relocating a portion of the sound wall at N. Minnesota Ave
- Adding new signage and road striping

Stage 2 (summer 2009)

- Widening I-5 northbound
- Widening Columbia Blvd Bridge northbound
- Widening northbound Columbia Slough Bridge

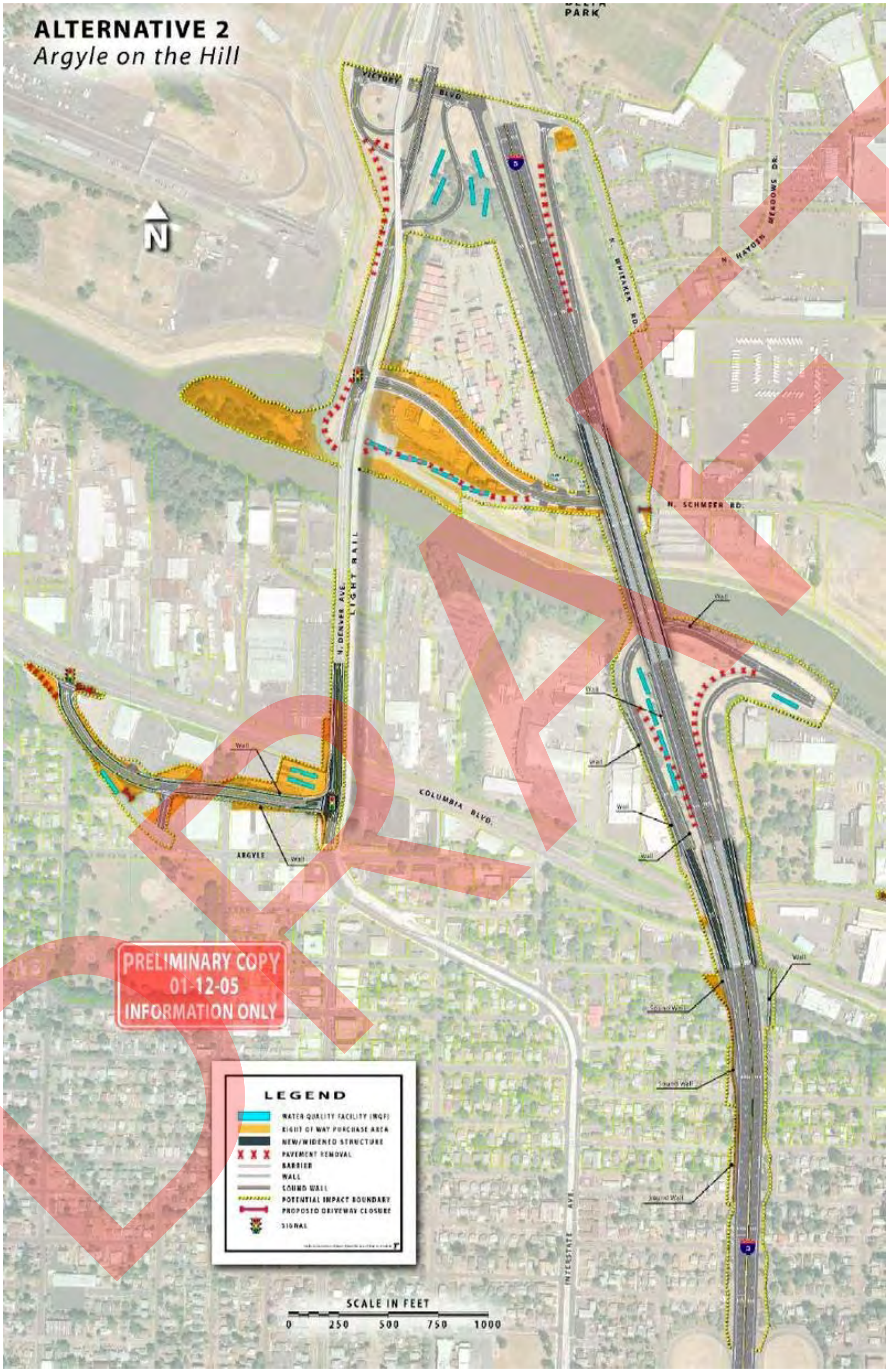
ODOT has stated that, “To mitigate noise impacts to the Kenton neighborhood, the sound wall on the west side of the freeway will be adjusted and reconstructed.”

In addition, the Delta Park Community Enhancement fund was created to benefit communities affected by transportation projects on I-5. One of the funded projects benefiting North Portland communities included:

- Installation of a traffic circle and other speed reduction measures on Denver Avenue in the Kenton neighborhood as part of the Downtown Kenton Business Association Community Enhancement project.

No additional mitigation is suggested.

Figure 18. Proposed Modifications of the I-5 Delta Park Project



Source: Oregon Department of Transportation

8.5 Portland International Airport (PDX)

Flight patterns for traffic arriving or departing PDX have, for the most part, been concentrated over the Columbia River and industrial or commercial land uses along this corridor. A conscious effort has been made by PDX to minimize the traffic over residential neighborhoods. However, it is our understanding that the Port of Portland has instituted a Home Sound Proofing program for owner occupied single-family residences constructed before October 1, 1998. Eligible homes must be located within the PDX DNL 65 contour, using the Noise Exposure Map from the Noise Compatibility Study. Floating homes and mobile homes were excluded from this program.

However, it is our understanding that North Portland homes do not fall within the PDX DNL 65 contour, and are therefore not eligible for the program.
No additional mitigation is suggested.

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I-5 Delta Park construction project information and figure: Oregon Department of Transportation.

10.0 ACKNOWLEDGEMENTS

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Gary Odenthal, City of Portland Bureau of Planning

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Portland International Raceway Staff

Residents of North Portland

Rich Peppin, Scantek, Inc.

APPENDIX

A1.0 NOISE MODEL OUTPUT FIGURES

Table X. Noise Model Output Figure Index

Figure	Description
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A3	PIR Late Night Drag 105 dBA trackside – Statistical meteorology (average)
A4	PIR Late Night Drag 105 dBA trackside – Spring evening meteorology
A5	PIR Late Night Drag 105 dBA trackside – Early summer evening meteorology
A6	PIR Late Night Drag 105 dBA trackside – Late summer evening meteorology
A7	PIR Late Night Drag 90 dBA trackside – No meteorology (baseline)
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A9	PIR Late Night Drag 90 dBA trackside – Spring night meteorology
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A11	PIR Late Night Drag 90 dBA trackside – Late summer night meteorology
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A26	PIR Late Night Drag 105 dBA trackside – No meteorology (baseline), residential code exceedance
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Table X. Noise Model Output Figure Index

Figure	Description
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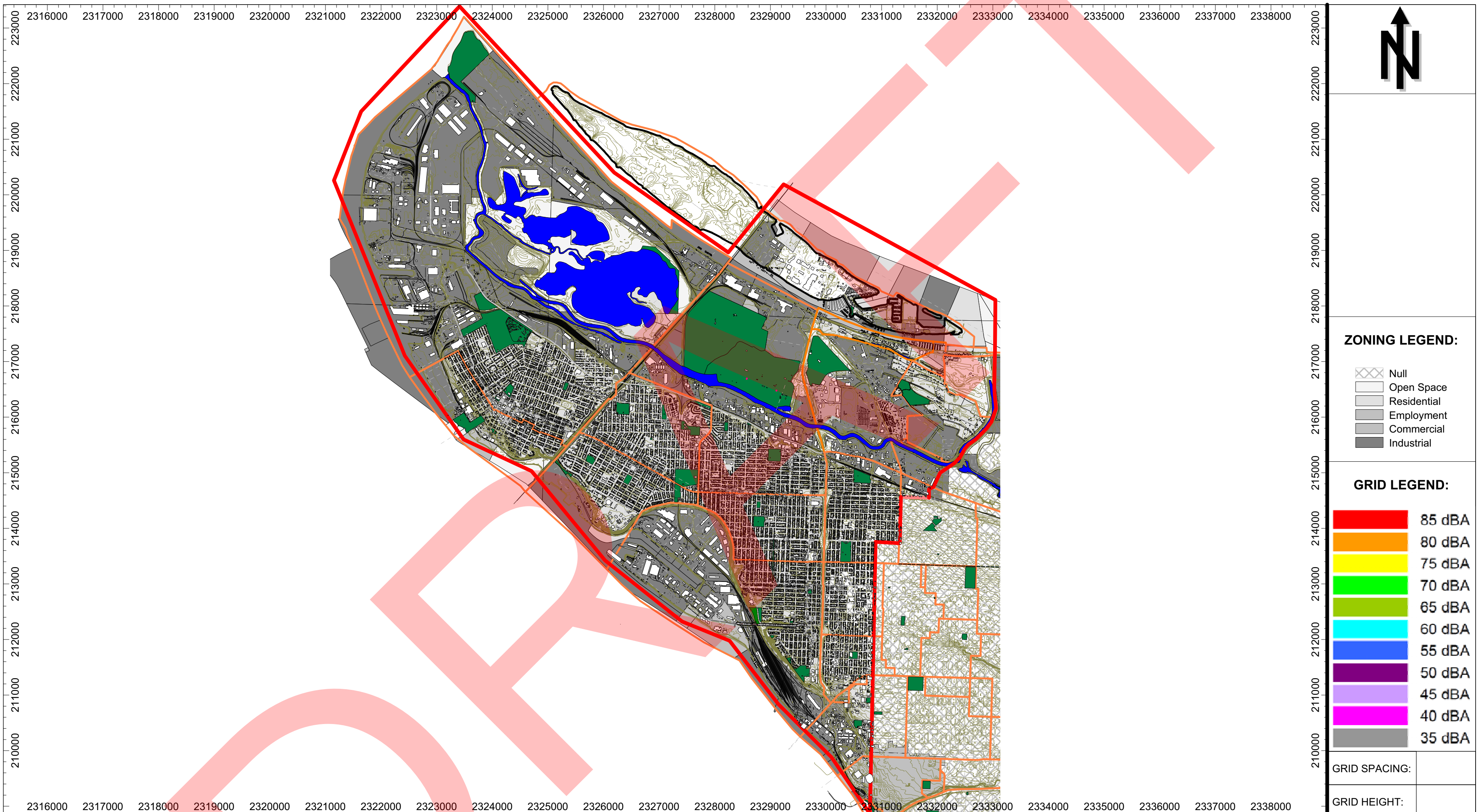
A55	Composite – PIR Full Race Track 103 dBA trackside, daytime traffic, Kenton train horn
A56	Composite – PIR Full Race Track 113 dBA trackside, daytime traffic, Kenton train horn

Source: The Greenbusch Group



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North Portland Noise Study

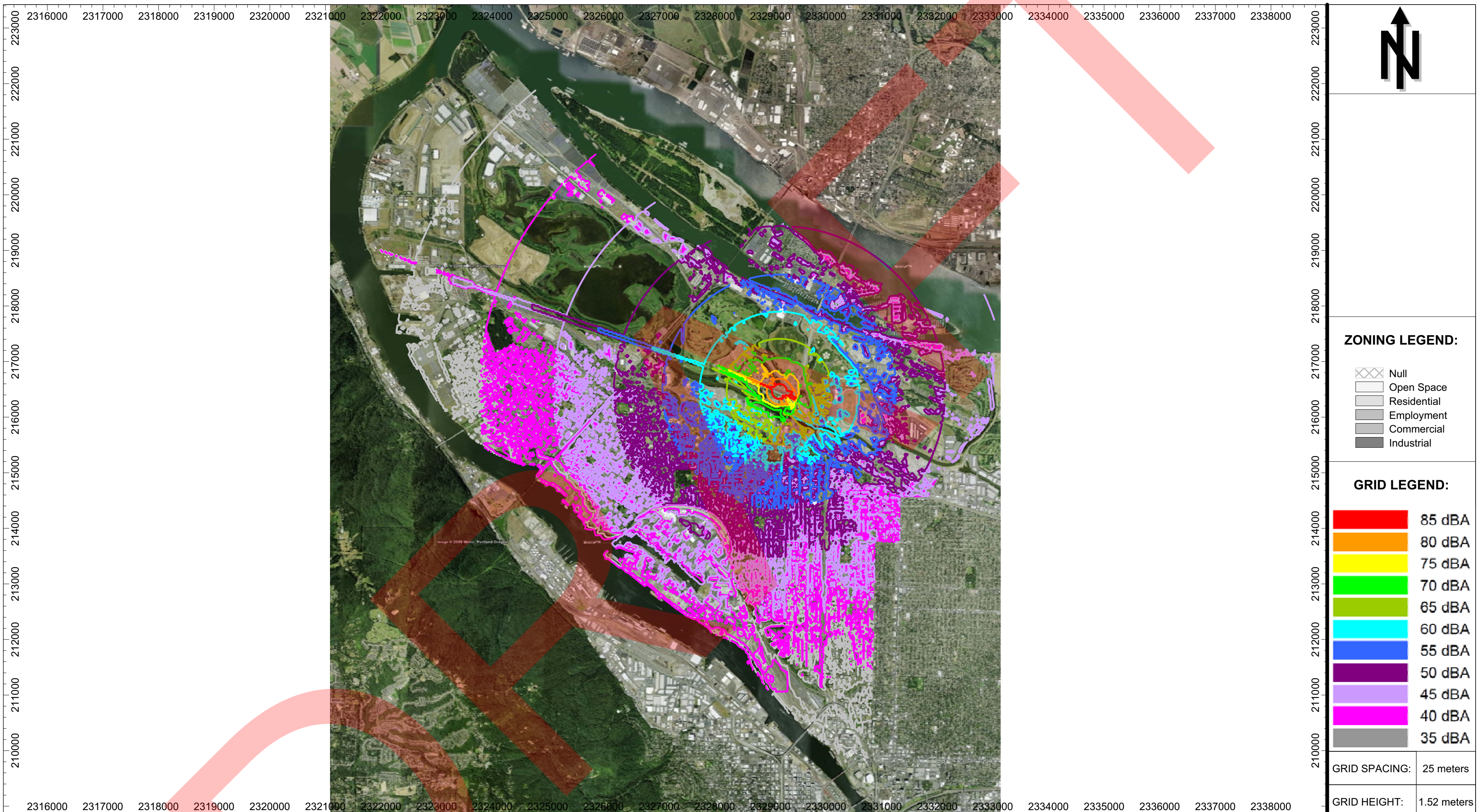
City of Portland
Portland, Oregon

REVISIONS		
NO.	REVISION	DATE

PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A1.
Noise Model



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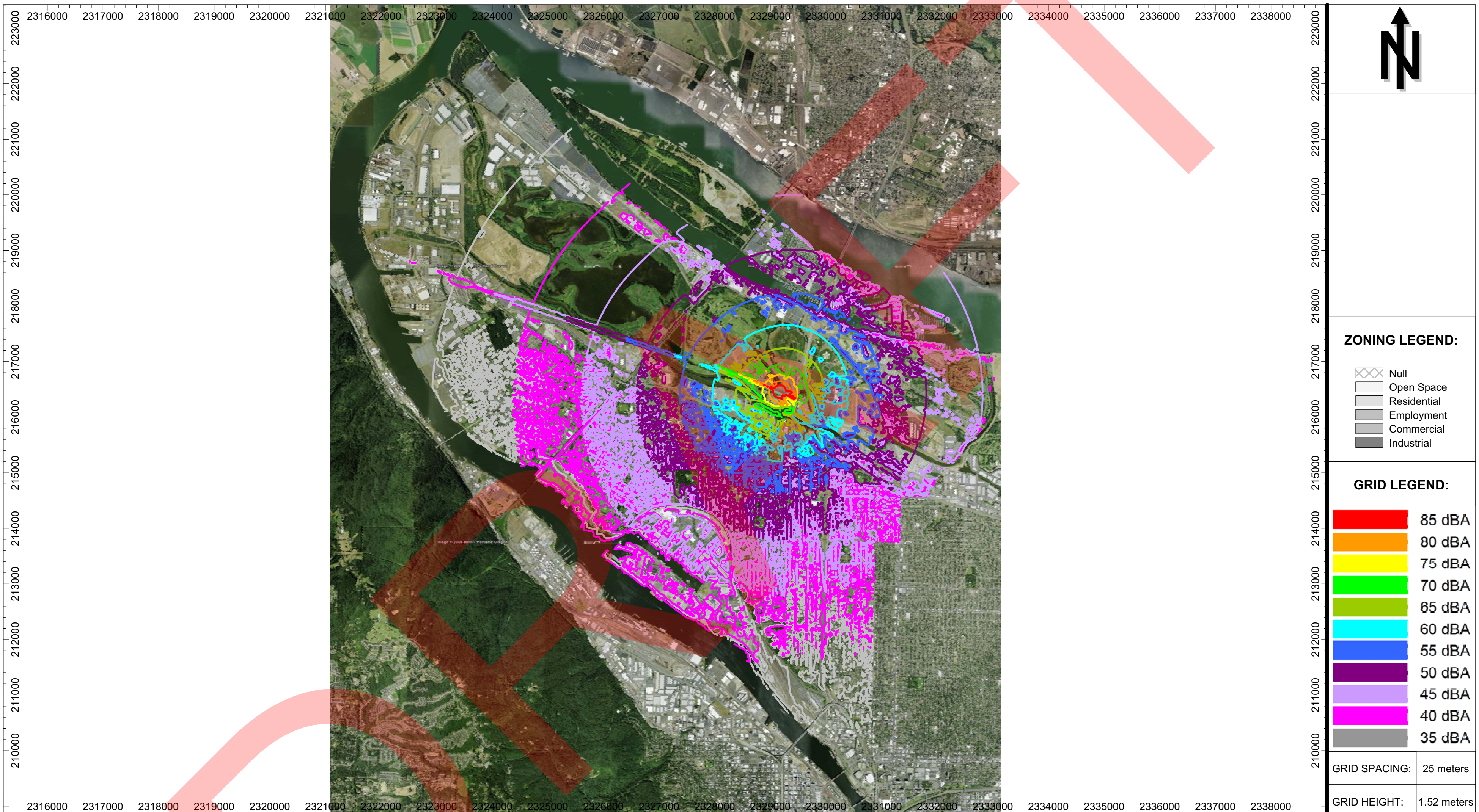
PLOT DESCRIPTION

Figure A2.
PIR Late Night Drag
105 dBA Lmax trackside
Met: None (baseline)



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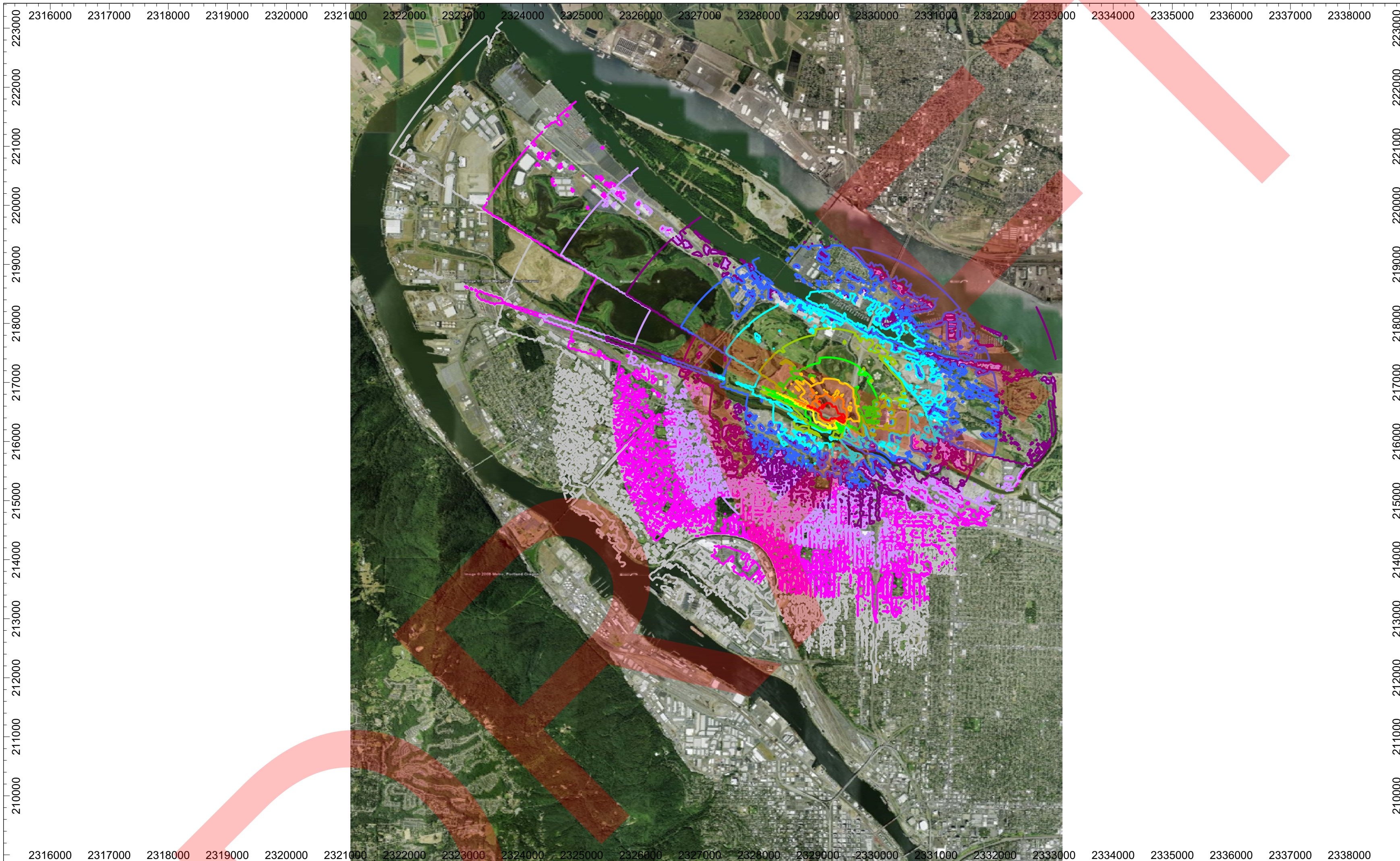
PLOT DESCRIPTION

Figure A3.
PIR Late Night Drag
105 dBA Lmax trackside
Met: Statistical (average)



N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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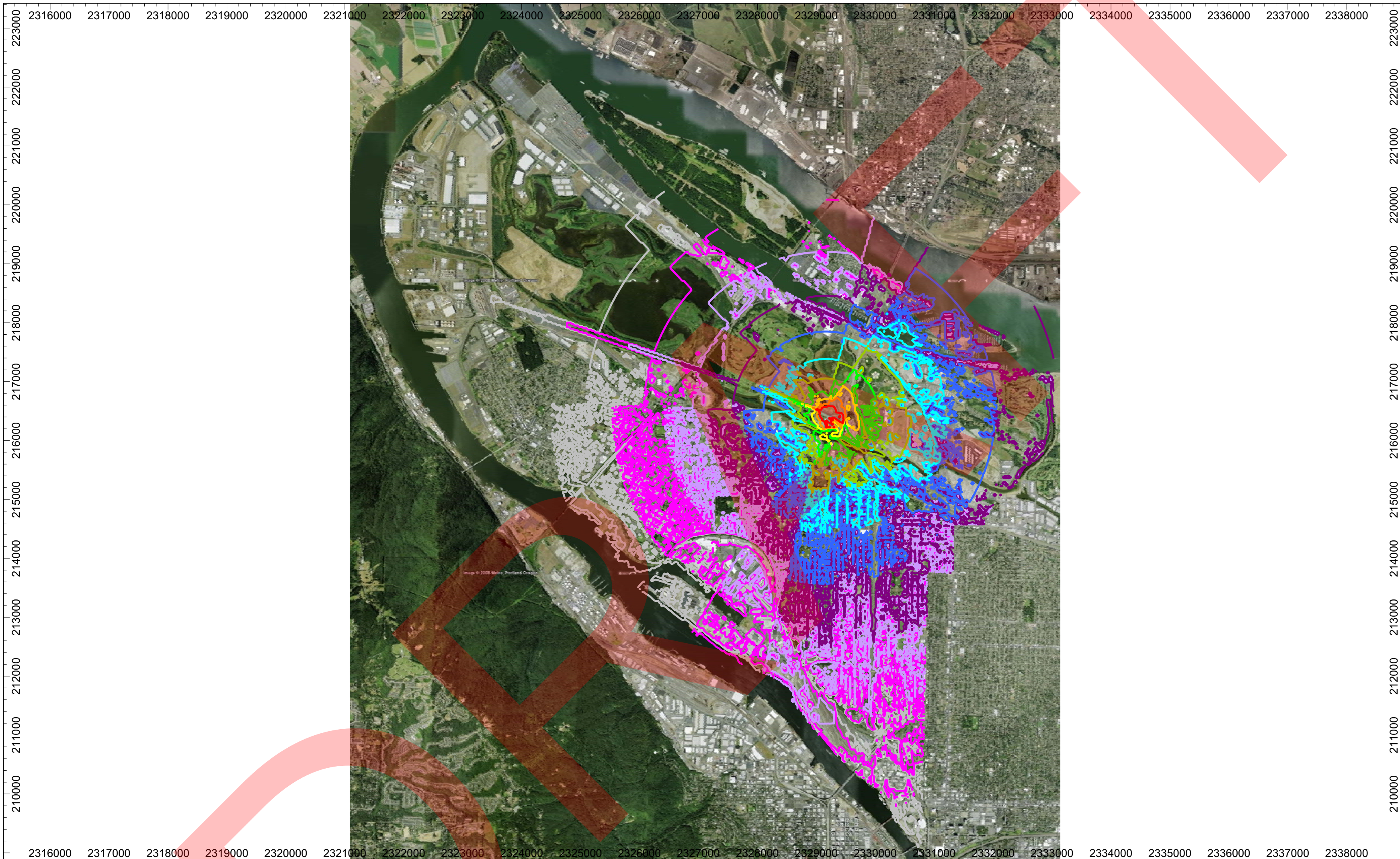
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A4.
PIR Late Night Drag
105 dBA Lmax trackside
Met: Spring evening



GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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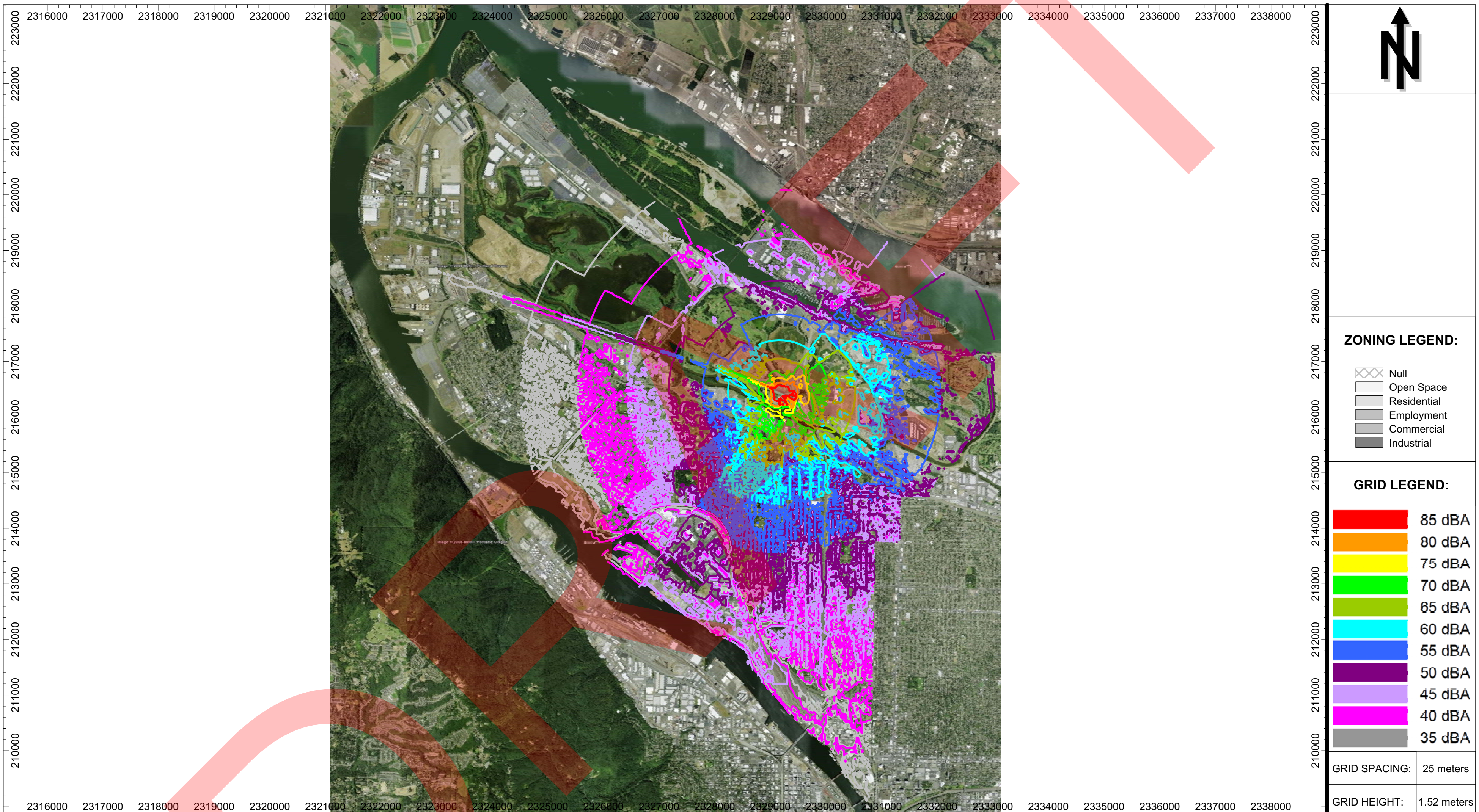
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A5.
PIR Late Night Drag
105 dBA Lmax trackside
Met: Early summer evening



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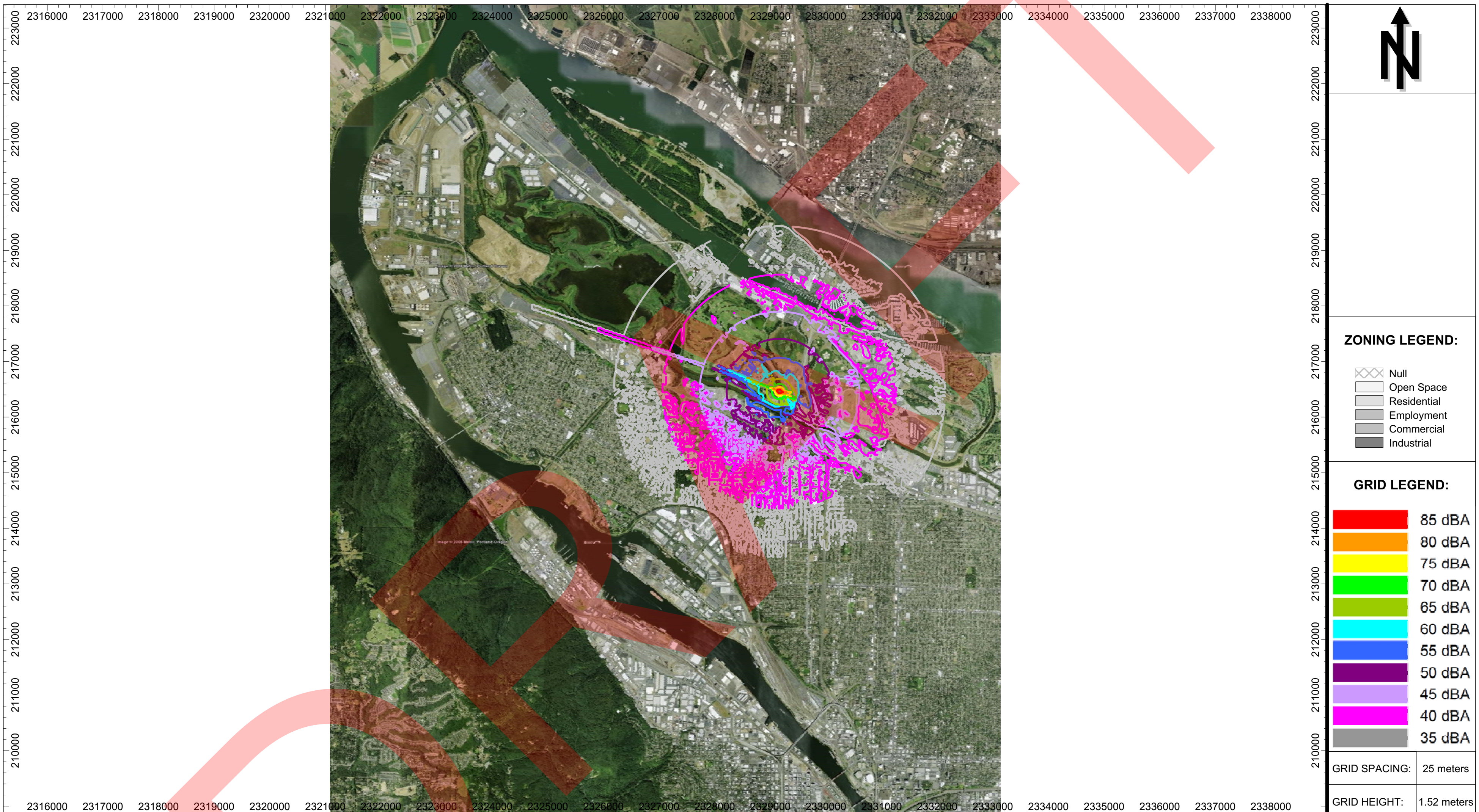
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A6.
PIR Late Night Drag
105 dBA Lmax trackside
Met: Late summer evening



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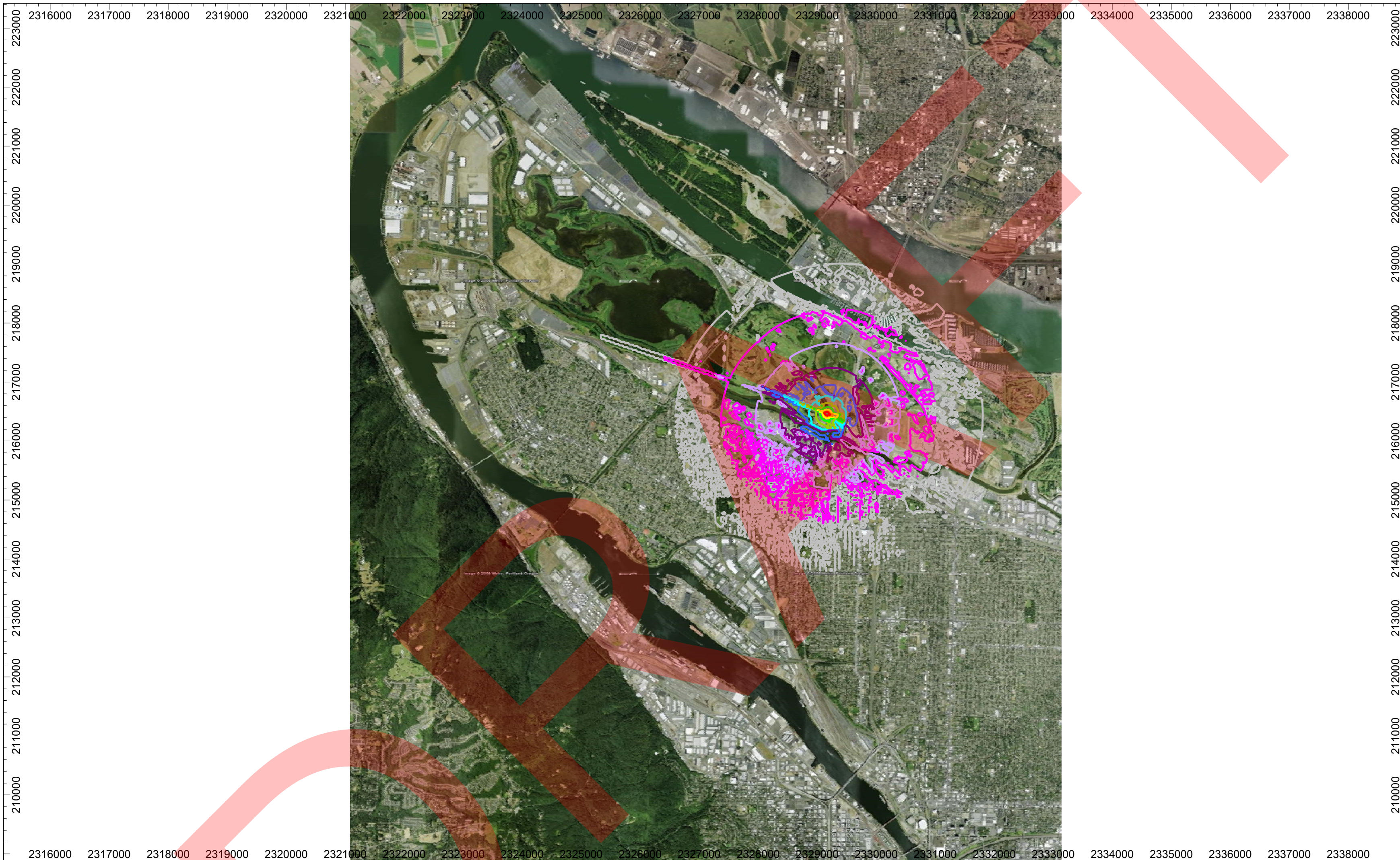
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A7.
PIR Late Night Drag
90 dBA Lmax trackside
Met: None (baseline)



GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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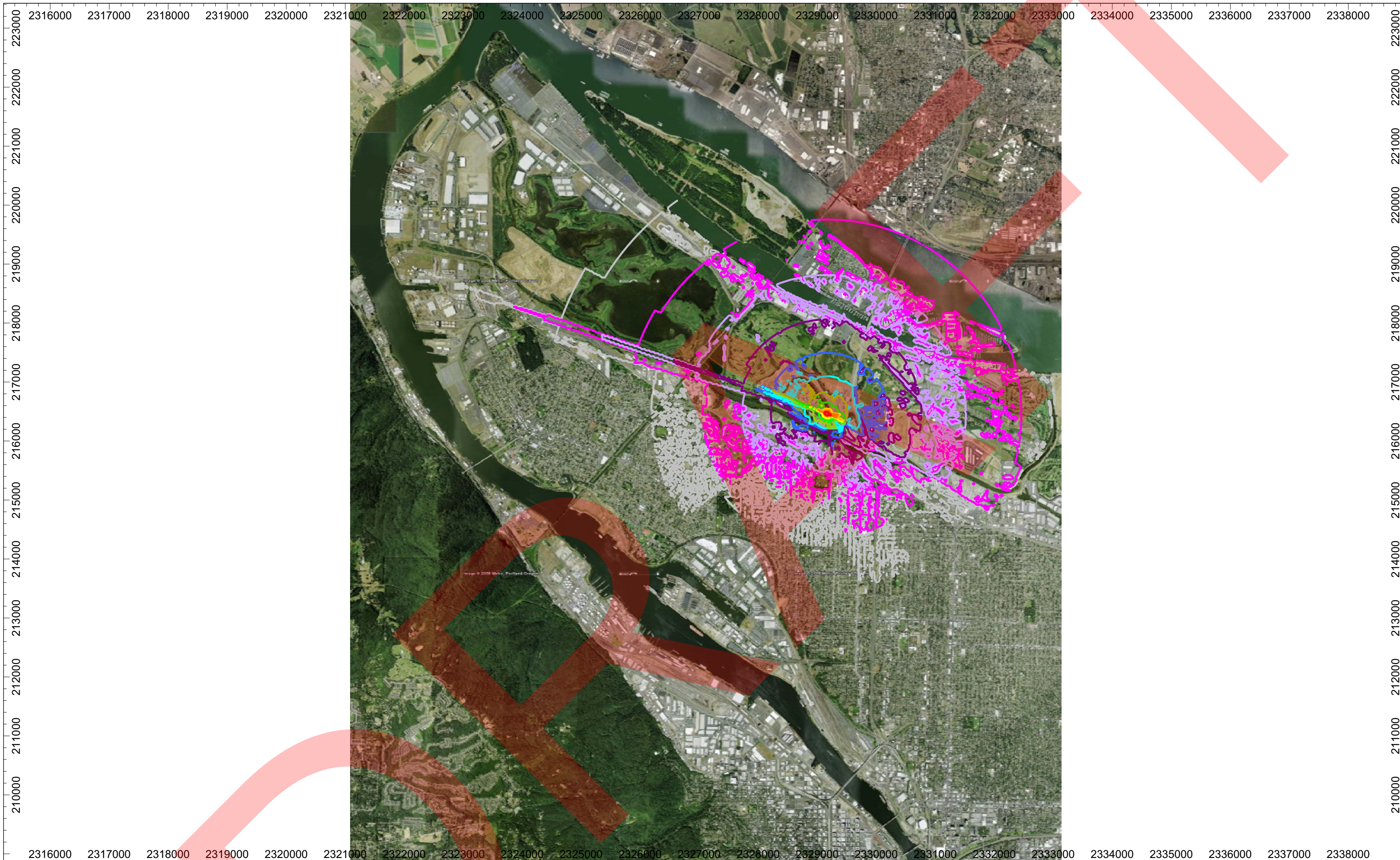
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A8.
PIR Late Night Drag
90 dBA Lmax trackside
Met: Statistical (average)



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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SCALE:	AS SHOWN
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JOB NO:	2006.049

PLOT DESCRIPTION

Figure A9.
PIR Late Night Drag
90 dBA Lmax trackside
Met: Spring night

N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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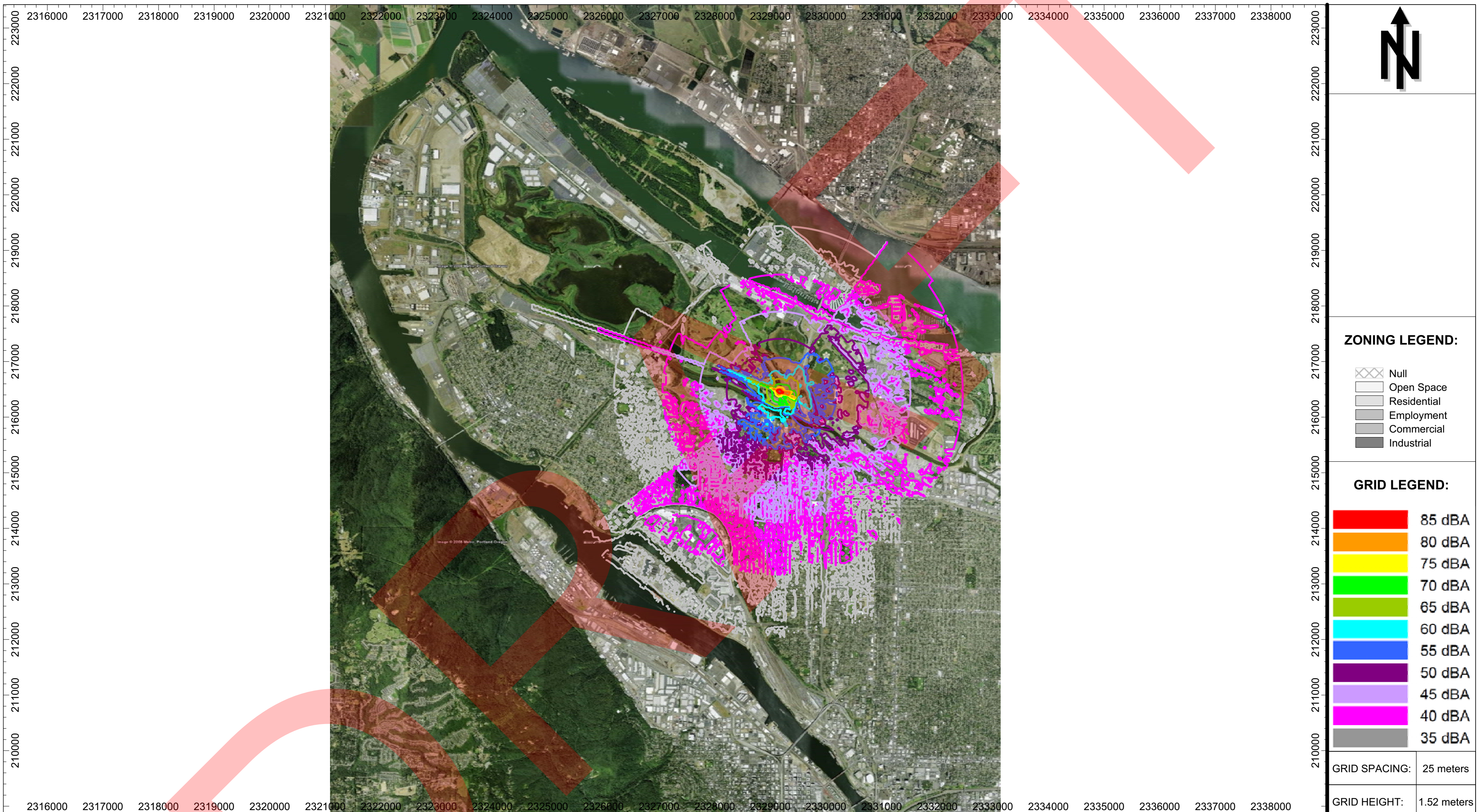
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A10.
PIR Late Night Drag
90 dBA Lmax trackside
Met: Early summer night



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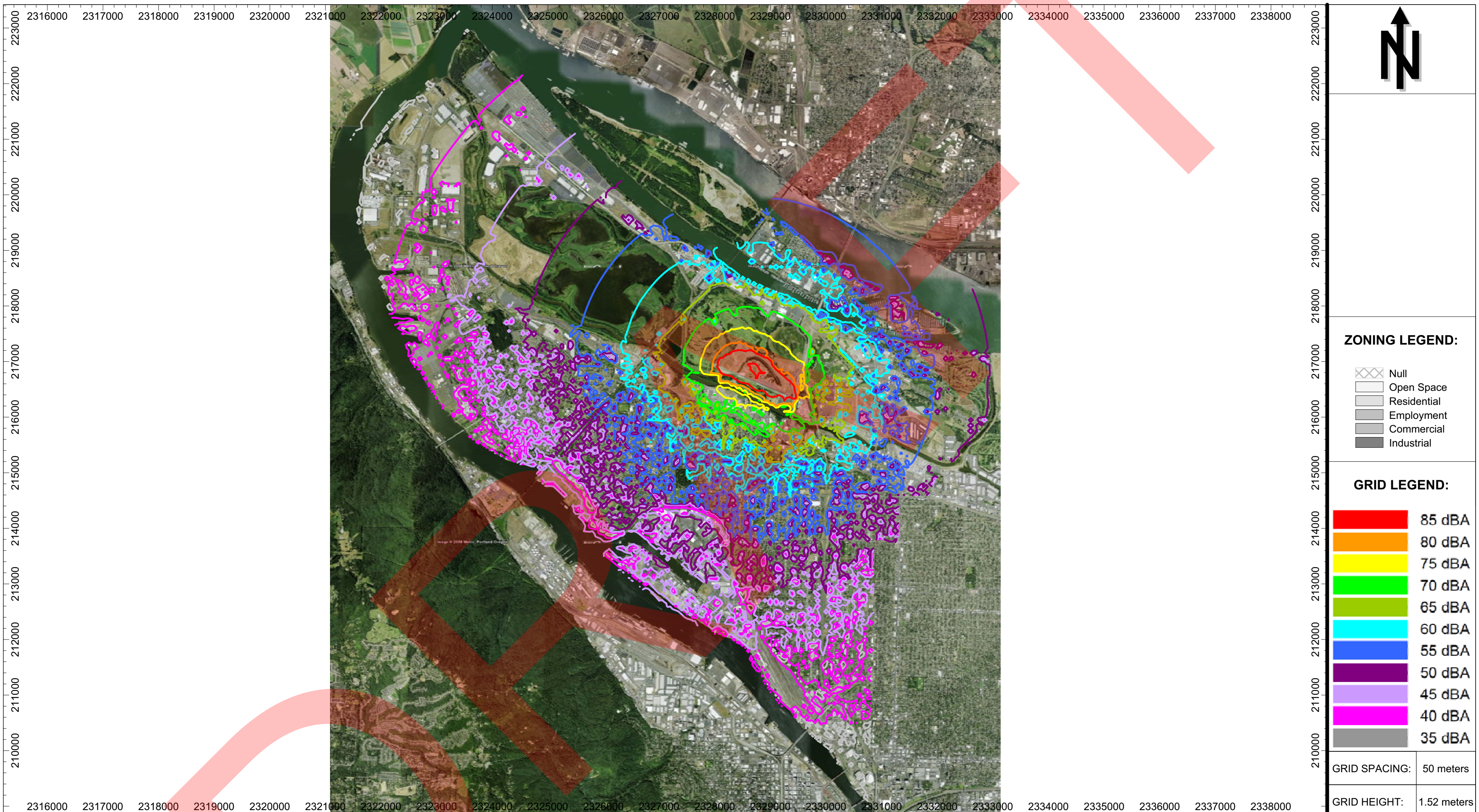
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A11.
PIR Late Night Drag
90 dBA Lmax trackside
Met: Late summer night



GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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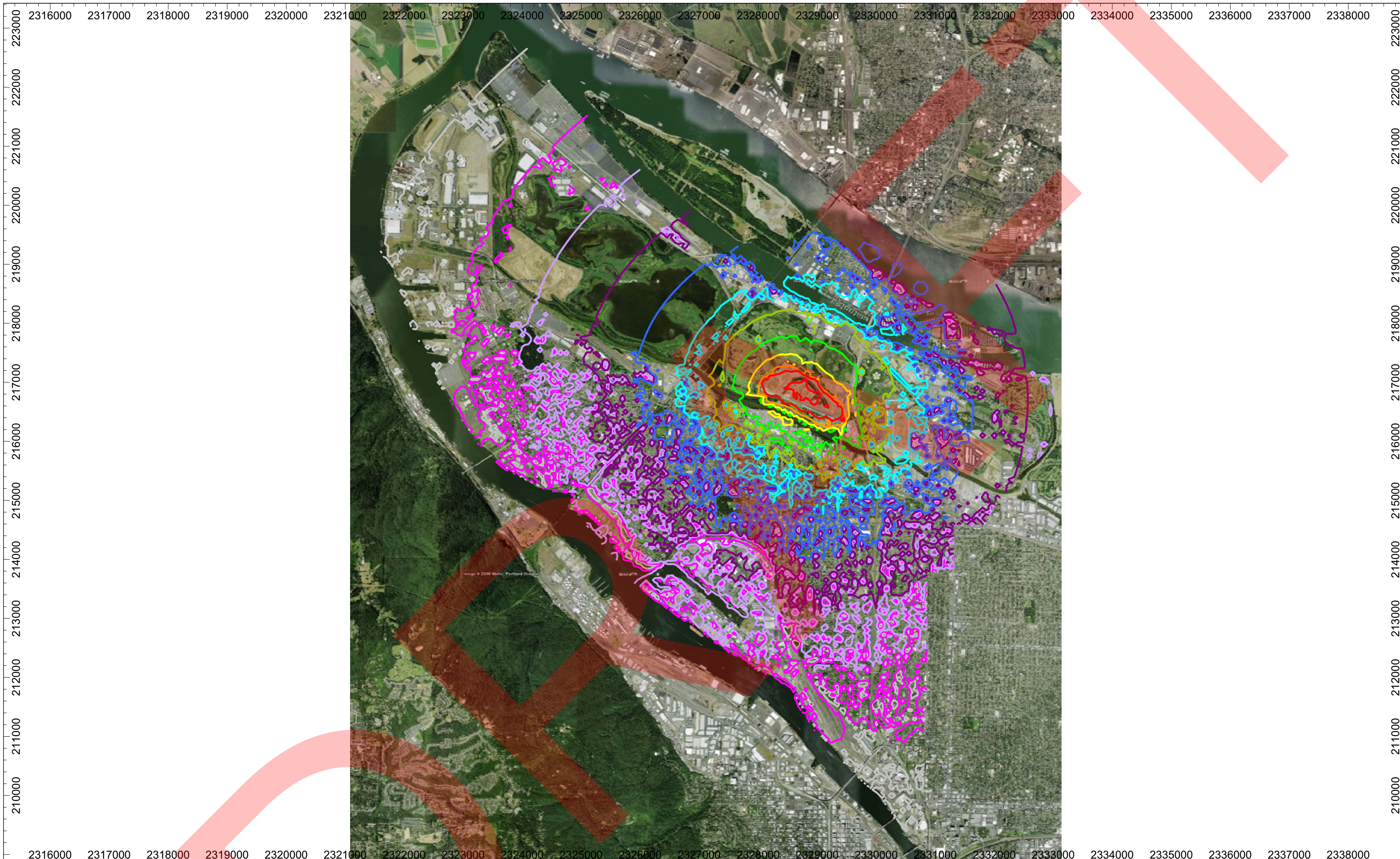
PLOT DESCRIPTION

Figure A12.
PIR Full Race Track
103 dBA Lmax trackside
Met: None (baseline)



GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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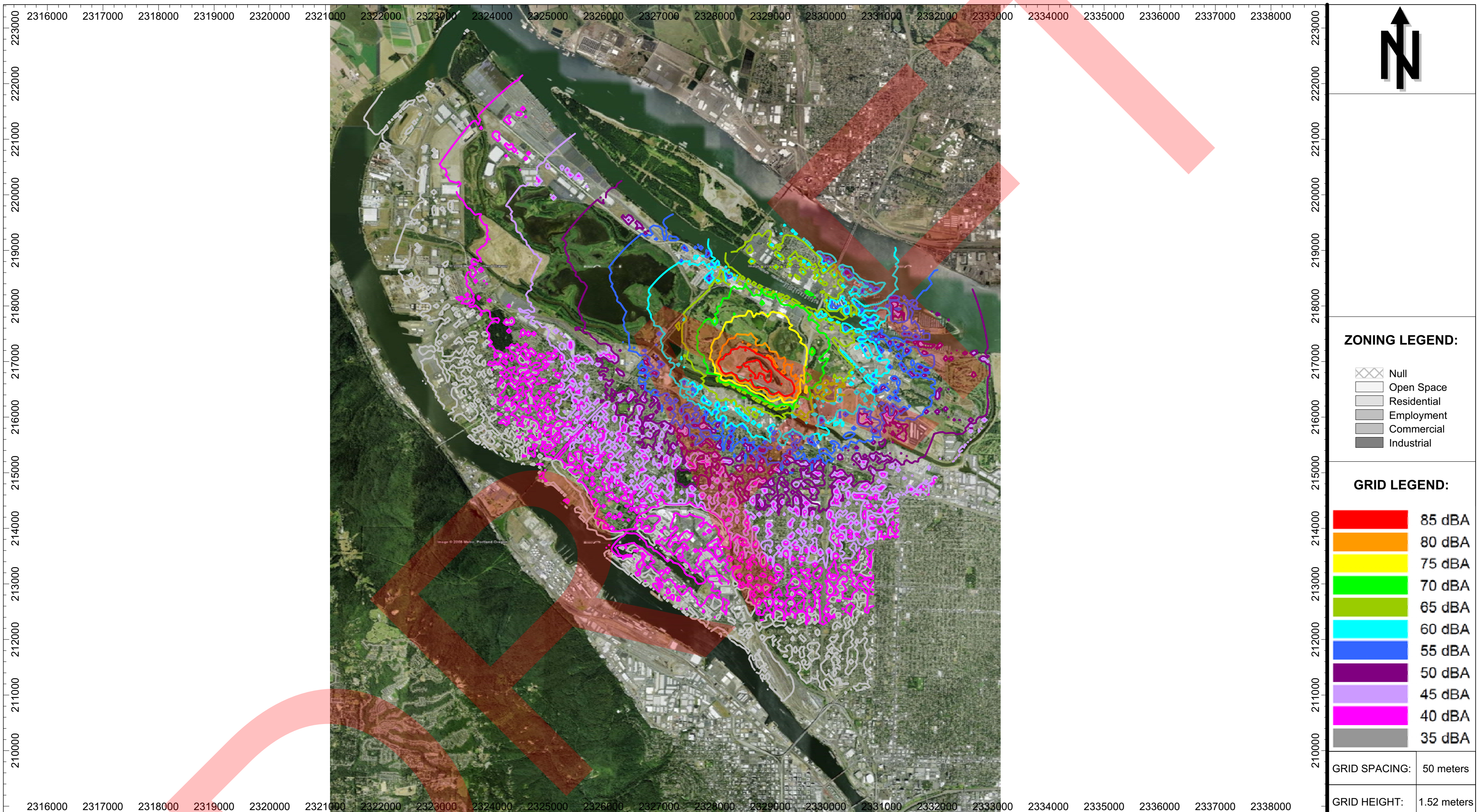
PLOT DESCRIPTION

Figure A13.
PIR Full Race Track
103 dBA Lmax trackside
Met: Statistical (average)



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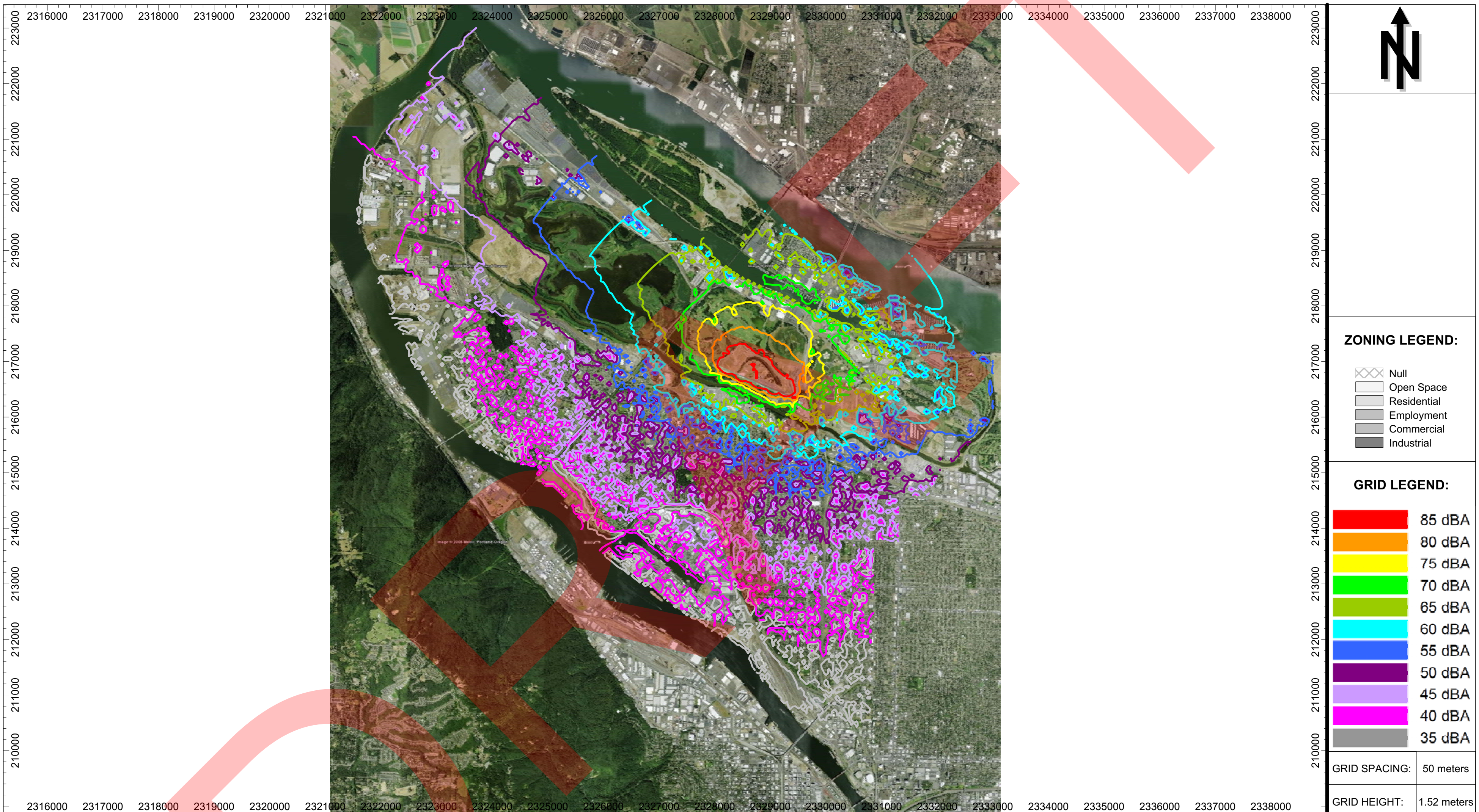
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A14.
PIR Full Race Track
103 dBA Lmax trackside
Met: Spring day



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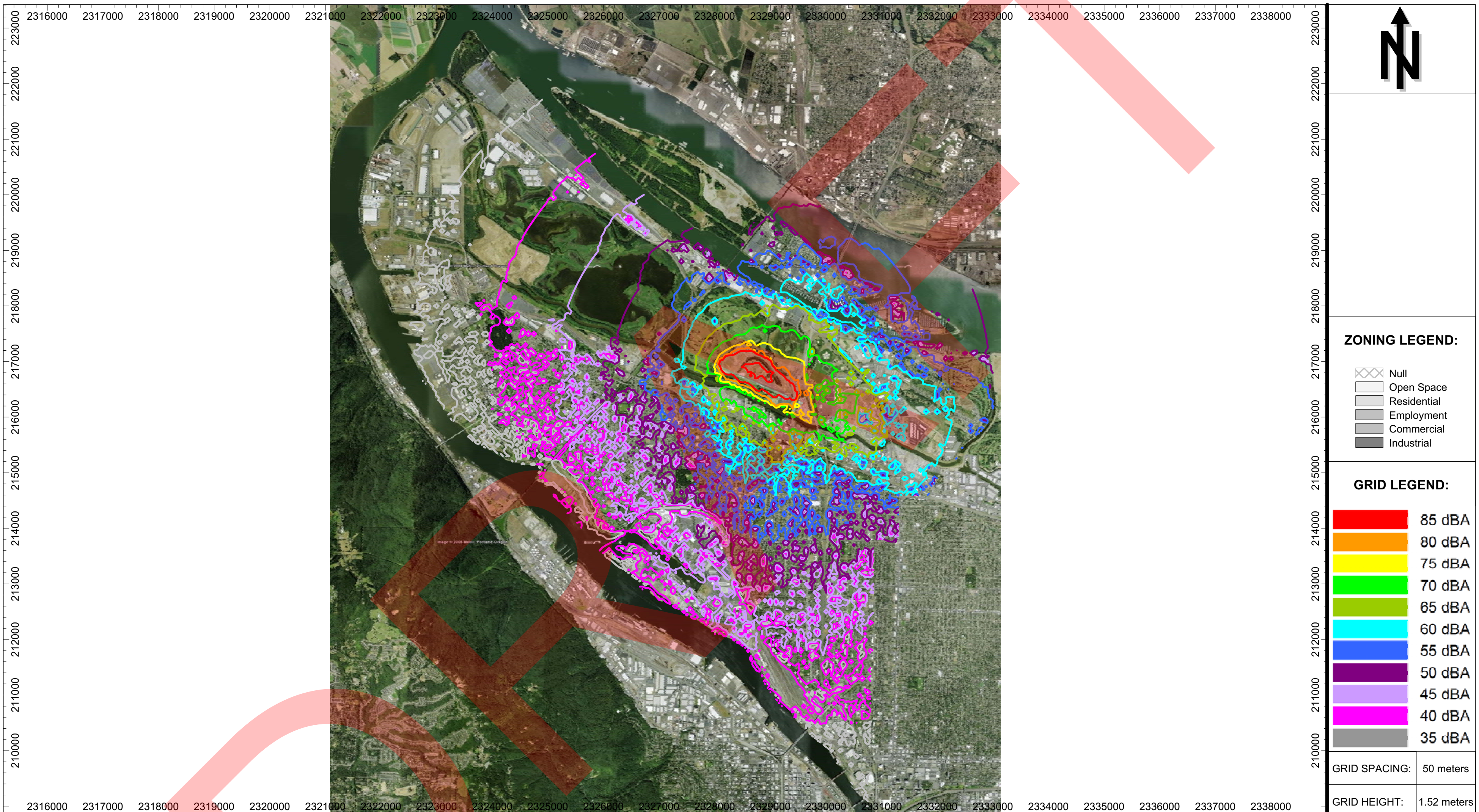
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A15.
PIR Full Race Track
103 dBA Lmax trackside
Met: Spring evening



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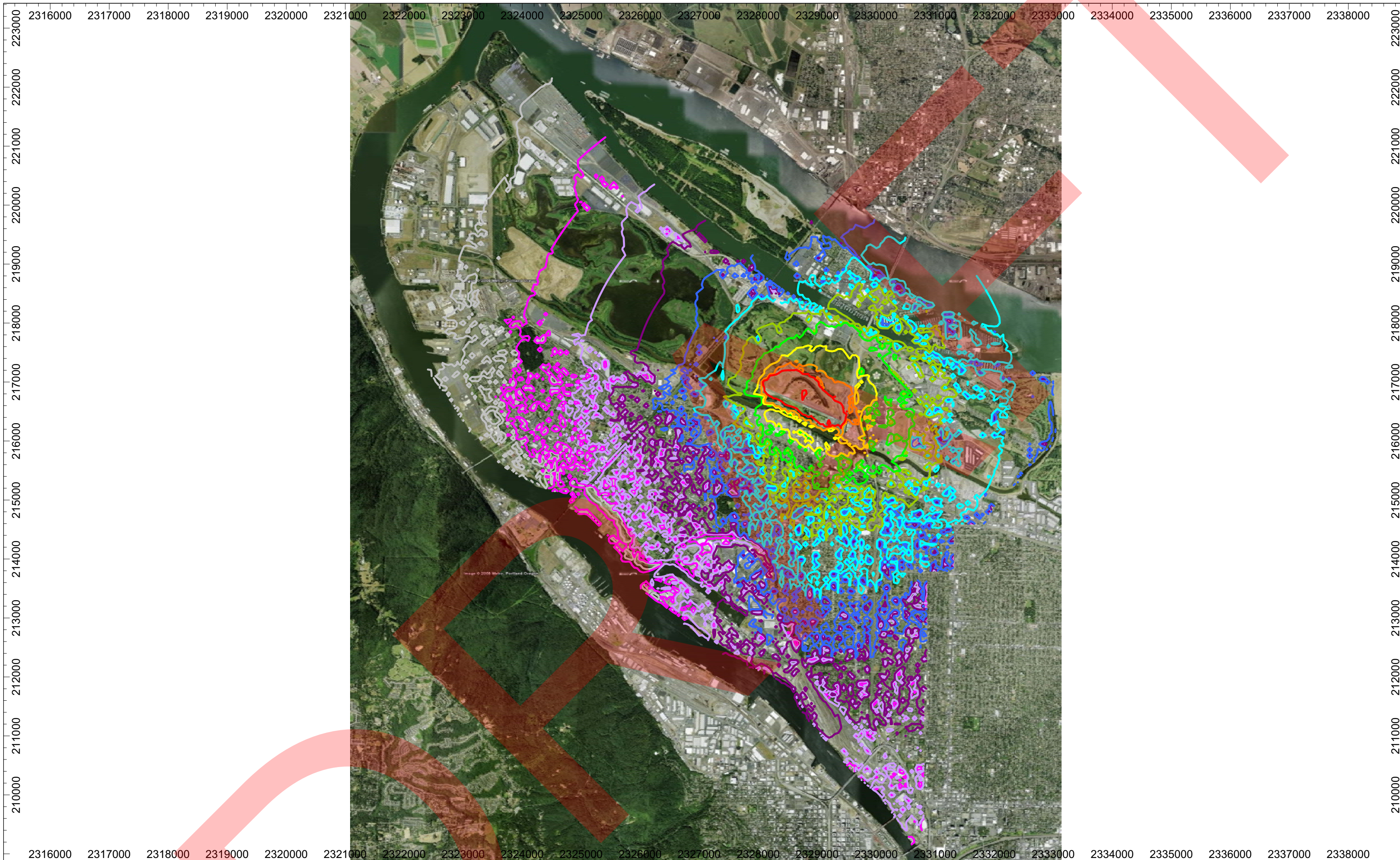
PLOT DESCRIPTION

Figure A16.
PIR Full Race Track
103 dBA Lmax trackside
Met: Early summer day



GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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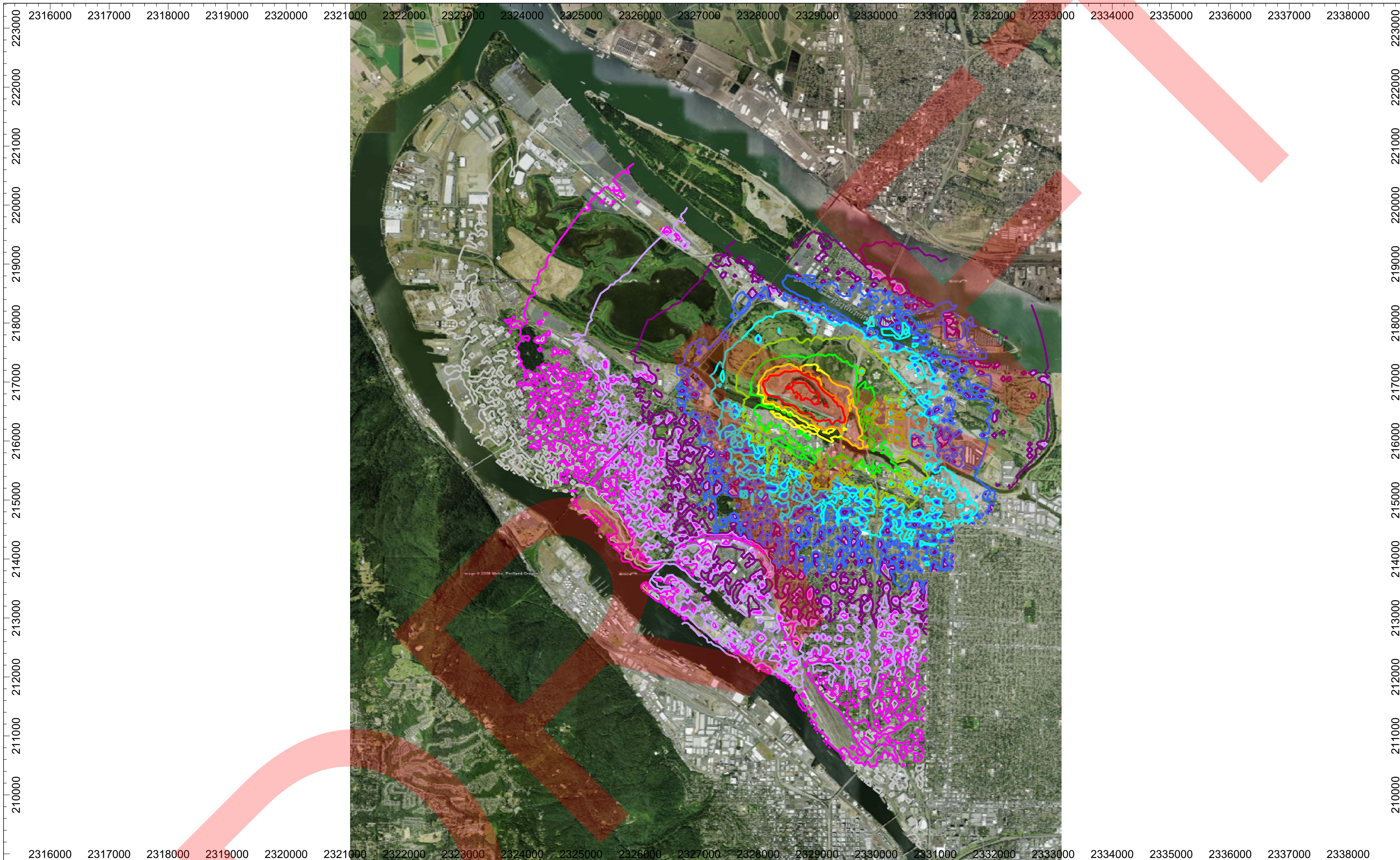
PLOT DESCRIPTION

Figure A17.
PIR Full Race Track
103 dBA Lmax trackside
Met: Early summer evening



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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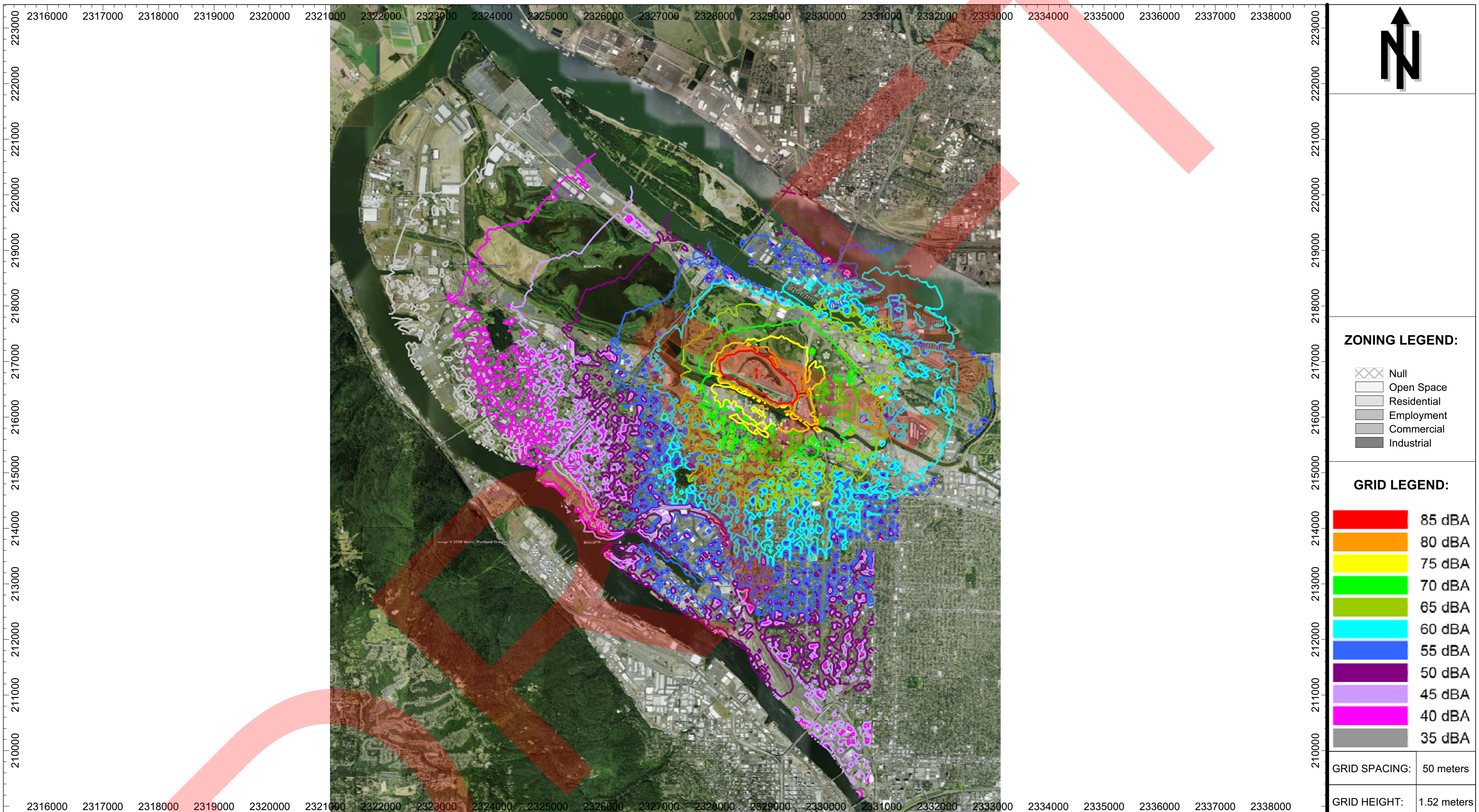
PLOT DESCRIPTION

Figure A18.
PIR Full Race Track
103 dBA Lmax trackside
Met: Late summer day



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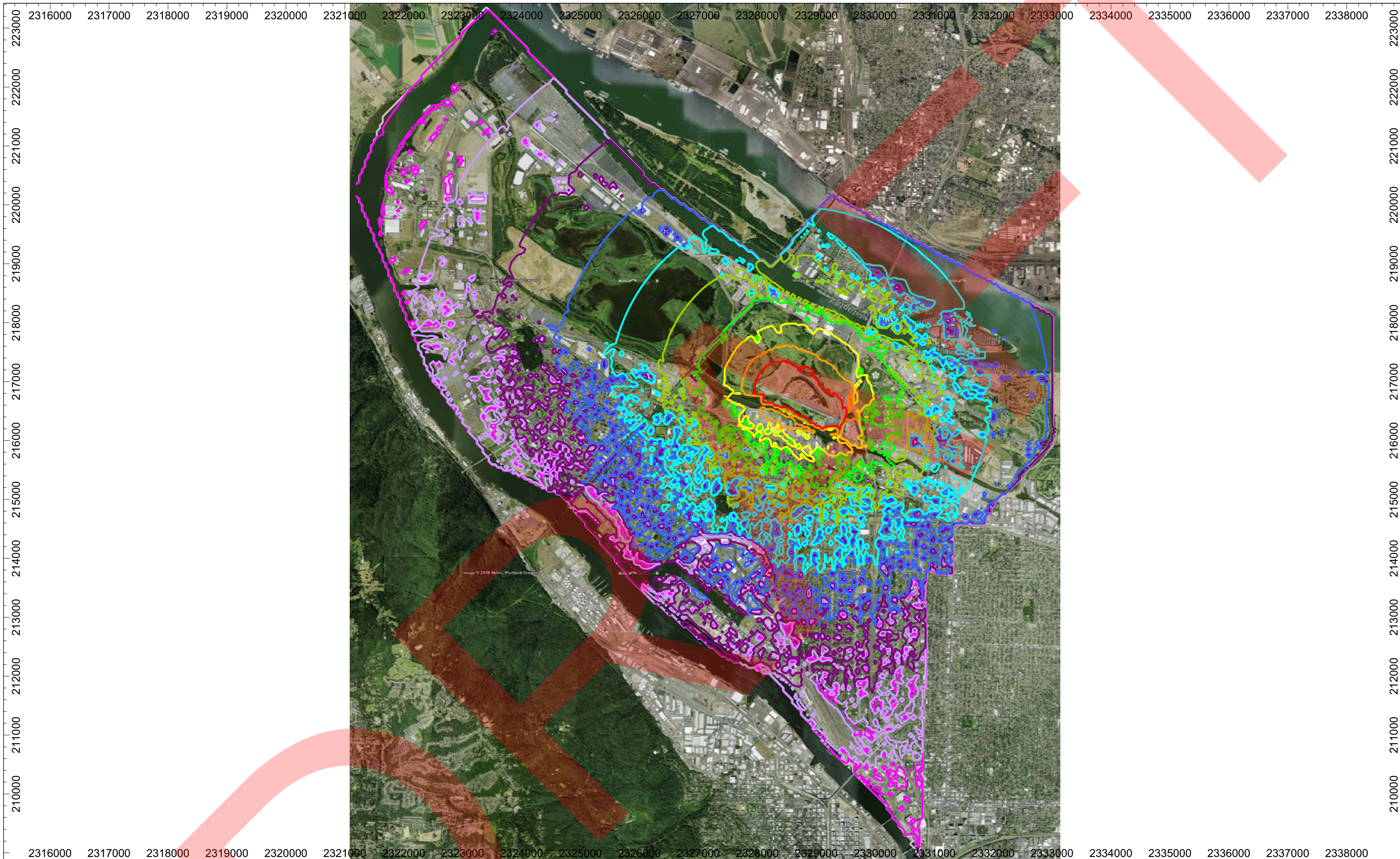
PLOT DESCRIPTION

Figure A19.
PIR Full Race Track
103 dBA Lmax trackside
Met: Late summer evening



GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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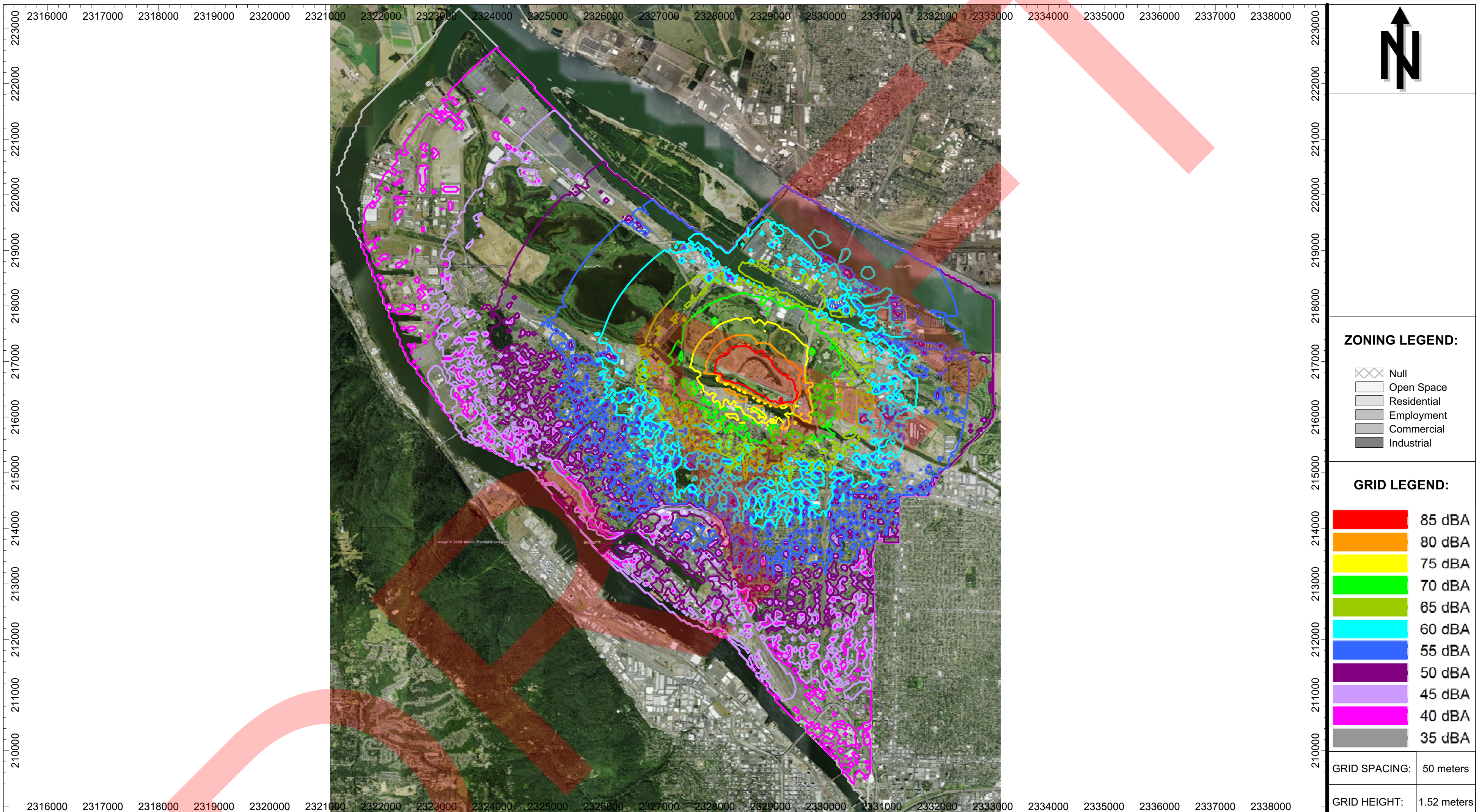
PLOT DESCRIPTION

Figure A20.
PIR Full Race Track
108 dBA Lmax trackside
Met: None (baseline)



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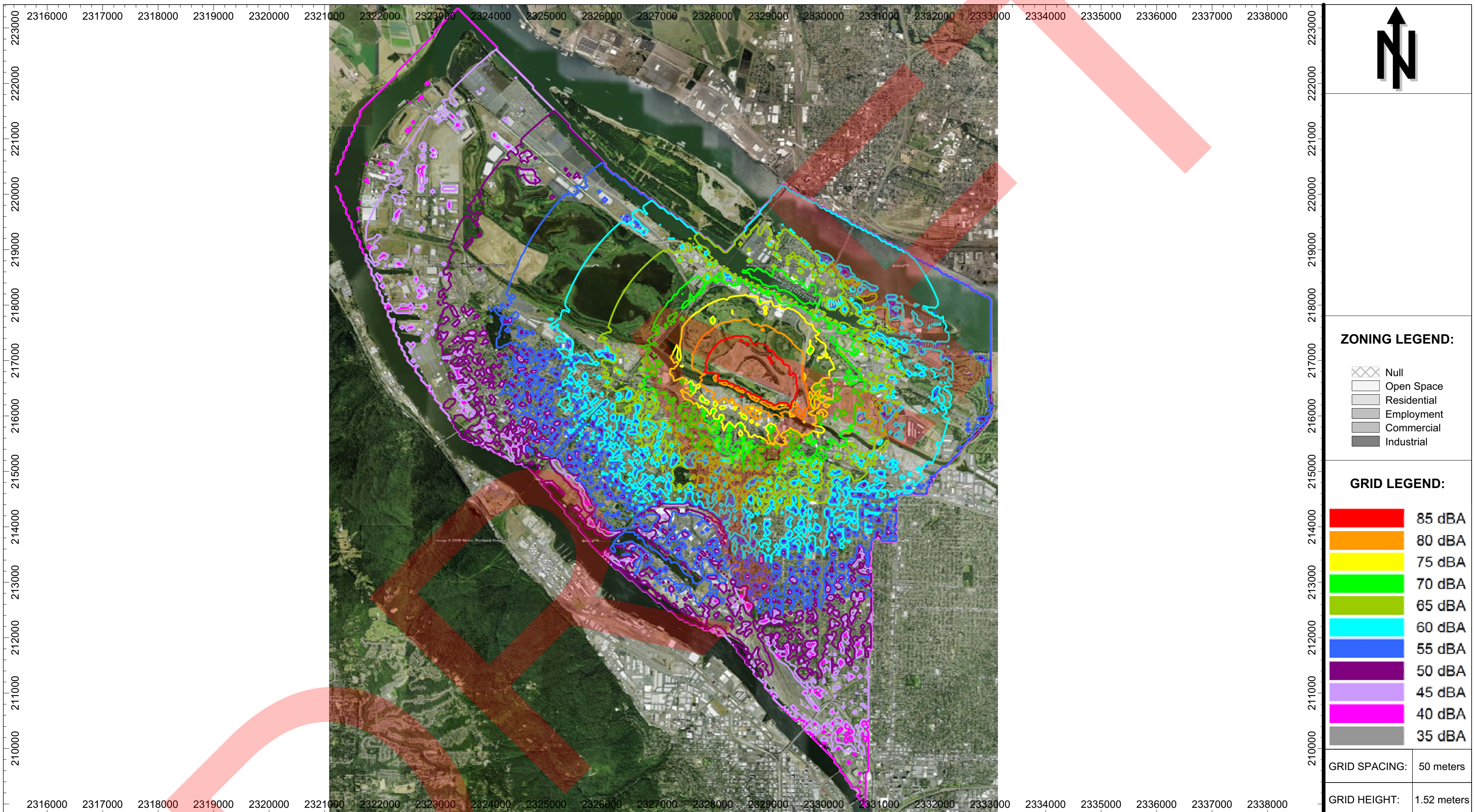
PLOT DESCRIPTION

Figure A21.
PIR Full Race Track
108 dBA Lmax trackside
Met: Statistical (average)



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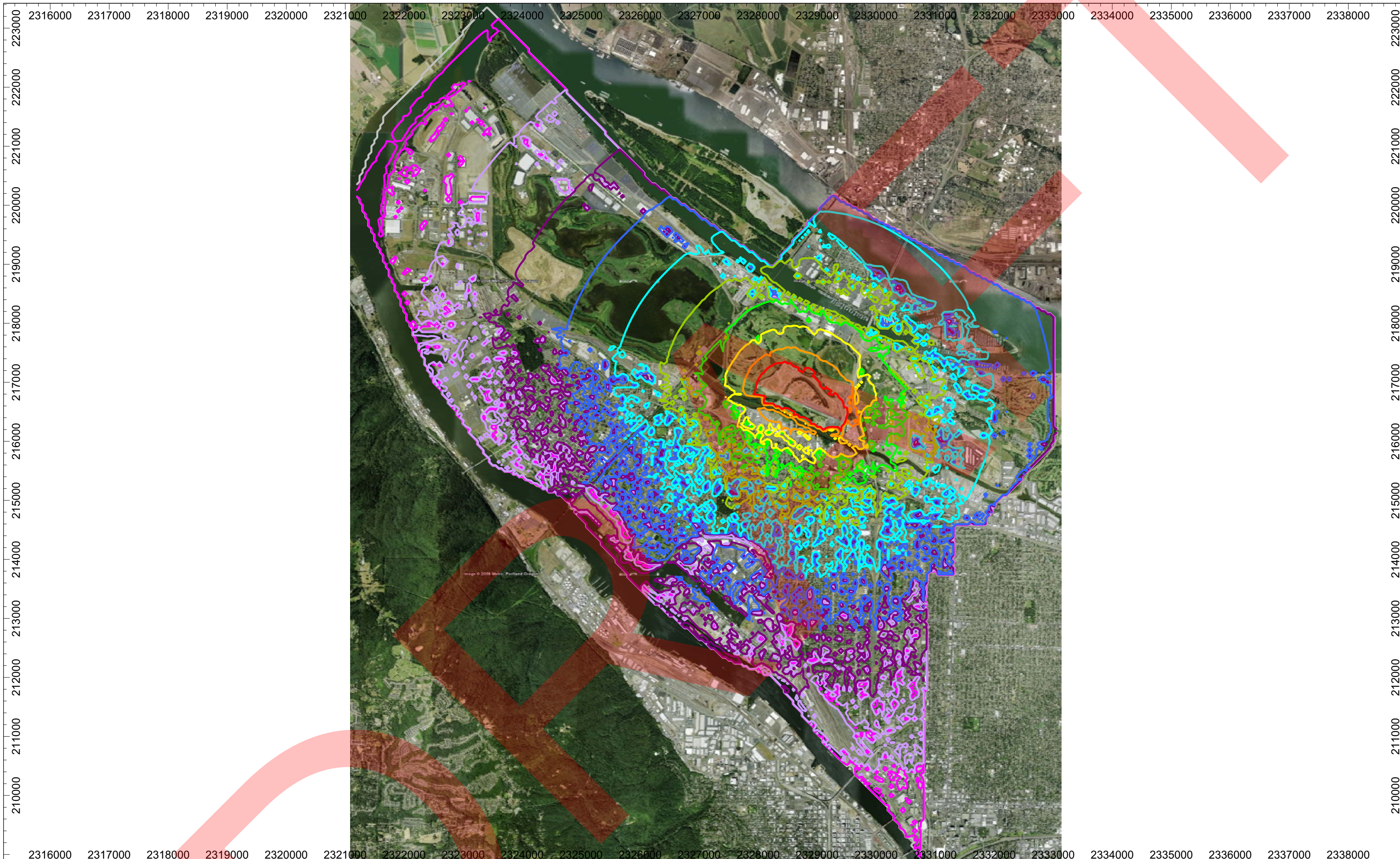
PLOT DESCRIPTION

Figure A22.
PIR Full Race Track
110 dBA Lmax trackside
Met: None (baseline)



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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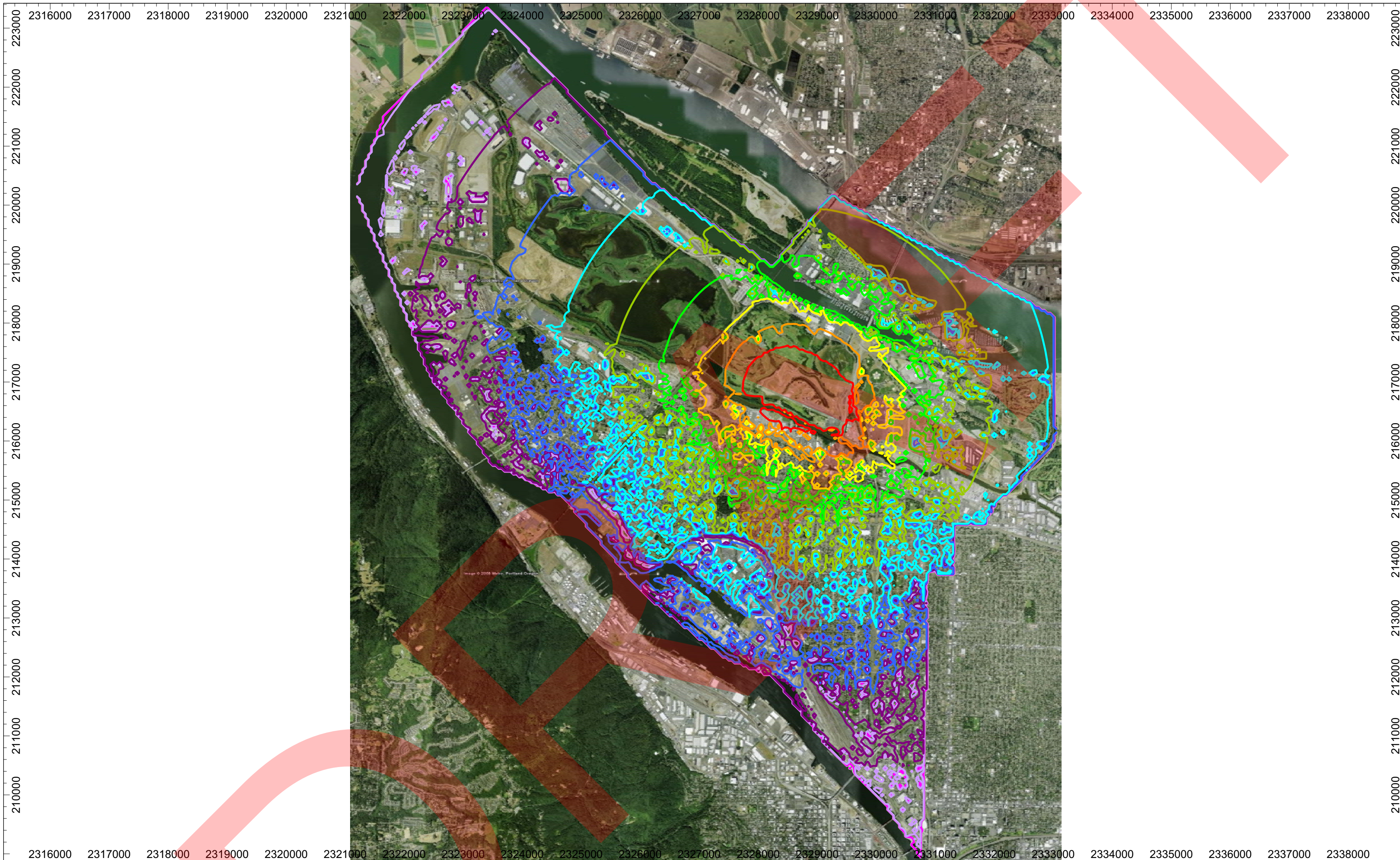
PLOT DESCRIPTION

Figure A23.
PIR Full Race Track
110 dBA Lmax trackside
Met: Statistical (average)



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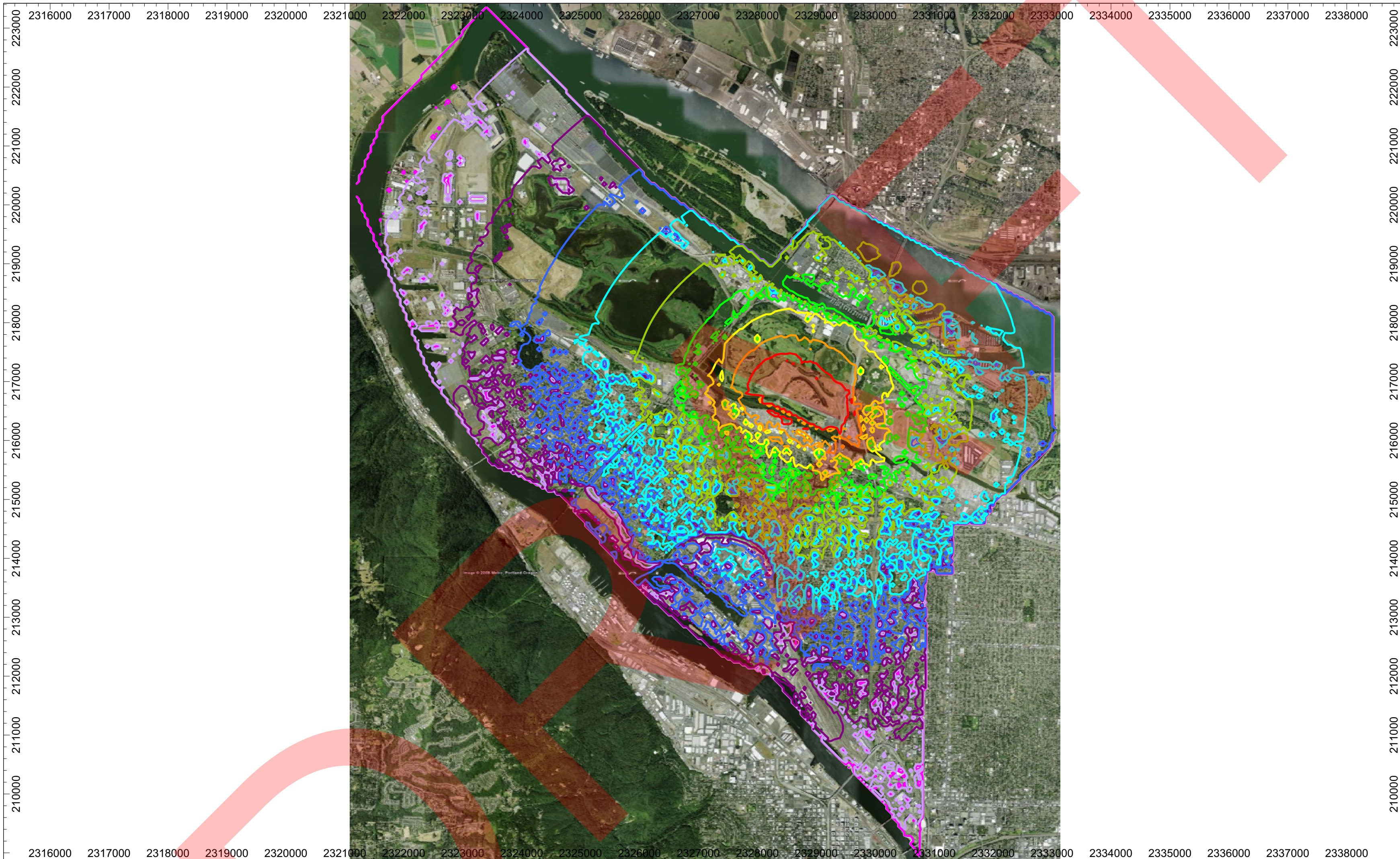
PLOT DESCRIPTION

Figure A24.
PIR Full Race Track
113 dBA Lmax trackside
Met: None (baseline)



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PLOT DESCRIPTION

Figure A25.
PIR Full Race Track
113 dBA Lmax trackside
Met: Statistical (average)

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JOB NO:	2006.049

PLOT DESCRIPTION

Figure A26.
PIR Late Night Drag
105 dBA Lmax trackside
Residential Code Exceedanc

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A27.
PIR Late Night Drag
90 dBA Lmax trackside
Residential Code Exceedanc

N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

Code exceedance area

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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JOB NO:	2006.049

PLOT DESCRIPTION

Figure A28.
PIR Full Race Track
103 dBA Lmax trackside
Residential Code Exceedanc

N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

Code exceedance area

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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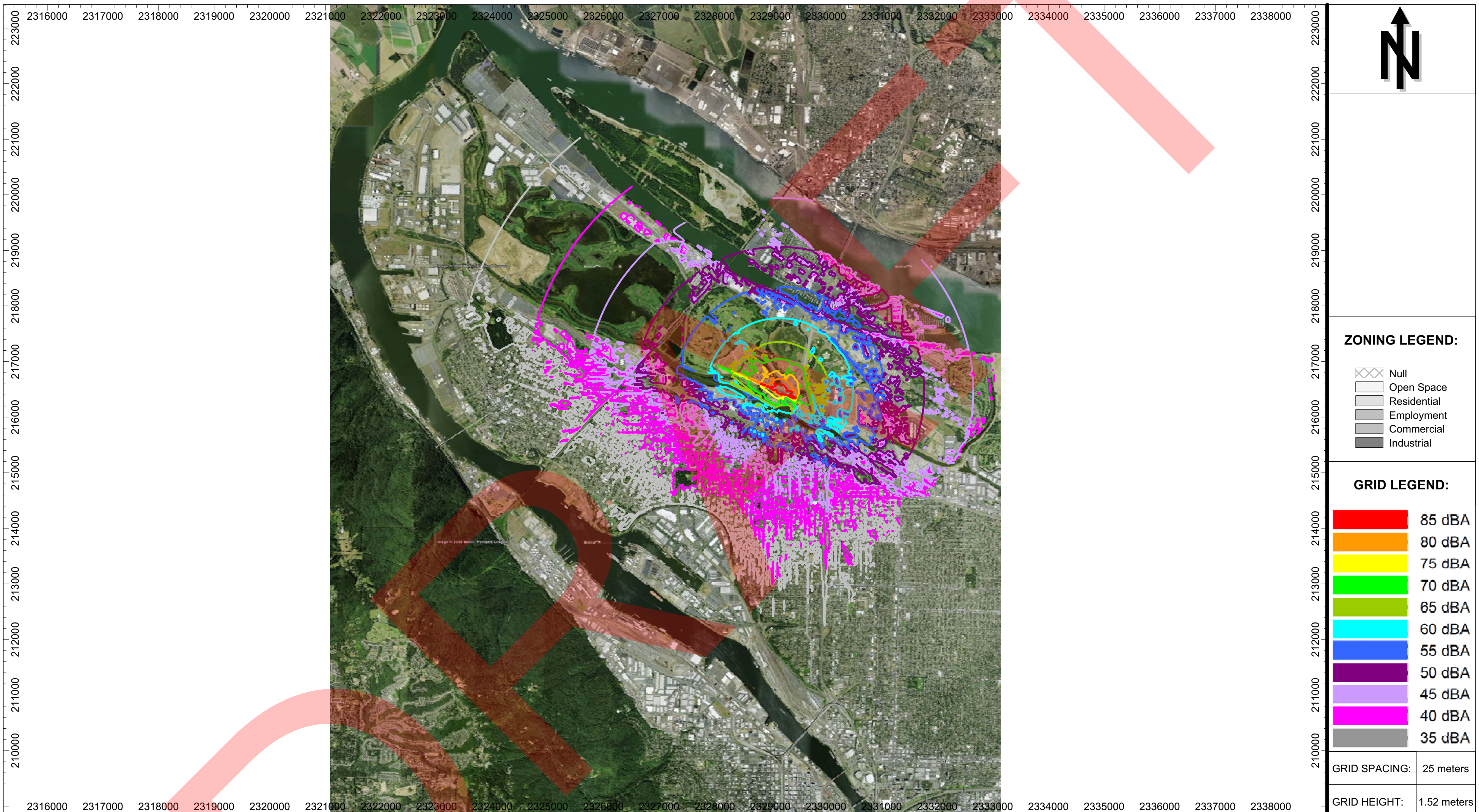
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A29.
PIR Full Race Track
113 dBA Lmax trackside
Residential Code Exceedanc



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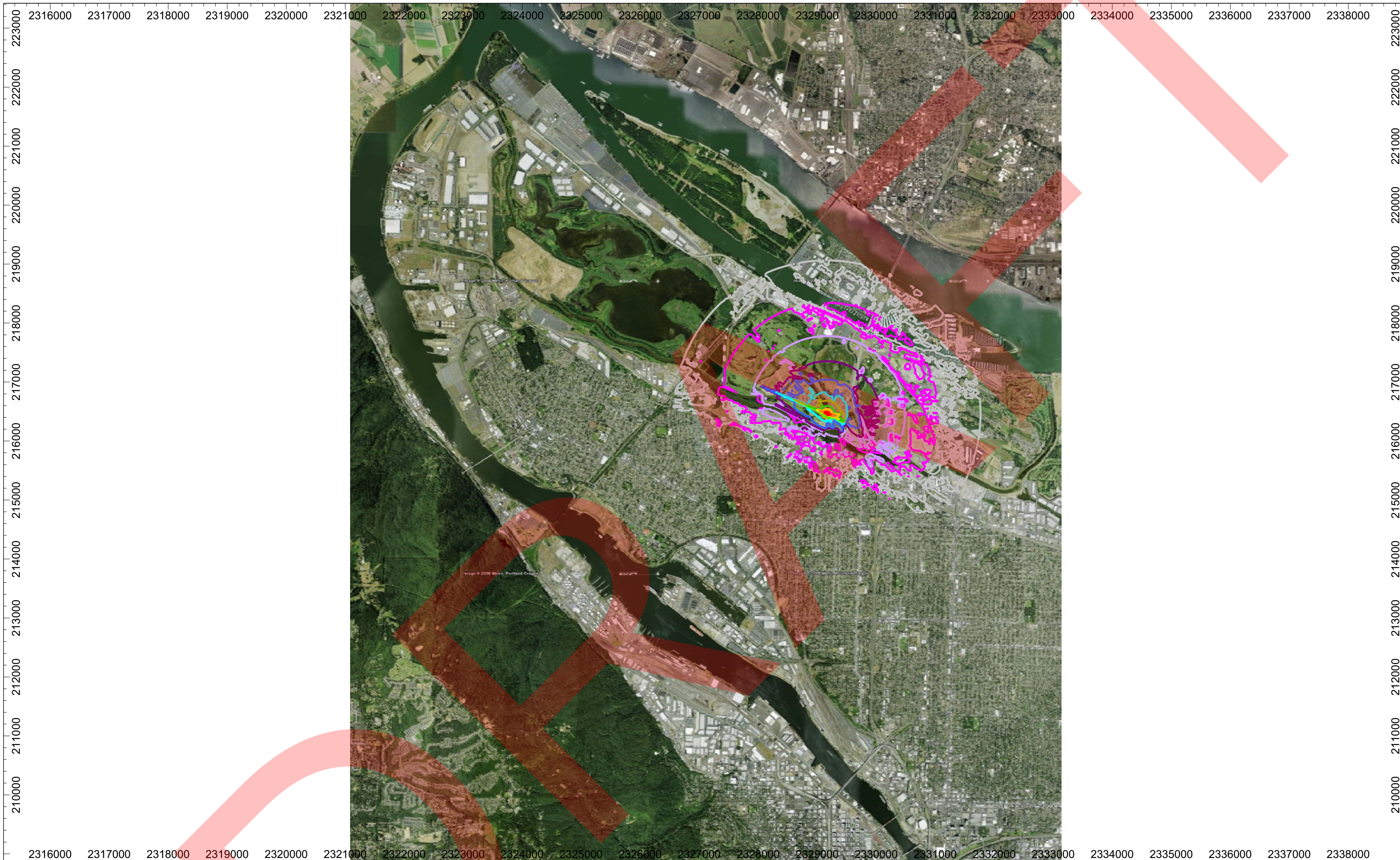
PLOT DESCRIPTION

Figure A30.
PIR Late Night Drag
105 dBA Lmax trackside
16' trackside barrier



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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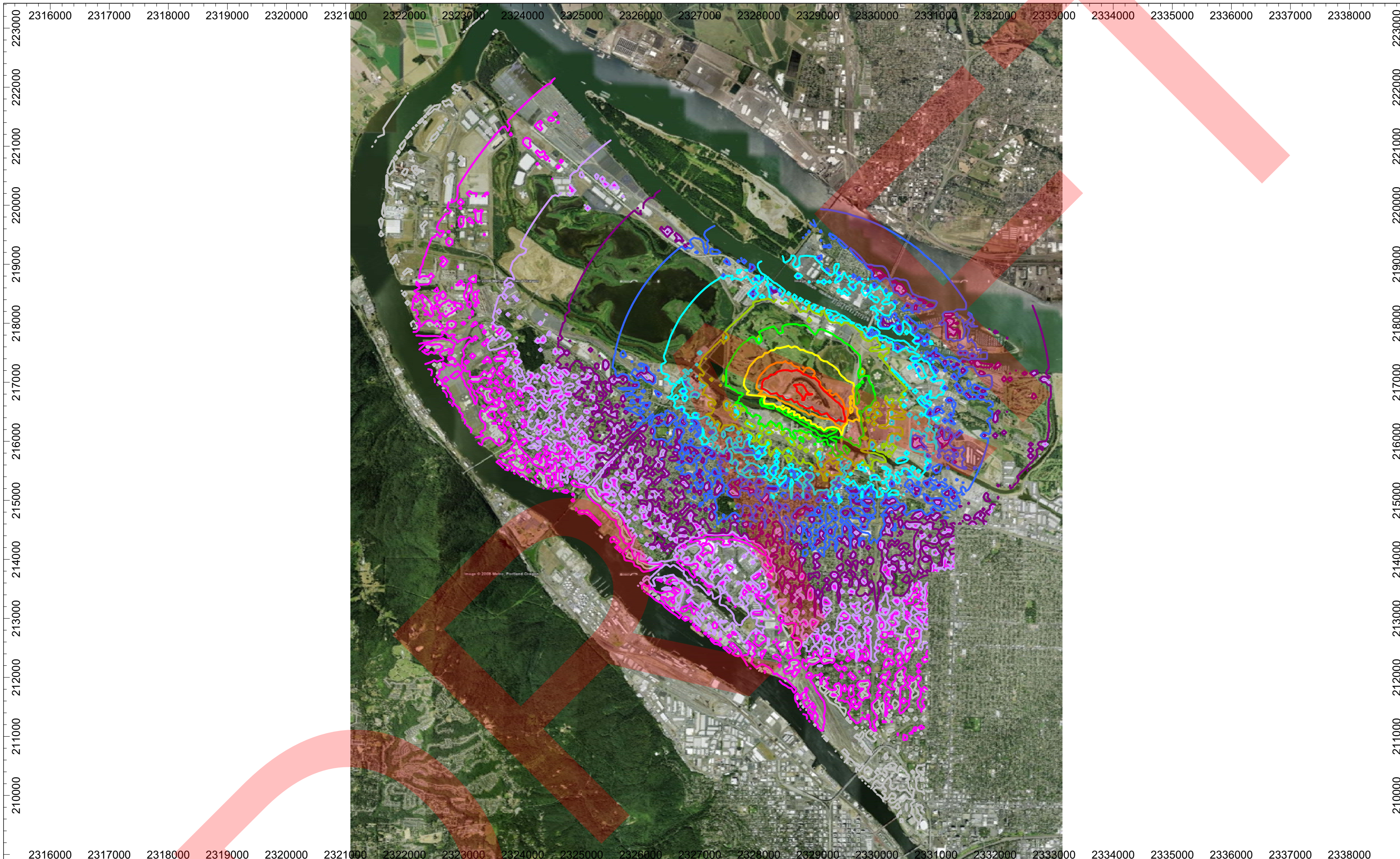
PLOT DESCRIPTION

Figure A31.
PIR Late Night Drag
90 dBA Lmax trackside
16' trackside barrier



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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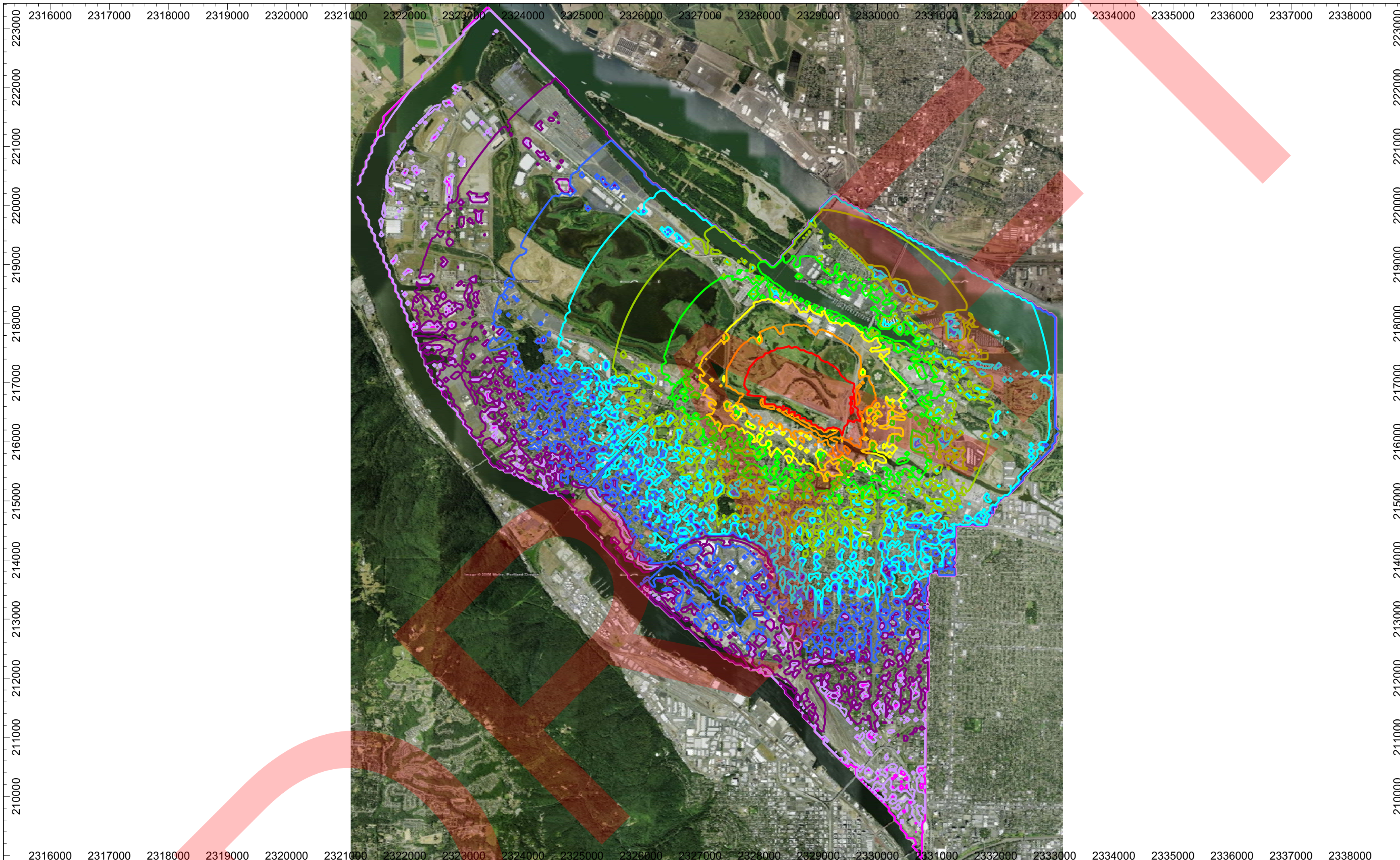
PLOT DESCRIPTION

Figure A32.
PIR Full Race Track
103 dBA Lmax trackside
16' trackside barrier



N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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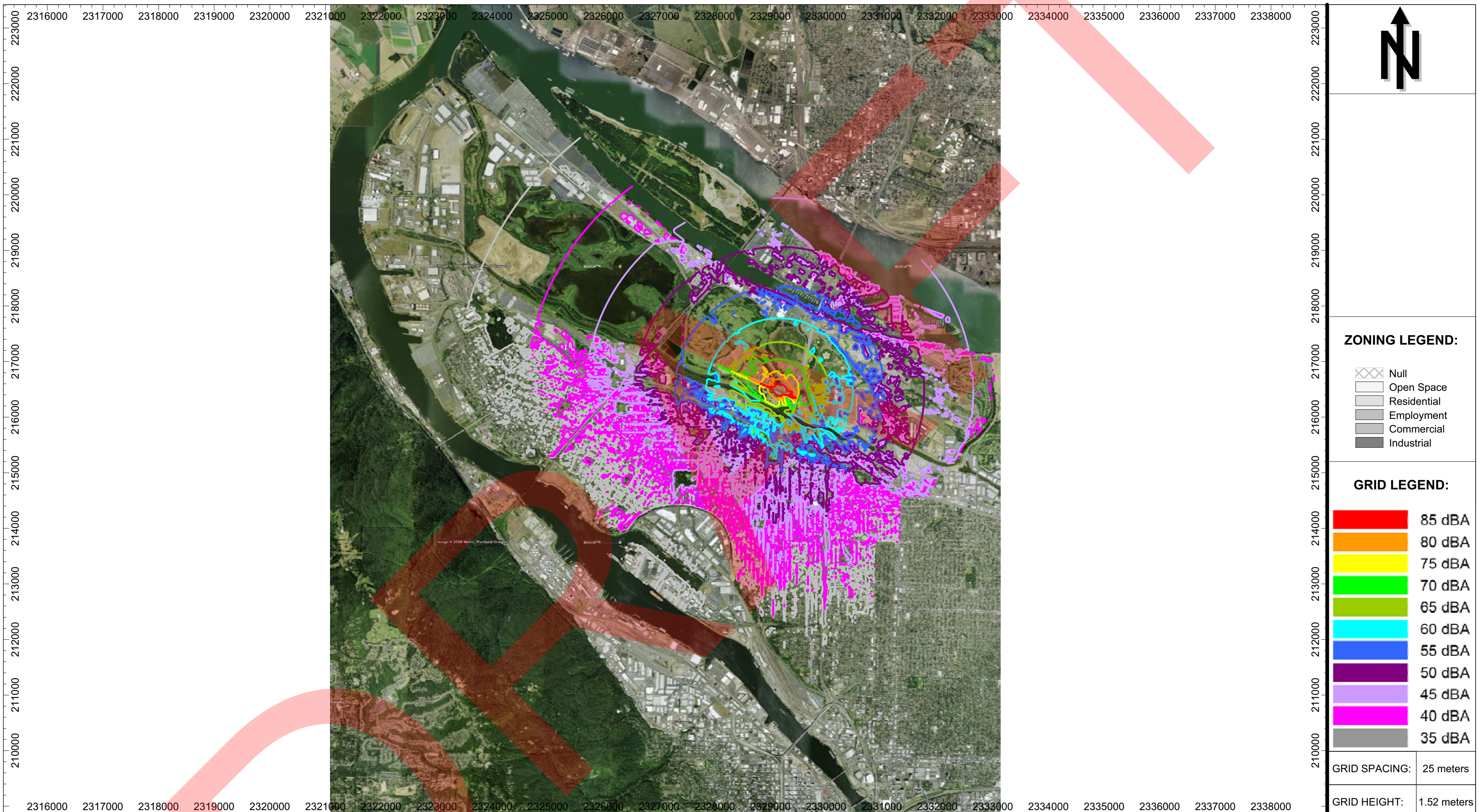
PLOT DESCRIPTION

Figure A33.
PIR Full Race Track
113 dBA Lmax trackside
16' trackside barrier



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North Portland Noise Study

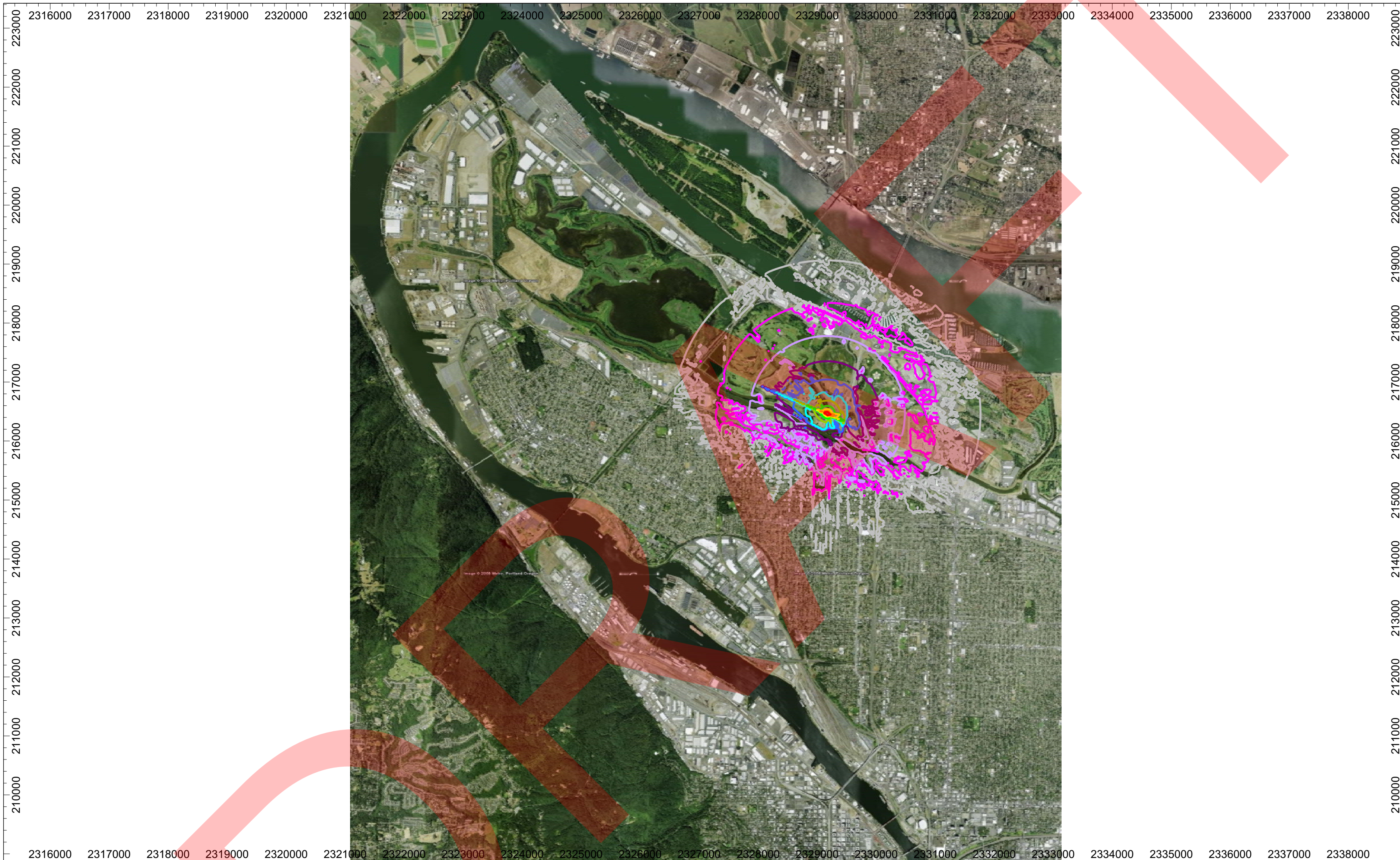
City of Portland
Portland, Oregon

REVISIONS		
NO.	REVISION	DATE

PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A34.
PIR Late Night Drag
105 dBA Lmax trackside
9' trackside barrier



N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	25 meters
GRID HEIGHT:	1.52 meters

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REVISIONS

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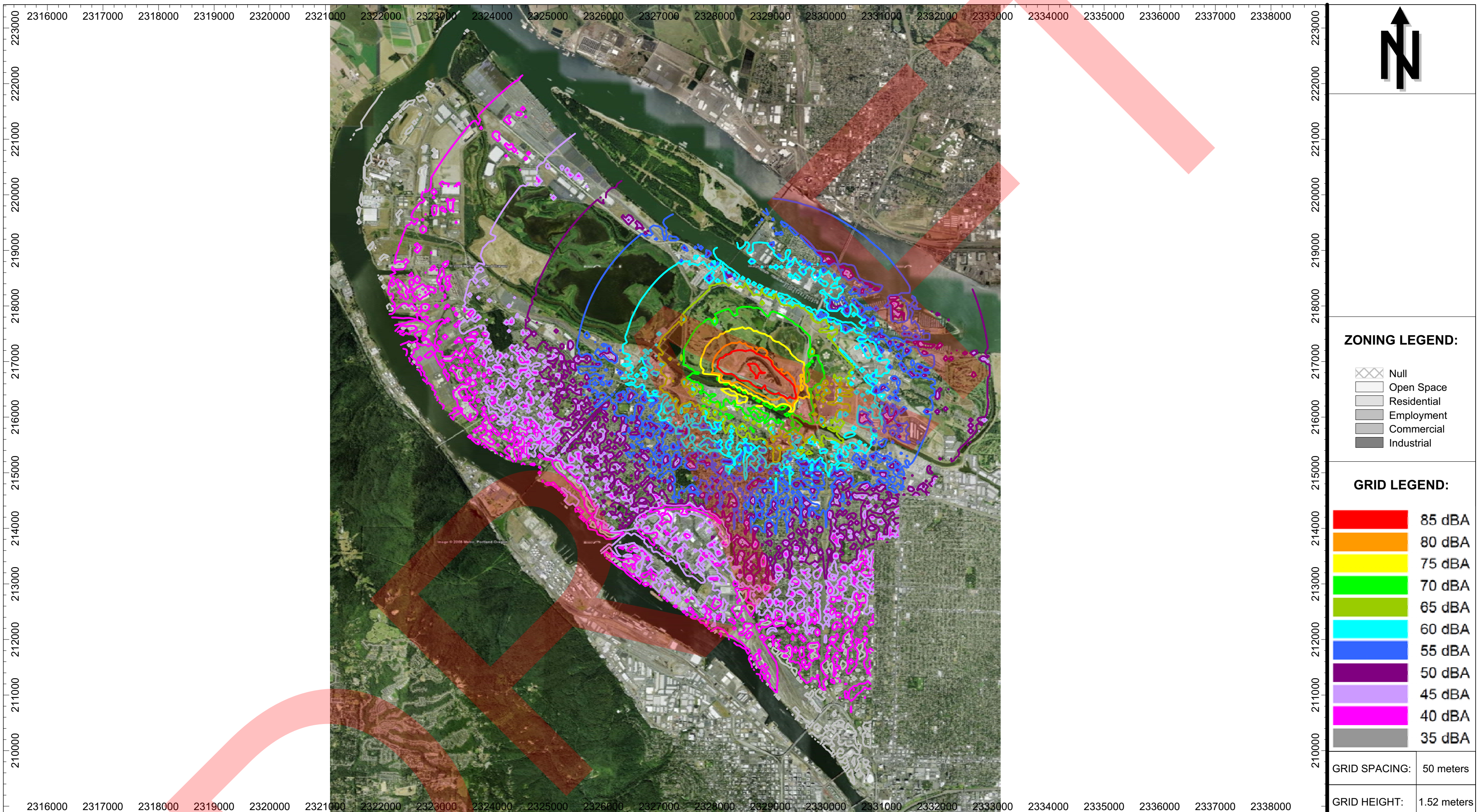
PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A35.
PIR Late Night Drag
90 dBA Lmax trackside
9' trackside barrier



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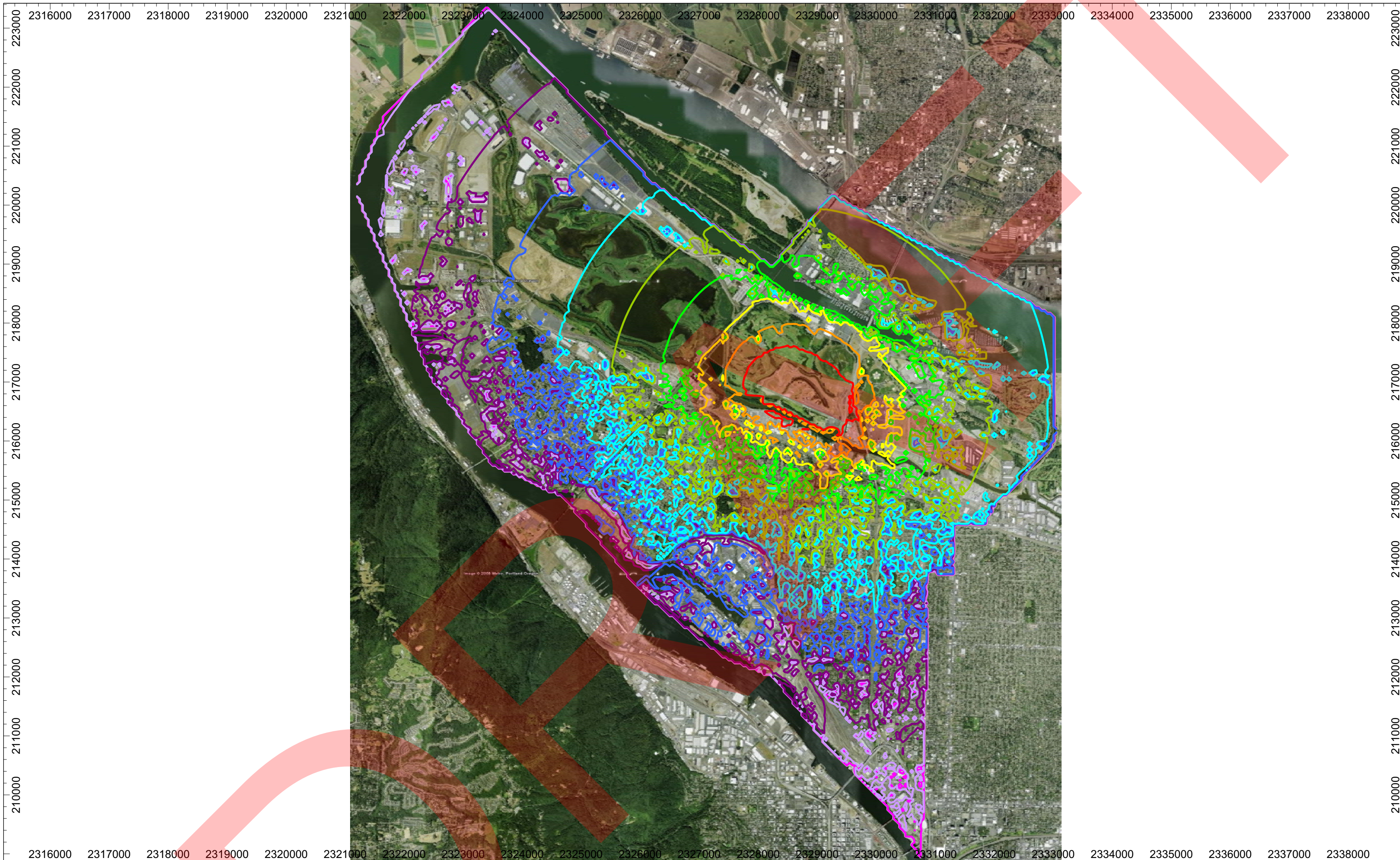
PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A36.
PIR Full Race Track
103 dBA Lmax trackside
9' trackside barrier



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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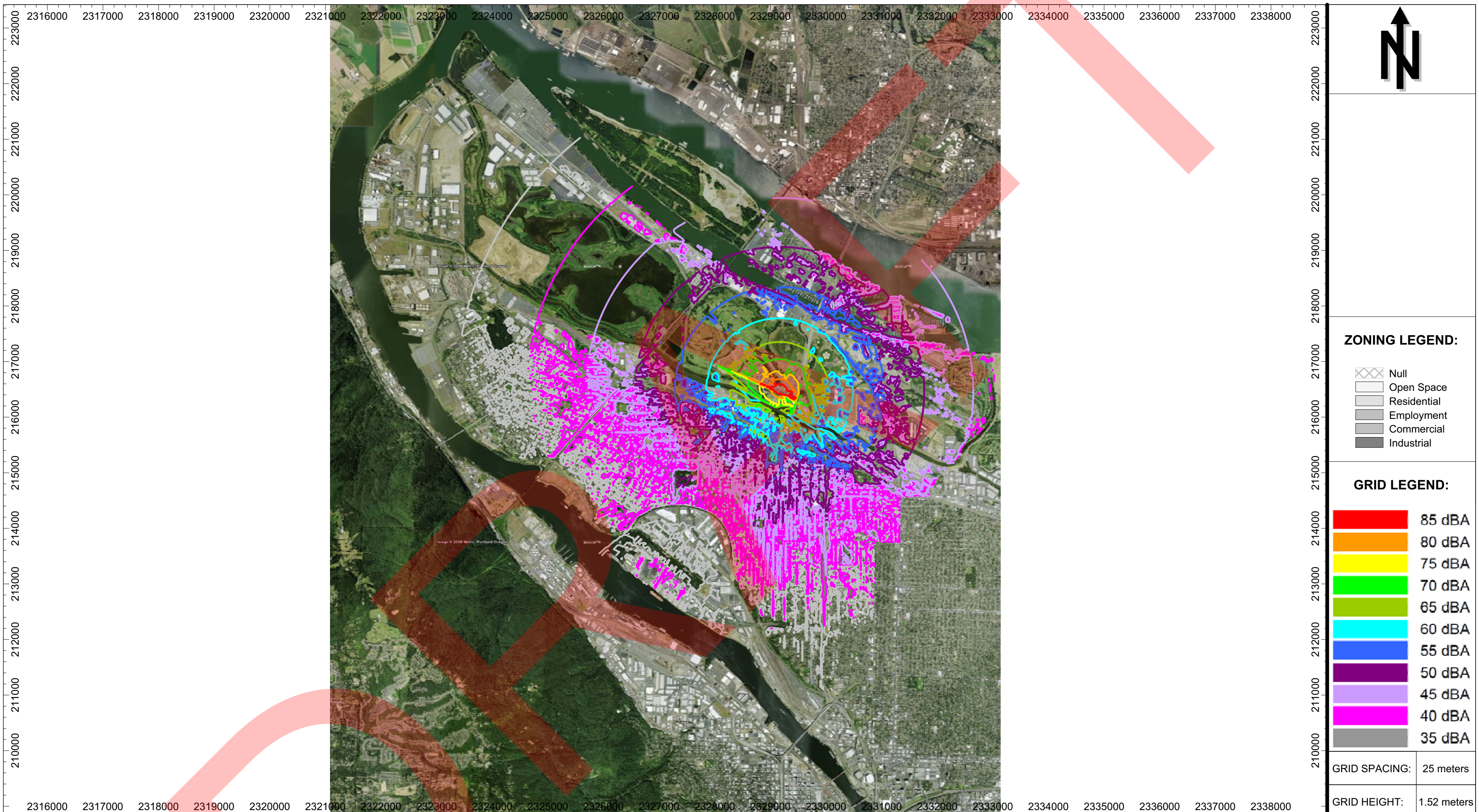
PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A37.
PIR Full Race Track
113 dBA Lmax trackside
9' trackside barrier



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PROJECT ACOUSTICIAN:	ACJ/JAW
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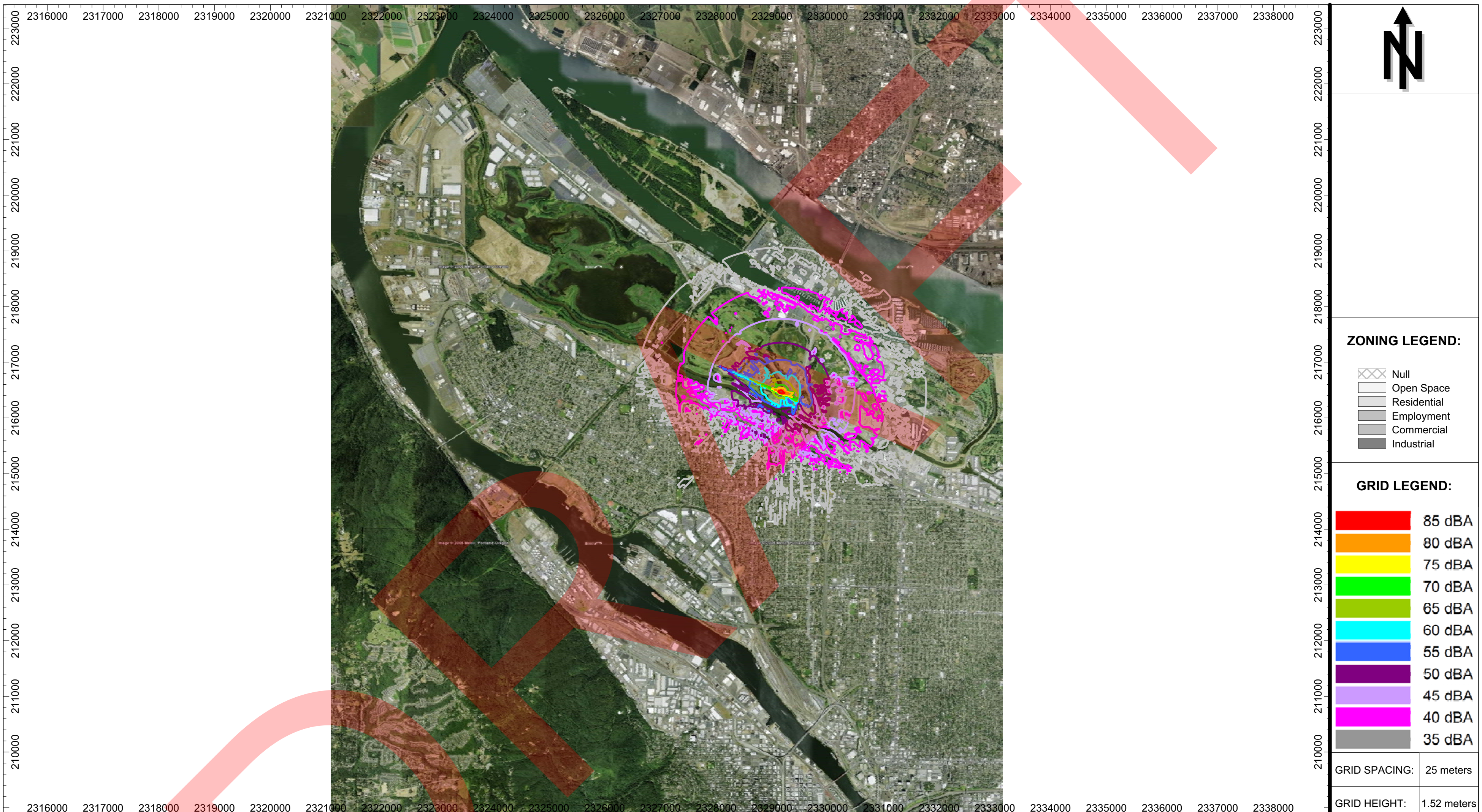
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A38.
PIR Late Night Drag
105 dBA Lmax trackside
16' bleacher barrier



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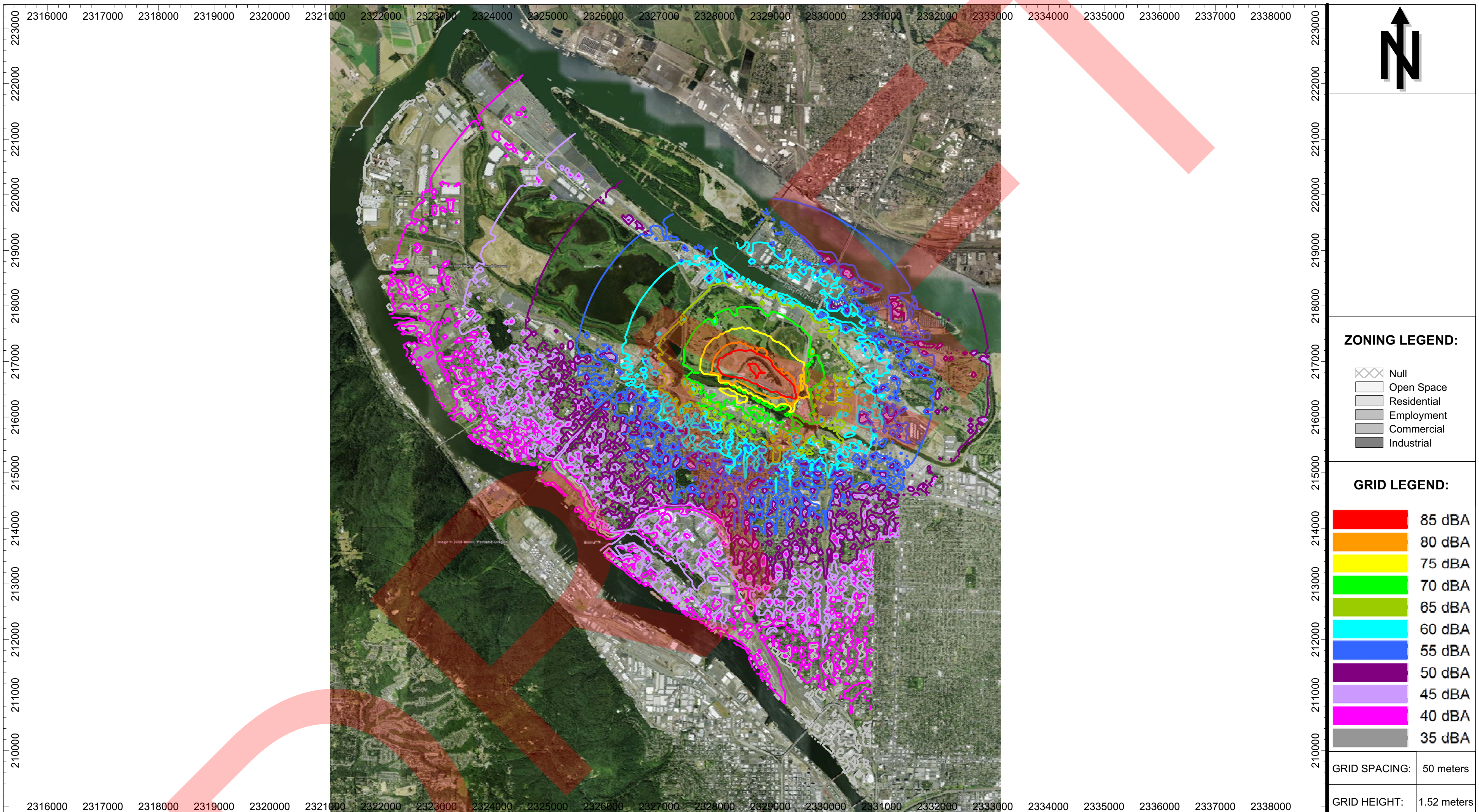
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A39.
PIR Late Night Drag
90 dBA Lmax trackside
16' bleacher barrier



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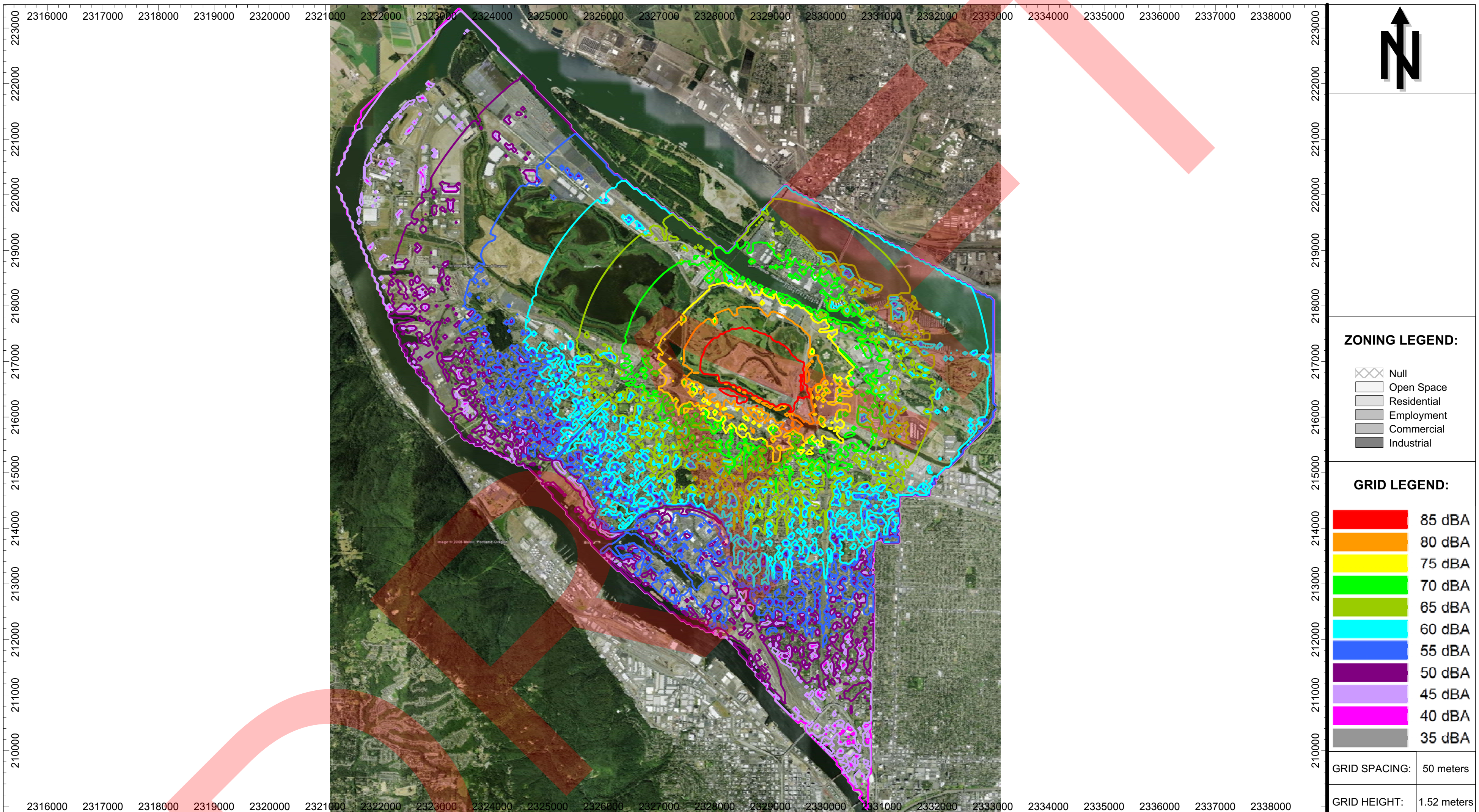
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A40.
PIR Full Race Track
103 dBA Lmax trackside
16' bleacher barrier



GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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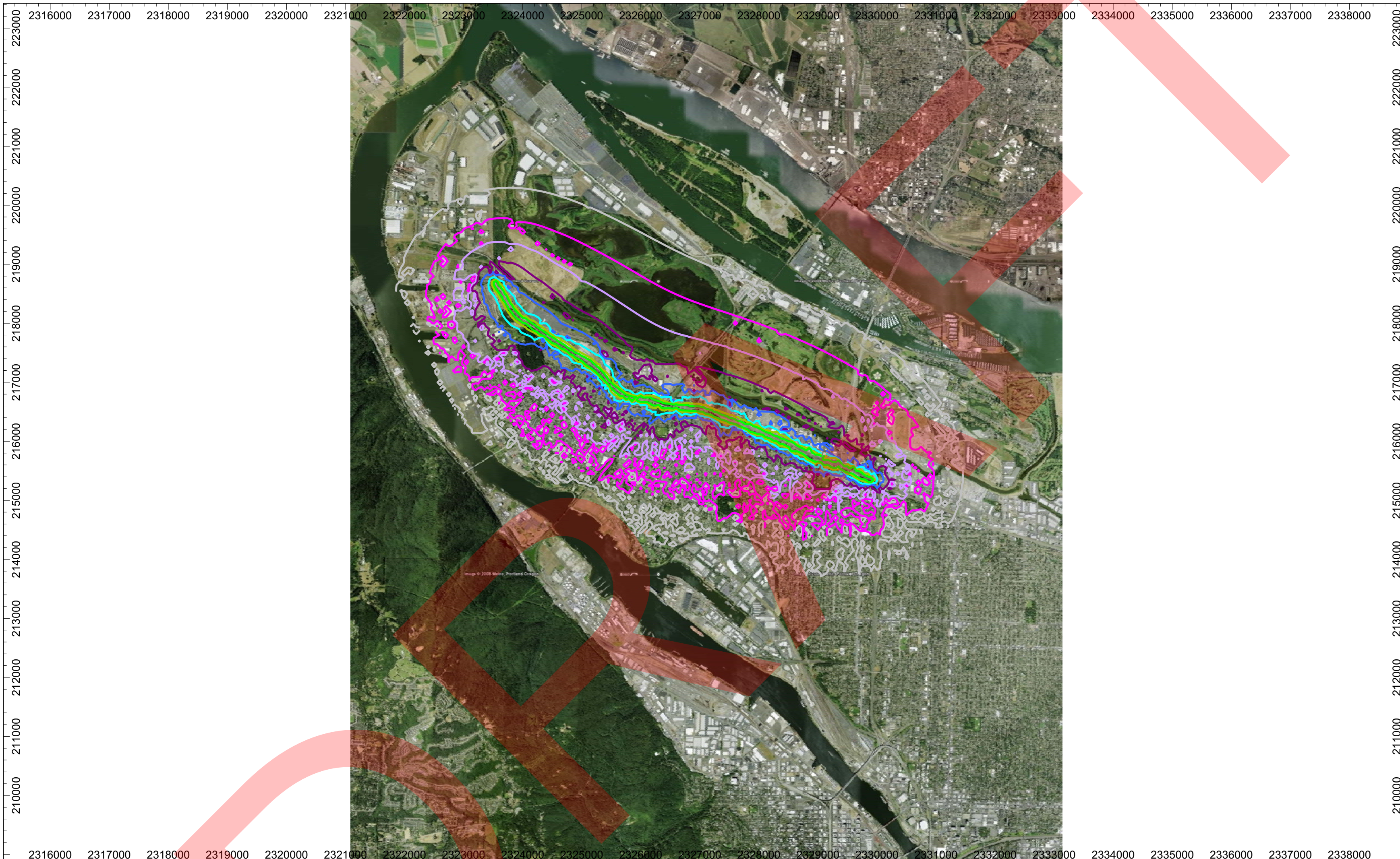
PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A41.
PIR Full Race Track
113 dBA Lmax trackside
16' bleacher barrier



N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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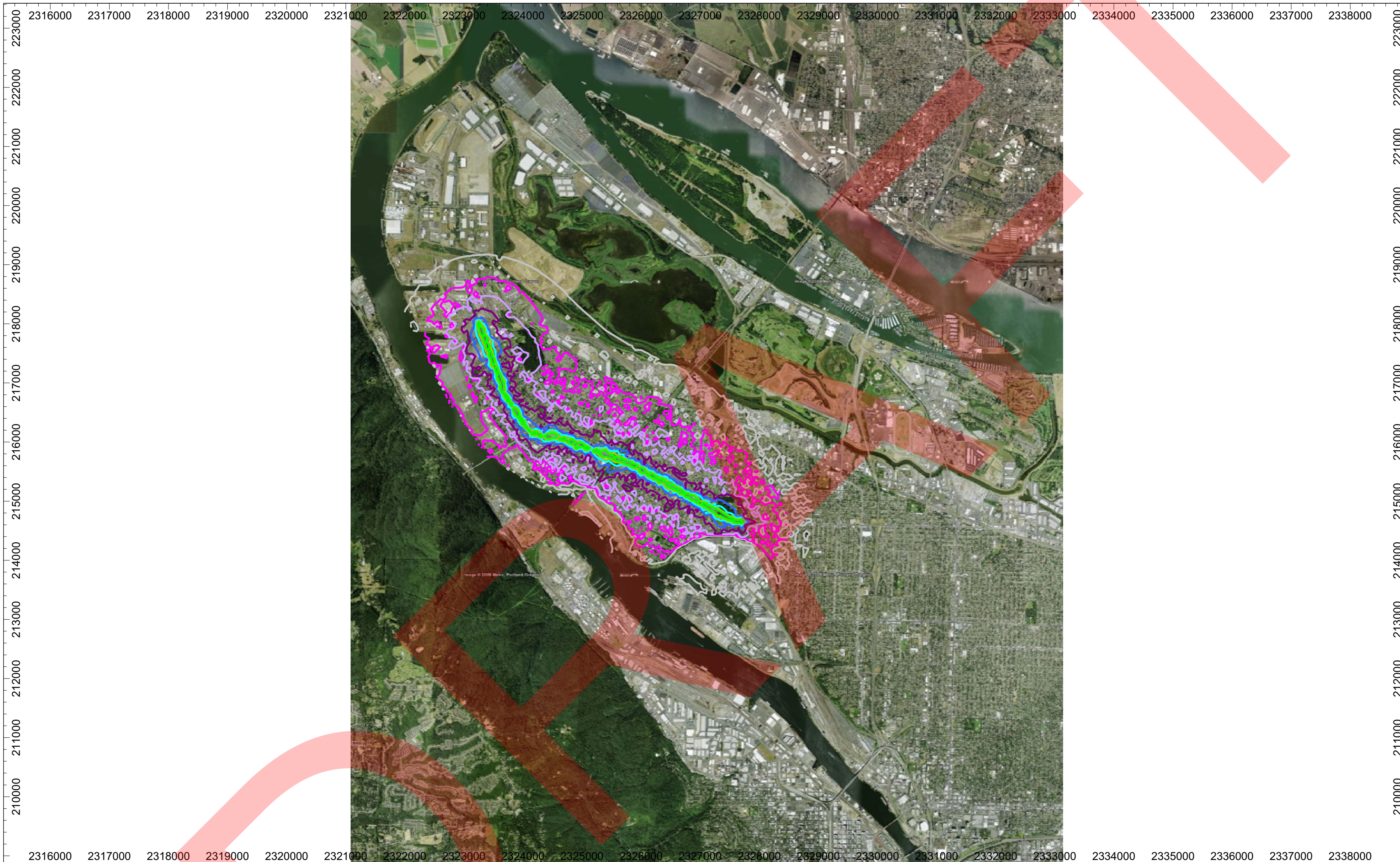
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A42.
North Columbia Boulevard Traffic
24-hour Ldn



N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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REVISIONS

NO.	REVISION	DATE

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DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A43.
North Lombard Street
Traffic
24-hour Ldn

N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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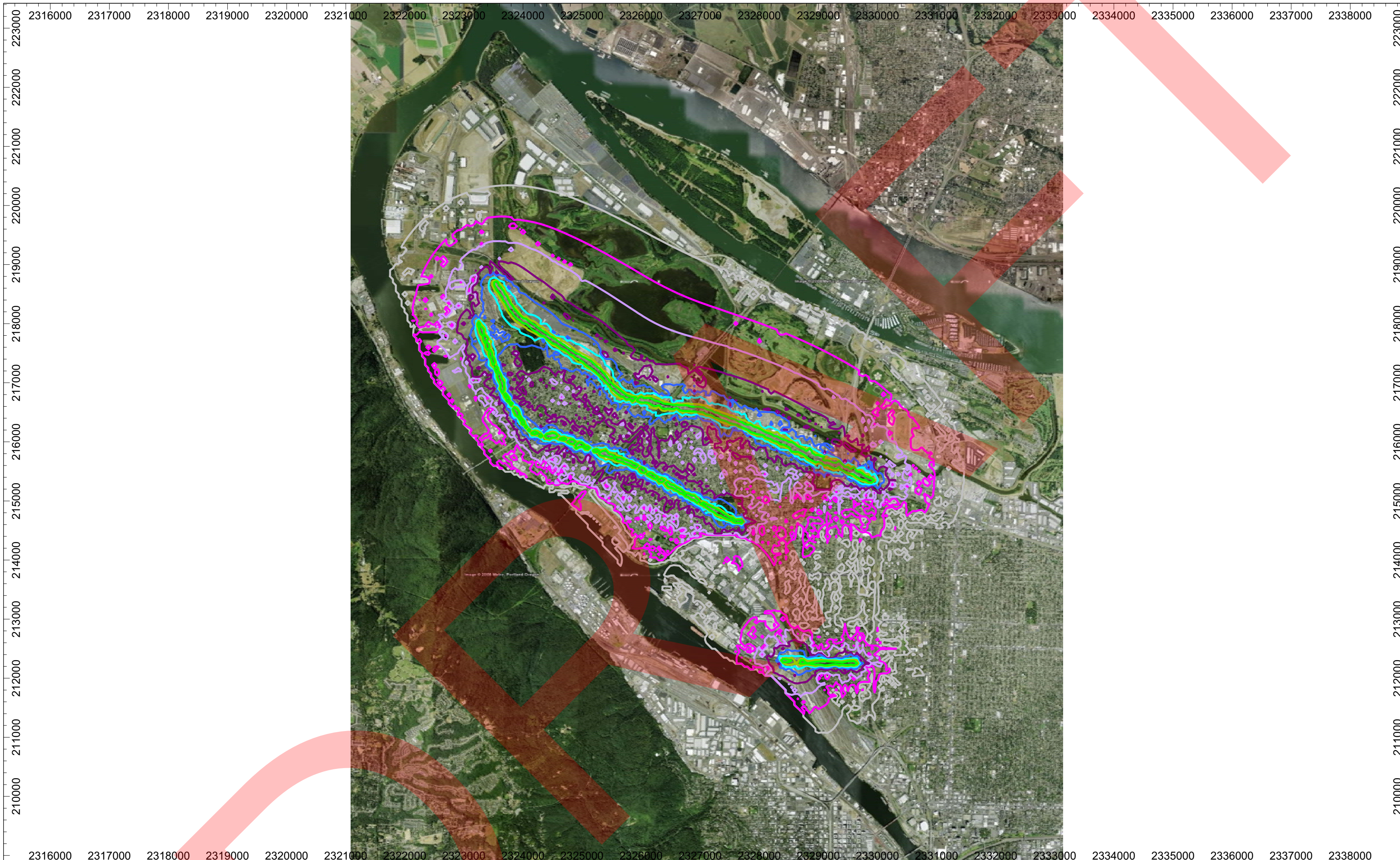
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A44.
North Going Street
Traffic
24-hour Ldn



N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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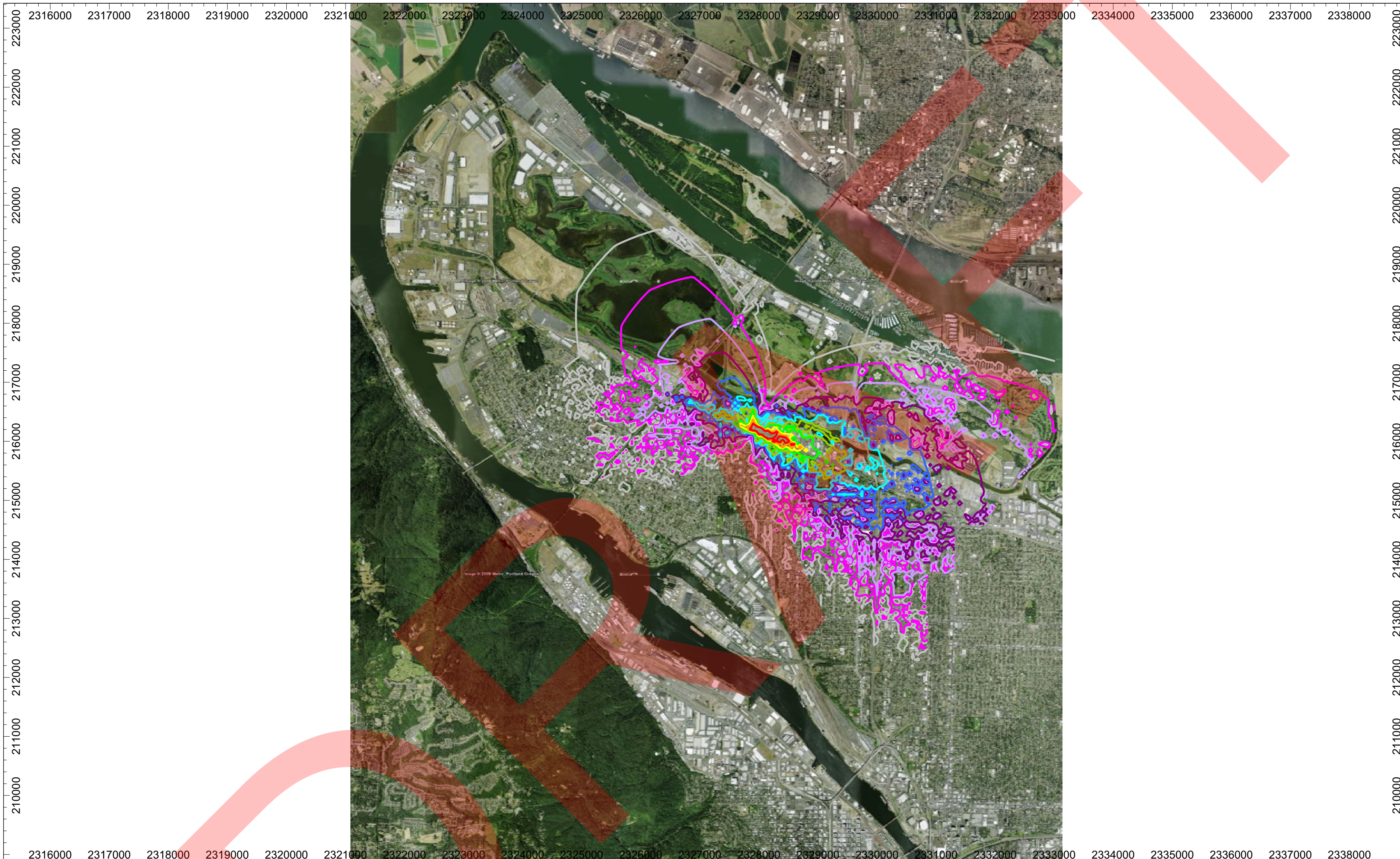
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A45.
Composite
Traffic
24-hour Ldn



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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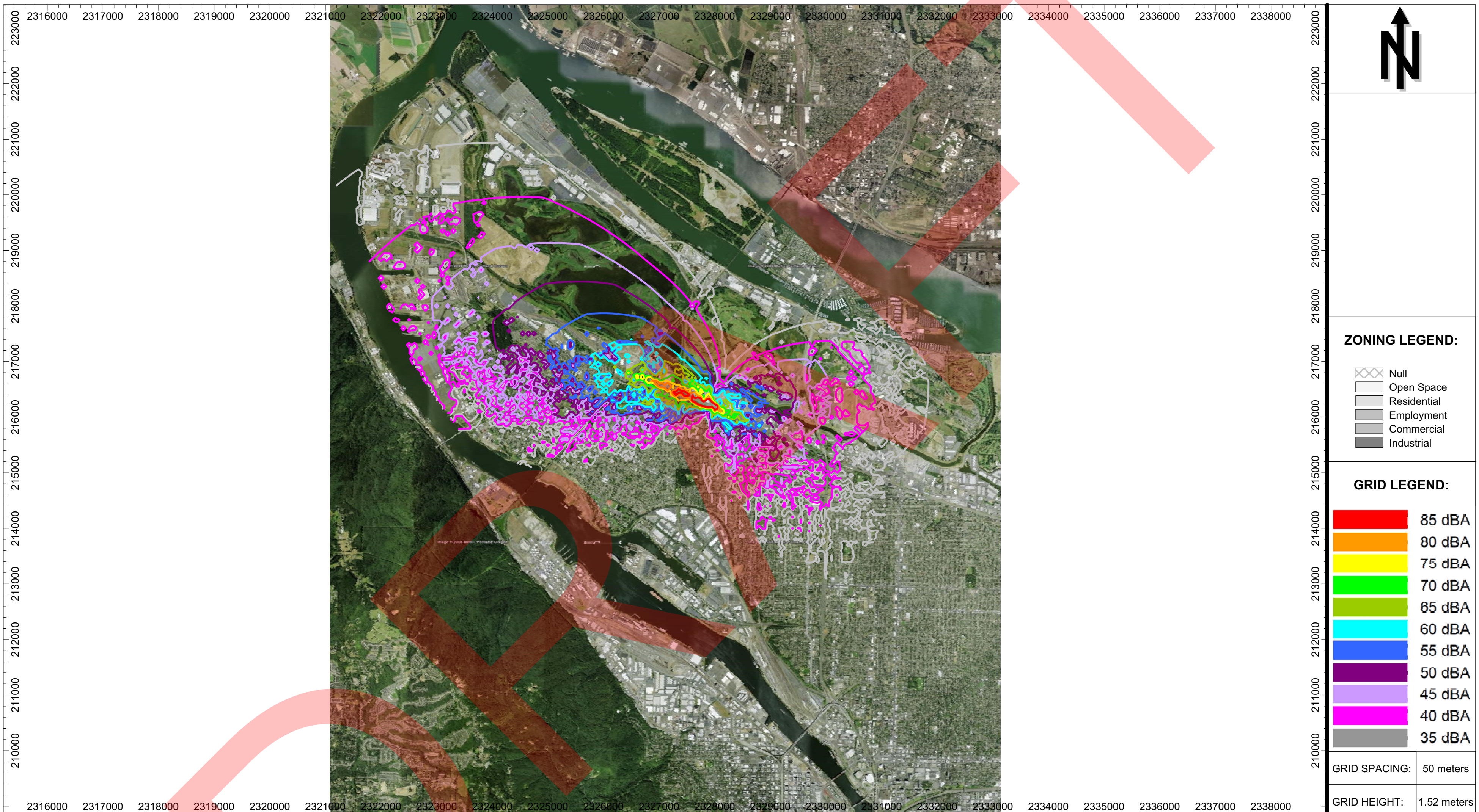
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A46.
Kenton Train Horn
Eastbound train
Lmax



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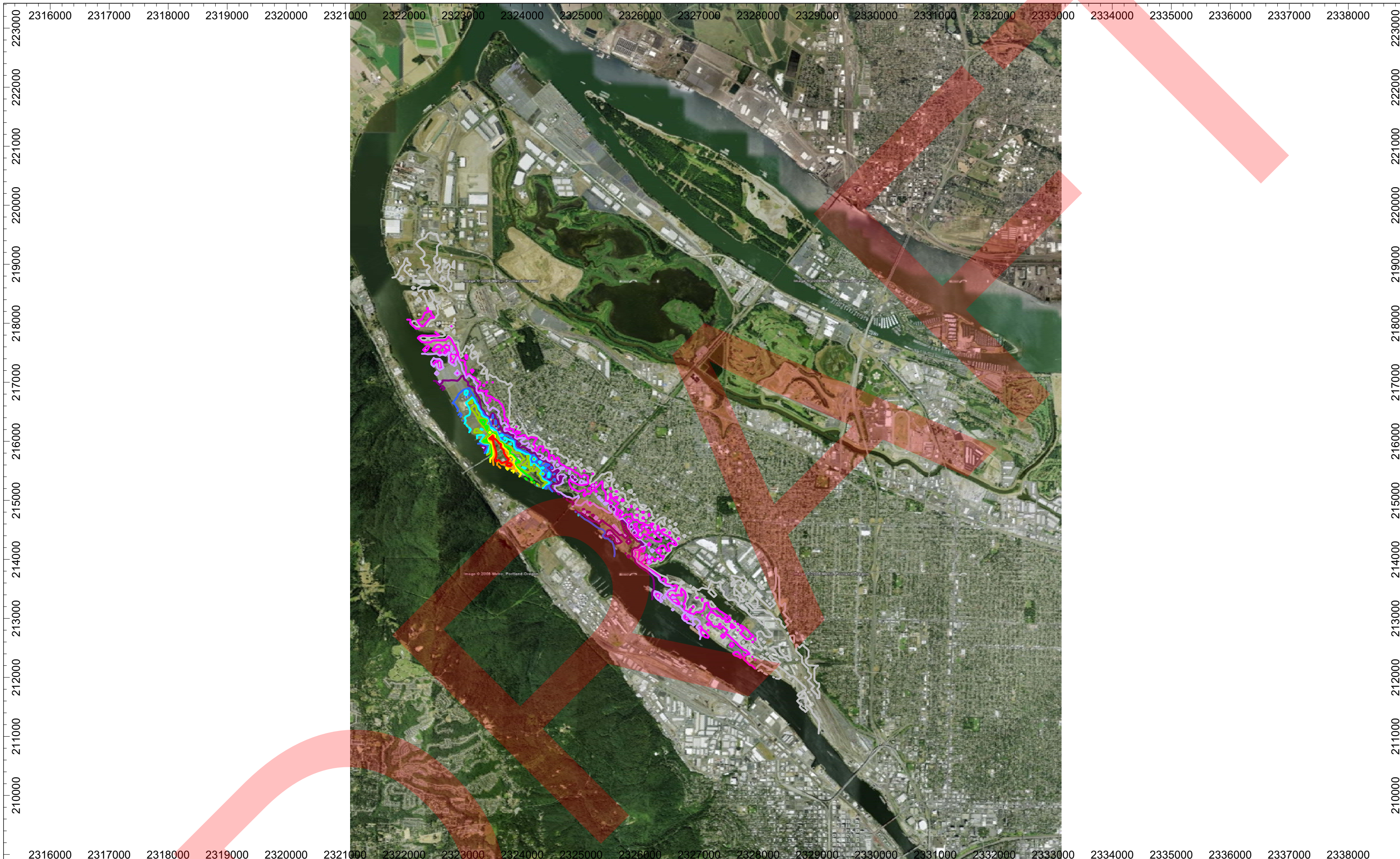
PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A47.
Kenton Train Horn
Westbound train
Lmax



GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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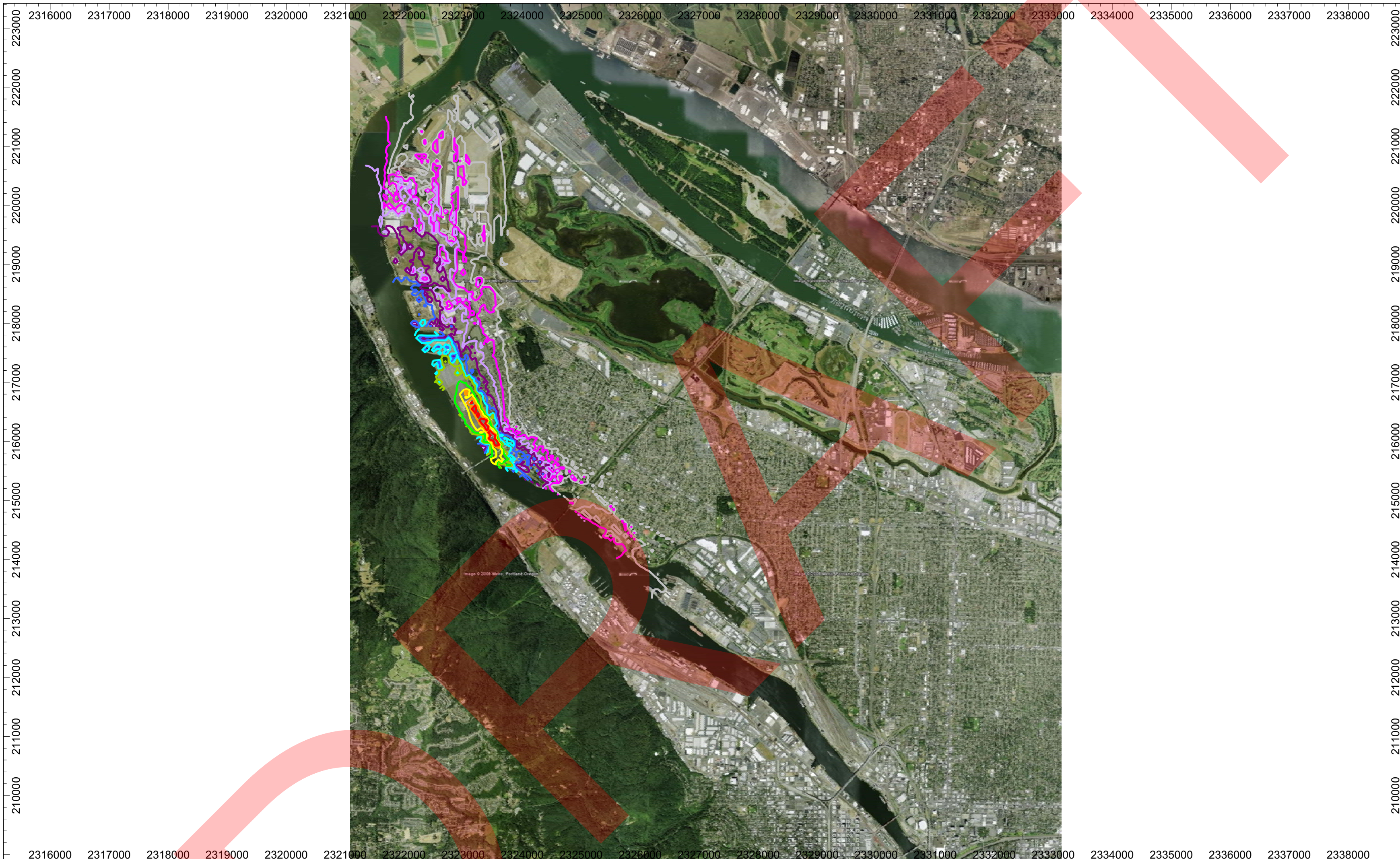
NO.	REVISION	DATE

PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A48.
Cathedral Park Train Horn
Eastbound train
Lmax



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A49.
Cathedral Park Train Horn
Westbound train
Lmax

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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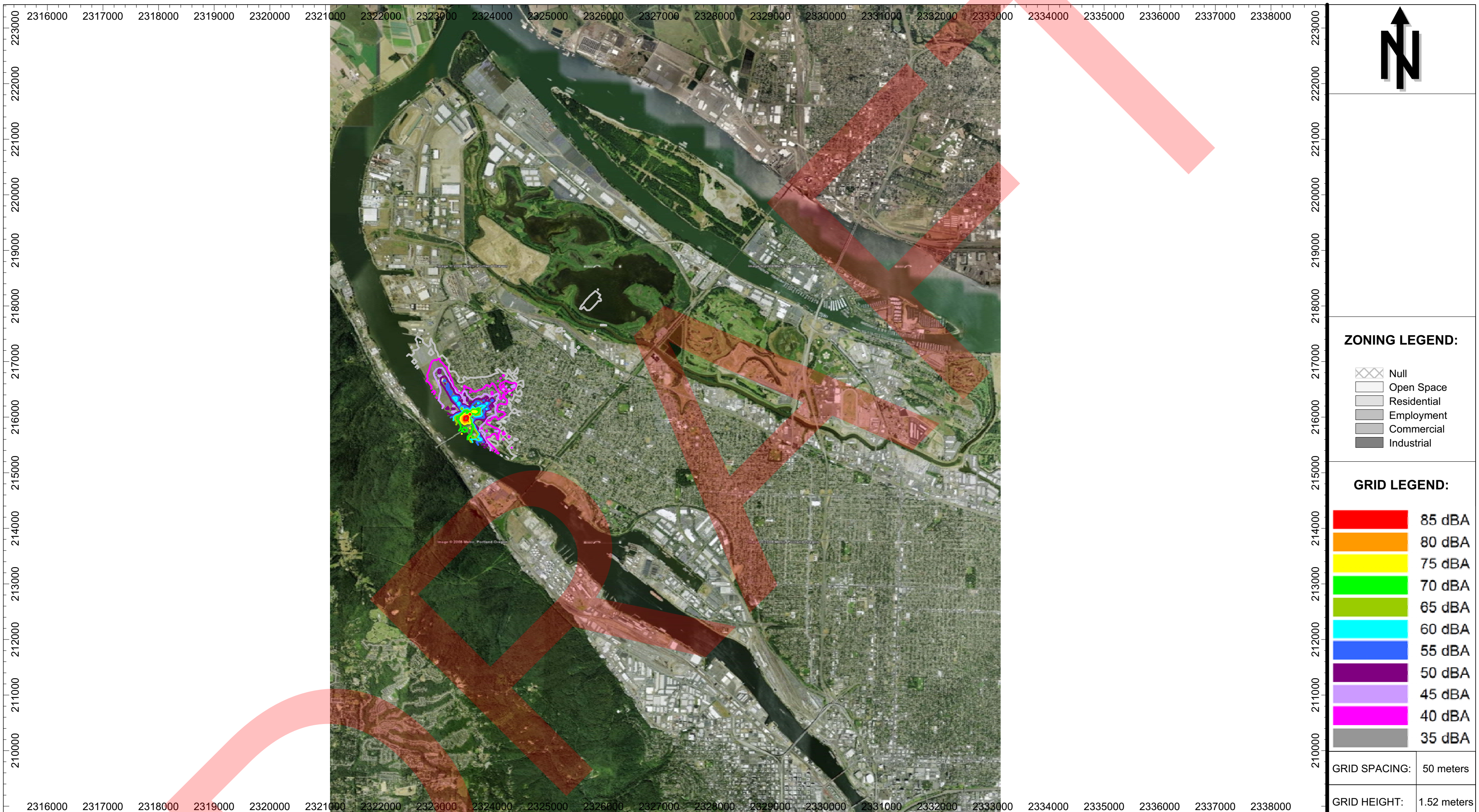
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A50.
Kenton Wayside Horn
Lmax



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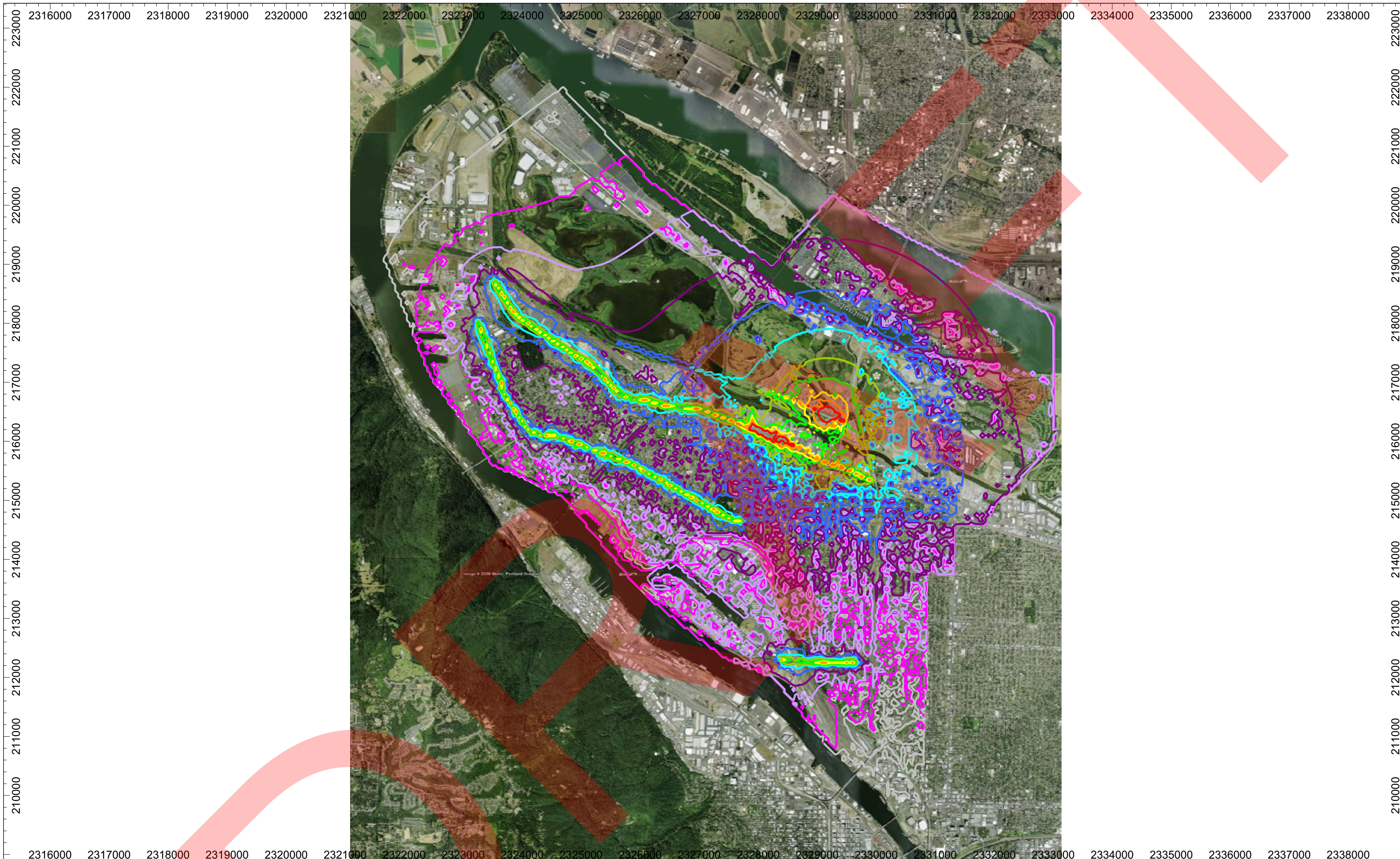
PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A51.
Cathedral Park Wayside Horn
Lmax



N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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REVISIONS

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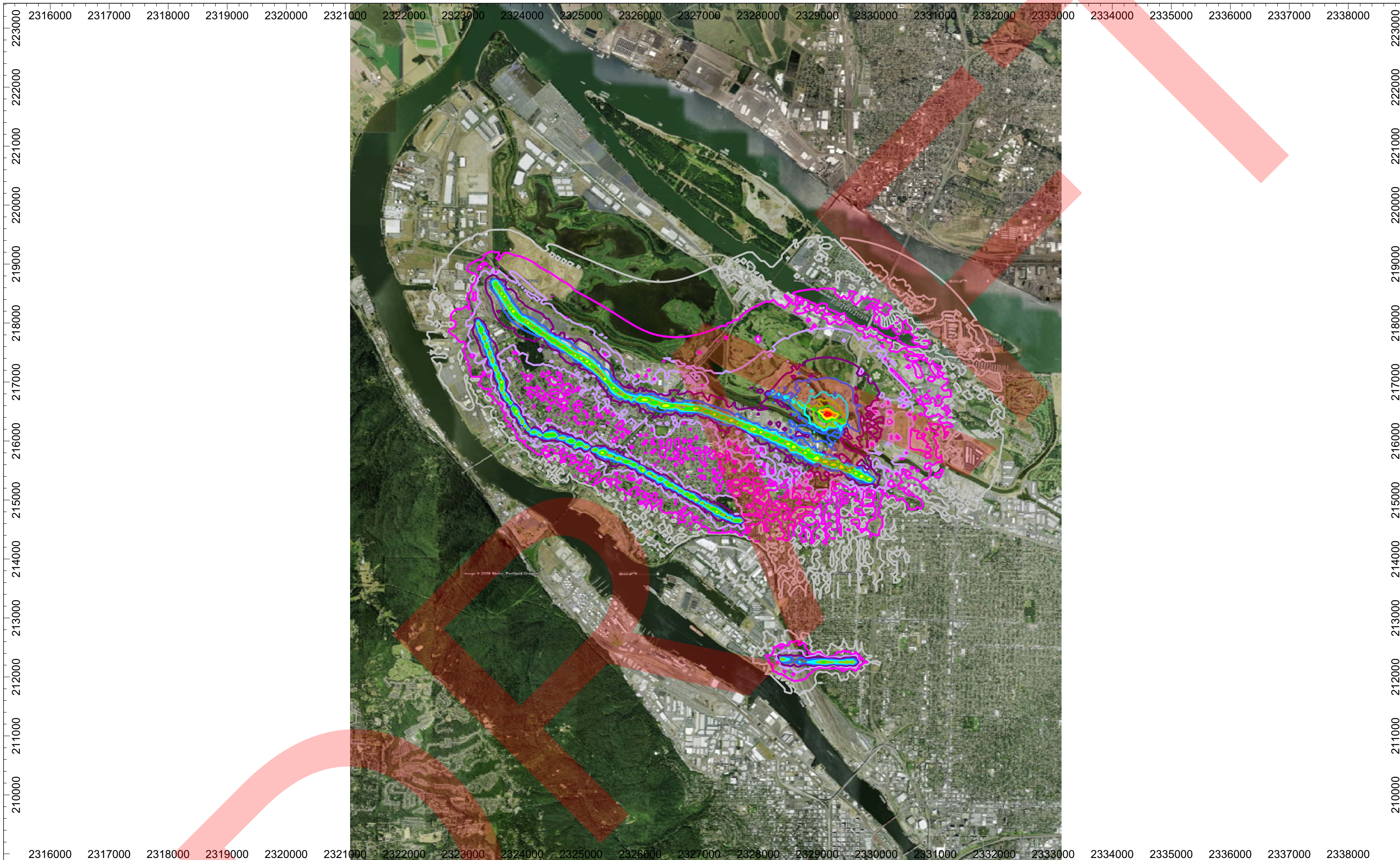
PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A52.
Composite
Daytime traffic, PIR
LND, and train horn



ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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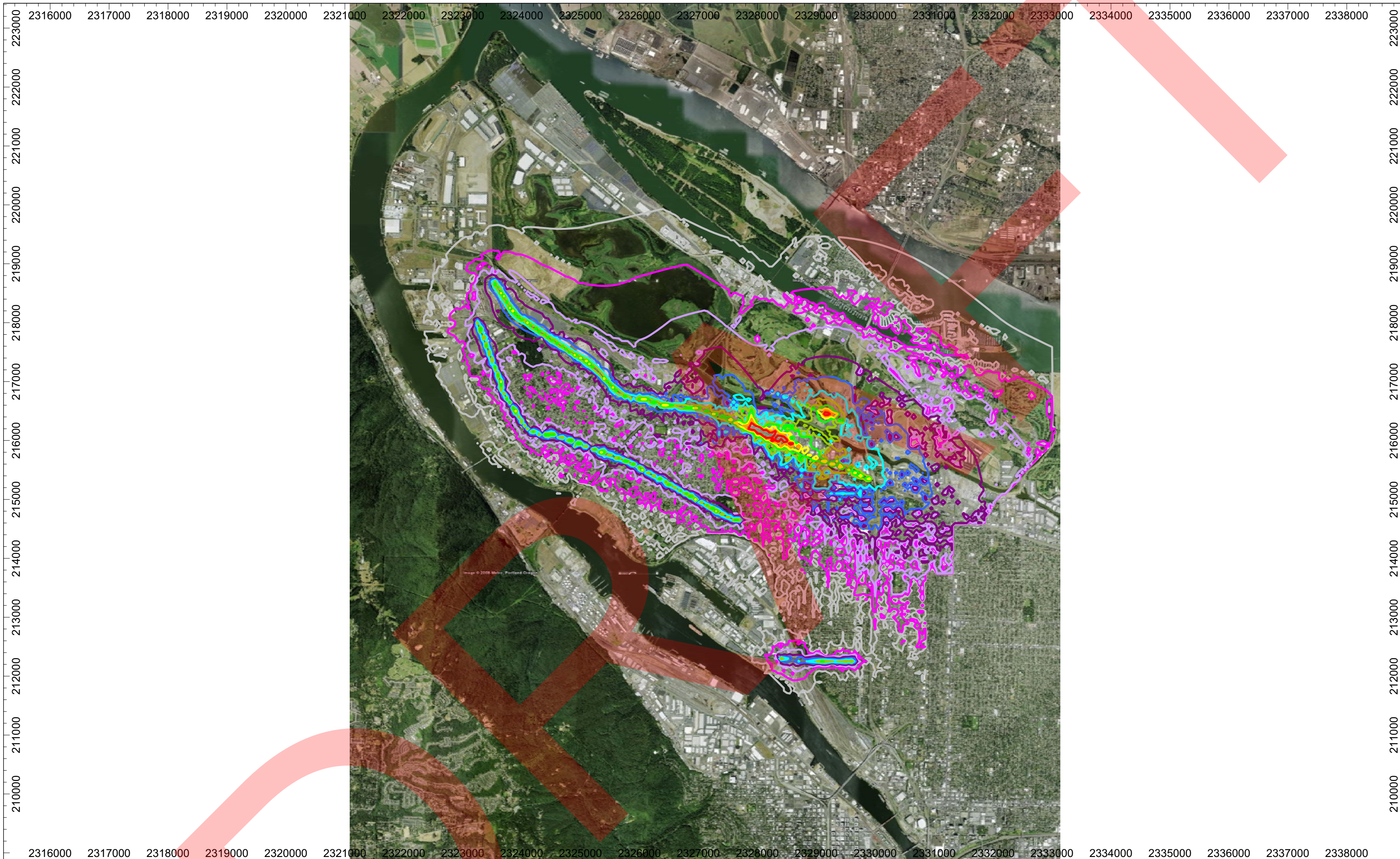
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A53. Composite Nighttime traffic and PIR LND



GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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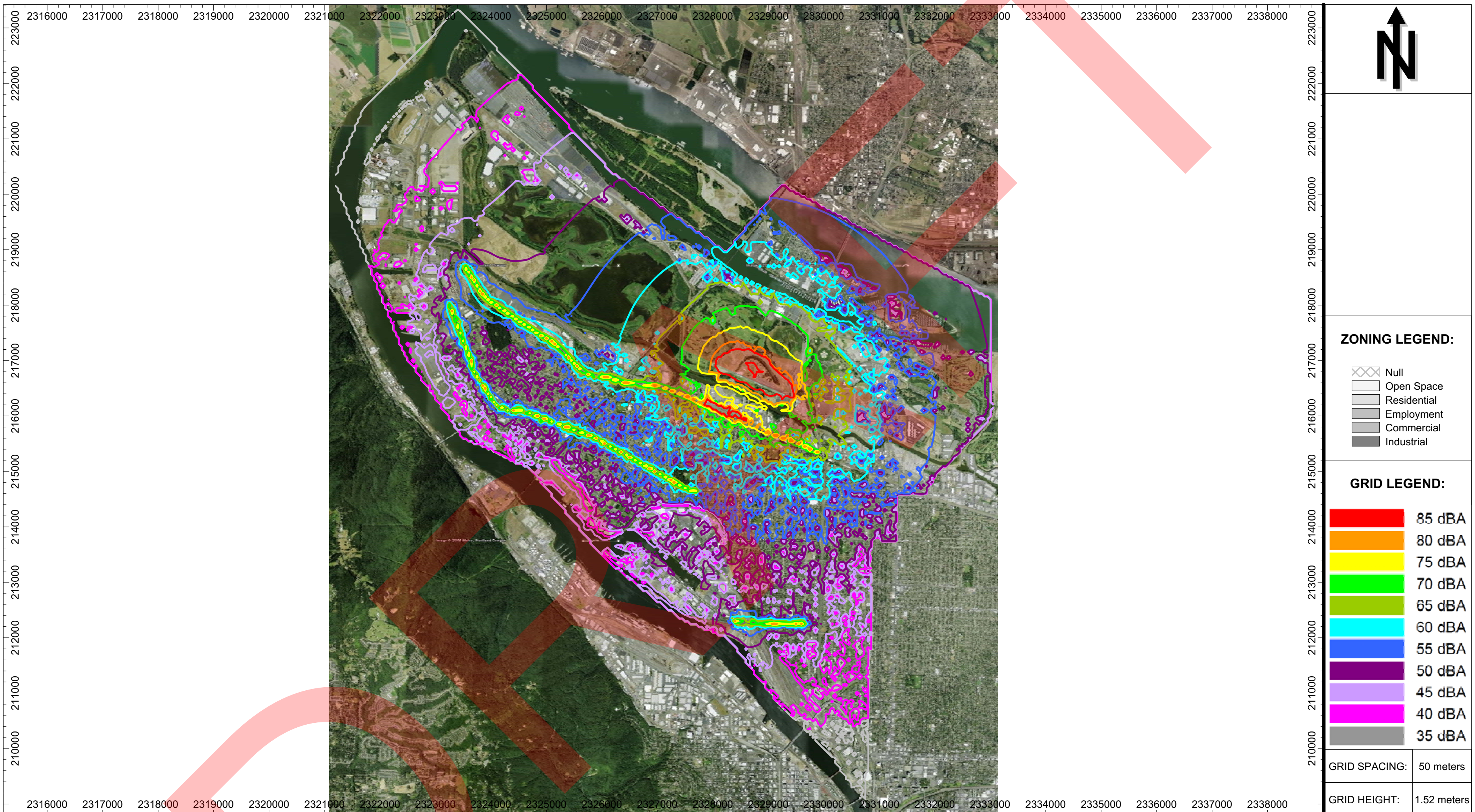
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A54.
Composite
Nighttime traffic, PIR
LND, and train horn



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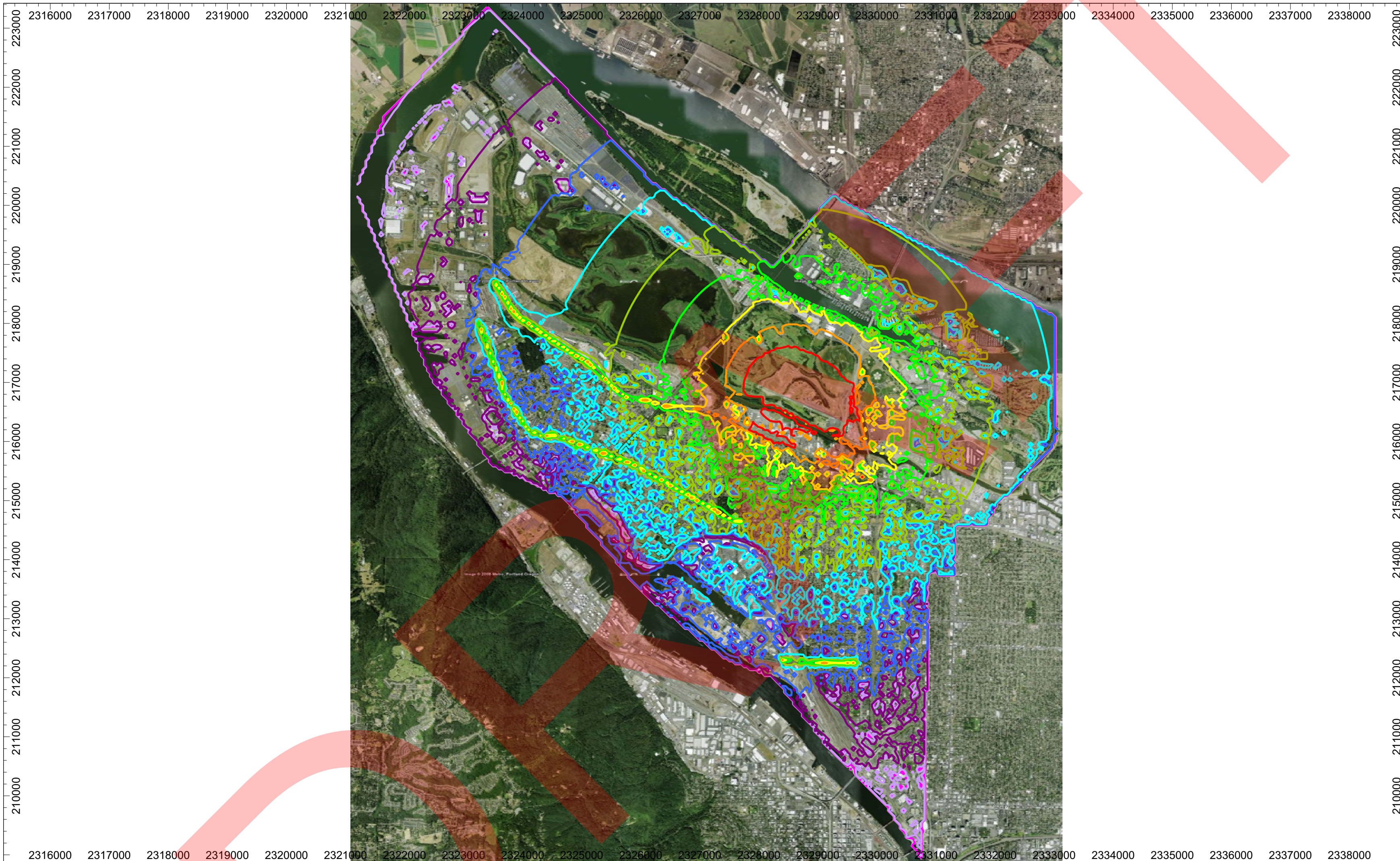
PROJECT ACOUSTICIAN:	ACJ/JAW
DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A55.
Composite
Daytime traffic, PIR
103 Race, and train horn



N

ZONING LEGEND:

- Null
- Open Space
- Residential
- Employment
- Commercial
- Industrial

GRID LEGEND:

- 85 dBA
- 80 dBA
- 75 dBA
- 70 dBA
- 65 dBA
- 60 dBA
- 55 dBA
- 50 dBA
- 45 dBA
- 40 dBA
- 35 dBA

GRID SPACING:	50 meters
GRID HEIGHT:	1.52 meters

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DRAWN BY:	ACJ
SCALE:	AS SHOWN
DATE:	06/12/08
JOB NO:	2006.049

PLOT DESCRIPTION

Figure A56.
Composite
Daytime traffic, PIR
113 Race, and train horn

A2.0 NOISE MODEL VERIFICATION

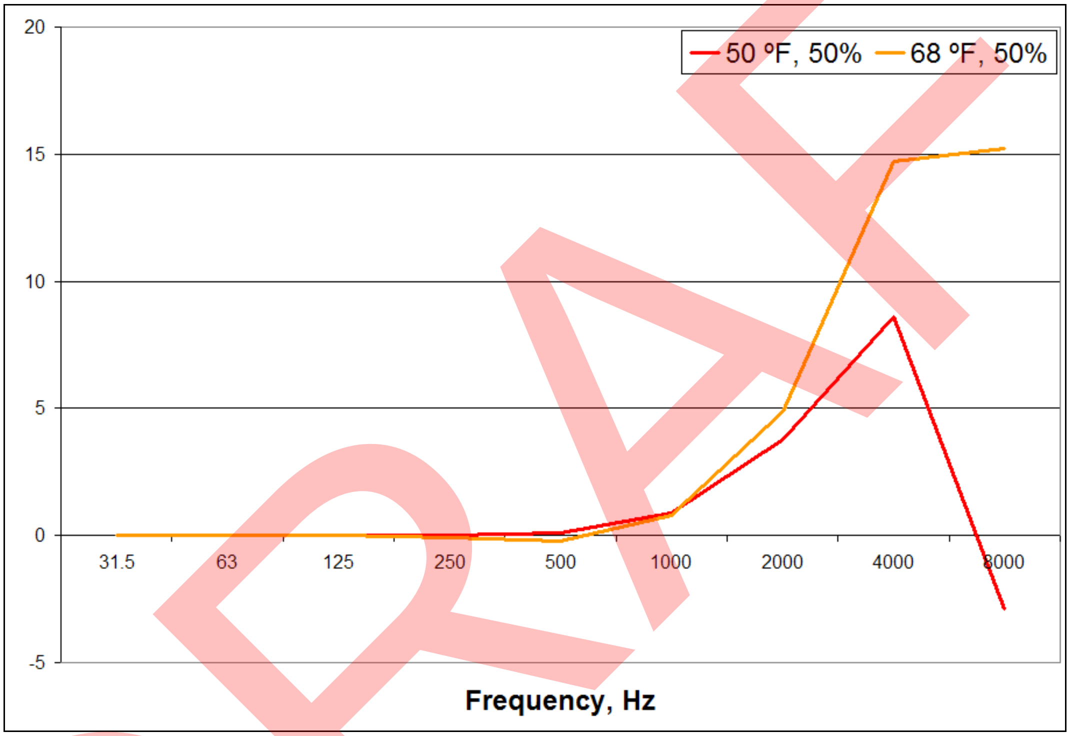
A2.1 Cadna/A Calculation Details

Temperature and humidity input in Cadna/A includes selecting values from three available options for each parameter as follows:

- Temperature: 32, 50, or 68 degrees F
- Relative humidity: 50, 70, or 90 percent

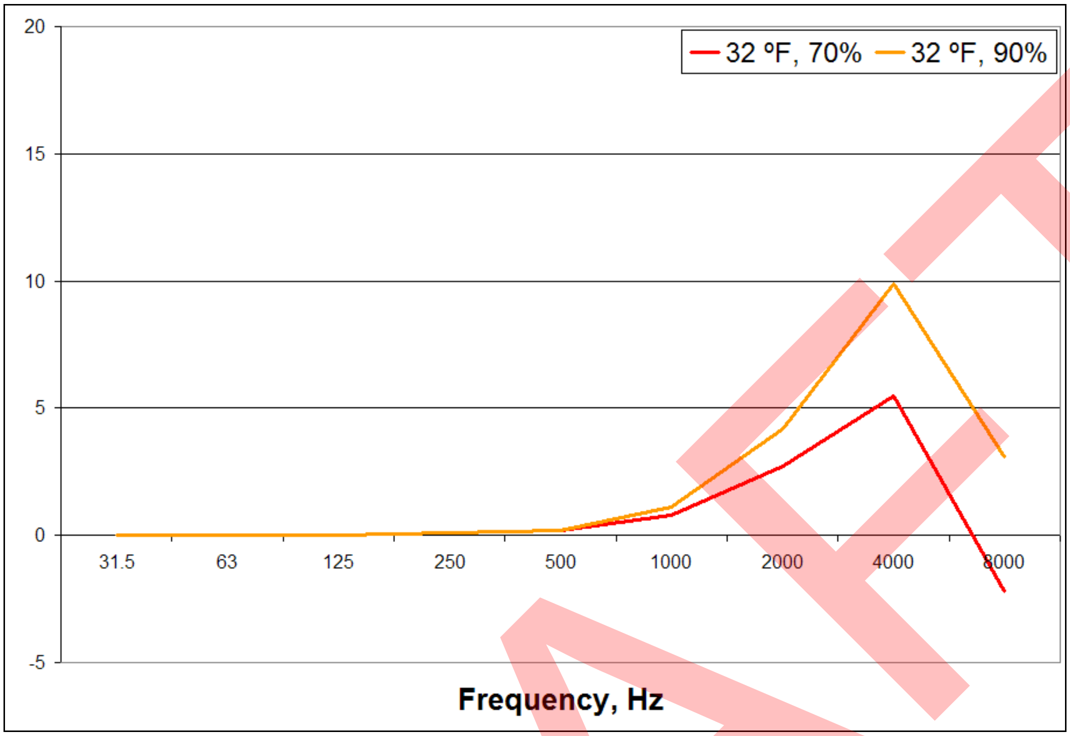
Correction factors used by Cadna/A to account for propagation influences of varying temperature and humidity are shown in Figures X and X below.

Figure X. Sample Cadna/A Adjustments for Varying Temperature, as Compared to 32° F, dB re: 20 μPa



Source: Cadna/A, The Greenbusch Group

Figure X. Sample Cadna/A Adjustments for Varying Humidity, as Compared to 32^o F 50% Relative Humidity, dB re: 20 μPa



Source: Cadna/A, The Greenbusch Group

The input of wind values in Cadna/A can be done in a variety of ways. The following input methods were utilized during this study:

- Wind statistics: Input of statistical wind values
- Conservation of Clean Air and Water in Europe (CONCAWE): Input of wind direction, speed, and stability class

Wind stability classes in Cadna/A are based on Pasquill stability classes. Pasquill stability class definitions and associated meteorological conditions are given in Tables X-X below.

Table X. Pasquill Stability Classes in Cadna

Stability Class	Definition
A	Very unstable
B	Unstable
C	Slightly unstable
D	Neutral
E	Slightly stable
F	Stable
G	Very stable[1]

1. Not present in source , extrapolated based on symmetry to other definitions

Source: http://en.wikipedia.org/wiki/Air_pollution_dispersion_terminology

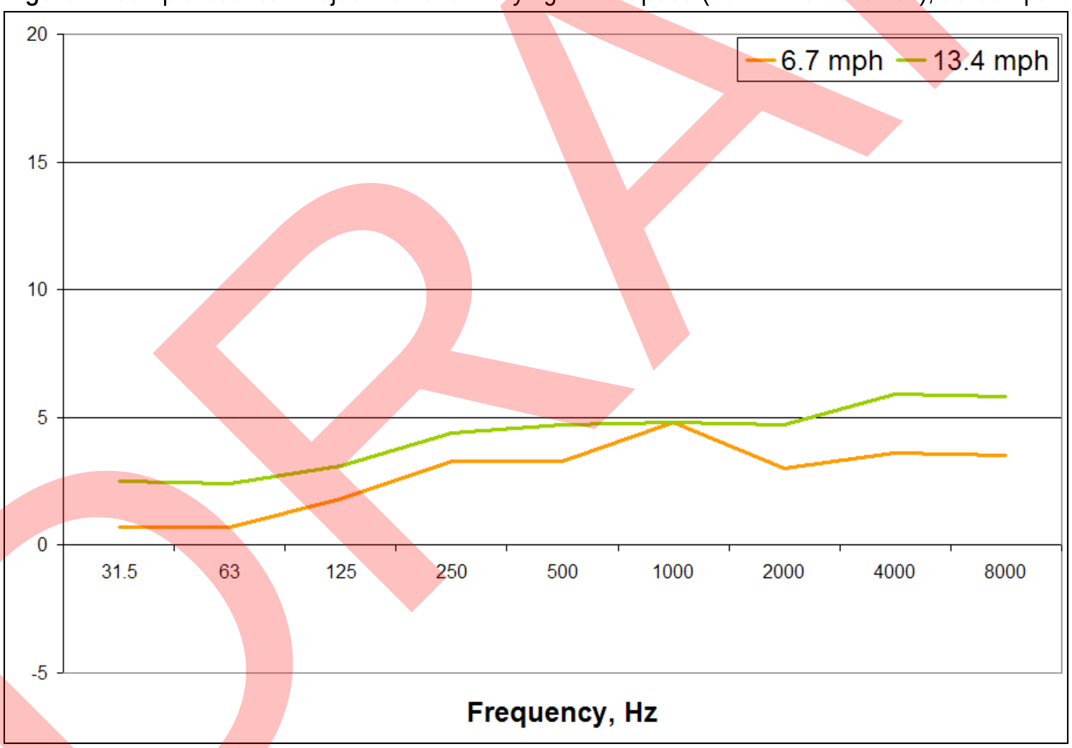
Table X. Pasquill Stability Class Meteorology

Surface Wind Speed, miles per hour	Daytime Incoming Solar Radiation			Nighttime Cloud Cover	
	Strong	Moderate	Slight	> 50%	< 50%
< 2	A	A – B	B	E	F
2 – 3	A – B	B	C	E	F
3 – 5	B	B – C	C	D	E
5 – 6	C	C – D	D	D	D
> 6	C	D	D	D	D

Source: http://en.wikipedia.org/wiki/Air_pollution_dispersion_terminology

Wind statistics input was used to assess the overall average sound propagation characteristics of North Portland. Most of the analysis performed for this study considered specific meteorological conditions present during field measurements and typical seasonal average wind conditions for modeling community exposure. Adjustment factors for downwind conditions of stability Class C as compared to no wind, are shown in Figure X below.

Figure X. Sample Cadna/A Adjustments for Varying Wind Speed (downwind condition), as Compared to No Wind, dB re: 20 μPa

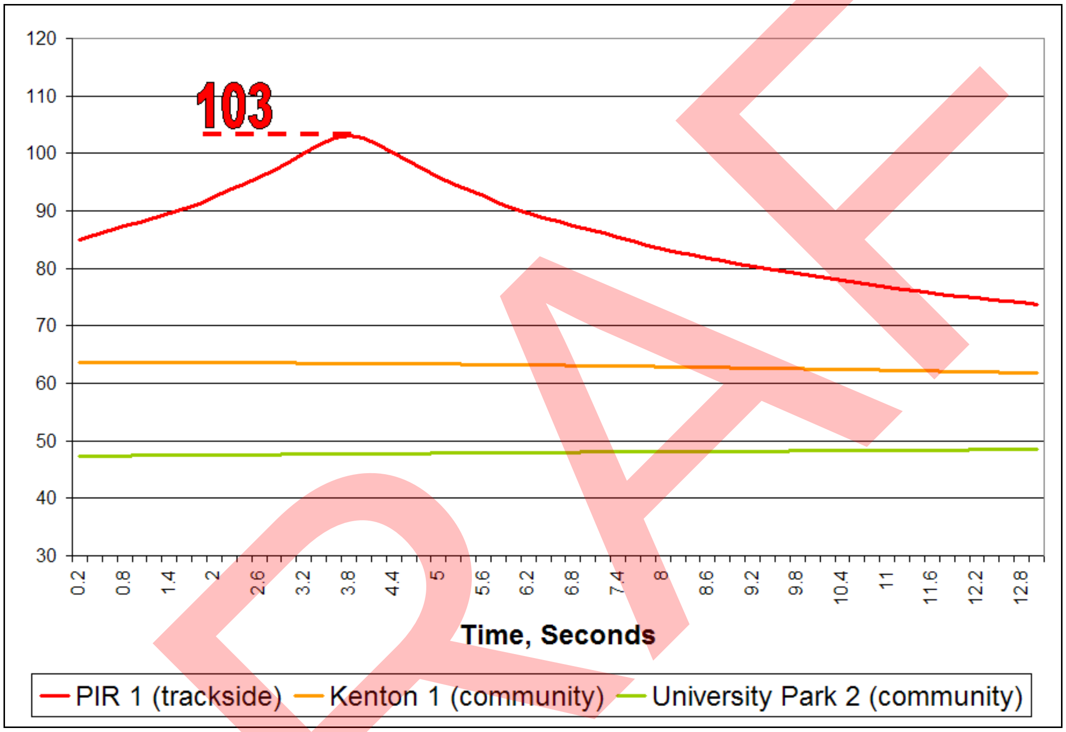


Source: Cadna/A, The Greenbusch Group

A2.2 PIR Late Night Drags Modeling and Verification with Measurements

The difference in distance between the race start point, trackside monitor, and race finish point are much less for distant residential receivers. Therefore, an idealized constant-level race vehicle would yield a fairly constant community sound level throughout the race duration. A comparison between trackside and community sound levels for a single idealized constant-level race vehicle are shown in Chart X below. For the purpose of comparison, the trackside sound level has been set to the permissible daytime trackside level of 103 dBA.

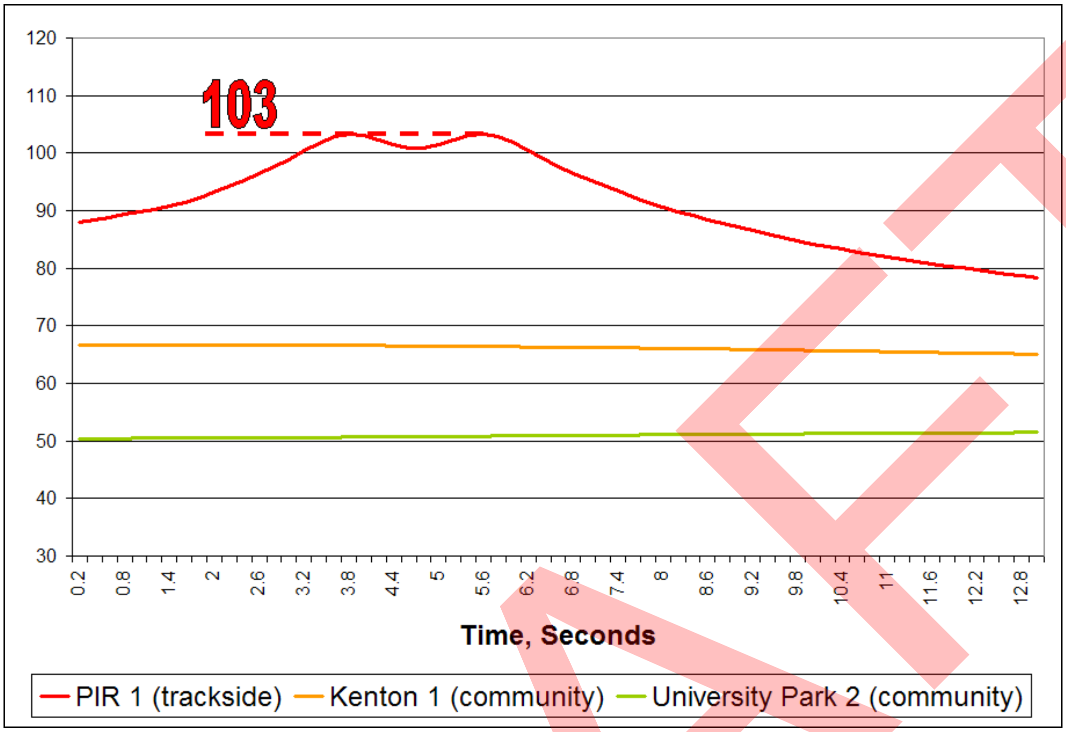
Chart X. Modeled Trackside and Community Pass-By Sound Levels from Idealized Constant-Level Drag Race Vehicle, L_p dBA re: 20 μPa



Source: Cadna/A, The Greenbusch Group

Typically, NHRA LND racing events run two vehicles simultaneously. In the case where both idealized constant-level vehicles stay side-by-side throughout the race duration, the relationship between trackside and community sound levels hold to those presented in Chart X above. However, if one vehicle lags behind the other, a different relationship between these two sound levels exists. The trackside monitor would record two separate sound level maximums, one for each vehicle as it passes the trackside monitor. However, due to the consistent nature of the community sound level, the overall community level will increase by 3-dB as shown in Chart X below.

Chart X. Modeled Trackside and Community Pass-By Sound Levels from Two Idealized Constant-Level Drag Race Vehicles, L_p dBA re: 20 μPa



Source: Cadna/A, The Greenbusch Group

Sound pressure level spectra recorded 50-feet from the track were used as the basis for the computer modeling of the NHRA LND race events. Within the computer model, an idealized constant-level race vehicle was modeled by a point source located on the race track near the trackside monitor. The sound power level was set such that the measured and modeled sound pressure level at the measurement location were identical. This modeling approach assumes either a single race vehicle, or two race vehicles remaining side-by-side during the entire racing event.

The computer noise model was used to predict typical community sound levels during a drag racing event where the trackside limit of 103-dBA was reached. Predicted levels were also calculated where the trackside limit of 90-dBA was reached. Sound level predictions were calculated for several meteorological conditions. Meteorological conditions used in the model were consistent with average temperature, wind speed, wind direction, and wind stability class for the Portland area. The meteorological conditions used in the noise model are summarized in Table X below.

Table X. Meteorological Conditions for NHRA LND Noise Model

Time Period	Temperature, degrees F	Relative Humidity, %	Wind Speed, mph	Wind Direction, degrees	Wind Stability, Pasquill class
None - baseline	68	50	None	None	None
Annual average	68	50	Statistical	Statistical	Statistical
Spring evening (Mar-Apr)	68	50	7.8	203	C-E
Spring night (Mar-Apr)	50	70	7.8	203	F-G
Early summer evening (May-Jun)	68	50	7.2	293	C-E
Early summer night (May-Jun)	50	70	7.2	293	F-G
Late summer evening (July-Oct)	68	50	6.9	315	C-E
Late summer night (July-Oct)	50	70	6.9	315	F-G

Source: www.windfider.com – daytime average wind direction and statistical weather information between 06/2001 and 03/2008, NCDC – average maximum and minimum temperature between 1970 and 2000, average wind speed between 1948 and 2002, average relative humidity between 1940 and 2001.

Model output was compared with measured data from four NHRA LND races, comparison results for octave band and broadband sound levels are presented in Table X and Figures X-X below.

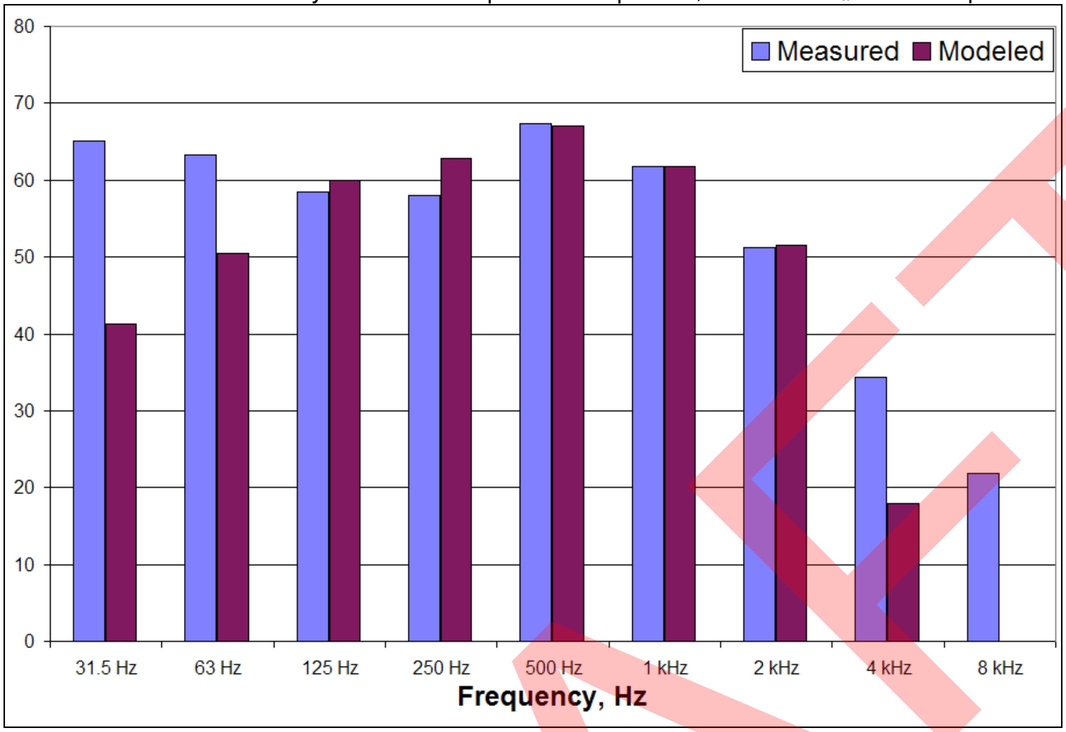
Table X. Model Verification for NHRA LND Races, 1-second L_{max} dB re: 20 μPa

Event	Description	Location	31.5	63	125	250	500	1000	2000	4000	8000	dBA
1	Modeled	Trackside	72.6	82.3	93.0	99.4	104.2	101.0	98.6	93.9	88.2	106.0
		Kenton 1	41.3	50.5	59.9	62.9	67.0**	61.7**	51.6	18.0	[1]	66.4*
	Measured	Kenton 1	65.1	63.2	58.4	58.0	67.4**	61.8**	51.1	34.3	21.9	65.6*
	Variance	Kenton 1	[2]	[2]	1.5	4.9	-0.4	-0.1	0.5	[2]	[2]	0.8
2	Modeled	Trackside	81.1	96.3	91.7	99.0	104.9	104.1	100.6	95.3	89.7	108.0
		Kenton 6	43.0	57.6	52.0	52.6	58.0	50.8	34.1	[1]	[1]	56.5
	Measured	Kenton 6	52.1	56.8	57.0	54.7	60.1	51.8	42.8	24.9	16.1	57.3
	Variance	Kenton 6	-9.1	0.8	-5.0	-2.1	-2.1	-1.0	-8.7	[2]	[2]	-0.8
3	Modeled	Trackside	79.4	102.8	104.7	105.1	105.4	102.2	97.5	90.5	86.4	106.8
		Kenton 7	38.4	61.2	62.0	55.9	55.5	45.2	23.5	[1]	[1]	54.8
	Measured	Kenton 7	58.2	63.2	63.4	54.8	48.8	43.8	41.5	22.8	16.5	53.5
	Variance	Kenton 7	[2]	-2.0	-1.4	1.1	6.7	1.4	[2]	[2]	[2]	1.3
4	Modeled	Trackside	74.5	94.9	100.3	97.3	102.9	99.0	94.9	85.6	76.0	103.6
		University Park 2	29.6	49.3	53.4	43.6	47.6	34.2	4.7	[1]	[1]	45.9
	Measured	University Park 2	57.6	60.1	58.2	56.1	48.6	43.1	33.7	27.0	20.1	50.5
	Variance	University Park 2	[2]	[2]	-4.8	[2]	-1.0	-8.9	[2]	[2]	[2]	-4.6

1. Modeled community sound level was less than 0 dB in this band due to distance, air absorption, and screening.
2. Modeled community sound level was more than 10 dB less than measured level in this band.
*Exceeds City Code permissible broadband levels
**Exceeds City Code permissible octave band levels

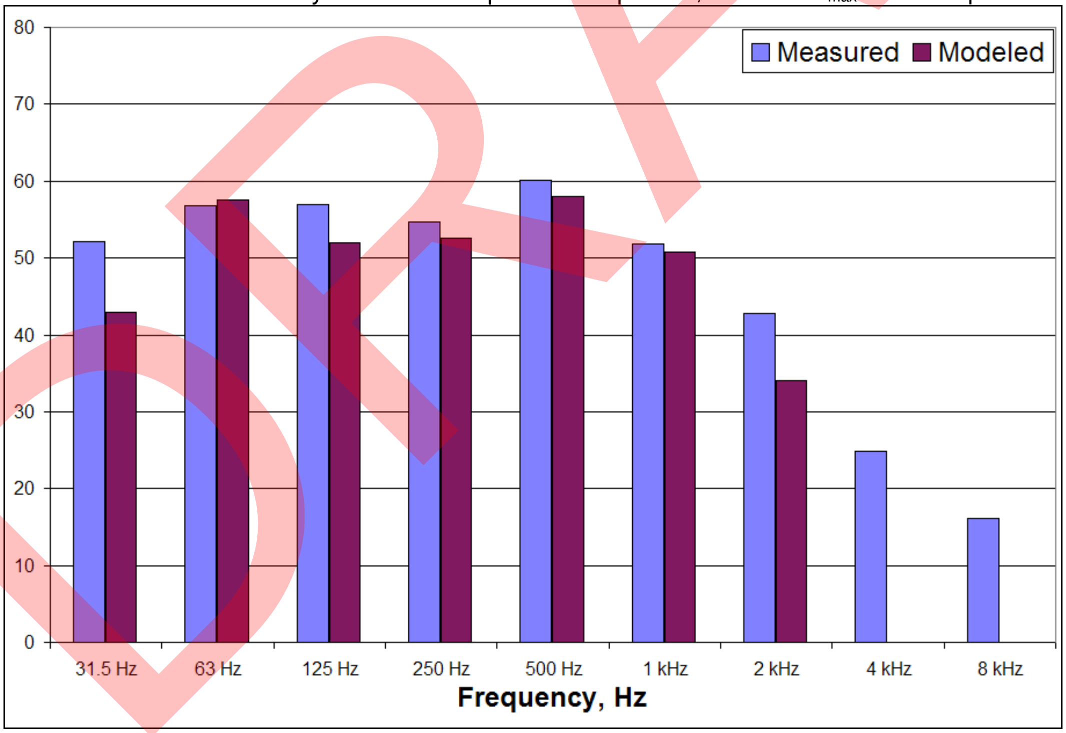
Source: Cadna/A, The Greenbusch Group

Chart X. Event 1 Community Sound Level Spectral Comparison, 1-second L_{max} dB re: 20 µPa



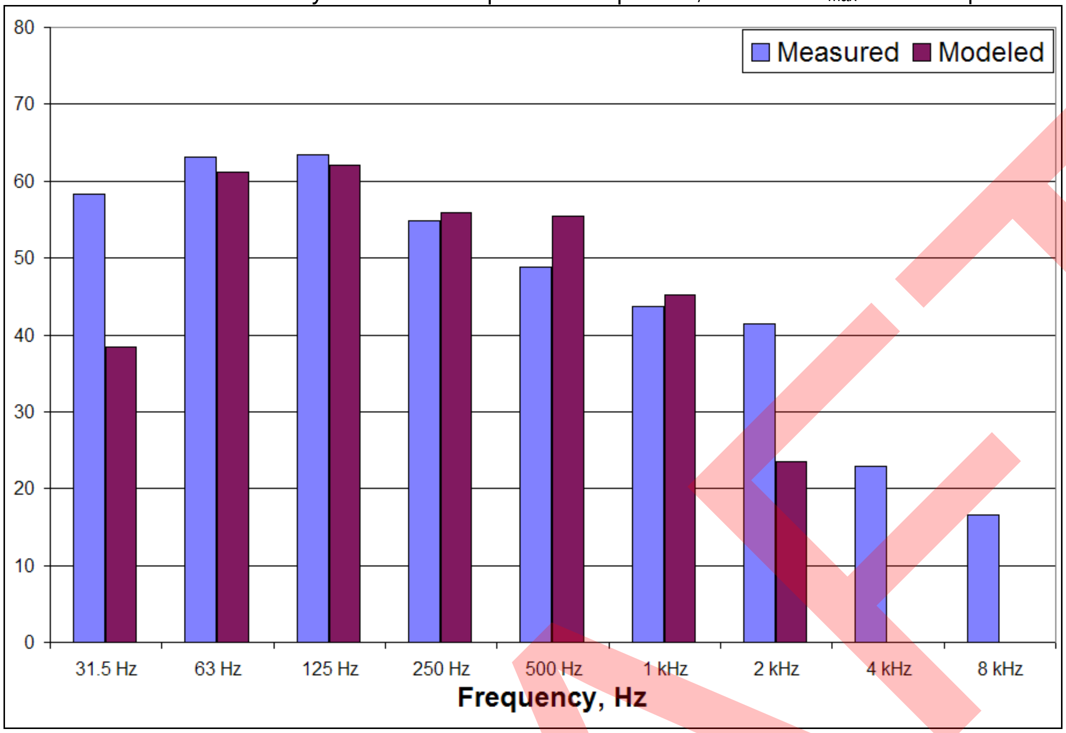
Source: Cadna/A, The Greenbusch Group

Chart X. Event 2 Community Sound Level Spectral Comparison, 1-second L_{max} dB re: 20 µPa



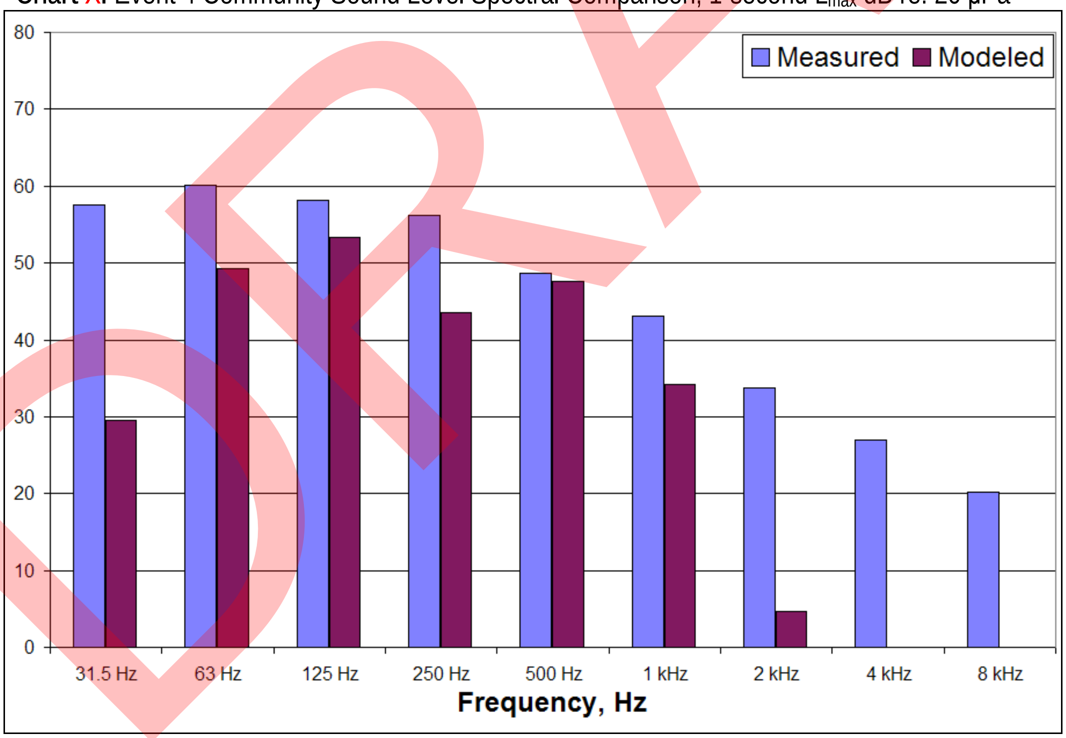
Source: Cadna/A, The Greenbusch Group

Chart X. Event 3 Community Sound Level Spectral Comparison, 1-second L_{max} dB re: 20 µPa



Source: Cadna/A, The Greenbusch Group

Chart X. Event 4 Community Sound Level Spectral Comparison, 1-second L_{max} dB re: 20 µPa

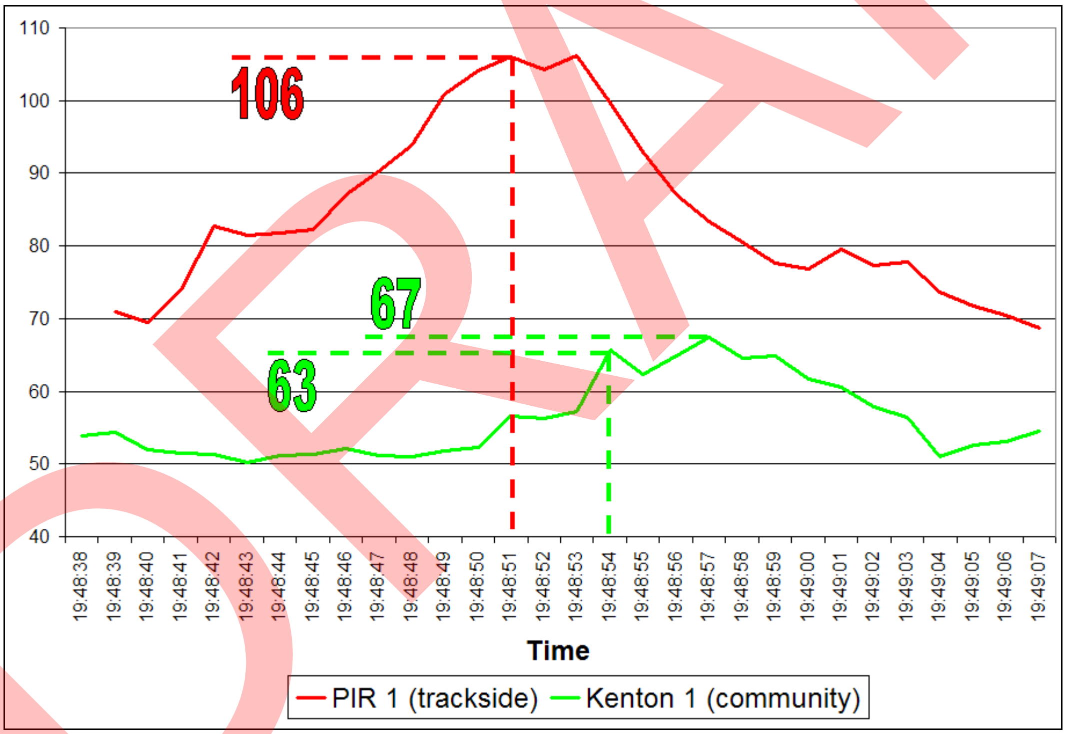


Source: Cadna/A, The Greenbusch Group

As seen in the Table and Charts above, the model was fairly accurate at predicting community sound exposure levels. In reality, community sound level measurements were not isolated to drag racing events, other local and distant extraneous sources were included in the measured values to varying degrees. In addition, high frequencies are attenuated much more than lower frequencies as sound travels through air due to atmospheric absorption. A qualitative assessment of the community exposure revealed a consistent emphasized presence of the mid-range frequencies, both model and measurement data supported this assessment generally showing higher sound levels in the 500-1000 Hz range. High frequency content (2-8 kHz) in the measured values is likely due to the presence of extraneous community noise sources. Low-frequency content (31.5 - 63 Hz) in the measured values is likely due to the presence of trains.

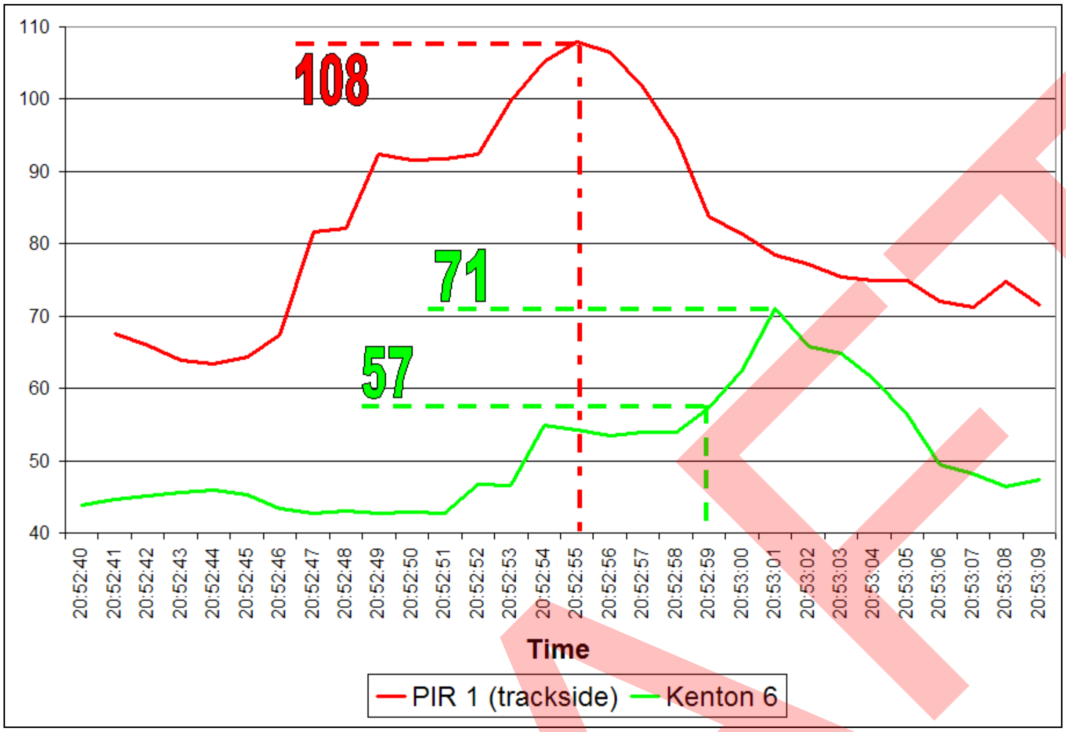
The four model comparison events were selected based on time series data that showed the greatest signal-to-noise ratio for the racing event. A maximum point was selected from the trackside sound data. Time-domain comparisons for the four comparison events are presented in Charts X-X below. Propagation time to the community receiver was calculated to determine sound exposure associated with the race vehicles passing the trackside monitor. The reference time to indicate the propagation delay for the trackside monitor is indicated by a dotted vertical red line. The corresponding propagation delay for the community receiver is indicated by a dotted green vertical line.

Chart X. NHRA Late Night Drags Event 1 Time-Domain Comparison, 1-second L_{max} dBA re: 20 μPa



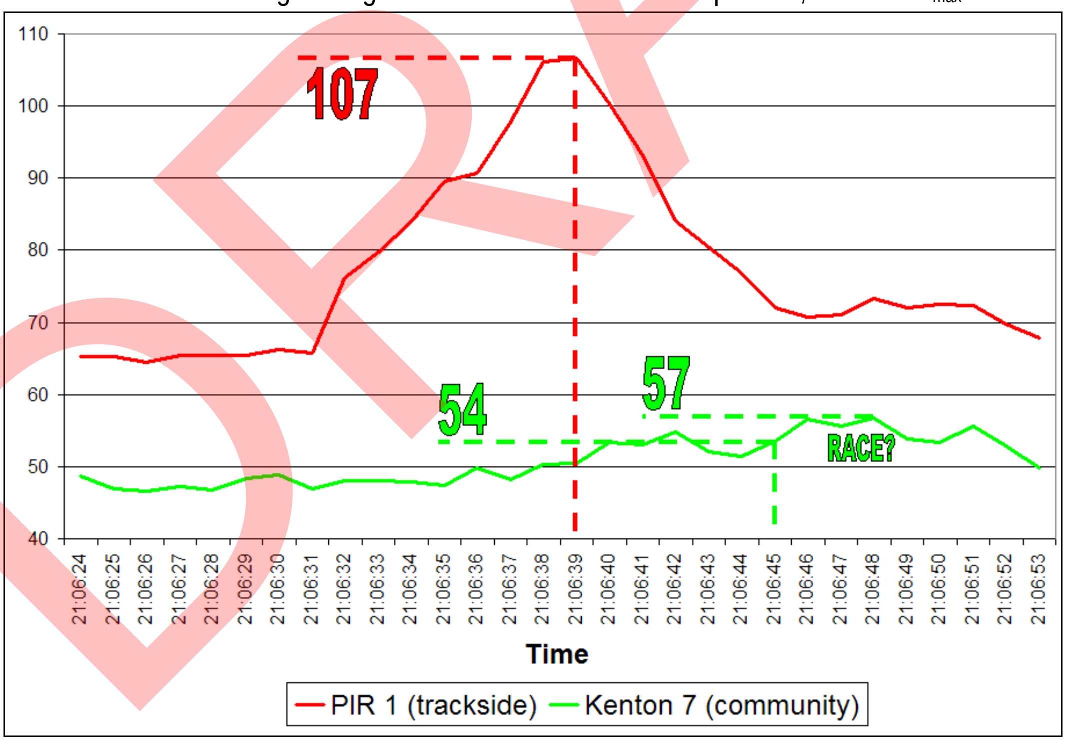
Source: City of Portland, The Greenbusch Group

Chart X. NHRA Late Night Drags Event 2 Time-Domain Comparison, 1-second L_{max} dBA re: 20 µPa



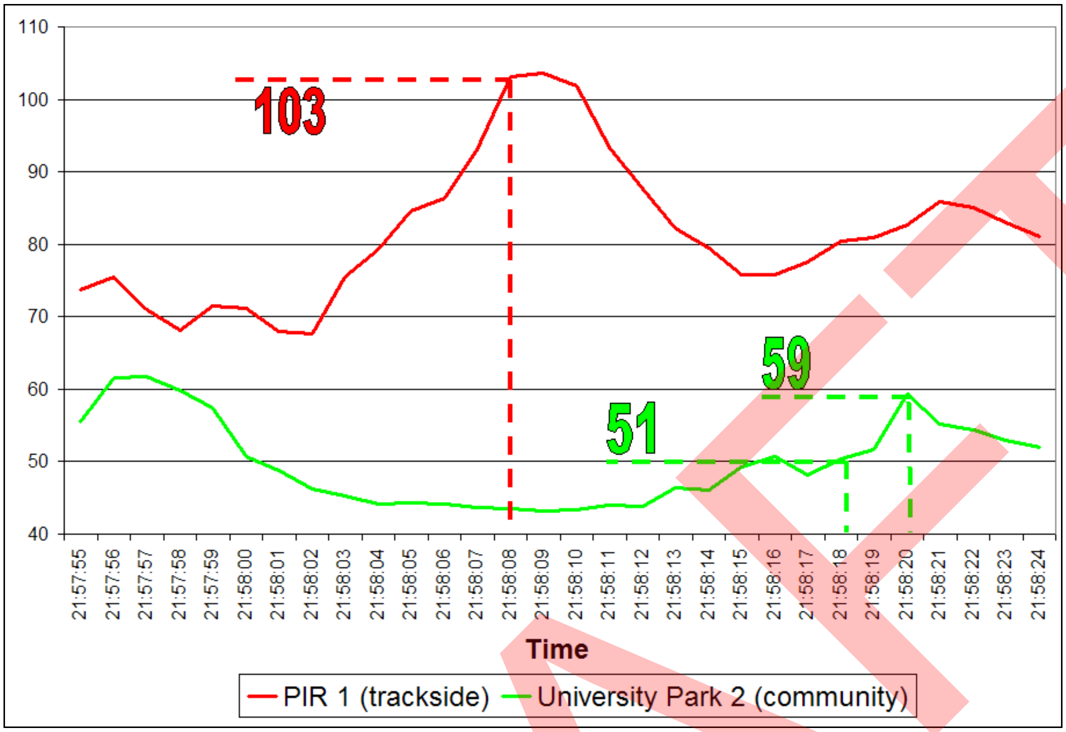
Source: City of Portland, The Greenbusch Group

Chart X. NHRA Late Night Drags Event 3 Time-Domain Comparison, 1-second L_{max} dBA re: 20 µPa



Source: City of Portland, The Greenbusch Group

Chart X. NHRA Late Night Drags Event 4 Time-Domain Comparison, 1-second L_{max} dBA re: 20 µPa



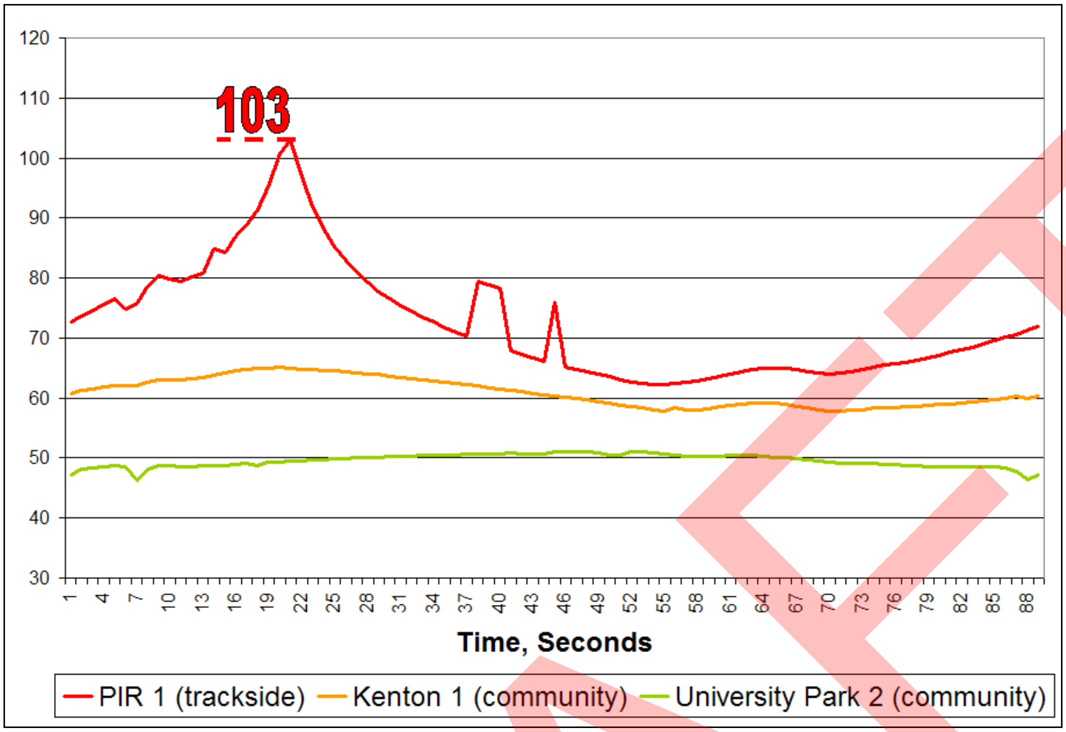
Source: City of Portland, The Greenbusch Group

As shown in the charts above, community exposure levels generated by drag race vehicles reaches a maximum approximately 2-3 seconds after the drag race vehicles pass the trackside monitor. As shown in section 8.2.1.1 above, an idealized constant-level drag race vehicle would generate a rather constant community exposure level. In reality, drag race vehicle sound emission changes significantly throughout the race. Factors such as tire slippage at the race start, gear shifting throughout the race, and potential engine backfires and finish line accelerations will cause the drag race vehicle sound emission to fluctuate. Comparisons between modeled and measured data showed that drag race vehicle sound exposure levels reached maximum levels up to 14-dBA above the sound exposure levels generated by the drag race vehicle as it passed the trackside monitor.

A2.2 PIR Full Race Track Modeling and Verification with Measurements

The difference in distance between any two points on the racetrack and a distant community receiver is minimal when compared to the difference in distance between any two points on the racetrack and the trackside monitor. Therefore, an idealized constant-level race vehicle would yield a fairly constant community sound level throughout the race duration. However, the community exposure level for an idealized constant-level race vehicle would vary more than that for a drag racing event, since more track is used than just the southern straightaway. A comparison between trackside and community sound levels for a single idealized constant-level race vehicle are shown in Chart X below. For the purpose of comparison, the trackside sound level has been set to the permissible daytime trackside level of 103 dBA.

Chart X. Modeled Trackside and Community Pass-By Sound Levels from a Single Idealized Constant-Level Race Vehicle, L_p dBA re: 20 µPa

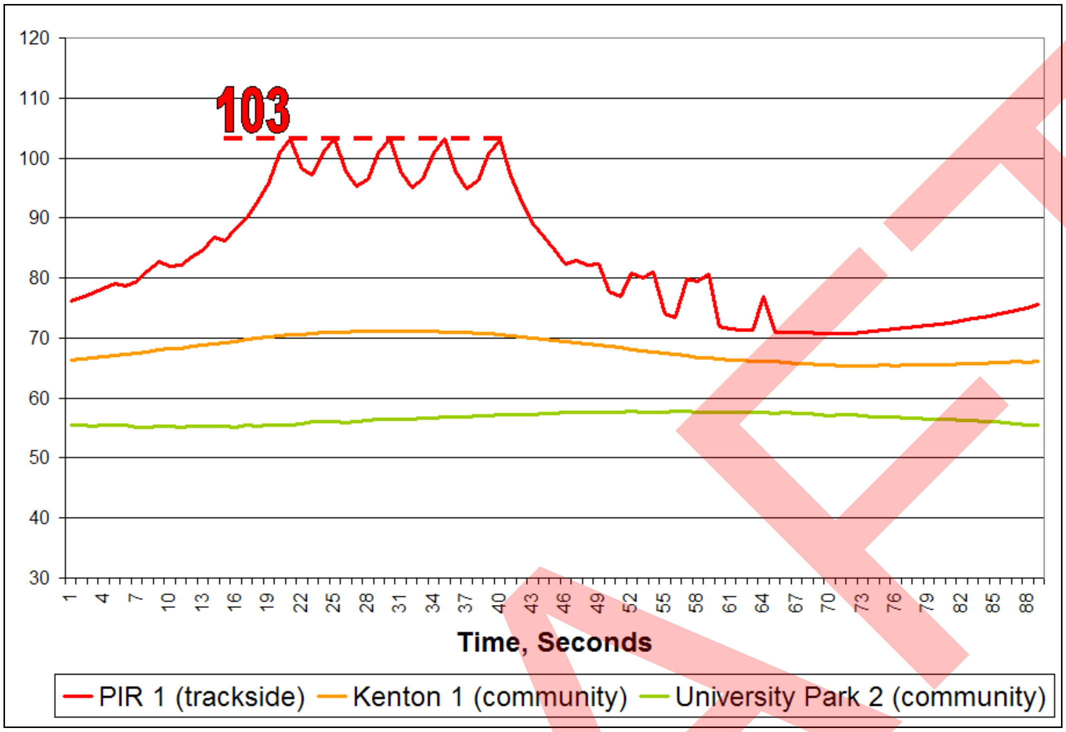


Source: Cadna/A, The Greenbusch Group

The quantity of race vehicles on the track at any given time varies significantly. With the NHRA LND modeling, no more than two vehicles needed to be considered. However, during full track race events, various race classes are likely to run a different number of race vehicles throughout a race day. Maximum sound levels recorded by the trackside monitor only provide sound level data for each vehicle as it passes by the monitor in the southern straightaway. In reality, each race vehicle could potentially generate very different sound emission levels and frequency characteristics.

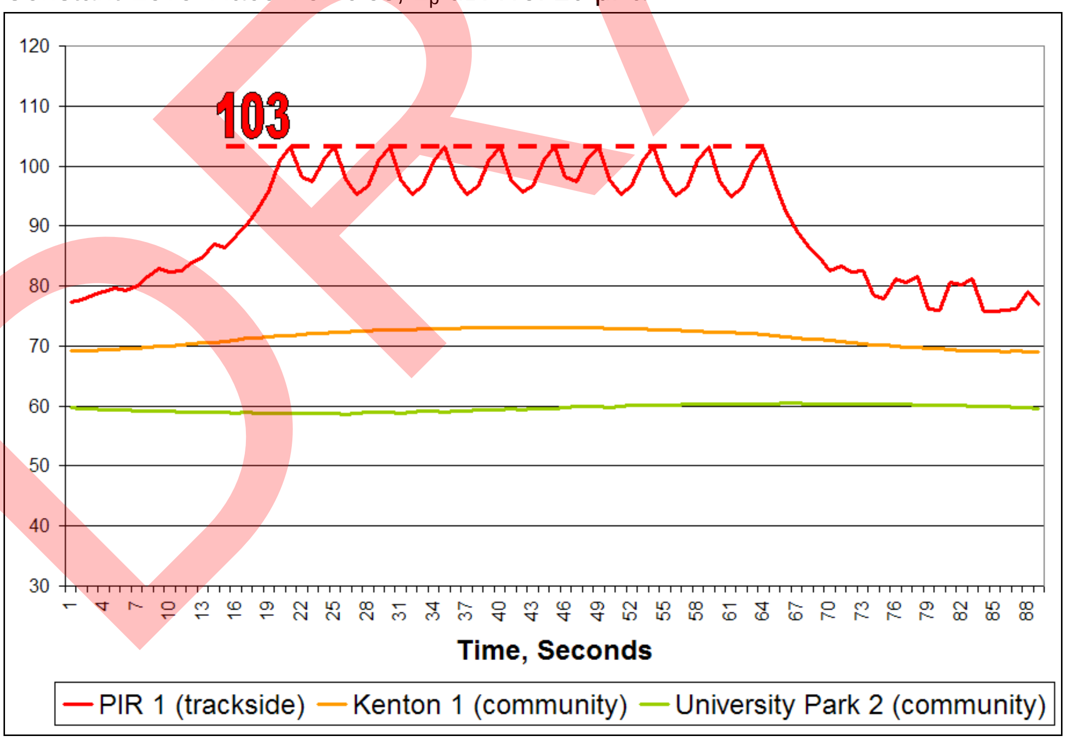
For modeling purposes, sound levels measured at the trackside monitor were considered representative of the maximum sound emission level for each vehicle on the track during a race. Community sound exposure levels are governed by two main factors: the maximum trackside sound level and the number of vehicles racing. The higher the trackside sound level for each vehicle and the more vehicles in a race, the higher the community sound exposure levels. A comparison between two race events with dissimilar vehicle counts and similar vehicle sound levels is presented in Charts X and X below.

Chart X. Modeled Trackside and Community Pass-By Sound Levels from Five Idealized Constant-Level Race Vehicles, L_p dBA re: 20 μPa



Source: Cadna/A, The Greenbusch Group

Chart X. Modeled Trackside and Community Pass-By Sound Levels from Ten Idealized Constant-Level Race Vehicles, L_p dBA re: 20 μPa



Source: Cadna/A, The Greenbusch Group

The computer noise model was used to predict typical community sound levels during a full track racing event where the trackside limit of 103 was reached by 10 racing vehicles. Predicted levels were also calculated for a varianced race event, where each vehicle reached the trackside limit of 115-dBA. These levels represent maximum community exposure levels assuming no race vehicle exceeds the modeled trackside level at any time during the race. In reality, sound exposure levels will vary depending on the number of race vehicles and their total combined sound emission at any moment in time.

The meteorological conditions used in the noise model are summarized in Table X below.

Table X. Meteorological Conditions for Full Race Track Noise Model

Time Period	Temperature, degrees F	Relative Humidity, %	Wind Speed, mph	Wind Direction, degrees	Wind Stability, Pasquill class
None - baseline	68	50	None	None	None
Annual average	68	50	Statistical	Statistical	Statistical
Spring daytime (Mar-Apr)	68	50	7.8	203	A-B
Spring evening (Mar-Apr)	68	50	7.8	203	C-E
Early summer daytime (May-Jun)	68	50	7.2	293	A-B
Early summer evening (May-Jun)	68	50	7.2	293	C-E
Late summer daytime (July-Oct)	68	50	6.9	315	A-B
Late summer evening (July-Oct)	68	50	6.9	315	C-E

Source: www.windfider.com – daytime average wind direction and statistical weather information between 06/2001 and 03/2008, NCDC – average maximum and minimum temperature between 1970 and 2000, average wind speed between 1948 and 2002, average relative humidity between 1940 and 2001.

Model output was compared with measured data from a full race track event, broadband sound level comparison results are presented in Table X and Figures X-X below.

Table X. Model Verification for Full Race Track Event (2007 SOVREN Historic Races), 1-second L_{max} dBA re: 20 µPa

Location	Time Period	Measured (trackside)	Measured (community)	Modeled (community)	Variance
Kenton 1	16:48:13 – 16:48:19	98.7	60.5	61.0	+0.5
Kenton 1	16:50:57 – 16:51:01	103.7	63.3	64.7	+1.4

Source: Cadna/A, The Greenbusch Group

A2.4 North Columbia Boulevard Traffic Modeling Verification with Measurements

Short-term (10-minute) traffic sound level measurements were performed at two locations in the east study Section of North Columbia Boulevard to compare with those predicted by the noise model. Traffic counts were taken during the measurement period; heavy vehicles were also counted for model input. Comparisons between measured and modeled data are provided in Table X below. Measurement locations are shown in Figure X below.

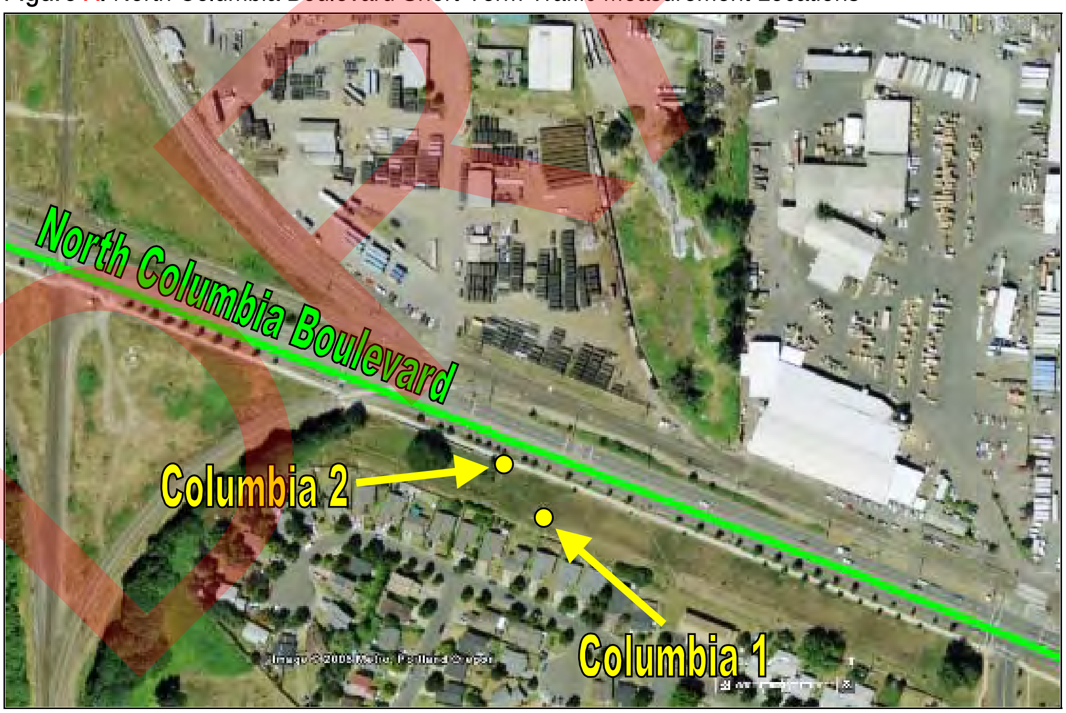
Table X. Measured and Modeled Traffic Sound Levels for North Columbia Boulevard, L_{eq} dBA re: 20 μPa

Receiver Location	Source	Total Hourly Vehicle Count	Percentage Heavy Vehicles	Average Sound Level
Columbia 1 (~100 feet from curb)	Measured	1098	5.5%	67.5
	Modeled	1098	5.5%	63.8
	Variance	-	-	-3.7[1,2,3]
Columbia 2 (~30 feet from curb)	Measured	1098	3.3%	70.4
	Modeled			68.9
	Variance	-	-	-1.5[2,3]

1. Field measurements included other extraneous sources such as distant aircraft, children at play nearby, and trains.
2. Field measurement contained minimal extraneous sources, traffic was considered the dominant sound source.
3. Heavy vehicle count excluded large trucks and vans, actual heavy vehicle count should be higher, increasing the modeled level.

Source: Cadna/A, The Greenbusch Group

Figure X. North Columbia Boulevard Short-Term Traffic Measurement Locations



Source: Google Earth™, City of Portland, The Greenbusch Group

A2.5 North Lombard Street Traffic Modeling Verification with Measurements

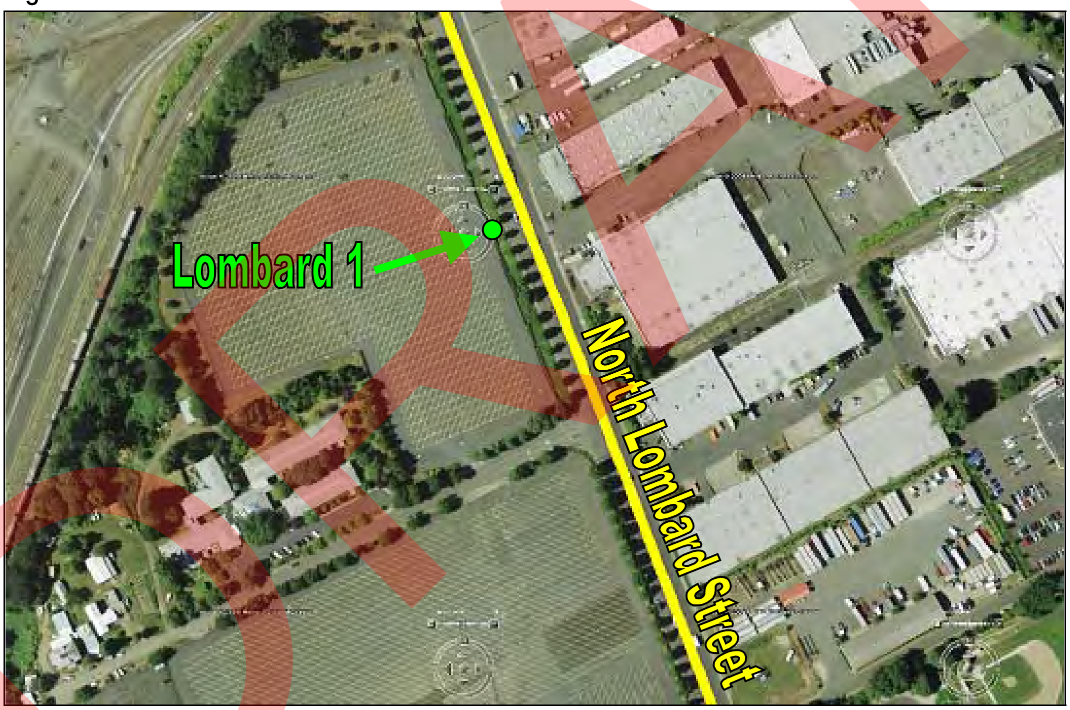
Short-term (30-minute) traffic sound level measurements were performed at one location in west study section of North Lombard Street to compare with those predicted by the noise model. Traffic counts were taken during the measurement period; heavy vehicles were also counted for model input. Comparisons between measured and modeled data are provided in Table X below. Measurement locations are shown in Figure X below.

Table X. Measured and Modeled Traffic Sound Levels for North Lombard Street, L_{eq} dBA re: 20 µPa

Receiver Location	Source	Total Hourly Vehicle Count	Percentage Heavy Vehicles	Average Sound Level
Lombard 1 (~25 feet from curb)	Measured	154	18.2%	60.6
	Modeled	154	18.2%	62.9
	Variance	-	-	+2.3

Source: Cadna/A, The Greenbusch Group

Figure X. North Lombard Street Short-Term Traffic Measurement Location



Source: Google Earth™, City of Portland, The Greenbusch Group

A2.6 North Going Street Traffic Modeling Verification with Measurements

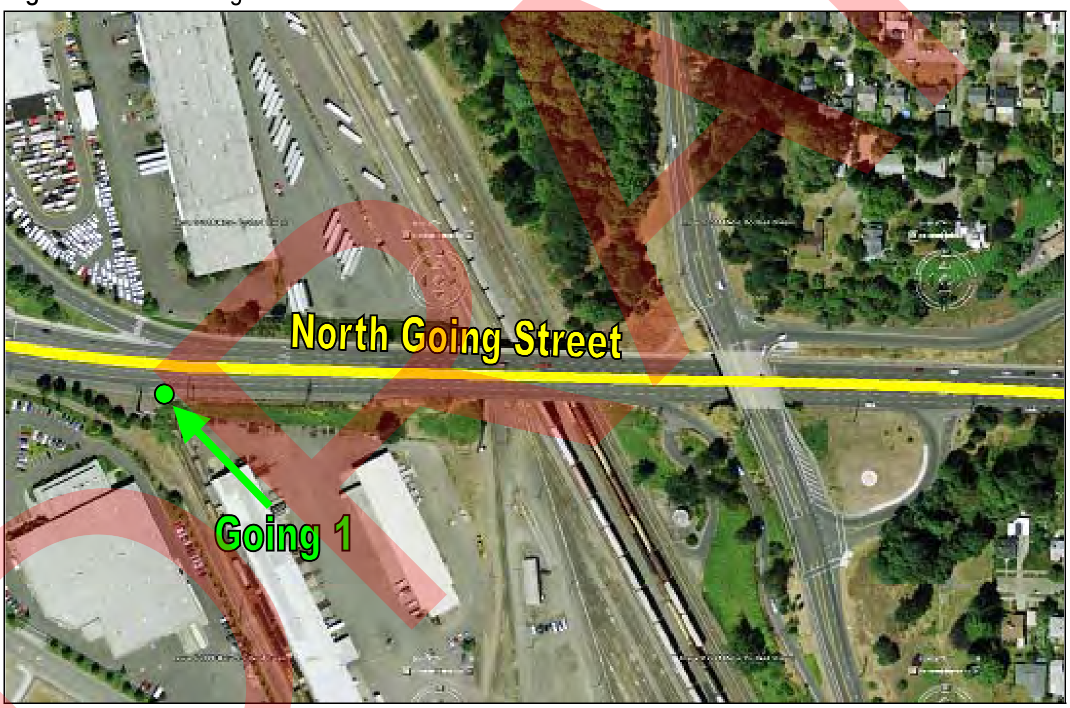
Short-term (30-minute) traffic sound level measurements were performed at one location in the study section of North Going Street to compare with those predicted by the noise model. Traffic counts were taken during the measurement period; heavy vehicles were also counted for model input. Comparisons between measured and modeled data are provided in Table X below. Measurement locations are shown in Figure X below.

Table X. Measured and Modeled Traffic Sound Levels for North Going Street, L_{eq} dBA re: 20 μPa

Receiver Location	Source	Total Hourly Vehicle Count	Percentage Heavy Vehicles	Average Sound Level
Going 1 (~25 feet from curb)	Measured	588	42.2%	73.5
	Modeled	588	42.2%	74.8
	Variance	-	-	+1.3

Source: Cadna/A, The Greenbusch Group

Figure X. North Going Street Short-Term Traffic Measurement Location



Source: Google Earth™, City of Portland, The Greenbusch Group

A3.0 MEASUREMENT LOG

Table X. Measurement Location Matrix

Location	Description	Approx. GPS Coordinates
Cathedral Park 1	8703 N Crawford St	+45° 35.300', -122° 45.608'[1]
Columbia 1	N Columbia Blvd	+45º 35.494', -122º 42.524'
Going 1	N Going St	+45º 33.352', -122º 41.814'
Hayden 1	Holiday Inn Express, 4th story room	+45º 36.939', -122º 41.461'
Hayden 2	Train bridge on Hayden Island	+45º 37.272', -122º 41.650'
Hayden 3	N Hayden Mobile Park, clubhouse bench	+45º 36.784', -122º 41.517'
Hayden 4	End of Hayden Island	+45º 37.278', -122º 41.642'[1]
Kenton 1	Across from 8749 N Delaware	+45º 35.154', -122º 41.533'
Kenton 2	Across from 8858 N Wilbur St	+45º 35.238', -122º 41.633'
Kenton 3	Force Lake, near golf course	+45º 36.277', -122º 41.636'
Kenton 4	Near Columbia, north of N Trenton St & N Curtis Ave	+45º 35.333', -122º 41.900'
Kenton 5	Trenton & Curtis	+45º 35.317', -122º 41.910'
Kenton 6	Near N Emerald Ave & N Halleck St	+45° 34.959', -122° 41.996'[1]
Kenton 7	Near N Chautauqua Blvd & N Winchell St	+45º 34.843', -122º 42.453'
Lombard 1	Lombard A, N Lombard St	+45º 36.289', -122º 45.937'
Lombard 2	Lombard B, N Lombard St	+45º 37.225', -122º 46.296'
Overlook 1	Near train switching yard	+45º 32.943', -122º 41.048'
Portsmouth 1	Southern corner of Columbia Park near N. Lombard St. & N Russet St.	+45º 34.682', -122º 42.662'
Portsmouth 2	Near corner of N Hunt St & N Foss Ave	+45º 35.102', -122º 42.634'
PIR 1	Track-side monitor	+45° 35.615', -122° 41.407'
PIR 2	East bleachers, even w/ track-side monitor	+45º 35.613', -122º 41.398'
PIR 3	385' away from track, ~ 10' above grade	+45º 35.560', -122º 41.436'
PIR 4	West bleachers, seat 5 5th row from back	+45º 35.669', -122º 41.601'
PIR 5	345' away from track, ~ 6' above grade	+45º 35.601', -122º 41.559'
PIR 6	Near SW corner of track	+45º 35.851', -122º 42.261'
St. Johns 1	Wildlife refuge	+45º 37.014', -122º 43.128'
St. Johns 2	Wildlife refuge, near water	+45º 36.723', -122º 42.858'
University Park 1	Portsmouth Park near N Princeton St & N Hodge Ave	+45º 34.721', -122º 43.433'
University Park 2	Near corner of N Princeton St & N Olin Ave	+45º 34.578', -122º 43.148'

1. Approximate location

Source: The Greenbusch Group

Table X. Portland International Raceway Measurements

Date	Event	Location	Operator
06/16/06	PIR Champ Car Race	Kenton 1	Greenbusch
		PIR 1	City of Portland
07/22/06	PIR Les Mans Car Race	Various	Greenbusch
		PIR 1	City of Portland
		Various	City staff and volunteers
09/02/06	PIR AFBM/SOVREN Race	Kenton 1	Greenbusch
		PIR 1	City of Portland
09/03/06	PIR AFBM/SOVREN Race	Kenton 2	Greenbusch
		Hayden 3	Greenbusch
		PIR 1	City of Portland
09/04/06	PIR AFBM/SOVREN Race	Hayden 2	Greenbusch
		Kenton 3	Greenbusch
		PIR 1	City of Portland
09/29/06	PIR NHRA Late Night Drag Races	PIR 1	City of Portland
		PIR 2	Greenbusch
		PIR 3	Greenbusch
		Various	City of Portland Staff
10/01/06	PIR OMMR Motorcycle Race	PIR 1	City of Portland
		PIR 4	Greenbusch
		PIR 5	Greenbusch
		Various	City of Portland Staff
09/01/07	PIR AFBM/SOVREN Race	PIR 1	City of Portland
		PIR 6	Greenbusch
		Kenton 1	Greenbusch
		Kenton 3	Greenbusch
		Kenton 4	Greenbusch
		Kenton 5	Greenbusch
		Portsmouth 1	Greenbusch
		Portsmouth 2	Greenbusch
		St. Johns 1	Greenbusch
		St. Johns 2	Greenbusch
		University Park 1	Greenbusch
	NHRA Late Night Drag Races	PIR 1	City of Portland
		PIR 2	Greenbusch
		Kenton 1	Greenbusch
		Kenton 4	Greenbusch
		Kenton 6	Greenbusch

Table X. Portland International Raceway Measurements

Date	Event	Location	Operator
		Kenton 7	Greenbusch
		Portsmouth 1	Greenbusch
		University Park 2	Greenbusch
09/02/07	PIR AFBM/SOVREN Race	PIR 1	City of Portland
		Various	Greenbusch
			Greenbusch

Source: The Greenbusch Group

Table X. Freight Corridor Measurements

Date	Event	Location	Operator
09/03/06	N Columbia Blvd traffic	Kenton 2	Greenbusch
09/30/06	N Going St traffic	Going 1	Greenbusch
	N Columbia Blvd traffic	Columbia 1	Greenbusch
	N Lombard St traffic	Lombard 1	Greenbusch
10/01/06	N Lombard St traffic	Lombard 2	Greenbusch

Source: The Greenbusch Group

Table X. Railway Measurements

Date	Event	Location	Operator
09/02/06	Train horn soundings	Kenton1	Greenbusch
	Train traffic and horn soundings	Hayden 1	Greenbusch
09/03/06	Train horn soundings	Hayden 1	Greenbusch
	Train traffic and horn soundings	Hayden 2	Greenbusch
		Kenton2	Greenbusch
09/04/06	Train traffic	Hayden 4	Greenbusch
	Train traffic and horn soundings	Kenton 3	Greenbusch
11/26/07	Train traffic and horn soundings	St. Johns 3	City of Portland staff

Source: The Greenbusch Group

Table X. Portland International Airport Measurements

Date	Event	Location	Operator
09/02/06	Aircraft traffic	Kenton 1	Greenbusch
		Hayden 1	Greenbusch
09/03/06	Aircraft traffic	Hayden 2	Greenbusch

Source: The Greenbusch Group

Table X. Ambient Sound Level Measurements

Date	Total Measurement Time Period	Location	Operator
06/18/06	1 minute	Kenton 1	Greenbusch
07/22/06	1 minute	Kenton 1	Greenbusch
09/02/06	34 minutes	Kenton 1	Greenbusch
	1 hour 53 minutes	Hayden 1	Greenbusch
09/03/06	1 hour	Hayden 1	Greenbusch
	6 minutes	Hayden 3	Greenbusch
	15 minutes	Kenton 2	Greenbusch
09/04/06	2 minutes	Hayden 4	Greenbusch
	2 minutes	Kenton 3	Greenbusch
08/31/07	5 hours	Kenton 4	Greenbusch
	4 hours	Portsmouth 1	Greenbusch
09/01/07	24 hours	Kenton 4	Greenbusch
	24 hours	Portsmouth 1	Greenbusch
09/02/07	18 hours 30 minutes	Kenton 4	Greenbusch
	18 hours	Portsmouth 1	Greenbusch

Source: The Greenbusch Group