Chapter III

Explanation on Key Techniques and Methods

Chapter III. Explanation of Main Technical Methods

1. Air quality, water quality, and soil quality

1.1 Air quality

1.1.1 Selection of environmental impact assessment items and survey, forecast and evaluation methods

1) Ascertaining project characteristics

Table III.1.1-1 shows examples of project characteristics to list under air quality.

Table III.1.1-1. Examples of project characteristics related to air quality

Impact factor	Example items
Implementation of Construction	・ Specifics and duration of construction ・ Location and extent of construction ・ Types and number of facilities and equipment used in construction, operating location, operating period, etc. ・ Number of construction vehicles in operation, type (large/small), period, route ・ Plans for temporary structures, soil pits, areas where soil generated from construction will be taken in and out, etc.
Existence/operation of facilities	・ Facility description, location, size ・ Facility service period ・ Type, concentration, amount, and height of facility emissions ・ Amount of traffic congestion generated by the facilities, types of vehicles (large/small) ・ Routes for traffic congestion generated

2) Ascertaining local characteristics

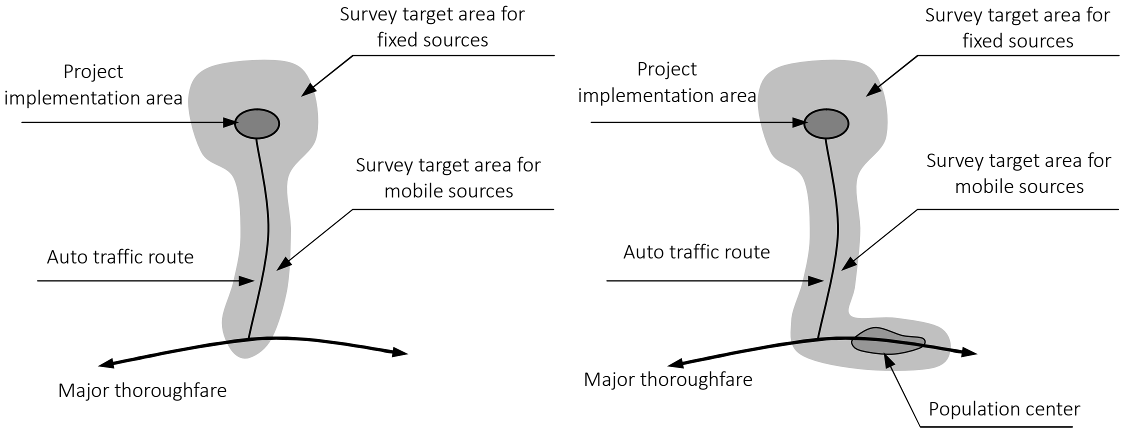
(1) Area

When setting the survey target area, project proponents is necessary to consider the range that project proponents anticipates being impacted by mobile sources (such as motor vehicles) in addition to the range that can be anticipated being impacted by sources in the project implementation area in order to understand regional characteristics related to air quality. Also note that survey target areas may differ from the project implementation area depending on the kinds of sources that are generating impacts.

Table III.1.1-2. Concepts for using impact factors to determine survey target area

Impact factor	Target survey area concepts
Fixed sources	When sources impacting air quality are fixed (such as smokestacks) or when mobile sources will be limited to a specific area during construction (as in the case of construction equipment), the scope of the survey target area should include the area in which project proponents anticipate a certain amount of impact on air quality due to those sources. When looking at impact distance, make sure to take into account topography, wind direction, and other conditions (particularly around the source location) as well as the similar case examples.

Mobile sources	When the sources impacting air quality are mobile (such as motor vehicles), the survey target area should include the area where project proponents anticipate a certain amount of impact from those mobile sources themselves as well as along their routes. Also take into consideration the environmental conditions in the surrounding area.



(A) Extending to an important main thoroughfare (B) Extending to an area particularly vulnerable to impacts

Figure III.1.1-1. Examples of survey target areas involving mobile sources

Table III.1.1-3 showes guidelines for determining survey ranges related to air quality using the distance from the project implementation area, mobile routes, and other sources.

Table III.1.1-3. Guidelines for survey ranges related to air quality

Type of emissions source		Maximum ground concentration distance and how to determine distance	Target range
Soot/smoke sources (stack height)	Less than 50 m	0.5 km (20 m)–2 km (100 m)	1–4 km
	50–150 m	2 km–9 km (200 m)	4–18 km
	150 m+	9 km–15 km (500 m)	18–30 km
Vehicle sources		–	1–2 km
Marine vessel sources Aircraft		Same as soot/smoke sources at less than 50 m Average distance until the aircraft reaches 1,000 m	1–4 km Around 10 km
Particulate sources Hydrocarbon sources Minor sources During construction		Same as soot/smoke sources at less than 50 m	1–4 km

Note: Figures in parentheses indicate effective stack height

Source: Prepared based on *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

(2) Listing up natural and social conditions in the region

Tables III.1.1-4 and III.1.1-5 show examples of natural and social conditions to list for the region.

Most of the existing documentation on air quality has data on isolated points at low density, so on-site surveys need to supplement this information with data on regional characteristics between these points. Project proponents can also find out the characteristics of daily life in the region and how roads are being used, for example, by looking at on-site surveys on the status of land and road usage. Ideally, when looking at the measurement points used in existing documentation, on-site surveys to identify the topography, natural features, and condition of sources in the surrounding area should be also taken into consideration.

Table III.1.1-4. Examples of natural conditions related to air quality

Classification	Description of example items
Air quality conditions	(a) Air quality conditions Information on air pollutants set forth in environmental standards is available from collected and organized data from continuous measuring and monitoring stations operated by national, prefectural, and municipal governments as well as from mobile measuring stations. National, prefectural, and municipal governments sometimes measure for hazardous air pollutants as well. The basic method for identifying air quality conditions in residential districts and other regular living areas is to collect data from the general atmospheric measuring stations closest to the project implementation area. It is important to collect data from multiple nearby stations in order to fully understand the characteristics of the survey target area. The basic method for checking the air quality conditions along roadways is to collect data from vehicle emissions measuring stations positioned along roads that may be impacted by the target project. Collect and organize the most recent version of these data sets from the past fiscal year in order to understand any changes over time. Most of this data is available from online sources. (b) Meteorological conditions Many weather observatories, weather bureaus, and other meteorological offices collect meteorological observations, as do continuous air quality measuring and monitoring stations, schools, and municipal offices. The ideal way to ensure consistency with the air quality data collected in (a) is to use meteorological data from continuous air quality measuring and monitoring stations, but in many cases the meteorological measurements taken by these stations are limited in terms of wind direction, speed, and similar factors. Solar radiation, cloud cover, and similar information can be obtained from measurement data taken by meteorological offices. When there is a possibility that weather phenomena (such as inversion layers) will have a major impact on air quality, project proponents the situation can be understood through documents and interviews with meteorological offices. The Japan Meteorological Agency also distributes GPV data[1], which can be used to understand weather conditions in more detail.
Topographical conditions	Check for topographical conditions that can affect air quality. These include whether the terrain is flat or mountainous, its position in relation to ocean areas or rivers, and valley formations.
Status of plant/animal habitats and/or vegetation and ecosystems	Survey ranges for plants, animals, and ecosystems are defined as the areas in which these continually undergo direct changes as well as surrounding areas, but because air quality impacts can cover a broad area, it is necessary to expand these survey ranges even more when there is a chance that changes in air quality will impact plants, animals, or ecosystems. Also, if there are important plants or other species distributed in the surrounding area that will suffer from air quality impacts, then project proponents needs to include these areas in air quality survey range as well. In this case, also necessary to look at the reciprocal relationships between air quality and plants, animals, and ecosystems in order to determine survey ranges and methods.
Status of landscapes and places for activities with nature	Concerns whether air quality changes will impact landscapes and places for activities with nature include situations where air quality changes markedly in important places for activities with nature and when particulate concentration becomes high around important landscape resources. In these cases, it is necessary to look at the reciprocal relationships between air quality and landscapes or places for activities with nature in order to determine survey ranges and methods.

Table III.1.1-5. Examples of social conditions related to air quality

Classification	Description of example items
Population and industry	(a) Population Check the population of the survey area and its distribution. (b) Industry When looking at industrial activity in the survey target area and the status of industrial

---

[1] Grid Point Value (GPV) data is data on meteorological components from lattice points in the air or on the surface. It is used by the Japan Meteorological Agency for numerical forecasting models.

<table>
<tr><td></td><td>activities that generate air pollutants, get a statistical summary of the conditions and identify the location of key facilities. If there are industries that would be anticipated vulnerable to impacts from air quality changes, identify the location of their key facilities as well.

Examples: Floriculture, fruit orchards, and other types of agriculture, manufacturing industries (e.g. dried food processing) that involve sun-drying, retail businesses (such as auto retailers) who keep their products outdoors</td></tr>
<tr><td>Land use</td><td>(a) Land use
Assess land use mainly with land use maps. In some cases, it is also necessary to make use of vegetation maps, aerial photos, and other general documents and/or on-site surveys.

(b) Zoning designations
Urban planning maps are the primary source for identifying the status of zoning designations in the survey target area. It is also necessary to refer to general plans and other documents issued by local governments in when looking at future impacts so that project proponents the direction of upcoming land usage trends would be understood.

(c) Status of manmade structures
Project proponents can usually get a general idea of the manmade structures (such as street canyons[2]) that impact air quality by looking at topographical and residential maps.</td></tr>
<tr><td>Traffic</td><td>(a) Motor vehicle traffic volume
When there will be construction work or the existence/use of land or structures and project proponents are looking at whether to select air quality impacts from motor vehicle traffic as a target for environmental impact assessment, identify traffic volume conditions along target roadways.

Motor vehicle traffic volume conditions can be found by looking at traffic volume measurements along major roadways found in traffic censuses (nationwide road traffic survey), and prefectures and municipalities sometimes measure traffic volume as well. Collect and organize the information in these documents. The information items collected during the item/method selection stage should include 24-hour traffic volume, 12-hour traffic volume, percentage of large vehicles, and level of traffic congestion.

Note that if documentation does not exist for target roadways, it should be ideally conducted an on-site survey to get a general idea of traffic conditions. It is also necessary to consider the possibility of future changes in traffic volume by looking at road plans as well as development plans in surrounding areas.

(b) Volume of other forms of traffic
If navigation routes for marine vessels, aircraft arrivals/departures, or other vehicle factors are likely to impact air quality, identify traffic volume for these forms of transport as well.</td></tr>
<tr><td>Features/facilities deemed vulnerable</td><td>(a) Distribution of facilities considered particularly vulnerable to impacts
I In addition to the spatial assessment of land use, the project proponent will take stock of the distribution of facilities considered vulnerable to changes in water quality.

<table>
<tr><th>Classification</th><th>Example facilities</th></tr>
<tr><td>Educational facilities</td><td>Nursery schools, kindergartens, elementary schools, junior high schools, high schools, universities, vocational schools, and other schools</td></tr>
<tr><td>Medical facilities</td><td>Hospitals, clinics offering residential services, long-term care facilities, etc.</td></tr>
<tr><td>Other public facilities</td><td>Libraries, foster homes, social services facilities, etc.</td></tr>
<tr><td>Parks</td><td>Children’s playgrounds, city parks, etc.</td></tr>
</table>

(b) General distribution of residential areas
In addition to looking at the status of zoning designations stemming from land usage conditions and urban planning laws, it should be ideally used on-site surveys to get an up-</td></tr>
</table>

---

[2] Street canyons are human-made canyons in urban areas that are usually the result of tall buildings flanking roads on both sides

	to-date picture of residential distribution. Particularly when it comes to air quality, it is necessary to have information on the vertical distribution of residential spaces, such as the existence of tall residential buildings or homes built along slopes. It should be also understood the possibility of future residential development by looking at general plans and other documents indicating, for example, land usage incentive policies by various local government agencies.
Status of legally-designated areas and regulations	Identify the environmental standards, regulatory standards, target values, and designated regions set forth in relevant laws and regulations. • Basic Environment Law (Environmental Standards on Air Pollution) • Air Pollution Control Act • Act on Special Measures for Total Emission Reduction of Nitrogen Oxides and Particulates from Automobiles in Specified Areas • Act on Special Measures against Dioxins • Pollution prevention plans • Local ordinances to prevent pollution, protect living environments, etc. • Local environmental basic plans

3) Selecting environmental impact assessment items

(1) Listing up impact factors

Table III.1.1-6 lists and describes the different processes by which atmospheric pollutants are generated. These are impact factors related to air quality.

Table III.1.1-6. How major atmospheric pollutants are generated

Process	Description
Combustion	Combustion of fossil fuels and other fuels, incineration, deodorizing, internal combustion engines
Vaporization	Pyrometallurgy, oil processing and transport, solvents, coatings
Manufacturing, treatment, or processing	Metal refining, metallurgic roasting, drying, reactions, processing of lumber or stone materials, waste treatment
Particulate processing or transport	Pulverizing, sifting, mixing, processing, or transporting raw materials, construction
Leakage or diffusion	Storage/processing in the gas and chemical industries, spraying of agricultural chemicals or disinfectants
Wear/abrasion	Wear and tear of tires and machinery

Source: Prepared based on *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

Points to be considered

Past environmental impact assessments for projects that impacted the current air pollutant (NOx, SPM) concentration typically had the percent contribution from construction vehicles, related post-service vehicle traffic and post-service fixed sources (long-term average concentration) at a few percentage points or less, while
percent contribution from construction equipment operation during construction work (short-term concentration came in at a few dozen percentage points.

In cases where there is a long-term construction period, make sure that construction equipment impacts are sufficiently taken into account.

(2) Arranging *up environmental components*

Environmental components that are related to air quality and classified according to major atmospheric pollutants can be used as reference items, but it is necessary to consider air pollutants other than the reference items according to the impact factors stemming from the project. Table III.1.1.-7 shows the major atmospheric pollutants designated in laws and regulations. Make sure to consider hazardous air pollutants and substances of serious concern to residents even if they are not legally restricted) as well as the substances designated in environmental standards.

Table III.1.1-7. Major atmospheric pollutants

Classification			Description of major atmospheric pollutants
Substances specified in environmental standards			Sulfur dioxide, carbon monoxide, suspended particulates, photochemical oxidants, nitrogen dioxide, fine particulates, benzene, trichloroethylene, tetrachloroethylene, dichloromethane, dioxins (polychlorinated dibenzofuran, polychlorinated dibenzo-para-dioxins, coplanar polychlorinated biphenyl)
Substances designated in the Air Pollution Control Act	Smoke and soot		Sulfur oxide, soot and dust
		Hazardous substances	Cadmium and cadmium compounds, chlorine and hydrogen chloride, fluorine/hydrogen fluoride and silicon fluoride, lead and lead compounds, nitrogen oxides
		Specified substances	Ammonia, hydrogen fluoride, hydrogen cyanide, carbon monoxide, formaldehyde, methanol, hydrogen sulfide, hydrogen phosphide, hydrogen chloride, nitrogen dioxide, acrolein, sulfur dioxide, chlorine, carbon disulfide, benzene, pyridine, phenol, sulfuric acid (including sulfur trioxide), silicon fluoride, phosgene, selenium dioxide, chlorosulfonic acid, yellow phosphorus, phosphorus trichloride, bromine, nickel carbonyl, phosphorus pentachloride, mercaptans
	Hazardous air pollutants		A total of 248 substances, including zinc and zinc compounds
		Designated substances	Benzene, trichloroethylene, tetrachloroethylene
		Priority substances	Acrylonitrile, acetaldehyde, vinyl chloride monomer, methyl chloride, chromium and trivalent chromium compounds, hexavalent chromium compounds, chloroform, ethylene oxide, 1, 2-dichloroethane, dichloromethane, mercury and mercury compounds, dioxins, tetrachloroethylene, trichloroethylene, toluene, nickel compounds, arsenic and arsenic compounds, 1, 3-butadiene, beryllium and beryllium compounds, benzene, benzo(a)pyrene, formaldehyde, manganese and manganese compounds
	General particulates		General particulates (any substance generated or dispersed as a result of crushing or sorting materials or any other mechanical process, or as a result of the accumulation of those materials)
	Specified particulates		Specified particulates (asbestos)
	Motor vehicle exhaust		Carbon monoxide, hydrocarbons, lead compounds, nitrogen oxides, particulates

Points to be consideredPoints to be considered: White smoke from cooling towers

Thermal power plants generally use seawater to cool the vapor used to generate electricity, but in some cases, they adopt a cooling method that recycles coolant through a cooling tower. Emissions from wet cooling towers are high in humidity, creating the possibility that the saturated water vapor within the emissions will be advected in the form of white smoke, which in turn can generate impacts in the form of visual obstructions and the like.

Make sure to take these factors into consideration if there are elevated roadways, residential areas, high-rises, or other living spaces near the project implementation area.

(3) Selecting environmental impact assessment items

Select target environmental impact assessment items based on the relationship between impact factors and environmental components.

Points to be considered:Points to be considered

A variable may not be selected as an Environmental Impact Assessment item (i) if it is clear that the extent of the environmental impact is non-existent or negligible as far as that variable is concerned, or (ii) if it is clear that there will be no areas or other features/facilities subject to environmental impacts regarding that variable in or around the project area for a significant period of time. In this case, it is important to show the information that forms the grounds for this decision in “Project content” or “Regional overview” in the scoping document.

Note that “areas or targets subject to environmental impacts” in (2) above refers to areas connected to human living environments as well as the presence of natural environments subject to air quality impacts. It is clear that targets do not exist “for the given period” when they are not in existence during the life of the project or while it is in service, or the project construction period at the very least—as indicated by land usage regulations, land usage incentive policies, and the like. This corresponds, for example, to localized air quality impacts in a construction zone where there are no residents or natural environments requiring consideration.

4) Selection of survey, forecast, and evaluation methods

(1) Approaches to Method Selection

Environmental impact assessments on air quality use different forecasting methods depending on whether the evaluation indicators are looking at long-term concentration or short-term concentration. The forecast methods and requirements that need to be applied also differ depending on the topographical, meteorological, and other features of the project implementation area—as do survey methods. For this reason, project proponents need to use a process like the one shown in figure III.1.1-2 to determine its evaluation indicators (annual average value, daily average value, one-hour value, etc.) and evaluation targets (continuous air quality measuring and monitoring stations, site boundaries, nearest residences, etc.) prior to selecting a forecast method in line with project and regional characteristics. Project proponents can then select the survey methods needed.

Note that when conducting environmental impact assessments on air quality, it is important to keep in mind that a variety of conditions can cause high concentrations of pollutants, and project proponents need to take these into account as well (see table III.1.1-9).

Table III.1.1-8. Survey/forecast method concepts for evaluation indicators used in environmental impact assessments on air quality

Evaluation indicator	Forecast method	Survey method
Long-term concentration (annual average value)	Long-term average concentration forecast (annual average value)	Survey of meteorological conditions throughout the year
Short-term concentration (daily average value, one-hour value)	Short-term high-concentration forecast (forecasts under special meteorological conditions, topographical impact forecasts)	Survey of meteorological conditions, topographical conditions, and/or source expected to generate high concentrations

Table III.1.1-9. Situations requiring consideration in air quality forecasts

Classification		Situation
Meteorological conditions	Inversion layer	An upper inversion layer limits the dispersal of waste gases upwards, trapping them between the inversion layer and the earth’s surface and causing high concentrations near the ground.
	Land and sea breezes	The alternation between sea and land breezes causes pollutants to temporarily blow back to their source, or the lull between the shift in wind direction traps pollutants and then returns them, causing high concentrations.

	Downwash, downdraft	Strong winds cause waste gases to infiltrate vortex areas around smokestacks or behind structures, preventing them from rising while increasing diffusion in these areas and causing high concentrations near the ground (see note 1).
	Fumigation	Waste gases emitted into a stable layer infiltrate the turbulent layer through a diffusion process, causing high concentrations near the ground (see note 2).
Topographical conditions	Elevation changes	Waste gases collide with elevated locations (such as high-rises) or slopes, causing concentrations that are different than on level ground (see note 3).
	Complex topography	Narrow valleys or other complex topography causes non-uniform or unsteady conditions in the dispersal area.
	Urban areas	Complex airflow patterns arise around buildings.
Roadway structures	Embankments, elevated structures	Road structures generate airflow patterns.
	Canals, tunnels	Pollutant emissions are impacted by airflows generated by traffic.
Temporal conditions	Short-term concentration	Consider that short-term high concentrations are generated due to special meteorological conditions and/or that changes in source intensity at unstable smoke sources may create short-term concentrations.

Notes:

1) Consider the following if there is a possibility of generating downwash:
    a) Downwash from smokestacks
    Vs/u < 1.5 (Vs: discharge speed of gas emissions u: windspeed at the top of the smokestack)
    b) Downwash from nearby structures (downdraft)
    hs ≧ hb + 1.5 Lb (hs: height of the smokestack hb: height of the building Lb: building height or width, whichever is smaller)
2) Fumigation occurs when (1) the ground inversion layer breaks down due to solar radiation, causing waste gases to infiltrate a turbulent layer near the ground (ground inversion layer breakdown) or (2) waste gases infiltrate an internal boundary layer that develops between to areas with different surface characteristics, such as ocean and land or urban and suburban areas (internal boundary layer).
3) The EPA defines “level” as topography that is higher than the smokestack within a 50-km area.

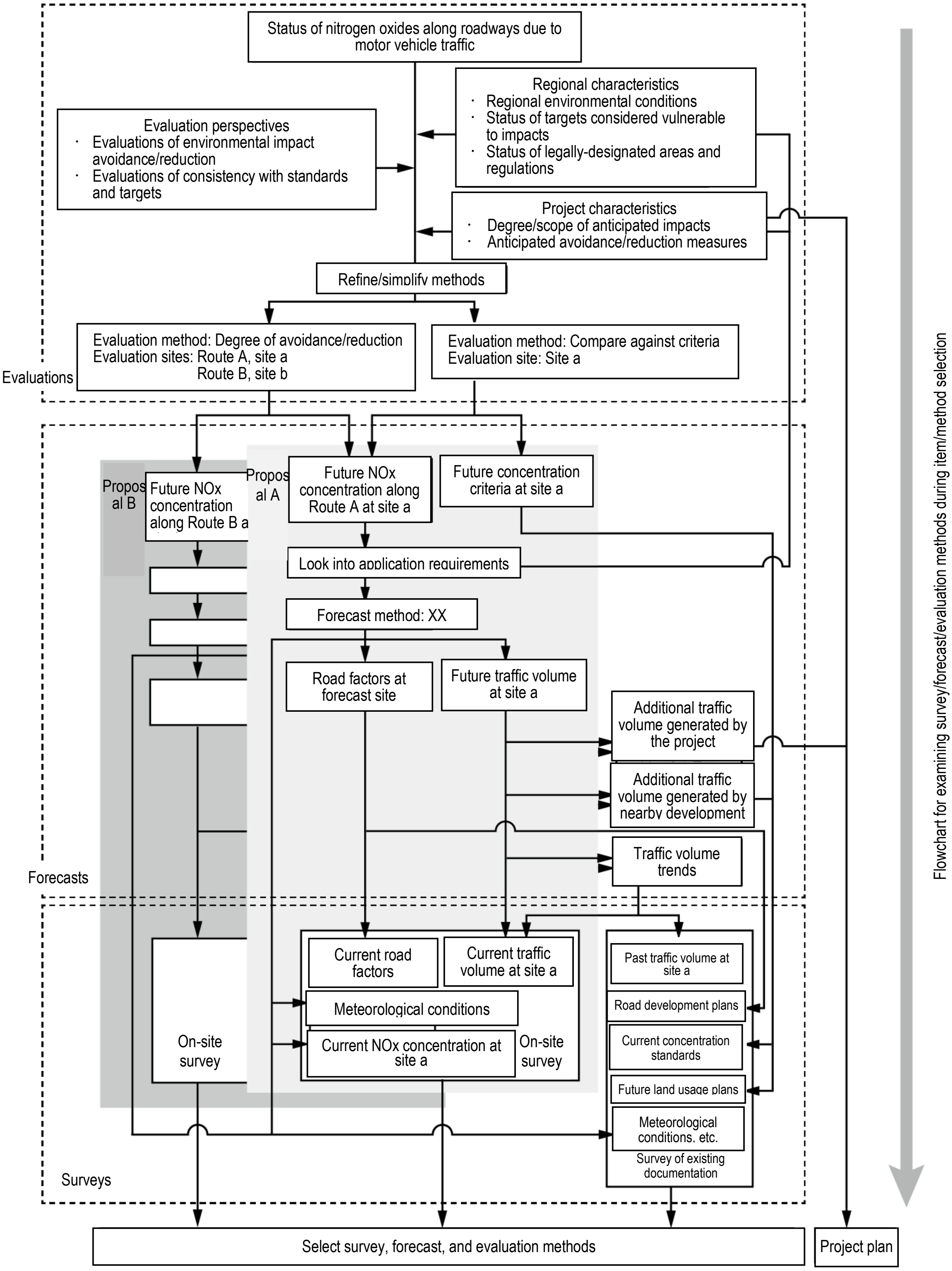


Figure III.1.1-2. Sample flowchart for determining air quality survey, forecast, and evaluation methods

(2) More detailed or simpler survey and forecast methods

Refining air quality survey and forecast methods may involve conducting detailed on-site surveys in order to collect information on the conditions needed to examine forecasts and environmental mitigation measures, densely distributing survey and forecast sites, or adopting sophisticated forecast methods. Simplifying survey and forecast methods may involve using existing documentation to determine the conditions needed for forecasts or adopting forecast methods that predict the degree of impact using emission volume calculations or comparisons with similar case examples.

The following are some examples that will help project proponents determine whether to refine or simplify survey/forecast methods

Examples when examining more detailed survey and forecast methods

1. When the degree of environmental impact is likely to be significant
    - When unique meteorological characteristics in the region (such as sea or land breezes) make it susceptible to frontal inversion or other phenomena and facilities that generate smoke and soot will be established
    - When regional conditions (valleys, street canyons, etc.) make it susceptible to the stagnation of atmospheric pollutants and facilities that generate smoke and soot will be established
2. When the region is vulnerable to environmental impacts or there are vulnerable targets
3. When the region is legally-designated for environmental conservation or when there are legally-designated targets
    - Regions designated under the Air Pollution Control Act
    - Regions targeted by the Act on Special Measures for Total Emission Reduction of Nitrogen Oxides and Particulates from Automobiles in Specified Areas
4. When the regional environment is already significantly compromised or at high risk
    - Regions that are not protected by environmental standards on air pollution
5. When project or regional characteristics will likely make it difficult to conduct forecasts using general-purpose methods
    - Areas with complex diffusion conditions due to unique topography or other characteristics
    - When structural or other characteristics create complex source or diffusion conditions
6. When local governments or project proponents have specific priorities when it comes to environmental conservation
    - When local governments or project proponents have determined that environmental conservation must be prioritized in light of regional characteristics, project characteristics and/or environmental conservation policies in the project

Examples when examining simpler survey and forecast methods

1. When it is clear that the degree of environmental impact will be minimal
    - When emission levels of atmospheric pollutants indicate that the degree of environmental impact will be minimal, project proponents may be able to use emission output for forecasts rather than calculating diffusion, for example.
2. When it is clear that there will not be any regions subject to environmental impact or any targets for a certain period of time
    - When it is clear that there are no residences, facilities, or other targets in the area at risk for impacts from air pollution, either currently in the future, project proponents may be able to use regionwide air pollutant emission output for forecasts rather than calculating diffusion, for example, for the areas where there are no regions or targets subject to impacts.
3. When it is clear from similar case examples that environmental impacts will be minimal
    - When the degree of impact can be estimated from surveys and other case examples from similar projects, project proponents may be able to use that data for forecasts.

Points to be considered:

It is important to determine how project proponents will refine or simplify its survey/forecast methods based on the project and regional characteristics of each individual project.

For example, if a project is being conducted in an area where air quality cannot meet the environmental standards on air pollution, project proponents can forecast the impact that the operation of construction equipment will have on air quality during construction activities, in other words, it may be a good idea to supplement its investigation into environmental mitigation measures by conducting forecasts that use a simplified method (e.g. using emissions ratios or excerpts from similar case examples) rather than conducting a detailed forecast to compare with environmental standards.

1.1.2 Surveys

1) Selection of survey items

As shown in table III.1.1-10, key survey items include current concentration and other features of atmospheric pollutants selected as environmental components as well as meteorological conditions. However, it is important that project proponents select items that will allow project proponents to supplement insufficient information from surveys in existing documentation or on-site surveys so that project proponents can obtain the information necessary to conduct forecasts and evaluations.

With atmospheric pollutants emitted in the course of project implementation, for example, if sufficient measurement information cannot be obtained from surveys in existing documentation, project proponents may have to measure the relevant substances in order to identify the current status and determine background concentrations needed for forecasts and evaluations. If the diffusion zone in the project implementation area or surrounding area has complex topography or if the project is in an urban area, project proponents may need to conduct the required surveys to measure upper air meteorological conditions as well as surface meteorology in order to set diffusion parameters and other conditions.

Table III.1.1-10. Description of key survey items for environmental impact assessments on air quality

Survey item		Description
Air quality conditions		Concentration and other features of atmospheric pollutants selected as environmental components
Meteorological conditions		Surface wind speed/direction, upper air wind speed/direction
		Solar radiation, radiation balance
		Upper air temperature/humidity
Source conditions	Traffic volume	Motor vehicles
		Marine vessels
		Aircraft
		Fixed sources (production plants, workplaces, etc.)

The targets for air quality survey items are typically the concentration of atmospheric pollutants selected as environmental components, but in some cases, it may become necessary to identify substances related to those pollutants as survey targets as well. For example, project proponents may need to track not only suspended particulate matter (SPM), but also the diesel exhaust particles[3] and fine particulate matter ($PM_{2.5}$) emitted by diesel engines as well.

There are also situations where project proponents may need to identify air quality conditions for environmental components as well as the atmospheric pollutants themselves (one example is white smoke emitted from cooling towers at thermal power plants). In cases like these, where environmental impacts are not due to atmospheric pollutants themselves and project proponents are forecasting/evaluating environmental impacts that target air quality conditions,

---

[3] Diesel exhaust particles: These are particulates resulting from incomplete combustion inside diesel engines, and are said to make up a significant portion of the suspended particulate matter along roadways.

project proponents need to sufficiently consider the survey items and survey methods required to conduct those forecasts/evaluations.

Points to be considered: Upper air meteorological observations

Consider carrying out upper air meteorological observations when project emission sources are up high or when the surrounding diffusion zone is complex. Upper air meteorological observations may be carried out using fixed instrumentation (on steel observation towers or smokestacks, for example) or by using weather balloons, aircraft, or other remote measuring technologies. Collect information on mixing height (the height at which pollutants emitted into the air near the surface mix with/dilute into the surrounding area and the atmospheric inversion layer (the height at which vertical temperature distribution in the atmosphere inverts) and reflect these conditions in forecast conditions.

Table III.1.1-11 Required meteorological components for topography and smokestack height (using a waste incineration facility as an example)

Topography of the forecast area	Smokestack height	Surface meteorological survey	Upper air meteorological survey
Level	Less than 50 m	Surface wind speed/direction Solar radiation, radiation balance	None (project proponents should consider land usage conditions, however, and conduct the following observations when they needed)
	50 m+	Same as above	Upper air wind speed/direction, vertical temperature distribution
Complex	Less than 50 m	Surface wind speed/direction (sites representative of the advection zone Solar radiation, radiation balance	Measured values of downward air currents (one simple method is observing the flow of smoke from a flare)
	50 m+	Surface wind speed/direction at sites representative of the advection zone (measure turbulence using ultrasonic wind speed/direction instruments when possible) Solar radiation, radiation balance	Upper air wind speed/direction, vertical temperature distribution, trajectory survey, etc.

Source: Prepared based on *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

2) Survey method concepts

There are sometimes official methods for measuring the concentration of atmospheric pollutants, meaning that measurement methods are designated in laws and regulations on substances subject to environmental standards and the like. In general, project proponents should follow these official methods.

When official methods call for the use of automated instrumentation to measure atmospheric pollutants, it is possible to obtain continuous concentration data in hourlong increments. However, it is sometimes difficult to get broad-ranging, whole-area measurements in custom locations or in mountainous areas due to problems securing power, obtaining sites, or with cost. The simplified measurement methods shown in table III.1.1-12 do not require a power source and can be done relatively easily and inexpensively, so they have the benefit of being able to be positioned in a large number of custom locations. However, because they do not allow for the collection of measurement values with a high time resolution, project proponents need to consider the features of each method before implementing it.

Table III.1.1-12. Simplified methods for measuring the concentration of atmospheric pollutants

Measurement method			Measurement items	Notes
Passive sampler methods	Ogawa Passive Sampler	PTIO method	Nitrogen monoxide (NO) Nitrogen dioxide (NO_2)	・NO and NO_2 can be measured at the same time ・There are two types of measurement: short-term (8–24 hours (less than a week)) and long-term (4–5 weeks)
			Sulfur dioxide (SO_2)	・There are two types of measurement: short-term (8–24 hours (less than a week)) and long-term (4–5 weeks)
			Ozone (O_3) Ammonia (NH_3)	・Short-term measurement takes place for 8–24 hours (less than a week)
	Gas pack		Nitrogen dioxide (NO_2)	・Sampling can be done for anywhere between a day and around a month
	Filter patch		Nitrogen dioxide (NO_2)	・Exposure times are designed to be anywhere from 24 hours to a week; maximum exposure time is a month ・The patch construction makes this an ideal method for measuring multiple sites at once or the amount of individual exposure
Detection tube method			Various types of atmospheric pollutants	・Measurements can be taken by fitting multiple detection tubes specific to certain air pollutants on a single detector (pump) ・This method allows for a direct read of concentrations in a few minutes, but is ill-suited to low-concentration measurements

Note: Prepared based on manufacturing company documents

3) Survey area/site concepts

(1) Survey area

The survey area is determined based on project characteristics (such as the type and location of sources) as well as regional characteristics derived from both natural characteristics (such as weather or topography) and social conditions (such as schools, hospitals, or other facilities requiring particular consideration in terms of environmental conservation or the distribution of residences). The range should also include sites that will experience maximum impacts from project implementation.

In general, the survey area needs to include a range within which the concentration of atmospheric pollutants due to project implementation will rise to a certain level or higher as well as encompass the forecast area described later. This range can change based on project size/details and regional characteristics, so err on the side of caution by making it larger than project proponents might need in order to account for forecast uncertainty.

(2) Survey sites

Air quality surveys are frequently conducted at fixed points, so project proponents will need to establish survey sites. Table III.1.1.-13 presents concepts for determining survey sites when conducting on-site surveys.

Table III.1.1-13. Concepts for determining survey sites when conducting on-site surveys

Site classification	Site determination concepts
Sites representative of the area	If project proponents are designating survey sites that will help project proponents determine background concentration and otherwise identify representative status of air quality in the survey area, select locations with stable meteorological conditions and little impact from neighboring sources.
Sites at risk for particularly major impacts	If project proponents are designating sites where project proponents anticipate impacts from the project to be particularly large (sites estimated to have maximum ground concentration or project site boundaries, for example), select an approximate location based on project characteristics and similar case examples. Project proponents also need to make sure that the site project proponents select has little impact from other sources.
Sites with targets requiring particularly careful consideration of environmental conservation	If project proponents assessment targets include residences or facilities requiring particularly careful consideration of environmental conservation (such as schools or hospitals), and project proponents expect that conditions there will be different than the sites representative of the area due to impacts from roads or other sources, select these locations as survey sites. When there are multistory residences near fixed sources of atmospheric pollution, consider selecting survey sites in the vertical direction as well.
Sites where environmental conditions are already significantly compromised	Select sites that are considered to have already experienced air quality deterioration due to impacts from roads and other fixed sources.
Sites where pollution or other environmental harm is already advancing	Identify conditions prior to project implementation in locations that are considered to be experiencing advanced air pollution due to other nearby sources. This will allow project proponents to distinguish project impacts from other impacts.

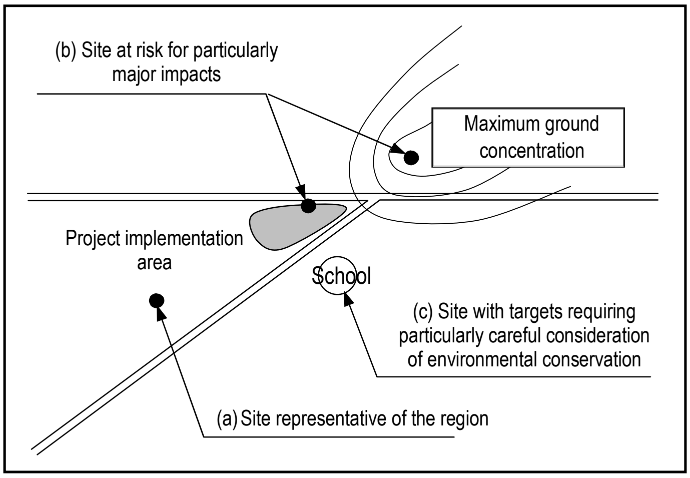


Figure III.1.1-3. Sample concepts for determining air quality survey sites

Points to be considered: Positioning survey sites in the vertical direction

Measurements for environmental components subject to impacts from project implementation should be taken at the height at which people breathe during the course of their daily lives. Substances like nitrogen dioxide and nitrogen monoxide that are impacted very little by sediment stirred up from the ground are typically sampled between 1.5 and 10 meters above the ground, while suspended particulate matter and fine particulate matter should be sampled at between 3 and 10 meters to eliminate the impact of sediment stirred up from the ground. Note that it is necessary to consider positioning survey/forecast sites higher as needed when there are high-rises in the area around emissions sources and when those buildings need to be protected.

4) Survey period and timing concepts

Air quality conditions are profoundly affected by atmospheric conditions; namely, areas of advection and diffusion. When deciding on a survey period and timing, project proponents must sufficiently account for fluctuations in atmospheric conditions, including seasonal fluctuations in meteorological conditions, and air pollutant concentrations. Air pollutant sources in particular have different emissions depending on the hour, day, season, and so on, so make sure project proponents select the survey period and timing project proponents need depending on whether they have short-term or long-term evaluation targets.

When short-term information is measured during on-site surveys, there are cases where the measurement year is an abnormal one or the measurement values are otherwise not representative. In these situations, project proponents need to examine the measurement values to find out how representative they are.

In situations where project proponents are using the results from surveys in existing documentation on regional characteristics for their forecasts/evaluations, project proponents also need to make sure that the existing sampling points are representative. There is a possibility, for example, that the distribution of the existing measurement sites or the surrounding conditions are different than their survey area; in this case, project proponents need to look at sampling in all four seasons or at two different times (heating period and non-heating period) for anywhere from a week to about a month during their on-site survey.

Points to be considered:

・Surveys that take forecast targets into account

Long-term forecasts are conducted to predict average annual values for expected general air quality. In this case, the forecast conditions are meteorological conditions derived from weather data over the course of a typical year. Note that when forecasting the formation of inversion layers[4] or internal boundary layer fumigation[5] in forecasts that take topographical conditions into account, consider conducting upper air meteorological observations in order to identify mixing height, the appearance of atmospheric inversion layers, and so on.

・Comparing data from existing documentation against on-site survey results

Make sure that the results obtained from on-site surveys are representative of the area, by examining the suitability of the data. Project proponents can examine the validity of the survey year by looking at existing long-term data (abnormal year test), or compare onsite-survey results with measurement data from established measurement stations gathered during the survey period to check the similarity of daily or periodic changes.

---

[4] Formation of inversion layers: Air in the troposphere generally decreases as altitude increases based on an environmental lapse rate of 0.6ºC per 100 meters. Meanwhile, various factors can create layers where temperature increases with increased elevation. When this happens (when the vertical temperature gradient is reversed), it causes a layer reversal called an inversion layer. The most common factor that forms an inversion layer is when radiative cooling cools the air near the surface overnight during fair weather conditions with little wind. When there is an inversion layer at the top of a smokestack, it prevents smoke emissions from diffusing higher than that layer, creating a “lid” effect that may increase ground concentration.

[5] Internal boundary layer fumigation: In coastal regions with pronounced land and sea breezes, winds blowing over the ocean form a stable atmospheric layer with little air turbulence, but when they reach land, they create turbulent layers close to the surface as a result of solar radiation and natural features. The turbulent layer close to the surface that is formed within this stable, low-turbulence layer over the ocean is called an “internal boundary layer”. When emissions from smokestacks in coastal regions are discharged into sea breeze layers and end up in the internal boundary layer, it can result in a fumigation phenomenon that rapidly diffuses them into that internal boundary layer and increases ground concentration.

1.1.3 Forecasts

1) Forecast method concepts

Tables III.1.1.-14 and III.1.1-16 show examples of air quality forecast methods. Different air quality forecast methods are applied depending on the type of sources, type of air pollutants, topographical conditions, natural features in the surrounding area, evaluation methods, and other factors. Therefore, when selecting a forecast method, project proponents need to choose one that is appropriate given a thorough consideration of the application scope of a variety of different methods rather than simply referring to the ones used in past environmental impact assessment case examples. In cases where the model project proponents select needs to be adjusted in order to fit their project application, project proponents must also clearly explain the details of that adjustment and their reasons for it.

Points to be considered: Topographical conditions (complex diffusion zones)

Even if the diffusion zone has complex topography, project proponents may be able to conduct forecasts with the standard puff-plume model used for flat terrain.

When there are concerns due to the regional characteristics of diffusion zones in survey and forecast areas, such as extremely complex local winds, valleys that create atmospheric stagnation in winter due to inversion layers, complex wind behaviors due to street canyons or similar features, and so on, they need to consider using a forecast method that is able to handle complex diffusion zones.

Forecast calculations for complex diffusion zones include 3D numerical models as well as models recommended by the US Environmental Protection Agency (CALPUFF, CTDMPLUS, etc.), but the models that the EPA recommends were created based on US meteorological, topographical, and other conditions and therefore must undergo careful consideration when applied to Japan in term of recreating current conditions, for example.

On the other hand, if project proponents are using the conventional puff-plume model for complex diffusion zones, they need to be aware of its applicable scope and forecast accuracy, referring to comparisons with numerical models and the like.

Note also that depending on project proponent’s evaluation targets, forecast methods may not be already established, information collected from sources may be insufficient, or forecasting technologies may require further research. In cases like these, compile the latest insights and other information on individual substances and phenomena while also looking into the optimum environmental mitigation measures available for their project.

Points to be consideredPoints to be considered: Essential environmental components for examining forecast methods (hazardous air pollutants)

Among the trace chemical substances that are harmful to human health are those whose generation mechanisms or formation processes are still unknown. Yet these substances also include those that are of high concern to residents and other stakeholders, so they must be considered as environmental components. When doing so, consider using forecast methods that are based on survey results from similar case examples.

Conventional air quality forecasting methods can be applied to the hazardous substances with low reactivity that fall into the category of hazardous air pollutants, but at present there are still difficulties with forecasting highly reactive substances.

Points to be consideredPoints to be considered: Essential environmental components for examining forecast methods (photochemical oxidants, fine particulate matter)

The formation of photochemical oxidants is heavily impacted not only by the atmospheric concentration of their causal agents (nitrogen oxides and volatile organic compounds), but also by meteorological conditions such as solar radiation, temperature, and atmospheric turbulence. In addition, fine particulate matter contains not only particles emitted directly into the atmosphere from incineration and similar sources (primary particle generation), but also from the participation that occurs due to chemical reactions between gaseous atmospheric pollutants (sulphur oxides, nitrogen oxides, volatile organic compounds, etc.) in the air. For this reason, it is necessary to consider atmospheric chemical reactions when forecasting concentrations of photochemical oxidants and fine particulate matter—though these estimates are difficult to formulate for individual projects given the many issues the currently involve.

Table III.1.1-14(1). Examples of air quality forecast methods

Method		Overview	Operational conditions/features	Operational status
Diffusion calculations	Plume model	Represents smoke plume advection/diffusion. Allows project proponents to find a stationary solution for concentration for concentration distribution when meteorological conditions, diffusion coefficient, and emissions volume are constant. Uses either a regular or irregular dispersion formula.	The basic formula assumes a steady source intensity, steady flow location, and a certain amount of wind. The regular formula assumes a fixed vertical wind speed/direction, while the irregular formula uses a fixed vertical wind direction and assigns a power function approximation to windspeed. The calculations are simple.	The regular dispersion formula has been used in numerous examples to calculate average annual values in windy conditions for point sources, linear sources, and diffuse sources. There are also examples of diffusion width (σ_y) being corrected and used for short-term diffusion. In some cases, correcting the regular formula can also make it applicable to meteorological conditions where mixed layer height cannot be ignored, undulating terrain, or areas subject to structural impacts. An attenuation coefficient can also sometimes be used to correct the formula for reactive or deposition effects.
	Puff model	Represents advection/diffusion for single puffs of smoke. There is a puff formula for low winds that takes advection effects into account and a simple integral puff formula that assumes no wind.	The basic formula assumes a fixed vertical wind speed/direction and a fixed diffusion coefficient in the vertical direction, and can handle distribution/changes in wind speed/direction within a horizontal plane as well as temporal changes in source intensity. The calculations are simple.	The puff model can be used to calculate average annual values for point sources, linear sources, and diffuse sources under windless conditions when used in conjunction with the plume model. There are many examples of the simple integral puff formula being used for calculations in windless conditions, but the low-wind puff formula is also increasingly being used.
	JEA model	This formula was designed for roads (linear surface sources). It uses a linear smoke source diffusion equation that assigns a vertical height exponent to windspeed or diffusion coefficients. There are formulas that can be used during crosswinds, parallel winds, and no wind.	The JEA model assumes a smoke source at the surface and considers road conditions, but otherwise assumes the same conditions as the plume model under windy conditions and the puff model under windless ones. Radiation balance and windspeed are used to represent atmospheric turbulence.	The JEA model is applied both to roads both under windy and windless conditions. It is particularly common in cases where there are expected to be problems with the accuracy of forecast concentrations. It is applied in areas near (within around 200 meters) roads.
	Box model	This model treats air as a box, assuming a uniform concentration within the box and using flows into and out of it to calculate concentrations based on internal generation/extinction. There is a simple one-box method as well as a multiple-box formula.	The box model is applied to targets with uniform internal systems and assumes that the transfer of substances and wind speed/direction are known at the boundaries of the system. It is used to forecast concentration changes, including concentration and chemical changes in irregular locations.	The box model is primarily used for research purposes and has rarely been applied to environmental impact assessments. Because the model makes it easy to take chemical reactions within the system into account, it is frequently used to forecast/evaluate relatively long-term advection and secondary substance generation.

Method		Overview	Operational conditions/features	Operational status
	Mass-consistent model + puff model	The mass-consistent model uses wind speed zones simply interpolated from actual wind speed/direction data at multiple sites as an initial value and topographical data as boundary conditions, repeatedly adjusting to satisfy a continuity equation and find windspeed zones free of hydrodynamic contradictions. Diffusion calculations that reflect topographical impacts are calculated by advecting puffs within these windspeed zones.	Because this model is based on actual measured values, it can be used to find practical windspeed zones that reflect the impact of temperature distribution. Though it requires as much wind speed/direction data as possible in order to cover the target area with any degree of resolution, it involves far less calculations than solving for a 3D numerical model. Since it uses the puff model for diffusion calculations, setting diffusion parameters is done in the same way as for the normal puff-plume model. Note, however, that this model cannot be applied to urban forecasts as it cannot recreate the turbulent flows caused by urban structures.	This model is commonly used for diffusion forecasts in mountainous areas or for target facilities located in flatland areas alongside mountains. There are also examples of it being used to forecast the impact of winds at the mouths of road tunnels.
	3D numerical model	This model uses differential equations for advection/diffusion, converting them into difference formulas to find numerical solutions.	The suitability of this model has been confirmed, as it offers the right resolution, its calculation codes have been verified (e.g. there is low numerical calculation error), and it has been compared to observed values and experimental results. It can be applied to windy conditions and neutral air turbulence where there is complex topography in coastal regions or due to street canyons. Finding average annual values involves a heavy calculation load.	This model is applied to air quality forecasts involving complex terrain in environmental impact assessments for thermal power plants. Academic guidelines have also been prepared for air quality forecasts targeting road projects near buildings. Its application in mountainous areas is also being studied. Note that there are numerous problems associated with applying this model under low-wind or stable conditions.

Table III.1.1-14(2). Examples of air quality forecast methods

Method	Overview	Operational conditions/features	Operational status
Statistical methods	Statistical methods are classified as either regression models or classification methods. Statistical analysis of the relevance of past concentrations or weather can be used to accurately forecast concentrations.	Statistical methods assume that there is sufficient accurate measurement data and that future conditions will remain within the current data range.	Statistical methods are rarely used to forecast concentrations for environmental impact assessments, but are used to forecast photochemical pollution, for example. They are used in environmental impact assessments to convert between annual and daily average values and for NOx→NO_2 conversions.
Wind tunnel tests	With this method, topography, structure, and smoke source models are placed inside a wind tunnel device to perform an actual simulation by experimentally measuring airflow and trace gas concentrations.	This model assumes that the models used are actually analogous to their real-world counterparts. It is suitable for studying the impact of complex factors that are difficult to numerically model, such as complex terrain or natural features.	Wind tunnel tests are used to study the relative impact of topography of structures on diffusion phenomena in order to supplement diffusion calculations.

Outdoor tests	Tracer gases are released outdoors while meteorological measurements are taken. Their concentrations and the meteorology are measured in order to analyze airflow and diffusion phenomena in the actual atmosphere.	This method assumes that the experimental meteorological conditions are representative and that the measuring systems are sufficient. It is an effective way of understanding phenomena in the actual atmosphere directly.	Outdoor tests are sometimes used on-site to estimate meteorological characteristics or diffusion parameters. In situations where there is complex topography, for example, they can be used to check whether existing charts can be used for diffusion width at particular sites.

Source: Prepared based on *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999) and Ichikawa, Yoichi "The Applicability of 3D Numerical Modeling to Air Quality Forecasts in Environmental Assessments", *Journal of the Japan Society for Impact Assessment* Vol. 10 No. 2 (2012)

Table III.1.1-15. Examples of air quality forecast methods

METI-LIS model	• The METI-LIS model is an atmospheric diffusion model that was developed by the Ministry of Economy, Trade and Transport for conducting diffusion forecasts for hazardous air pollutants, which are typically emitted at relatively low elevations near the ground. It is based on the ISC model from the US Environmental Protection Agency (EPA). METI conducted tracer gas diffusion experiments in multiple production plants, took distribution measurements of benzene and other substances within those plants, and conducted wind tunnel experiments, using the data to revise the diffusion parameters from the ISC model so that structural impacts (downwash) could be taken into account. • The model makes it possible to forecast the diffusion of hazardous air pollutants that are toxic under short-term exposure, those that react with the surrounding air, and those that do not dissipate. It can also perform diffusion forecasts for other substances with known emissions factors. • When the positional relationship between emissions sources and structures causes downwash, the METI-LIS model can serve as a diffusion model that takes that downwash into account. When there is no downwash, it can be used to perform calculations as a regular diffusion model. Even if wind direction changes (as in calculations of average annual value), the computer can automatically determine which structures are impacted by the wind direction. • Note that the METI-LIS model does not perform numerical calculations using strict hydrodynamic equations, but rather calculates diffusion concentration in the wake of structures by correcting effective smokestack height and diffusion width under a regular, uniform Gaussian plume model. It therefore cannot be used when the range is closer than three times (3L) the shorter of either the height or width of the structure (L) from the smoke source.

Note: The METI-LIS model was developed for low-rise smoke sources, but the EPA has developed ISC-PRIME model as a successor to the ISC model and both are widely used to determine the impact of elevated smoke sources on buildings.

Source: *Manual of Environmental Impact Forecast Methods for Areas Near Hazardous Air Pollutant Sources*, (Ministry of Economy, Trade and Industry Low Rise Industrial Source Dispersion Model (METI-LIS Model)) Ver. 3.02, Ministry of Economy, Trade and Industry (2012)

Table III.1.1-16. Suitability research project for numerical model air quality forecasting

Japan Society for Atmospheric Environment project	• Although the basic system of equations is the same as models used to calculate actual flows, each research institution or consulting firm that has developed these models currently uses different specific calculation methods and calculation conditions, and the source code has yet to be released. Side-by-side comparisons of these models have also not yet been done, so they have not necessarily been validated in terms of the suitability of their calculation results. The Japan Society for Atmospheric Environment is currently studying the Diffusion Model with Computational Fluid Dynamics (DiMCFD) as a simulator in an attempt to resolve these issues. • A method that allows for evaluation against target values in environmental standards and the like is required in order for it to be applied to environmental assessments, but at present, the DiMCFD has not been sufficiently studied in terms of its applicability to daily average values.

Source: *Guidelines for CFD Model (DiMCFD) Atmospheric Environmental Assessment Tools*, CFD Model Environmental Assessment Applicability Lab under the Forecast, Planning, and Evaluation Subcommittee at the Kanto Branch of the Japan Society for Atmospheric Environment (2013)

Reference: Example air quality forecasting support tool

■ Atmospheric assessment support tools for thermal power plants

A forecasting tool for calculating diffusion, average annual and daily surface concentration values around power plants, and short-term concentration spikes (one-hour values) under special meteorological conditions (during the formation of inversion layers, smokestack downwash, building downwash, fumigation due to inner boundary layer development) has been released based on the *Environmental Impact Assessment Guide for Power Plants* (revised January 2007, edited by the Nuclear and Industrial Safety Agency at the Ministry of Economy, Trade and Industry)*.

The tool combines geographic information systems with atmospheric diffusion calculation systems and can be operated easily via a graphical user interface (GUI) to smoke source location and concentration calculation points, enter various parameters, and so on. The tool also uses publicly available databases to extract atmospheric environment (background) concentrations linked to smoke source locations and display them on a map and can also automatically preprocess calculations, making it possible to easily and quickly evaluate the impact of power plant emissions. It also performs a variety of other functions required for power plant assessments, such as windspeed altitude corrections, setting windspeed rankings and representative windspeed, determining/converting atmospheric turbulence, and more.

Source:) *Developing Atmospheric Assessment Support Tools for Thermal Power Plants*, Central Research Institute of Electric Power Industry (2014) (Central Research Institute of Electric Power Industry Report V13020)

*The *Revised Environmental Impact Assessment Guide for Power Plants* was published in July 2015, but the tool described above can be utilized under this revised version as well.

(1) Forecast conditions: Concepts

Set forecast conditions by looking at the conditions necessary for the forecast target items and forecast methods project proponents are using, taking project and regional characteristics into account. The main forecast conditions for the puff-plume model, which has typically been used for air pollutant diffusion forecasts in past environmental impact assessments, are shown in table III.1.1-17. As shown under (2) Forecast uncertainty, there are factors that may contribute to uncertainty in these forecast conditions, so these need to be considered when determining their conditions.

Table III.1.1-17. Forecast conditions for diffusion forecasts using the puff-plume model

Forecast conditions		For fixed sources	For mobile sources
Source conditions	Emissions amount	・Emissions conditions: Fuel usage, emissions concentration, amount of emissions gasses, emissions temperature, etc. based on planned factors and operational plans for facilities emitting soot and smoke ・Temporal fluctuations in emissions intensity	・Emissions conditions: Traffic volume (motor vehicles, marine vessels, aircraft), travel speed, emissions coefficients, percentage of large vehicles, weight composition, etc. ・Temporal fluctuations in emissions intensity
	Emissions location	・Location of emissions sources	・Location of roads ・Shipping channels ・Flight paths, etc.
	Emissions height, etc.	・Actual height of emissions sources ・Effective smokestack height	・Road structure (height of road surface, height of soundproofing walls, etc.) ・Height of smokestacks on marine vessels, flight altitude, etc.
Meteorological conditions		・Wind speed/direction ・Pasquill atmospheric turbulence	・Wind speed/direction ・Pasquill atmospheric turbulence

Diffusion parameters	・Pasquill-Gifford diagrams ・Turner diagrams ・Briggs diffusion width ・Diffusion width during turbulence (according to OML/AERMOD)	・Parameters based on Pasquill-Gifford diagrams/Turner diagrams ・Parameters set based on actual results measured along roadways while referencing the above diagrams
Background concentration	・Concentration of atmospheric pollution in the general environment	・Concentration of atmospheric pollutants without the impact of sources targeted by forecasts/evaluations

a. Source conditions

Emissions conditions at power plants, production plants, and other large fixed sources are determined from project characteristics and are frequently set based on conditions at similar facilities or operational characteristics. Fixed sources are also under the management of product proponents. All of these factors make it likely that there is relatively little uncertainty associated with them.

Motor vehicles on the other hand (a type of mobile source), involve emissions coefficients determined separately at national or sometimes local government agencies for each vehicle type by speed for each upcoming year, while forecasts are set based on these emissions coefficients as well as emissions intensity figures derived from traffic volume and vehicle composition. Emissions coefficients are based on the acceptable limits for emissions gas volume, which come from target values in the individual regulations reported by the Central Environmental Council—and therefore require that project proponents are clear on the details of the individual regulations being applied. Emissions intensity is calculated based on these emissions coefficients as well as traffic volume, vehicle composition, speed, and other factors, and keep in mind that these traffic conditions are factors that can greatly affect emissions intensity. Emissions coefficients are frequently applied to two different vehicle categories (large and small vehicles), and in cases where there is a high percentage of dump trucks, trailers, and other large vehicles, it is likely that emissions intensity estimates can come out too low. At present, there are difficulties associated with determining emissions coefficients that can be applied to these large vehicles, so project proponents need to consider how closely the emissions coefficients project proponents are using for their forecasts match actual vehicle composition.

Traveling speed is frequently set based on speed limits and designed speed, but it should reflect actual road conditions in the forecast area and of planned roads (e.g. by using actual measured speed in the forecast area or along roads that are similar to those planned).

b. Meteorological conditions

Wind speed/direction and other meteorological conditions have a major impact on recreating diffusion zones during air quality forecasts. With meteorological conditions, predictable cases where representative regional conditions cannot be maintained or when the measurement year is not representative (i.e. there are deviations from the average year), which means that project proponents must verify the suitability of measured values both temporally and spatially by comparing them against regional or long-term measurement data, for example.

Long-term concentration forecasts generally use a method by which forecast conditions are determined by targeting the latest/most representative years based on past meteorological data after running an abnormal year test.

c. Diffusion parameters

Pasquill-Gifford diffusion parameters are typically used, but these parameters are created based on diffusion experiments derived from ground-level sources in flat, grassy areas. When applying them to diffusion from elevated smoke sources or rugged regions (such as urban areas), it is necessary to consider whether the Pasquill turbulence category corresponds to the actual turbulence level and examine/select parameters that are appropriate for smoke source conditions.

d. Background concentration

When forecasting the future concentration of atmospheric pollutants, project proponents need to set a future background concentration of the atmospheric pollutants targeted by their forecasts. When they have a widespread forecast area spanning several or several tens of kilometers (as with large fixed sources or diffuse sources) or when planned roads are scheduled to span multiple areas with different air quality conditions, project proponents need to set background concentration for each area rather than uniformly across the entire region.

Points to be considered:

・Emissions coefficients

Emissions coefficients for atmospheric pollutants from vehicles and other primary units from which pollutant emissions amounts are calculated are determined using (1) primary unit emissions coefficients for individual emissions gas regulation years and by fuel and (2) average half-loaded weight ‘for cargo vehicles only). Changes in social and other conditions as well as fluctuations in anticipated vehicle composition ratios (gasoline vs. diesel engines) and vehicle composition by model year can make the set values for future years different than forecasted. For this reason, it needs to find out whether the characteristics used as calculation assumptions are applicable to forecast area or route when using emissions coefficients found in existing literature/documentation.

Forecasts involve two types of vehicles (large and small), and in many cases different emissions coefficients are applied to each at a set traveling speed. This is because forecasts use two separate estimated traffic volumes for large and small vehicles. However, if project proponents are adding construction vehicles to current traffic volume (in order to forecast changes in air quality during construction, for example), they can use separate emissions coefficients for three or more vehicle types in order to conduct forecasting.

・Effective smokestack height

When emissions gas containing atmospheric pollutants is at a higher temperature than the air surrounding the emissions source or when the emitted gas has velocity in the upward direction, the plume is advected/diffused at a higher elevation than the actual smokestack height (H_0). This increase in height (ΔH) is expressed as effective smokestack height (He), and includes the actual height of the emissions exit point. A variety of methods can be used to calculate the increase in height (ΔH), among them theoretical formulas like the Briggs equation and empirical formulas like the CONCAWE or Moses & Carson equations. Make sure to apply a suitable calculation formula given project characteristics, emissions format, and similar factors.

・Diffusion parameters

Diffusion parameters are set in cases where the topography is not flat or there is an upper-level diffusion zone. Among them are the Pasquill-Giffort diffusion parameters, which are based on a roughness correction method that takes Smith surface roughness into account, and diffusion parameters set based on the relationship between maximum ground concentration and effective smokestack height, which is calculated using the results of diffusion experiments that the Central Research Institute of Electric Power Industry did on Japanese thermal power plants. Diffusion parameters based on the Smith roughness correction method are calculated based on a roughness level of 3 cm used during the Pasquill experiments. If project proponents need diffusion parameters for the vertical direction when roughness is high, *Environmental Assessment Techniques* (1999) includes a table that allows them to find horizontal diffusion parameters using the same concepts used for the vertical direction. For diffusion parameters in upper-level diffusion zones, the Central Research Institute of Electric Power Industry has some example settings, which are shown in table III.1.1-18.

Table III.1.1-18. Example upper-level diffusion parameter settings

Time of day	Day		Night	
Ground turbulence	A～BC	C～Dd	Dn	E、F、G
Upper-level diffusion parameter	C	CD	D	E

When setting diffusion parameters for roadway diffusion, the *Environmental Impact Assessment Techniques for Roadways (FY2012 edition)* published by the MLIT National Institute for Land and Infrastructure Management and the Public Works Research Institute (2013), indicates diffusion widths derived using the puff-plume model and based on survey case examples involving diffusion experiments conducted near roadways. The rationale for these diffusion widths is that the relationship between turbulence/roadway structure and diffusion parameters is unclear near roadways, so the parameters are independent of turbulence and roadway structure. There is also the JEA linear smoke source diffusion formula, which sets diffusion parameters according to radiation balance and windspeed. If project proponents are forecasting impacts from sources at elevation (such as elevated roadways) and are applying the JEA corrected linear smoke source diffusion formula, they can set parameters according to roadway structure.

(2) Forecast uncertainty

Uncertainty in air quality forecasts can come from various sources. There may be uncertainty caused by in the forecast conditions, as when there are manmade fluctuations in the current status used for forecast assumptions, when there is scientific uncertainty about the behavior of target substances due the stage of research, or when there is insufficient insight into how the forecast models work. There may also be uncertainties in the forecast methods, such as when there are limits to the models themselves or uncertainties inherent in their parameters or primary units. When conducting forecasts amidst these uncertainties, the project proponent must set their own conditions (anticipate scenarios) that take natural conditions (such as meteorological changes) and social conditions (such as socioeconomic factors) into account.

That said, in reality there are conditions that fluctuate based on external factors that project proponents cannot account for, making it even more critical that conditions be set carefully should forecast uncertainty increase as a result of those factors.

Air pollutant concentration undergoes probabilistic changes, and can fluctuate dramatically according to land usage characteristics and the status of the sources generating the pollutants. In addition, forecasting the concentration of air pollutants involves finding average pollutant concentration values based on preset meteorological and emissions conditions, so project proponents should be aware that calculating averages itself includes a range of fluctuation.

Reference: Probabilistic changes

Measurement results on nitrogen dioxide concentrations (hourly average values) for FY2000 taken at Tokyo air quality monitoring stations (an ambient air pollution monitoring station and roadside air pollution monitoring station) were used to create figure III.1.1-4, which shows annual distribution conditions by placing concentration on the horizontal axis and annual frequency of appearance on the vertical axis.

Figure III.1.1-4(1) shows measurement results from an ambient air pollution monitoring station in a Category II exclusive residential district for mid- and high-rise buildings in the city of Hachioiji. The correlation between hourly average values and frequency of appearance shows a distribution pattern very close to a log-normal distribution (annual average value 16.9 ppb, average standard deviation 16.9 ppb, standard deviation 9.1 ppb).

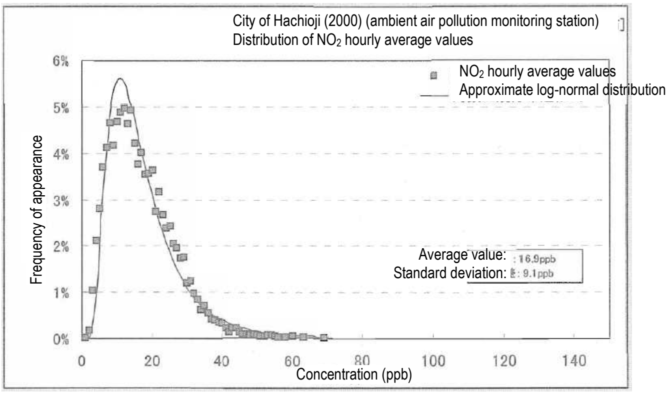


Figure III.1.1-4(1). Distribution of nitrogen dioxide concentration, hourly average values

(Hachioji Station No. 4, April 2000–March 2001)

Figure III.1.1-4(2) shows measurement results from a roadside air pollution monitoring station along National Route 256 and Yamate-dori Street in Meguro City. The correlation between hourly average values and frequency of appearance shows a distribution pattern very close to a normal distribution pattern (annual average value 42.2 ppb, standard deviation 18.6 ppb).

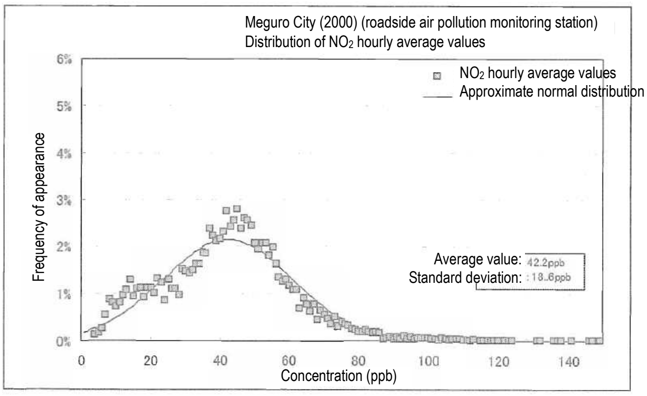


Figure III.1.1-4(2). Distribution of nitrogen dioxide concentration, hourly average values (Osakabashi Station, April 2000–March 2001)

Measurement results from the above two sites make it clear that annual average values and standard deviation varies greatly depending on land usage characteristics and the status of the sources generating the pollutants in the areas around the monitoring sites.

Reference: Differences in forecast results resulting from traffic forecast condition settings

There are a variety of indicators that can be used when setting traffic-related forecast conditions for air quality forecasts, such as traffic volume and percentage of large vehicles, and each one comes with its own level of uncertainty.

There are case examples where major differences were found between traffic volume set as a forecast condition and traffic volume measured during follow-up surveys, but the significance that those discrepancies have in terms of forecast results has not been sufficiently verified.

In the future, it is likely that the process of accumulating actual results and other data from follow-up surveys will be subject to verification as well, but here, when it comes to traffic-related forecast conditions, we have focused on traffic volume, percentage of large vehicles, and traveling speed, looking at the extent to which the amount of atmospheric pollutant emissions changes based on these settings. Note that emissions coefficients set based on traveling speed must be treated with caution as they contain inherent uncertainty. Below is a detailed explanation of the traffic-related forecast condition setting used in our examination.

Conditions used for the study:
Forecast method: Based on methods given in the *Environmental Impact Assessment Techniques for Roadways (FY2012 edition)* published by the MLIT National Institute for Land and Infrastructure Management and the Public Works Research Institute (2013)
Forecast air pollutant: Nitrogen oxides
Forecast conditions: Several parameters (traffic volume, percentage of large vehicles, traveling speed) were set and changed. Fixed values were used for a 24-hour period for percentage of large vehicles and travelling speed (see tables III.1.1-19 and III.1.1-20).

Table III.1.1-19. Study cases

Case	Traffic volume (vehicles per day)	Percentage of large vehicles (%)	Traveling speed (see note) (km/h)
1	40,000	10	60
2	50,000		
3	60,000		
4	70,000		
5	80,000		
6		5	
7		15	
8		20	
9		10	20
10			40
11			80

Note: Traveling speed is used to set emissions coefficients (see table below).

Table III.1.1-20. Emissions coefficients for nitrogen oxides

(unit: g/km per vehicle)

Traveling speed	Vehicle category		Emissions coefficient ratio (large/small)
	Small vehicles	Large vehicles	
20 km/h	0.073	0.594	8.1
40	0.048	0.353	7.4
60	0.037	0.274	7.4
80	0.040	0.340	8.5

Source: *Environmental Impact Assessment Techniques for Roadways (FY2012 edition)*, MLIT National Institute for Land and Infrastructure Management (2013); MLIT National Institute for Land and Infrastructure Management Document No. 714/Public Works Research Institute Document No. 4254)

Diffusion calculation results:

Table III.1.1-21 and figure III.1.1-5 show forecast results when forecast conditions were changed.

Table III.1.1-21. Forecast results under altered forecast conditions (nitrogen oxides)

Case	Traffic volume (vehicles per day)	Percentage of large vehicles (%)	Traveling speed (km/h)	Average emissions per hour (cc/sec/m)
1	40,000	10	60	0.015
2	50,000			0.018
3	60,000			0.022
4	70,000			0.026
5	80,000			0.029
6		5		0.024
7		15		0.035
8		20		0.041
9		10	20	0.061
10			40	0.038
11			80	0.034

If traffic volume exceeds 10,000 vehicles per day, the increase in average NOx emissions per hour is about 0.004 cc/sec/m. If traffic volume doubles, the per-hour average emissions double as well. Changes in the percentage of large vehicles create a fluctuation of about 0.006 cc/sec/m in per-hour average emissions for every 5% change. Changes in traveling speed create an increase of about 30% at 40 km/h, and increase of about 20% at 80 km/h versus 60 km/h travel. Emissions approximately double at 20 km/h.

A fluctuation in traffic volume of 10,000 vehicles per day can be seen as having a smaller impact on emissions volume than a fluctuation of 5% in percentage of large vehicles of a fluctuation of 20 km/h in traveling speed, but because traffic volume fluctuations affect direct emission intensity, a doubling of traffic volume will also generate double the emissions.

Traveling speed is frequently set based on speed limits and designed speed, which creates the potential for major discrepancies to arise between forecast speeds and actual speeds. Figure III.1.1-5 shows the correlation between traveling speed and emissions volume. It can be observed the difference between 60 km/h and 20 km/h results nearly double the emissions amount, so make sure to consider traffic congestion when setting speeds for urban roads or other areas that are likely to experience reduce speeds due to traffic jams.

The percentage of large vehicles is frequently set based on the characteristics of the planned roadway, according to actual measured results from similar roadways. It may seem like the fluctuation in this value would be relatively small, but like traffic volume, the percentage of large vehicles has a linear relationship with emissions volume—and large vehicles have a high emissions coefficient (7.4 to 8.5 times that of small vehicles for nitrogen oxides, for example (see table III.1.1.-20). For this reason, it is also necessary to consider regular daily and hourly changes in forecast conditions like the percentage of large vehicles.

Forecast conditions like traffic volume and percentage of large vehicle change by the day and by the hour, so it is impossible to fully predict and recreate them. Using figures with the highest possible probability, however, will make the environmental impact assessments more objective and convincing.

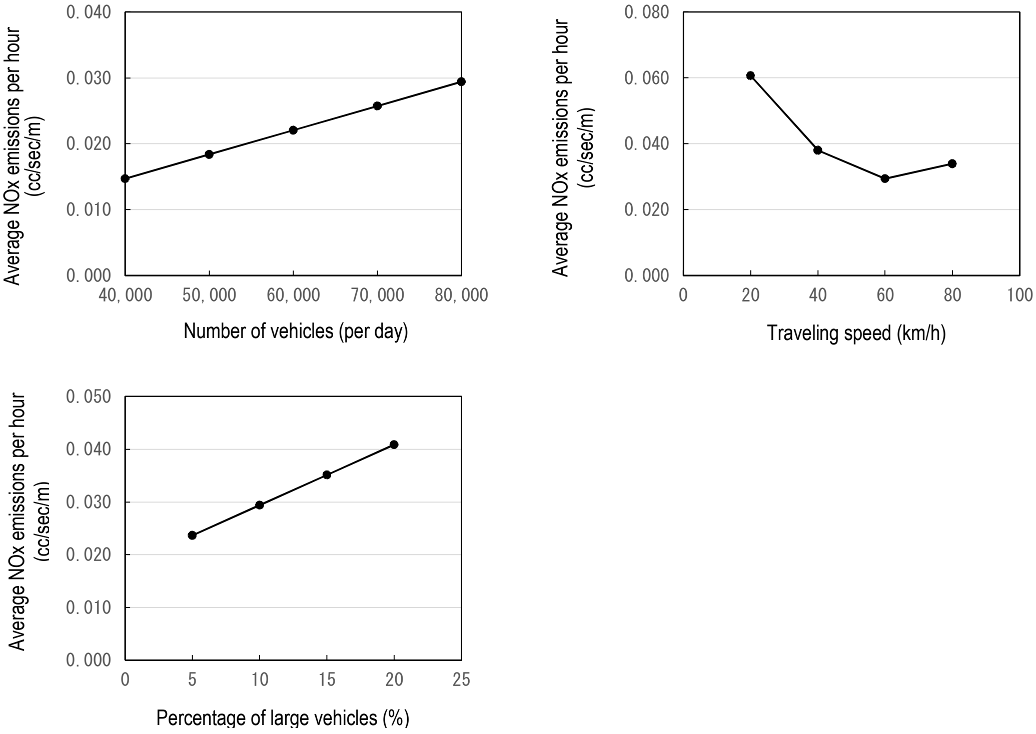


Figure III.1.1-5. Forecast result fluctuations under altered forecast conditions

2) Forecast area/site concepts

As with survey area/site concepts, the concepts project proponents use for forecast areas and sites will change as the scope of impact varies depending on whether they are dealing with fixed sources or with mobile sources like motor vehicles.

With fixed impacts like power plants or production plants, emission conditions are frequently set based on facility operational conditions, making it possible to anticipate forecast conditions to a certain extent. Representative meteorological conditions and smoke source conditions can be used to run trial calculations with the plume model (a general-purpose diffusion model), and project proponents can use a range that includes sites where maximum ground concentration will occur as a guideline for the forecast area.

With motor vehicles and other mobile sources, impacts are limited to a relatively confined area, so a range of between a few hundred meters and a few kilometers from the roadside is a good guideline for the forecast area. In this way, project proponents should use the diffusion characteristics of atmospheric pollutants and the range in which impacts are generally at risk of spreading for each source type as a guideline for setting their forecast area. Table III.1.1-3 lists these guidelines in detail.

When the forecast involves a comparison between atmospheric pollutant emissions from target facilities expected based on project characteristics and from similar existing facilities, project proponents may be able to get by without designating a specific forecast area.

Note also that in most cases forecast sites are set at 1.5 meters high in the vertical direction, but it may be necessary to consider the vertical direction in terms of how facilities are being used in cases where there are elevated structures along roadways or near facilities producing smoke and soot.

3) Forecast period concepts

Longer forecasts are based on annual average values, so consider setting forecast periods as follows.

- A year in which 12 consecutive months of atmospheric pollutants from facilities and equipment reach maximum emission amounts
- A year in which the number of operating facilities and equipment reach their maximum for 12 consecutive months

Even short-term forecast periods can be set in the following ways, using the same concepts as for periods when air pollutant emissions are high.

- A period in which per-day atmospheric pollutants from facilities and equipment reach maximum emission amounts
- A period in which the total number of operating facilities and equipment per-day reaches its maximum

Note that for projects who will go into service in stages, partial operational stages may have greater environmental impacts than the final service stage—making it necessary to set multiple forecast periods corresponding to each stage of the project. For example, project proponents may have roadway project where traffic volume is expected to be higher during partial operation than during the final service stage, or a power plant renovation project where impacts from the partially-operating new facility will occur at the same time as impacts from the existing facility. In this case, the degree of environmental impact during construction will be higher than during the post-renovation steady state.

1.1.4 Environmental mitigation measures

1) Consideration procedures

(1) Examining environmental mitigation measure policies

When considering policies for environmental mitigation measures targeting air quality, possible areas of focus include (a) the status of targets requiring particular consideration in terms of environmental mitigation measures given project and regional characteristics (for example, areas where there are schools or hospitals, or areas where environmental conditions are already significantly compromised or at risk), (b) environmental mitigation measure plans that are possible to carry on (for example, source countermeasures, diffusion process countermeasures, long-term concentration countermeasures, or short-term concentration countermeasures), and (c) targets from regional environmental basic plans and the like (such as protecting regions where the air is clean).

(2) Considering environmental mitigation measures and tracking the investigation process

With air quality, project proponents need to consider specific environmental mitigation measures that target both source facilities and the diffusion process, comparing multiple environmental mitigation proposals (such as elevating smokestacks, changing the arrangement of fixed sources, and introducing efficient NOx removal equipment) as well as looking at whether feasible and better technologies can be introduced. Note that their investigation process also needs to be clearly described and outlined.

(3) Confirming impacts on other environmental components

If project proponents are looking at elevating smokestacks as an environmental mitigation measure for air quality, there are cases where project they will need to reconsider the impact this will have on the landscape. Conversely, if project proponents are considering erecting a new soundproofing wall as an environmental mitigation measure against noise as part of a roadway project, there are times when they will need to reconsider air quality impacts in light of those conditions. In sum, it is important take appropriate steps when adding or adjusting environmental mitigation measures based on a thorough consideration of the degree of impact they will have on other environmental components when there is a chance that their mitigation measures will impact environmental components other than air quality.

2) Environmental mitigation measure details

Basic environmental mitigation measures designed to avoid or reduce air quality impacts can be roughly classified as either (a) countermeasures against sources of atmospheric pollutants or (2) countermeasures against the diffusion process once pollutants are emitted (e.g. maintaining diffusion distance). They can also be classified according to who will implement them; i.e. whether the measures will be carried out by the project proponent or someone else. Table

III.1.1.-22 shows examples of general environmental mitigation measures targeting atmospheric pollutants generated along roadways, while table III.1.1-23 shows examples of general environmental mitigation measures targeting atmospheric pollutants from fixed sources.

Table III.1.1-22. Sample countermeasures for atmospheric pollutants along roadways

Classification	Implemented by	Example countermeasures
Source countermeasures	Third party	・Improving motor vehicle mechanisms ・Measures to improve road networks (constructing loop roads or bypasses) ・Using traffic regulations to address problems
	Project proponent	・Measures to improve road networks (constructing loop roads or bypasses)
Diffusion process countermeasures	Project proponent	・Countermeasures for road structures (addressing basic structures) ・Setting up roadside greenbelts

Table III.1.1-23. Sample countermeasures for atmospheric pollutants from fixed sources

Classification	Implemented by	Example countermeasures
Source countermeasures	Third party	・Curbing emissions of atmospheric pollutants with emissions regulations ・Developing higher-quality fuels
	Project proponent	・Developing and adopting higher-quality fuels ・Introducing desulfurization, denitrification, or dust collection equipment ・Improving fuel technologies
Diffusion process countermeasures	Third party	・Using land-use plans to limit development in dense residential areas
	Project proponent	・Changing smokestack position or height to account for wind direction around the project site, land use conditions, etc.

Tables III.1.1-24 and 1.1-25 show representative examples of environmental mitigation measures for air quality that may be feasibly carried out by project proponents.

Environmental mitigation measures implemented by parties other than project proponents include efforts to reduce the concentration of atmospheric pollutants across the entire region in line with national or local government regulations. Some examples are emissions restrictions on fixed sources, motor vehicle emissions restrictions, the introduction of low-emissions vehicles, and countermeasures against traffic demand.

Table III.1.1-24. Examples of air quality environmental mitigation measures implemented by project proponents

For fixed sources

Target project status	Example environmental mitigation measures	Details	
		Source countermeasure	Diffusion process countermeasure

During construction	Adopting construction equipment with emissions controls	○	
	Using high-quality fuel	○	
	Reconsidering construction areas, leveling out fuel usage	○	
	Setting up temporary enclosures around construction areas		○
	Sprinkling water in the construction area or where construction vehicles come in and out		○
Once facilities are in service	Reconsidering site location (avoiding dense residential areas)		○
	Selecting low-pollutant fuel sources	○	
	Proper fuel management	○	
	Improved (high-efficiency, low-consumption) fuel technologies	○	
	Preventing incomplete combustion through steady operation	○	
	Monitoring operational status/inspecting, maintaining, and managing facilities	○	
	Setting up planting strips (buffer zones) near the project implementation area		○
	Adopting dust /hazardous substance removal equipment	○	
	Reconsidering smokestack position/height		○

Table III.1.1-25. Examples of air quality environmental mitigation measures implemented by project proponents

For mobile sources

Target project status	Example environmental mitigation measures	Details	
		Source countermeasure	Diffusion process countermeasure
During construction	Reconsidering construction vehicle routes		○
	Use of high-quality fuels	○	
	Adopting vehicles that conform to the latest environmental regulations	○	
	Vehicle inspections	○	
Once facilities are in service	Reconsidering routes (avoiding dense residential areas)		○
	Structural considerations (moving facilities underground or creating multi-level structures)		○
	Developing greenbelts or greenspaces		○
	Using dust collectors or other equipment to trap/treat pollutants		○

1.1.5 Evaluations

In addition to evaluations that look at environmental impact avoidance and reduction, evaluations are also conducted to make sure that the selected assessment items are consistent with any standards or targets set forth in environmental conservation policies issued by national or local governments.

1) Evaluation of avoidance and/or reduction

Evaluations of avoidance or reduction describe and assess project proponents' efforts to avoid or reduce environmental impacts as well as the considerations they make towards that end. Some of the methods used to perform these evaluations include comparing multiple environmental mitigation measure proposals and looking at whether proponents are incorporating feasible and better technologies. Other methods assess whether the project will leave the environment worse off than it currently is.

It is important to describe in detail the efforts that the project proponent is making to avoid or reduce impacts within practicable bounds. For example, a project proponent may demonstrate that they have adopted a feasible and better technology to improve the efficiency of their smoke and soot treatment equipment, or that the percentage of air pollutants that the project contributes to existing concentration levels is so small that it will not worsen current conditions.

2) Evaluation of consistency with standards and/or targets

Table III.1.1-26 lists examples of air quality standards and targets issued by the national government and local government agencies.

Table III.1.1-26. Examples of air quality standards and targets

National government	Environmental standards on air pollution based on the Basic Environment Law Environmental and regulatory standards on air pollution based on the Act on Special Measures against Dioxins Regulatory standards based on the Air Pollution Control Act
Local government agencies	Standards based on anti-pollution ordinances and ordinances to protect living environments Standards and targets from environmental basic plans and environmental management plans

Evaluations of consistency with standards and targets assess whether environmental mitigation measures and other initiatives associated with the target project are in line with environmental conservation policies formulated by national or local governments. Start by finding out the relative positioning of reference standards and targets in terms of those policies and then clearly define the concepts guiding the way those standards and targets will be used in evaluations.

Also note that when comparing standards and targets to forecast results, to list both the concentrations contributed by the project and background concentration is needed so that the degree of impact from the project becomes clear.

With background concentration, project proponents must justify the suitability of their figures based on yearlong trends in existing documentation, comparisons against on-site survey results, and so on. When the current air quality status does not conform to environmental standards and project proponents use a future background concentration defined in reduction plans issued by the local government, make sure to consider a future background concentration level that leaves a range of what is expected under that reduction plan. Finally, in cases where effects from environmental mitigation measures implemented by parties other than the project proponent are expected, the prospect of those goals being realized must also be clearly indicated.

Once project proponents have clarified all of the above points, conduct evaluations not only from the perspective of whether their forecast results will conform to standards and targets, but also looking at whether there is a risk that the degree of impact from the target project will hinder environmental conservation in light of those standards and targets.

Points to be considered: Environmental standards vs. regulatory standards

Environmental standards are government-issued targets that stipulate ideal criteria under which environmental conservation should be maintained. They are conceptually different than the regulatory standards in the Air Pollution Control Act. The emissions standards and total emissions control standards stipulated in the Air Pollution Control Act are designed to regulate the emission of air pollutants on the level of individual facilities or individual plants/workplaces, and must be complied with regardless of whether there is an environmental impact assessment in place. Environmental standards, on the other hand, are designed to be achieved and upheld through a wide variety of government policies.

When referring to environmental standards in preparing environmental impact assessments, project proponents must conduct appropriate evaluations not only from the perspective of whether their forecast results conform to those standards, but also with the understanding that they are expected to take steps to avoid or reduce project impacts within practicable bounds in order to keep the components that make up the natural environment in good condition.

Points to be considered: Applying future reduction plans to background concentration

In the past, environmental impact assessments frequently applied future background concentrations taken from air pollution reduction plans or reduction targets issued by local governments. In regions where it is recognized as difficult to uphold the environmental standards in the Air Pollution Control Act or the Law Concerning Special Measures for Total Emission Reduction of Nitrogen Oxides and Particulate Matter (see table II.2-3) these reduction plans and targets establish future goals based on the implementation of a variety of measures.

However, because there are cases where these reduction plans do not produce the expected effects (due to social changes, for example), future background concentration needs to be set within a range taken from expected future concentrations based on yearlong trends as well as those based on reduction plans—taking into account the details and timelines of those reduction plans as well as current and improved air pollution conditions.

Points to be considered: Expected effects from third-party environmental mitigation measures

When project proponents expect that there will be effects from environmental mitigation measures conducted by parties other than themselves, they must include a detailed description of the prospects for those measures. Project proponents can also incorporate the effects of environmental mitigation measures carried out under projects other than the target project if they are being implemented by the same project proponent near the target project implementation area.

Past environmental impact assessments include examples where the Director-General of the Environmental Agency (now the Minister of the Environment) requested that Environmental Impact Statements to be submitted to him/her include information on the efforts of environmental load reductions and air quality improvements prompted by cooperation with relevant agencies .

If project proponents expect that there the effects from environmental mitigation measures conducted by parties other than theemselves will be delivered with a high degree of certainty or can otherwise conduct comprehensive forecasts/evaluations with other projects, they may be able to consider the benefits of working towards total impact reduction across multiple projects. With roadway projects, for example, when multiple road development projects will ultimately lead to the creation of a road network, there may be positive environmental effects resulting from smoother traffic flow (and therefore a reduction in emissions intensity).

Project proponents can consider adding in these positive effects when project proponents conduct their evaluations.

Note that considering the impacts of multiple projects does not always result in benefits—there are times where negative environmental effects may be generated as well. In the previous example, the road networks will also result in greater traffic volume. Make sure project proponents take these points into proper consideration as well.

1.1.6 Follow-up surveys

Because environmental impact assessments are carried out before projects are implemented, follow-up surveys are used to compensate for the uncertainty of their results. In cases where there is a large degree of uncertainty in forecasts or where environmental mitigation measures are carried out without sufficient understanding of their effects, consider whether a follow-up survey is needed based on the severity of environmental impacts. It is also necessary to look at adding or revising environmental mitigation measures as needed based on the results of follow-up surveys.

When conducting follow-up surveys, project proponents will of course need to identify the status of atmospheric pollutant generation resulting from the target project, but they also need to check to make sure that the status of atmospheric pollutant sources in the areas around the project implementation area and changes in social conditions or the development of nearby roads are still in line with what are predicted during forecasts.

Follow-up survey periods must take into account the temporal fluctuations in atmospheric pollution sources depending on the time of day, day of the week, and the season. Ideally, project proponents should look at linking their survey to regional characteristics and forecast/evaluation indicators whenever possible (i.e. hourly values, daily average values, and/or annual average values).

1.2 Offensive odors

1.2.1 *Selection of environmental impact assessment items and survey/forecast/evaluation methods*

1) Understanding project concepts

Table III.1.2-1 shows examples of project characteristics to list under offensive odors.

Table III.2-1. Examples of project characteristics related to offensive odors

Impact factor	Example items
Construction	・ Construction details, methods, time period ・ Construction location, scope
Existence/operation of facilities	・ Facility description, location, size ・ Facility service period ・ Type, concentration, amount, and height of offensive odors emitted from facilities

2) Understanding of regional characteristics

(1) Scope

When setting the survey target area, consider the range that project proponents anticipate being impacted by sources in the project implementation area in order to understand regional characteristics related to offensive odors. Also note that their survey target area may differ depending from the project implementation area on the kinds of sources that are generating impacts.

(2) Listing up natural and social conditions in the region

Tables III.1.2-2 and III.1.2-3 show examples of natural and social conditions to list for the region. Existing documentation on offensive odors frequently only includes complaint statistics, but project proponents can identify the current status of offensive odors and living conditions in the region by looking at on-site survey sin conjunction with land use status.

Table III.1.2-2. Examples of natural conditions related to offensive odors

Classification	Description of example items
Air quality conditions	(a) Offensive odor conditions Except in cases where there are particularly notable sources of offensive odors, offensive odor conditions are normally limited to the preparation of complaint statistics by local governments. To determine the status of offensive odors in the target region, project proponents will need to conduct an on-site survey in order to identify regional characteristics. (b) Meteorological conditions Many weather observatories, weather bureaus, and other meteorological offices collect meteorological observations, as do continuous air quality measuring and monitoring stations, schools, and municipal offices.
Topographical conditions	Check for topographical conditions that can affect the diffusion of offensive odors. These include whether the terrain is flat or mountainous, its position in relation to ocean areas or rivers, and valley formations.
Status of plant/animal habitats and/or vegetation and ecosystems	Situations in which there are concerns that the generation of offensive odors may impact animals or ecosystems include those in which the odors may trigger aversive behavior in animals. In these cases, project proponents need to look at the interrelationships between odors and animals/ecosystems and select survey ranges and methods accordingly.
Status of places for activities with nature	Situations in which there are concerns that the generation of offensive odors may impact places for activities with nature include cases where important places for activities with nature are subject to the effects of those odors. In these cases, project proponents need to look at the interrelationships between odors and conditions in places for activities with nature and select survey ranges and methods accordingly.

Table III.1.2-3. Examples of social conditions related to offensive odors

Classification	Description of example items
Population and industrial features	(a) Population features Identify the size and distribution of the population in the survey target area. (b) Industrial features When looking at industrial activity in the survey target area and the status of industrial activities that generate offensive odors, get a statistical summary of the conditions and identify the location of key facilities. There are sometimes production plants or other sources that generate distinct offensive odors in the region so make sure to use an on-site survey in conjunction with their

<table>
<tr><td></td><td>research in order to understand these as well. If there are industries that project proponents anticipate being vulnerable to impacts from offensive odors, identify the location of their key facilities as well.

Example: Manufacturing industries (e.g. dried food processing) that involve sun-drying</td></tr>
<tr><td>Land usage conditions</td><td>(a) Land usage
Project proponents can typically get an understanding of land usage conditions by looking at a land usage map. In some cases, they will also need to make use of vegetation maps, aerial photos, and other general documents and/or on-site surveys.

(b) Zoning designations
Urban planning maps are the primary source for identifying the status of zoning designations in the survey target area. Project proponents also need to refer to general plans and other documents issued by local governments in when looking at future impacts so that they understand the direction of upcoming land usage trends.

(c) Status of manmade structures
Project proponents can usually get a general idea of the manmade structures (such as large buildings) that will impact the diffusion of offensive odors by looking at topographical and residential maps.</td></tr>
<tr><td>Status of targets considered particularly vulnerable to impacts</td><td>(a) Distribution of facilities considered particularly vulnerable to impacts
Identify facilities likely to be particularly vulnerable to impacts from offensive odors in addition to general land usage conditions in the area.

<table>
<tr><th>Classification</th><th>Example facilities</th></tr>
<tr><td>Educational facilities</td><td>Nursery schools, kindergartens, elementary schools, junior high schools, high schools, universities, vocational schools, and other schools</td></tr>
<tr><td>Medical facilities</td><td>Hospitals, clinics offering residential services, long-term care facilities, etc.</td></tr>
<tr><td>Other public facilities</td><td>Libraries, foster homes, social services facilities, etc.</td></tr>
<tr><td>Parks</td><td>Children’s playgrounds, city parks, etc.</td></tr>
</table>

(b) General distribution of residential areas
In addition to looking at the status of zoning designations stemming from land usage conditions and urban planning laws, project proponents should ideally use on-site surveys to get an up-to-date picture of residential distribution.

Project proponents should also understand the possibility of future residential development by looking at general plans and other documents indicating, for example, land usage incentive policies by various local government agencies.</td></tr>
<tr><td>Status of legally-designated areas and regulations</td><td>Identify the regulatory standards, target values, and designated regions set forth in relevant laws and regulations.
• Offensive Odor Control Law
• Pollution prevention plans
• Local ordinances to prevent pollution, protect living environments, etc.
• Local basic environment plans</td></tr>
</table>

3) Selecting environmental impact assessment items

(1) Listing up impact factors and environmental components

In listing impact factors related to offensive odors, project proponents need to consider not only the specified offensive odor substances stipulated in the Offensive Odor Control Act (see table III.1.2-4), but also the characteristics of the facilities acting as a source of these substances. Take into account a scope of anticipated impacts that includes secondary odors (such as those generated from wastewater) as well as offensive odors directly produced within the project implementation area.

Table III.1.2-4. Key sources of specified offensive odor substances under the Offensive Odor Control Act

Substance	Main sources
Ammonia	Livestock areas, chemical plants, fecal sludge treatment plants
Methyl mercaptan	Pulp factories, chemical plants, fecal sludge treatment plants
Hydrogen sulfide	Livestock areas, pulp factories, fecal sludge treatment plants
Methyl sulfide	Pulp factories, chemical plants, fecal sludge treatment plants
Dimethyl sulfide	Pulp factories, chemical plants, fecal sludge treatment plants
Trimethylamine	Livestock areas, chemical plants, seafood canneries
Acetaldehyde	Chemical plants, fishbone processing plants, tobacco plants
Propionaldehyde	Plants that use a baked-paint process
Normal butyraldehyde	Plants that use a baked-paint process
Isobutyraldehyde	Plants that use a baked-paint process
Normal barrelaldehyde	Plants that use a baked-paint process
Isovaleraldehyde	Plants that use a baked-paint process
Isobutanol	Plants that use a coating process
Ethyle acetate	Plants that use a coating or printing process
Methyl isobutyl ketone	Plants that use a coating or printing process
Toluene	Plants that use a coating or printing process
Styrene	Chemical plants, FRP product manufacturing plants
Xylene	Plants that use a coating or printing process
Propionic acid	Fatty acid manufacturing plants, dyeing plants
Normal butyric acid	Livestock areas, chemical plants, starch factories
Normal valeric acid	Livestock areas, chemical plants, starch factories
Isovaleric acid	Livestock areas, chemical plants, starch factories

Source: *Offensive Odor Control Act Handbook (Sixth Edition)*, Japan Association on Odor Environment (2012)

(2) Selection of environmental impact assessment items

Select environmental impact assessment items based on the relationships between impact factors and environmental components.

Points to be considered

In situations where it becomes clear that (1) there are no environmental impacts related to the environmental impact assessment items or the level of environmental impact is extremely small; or (2) the project implementation area and its surroundings do not include areas or targets subject to environmental impacts related to those items for the given period, it is possible that none of the items will be selected for the environmental impact assessment. In cases like these, be sure to include information in the Scoping Document and other documents under “target project details” and “general conditions in the area” that provides a rationale for their decision.

Note that “areas or targets subject to environmental impacts” in (2) above refers to areas connected to human living environments as well as the presence of natural environments subject to the generation of offensive odors. It is clear that targets do not exist “for the given period” when they are not in existence during the life of the project or while it is in service, or the project construction period at the very least—as indicated by land usage regulations, land usage incentive policies, and the like. Prefectural governors designate regulated areas under the Offensive Odor Control Act, but consider the fact that exclusive industrial zones also designate areas where offensive odors are restricted.

4) Selection of survey, forecast, and evaluation methods

(1) Method selection concepts

The Offensive Odor Control Act stipulates that prefectural governors (or mayors in cities) designate, in consideration of natural and social conditions, regulatory standards on an “odor index" or "specified offensive odor substances" in areas in which control of offensive odors is needed.

Environmental impact assessments on offensive odors use different survey and forecasting methods depending on the odor indices used for the target project or the concentration of specified offensive odor substances. For this reason, project proponents need to clarify the targets of their evaluation before selecting a forecast method in line with regional characteristics, and then select the survey methods needed to conduct those forecasts.

(2) Refining and simplifying survey and forecast methods

Refining offensive odor survey and forecast methods may involve conducting detailed on-site surveys in order to collect information on the conditions needed to examine forecasts and environmental mitigation measures, densely distributing survey and forecast sites, or adopting sophisticated forecast methods. Simplifying survey and forecast methods may involve using existing documentation to determine the conditions needed for forecasts or adopting forecast methods that identify the degree of impact using emission volume calculations or comparisons with similar case examples.

The following are some examples that will help determine whether to apply refined or simplified survey/forecast methods.

Examples of situations when more detailed methods should be considered

1. When the degree of environmental impact is likely to be significant
2. When the region is vulnerable to environmental impacts or there are vulnerable targets
3. When the region is legally-designated for environmental conservation or when there are legally-designated targets
4. When the regional environment is already significantly compromised or at high risk
5. When project or regional characteristics will likely make it difficult to conduct forecasts using general-purpose methods
    - Areas with complex diffusion conditions due to unique topography or other characteristics
    - When structural or other characteristics create complex source or diffusion conditions
6. When local governments or project proponents have specific priorities when it comes to environmental conservation
    - When local governments or project proponents have determined that environmental conservation must be prioritized in light of regional characteristics, project characteristics and/or environmental conservation policies in the project

Examples of situations when simplifying methods should be considered

1. When it is clear that the degree of environmental impact will be minimal
    - When project plan details make it possible to explain that the degree of environmental impact will be minimal, project proponents may be able to use that as a rationale for simplifying their forecasts.
2. When it is clear that there will not be any regions subject to environmental impact or any targets for a certain period of time
    - When it is clear that there are no residences, facilities, or other targets in the area at risk for impacts from offensive odors, either currently in the future, project proponents may be able to use offensive odor emission output for forecasts rather than calculating diffusion, for example, for the areas where there are no regions or targets subject to impacts.
3. When it is clear from similar case examples that environmental impacts will be minimal
    - When the degree of impact can be estimated from surveys and other case examples from similar projects, that data could be used for forecasts.

1.2.2 Surveys

1) Selection of survey items

As shown in table III.1.2-5, key survey items include current concentration and other features of offensive odors selected as environmental components as well as meteorological conditions. However, it is important that project proponents select items that will allow them to supplement insufficient information from surveys in existing documentation or on-site surveys so that they can obtain the information project proponents need to conduct forecasts and evaluations.

Table III.1.2-5. Description of key survey items for environmental impact assessments on offensive odors

Survey item	Description
Offensive odor conditions	Concentration of specified offensive odor substances, odor index
Meteorological conditions	Wind speed/direction
	Solar radiation, radiation balance
	Upper air temperature/humidity

2) Survey method concepts

The Offensive Odor Control act stipulates official measurement methods for measuring offensive odors, so in general project proponents should follow these methods. Table III.1.2-6 shows some of the advantages and drawbacks of each official method used to measure offensive odors.

Table III.1.2-6. Advantages and drawbacks of official methods for measuring offensive odors

Evaluation target	Odor index	Specified offensive odor substances
Measurement method	Olfactory measurement method	Instrumental analyses
Advantages	• Ability to handle what are thought to be tens of thousands of types of odorous	• Maintaining precision is easy in principle • Allows for a certain level of qualitative

	substances • Ability to assess the synergistic and offset effects of irregular, complex odors as well • Use of the olfactory sense makes it easy to get a real sense of what numerical results mean • Can identify the lower detection limit so measures can only address human olfactory perception • Inexpensive equipment costs	analysis of key components if a gas chromatography–mass spectrometer is used • Continuous measurement can be performed for certain substances • Multiple specimens can be measured in a short period of time • Concentrations can be quantified for each substance
Drawbacks	• No standardized smells, requires technology for precision management • Not suited to estimated contribution ratios from key components • Cannot perform continuous measurements • Testers (operators) must have knowledge and experience	• Unable to determine correlation to subjective intensity except with single substances • Frequently impossible to qualify/quantify all unknown substances comprising a given smell • Measurements themselves are difficult, and anticipated lower limits are higher than human thresholds for some substances • High equipment costs

Source: *Odor Index Regulatory Guidelines*, Environmental Management Agency, Ministry of the Environment (2001)

3) Survey area/site concepts

(1) Survey area

The survey area is determined based on project characteristics (such as the type and location of sources) as well as regional characteristics derived from both natural characteristics (such as weather or topography) and social conditions (such as schools, hospitals, or other facilities requiring particular consideration in terms of environmental conservation or the distribution of residences). The range should also include sites that will experience maximum impacts from project implementation.

In general, the survey area will include a range within which offensive odors due to project implementation will rise to a certain level or higher as well as encompass the forecast area described later. This range can change based on project size/details and regional characteristics, so err on the side of caution by making it larger than project proponents might need once they have accounted for forecast uncertainty.

(2) Survey sites

Table III.1.2.-7 presents concepts for determining survey sites when conducting on-site surveys.

Table III.1.2-7. Concepts for determining offensive odor survey sites

Site classification	Site determination concepts
Sites representative of the area	If project proponents are designating survey sites that will help project proponents identify the representative status of offensive odors in the survey area, select locations with stable meteorological conditions and little impact from neighboring sources.
Sites at risk for particularly major impacts	If project proponents are designating sites where project proponents anticipate impacts from the project to be particularly large (sites estimated to have maximum ground concentration or project site boundaries, for example), select an approximate location based on project characteristics and similar case examples. It is

	also necessary to make sure that the site project proponents select has little impact from other sources.
Sites with targets requiring particularly careful consideration of environmental conservation	If project proponents set forecast sites that include residences or facilities requiring particularly careful consideration of environmental conservation (such as schools or hospitals), and they expect that conditions there will be different than the sites representative of the area due to impacts from roads or other sources, select these locations as survey sites.
Sites where environmental conditions are already significantly compromised	Select sites that are considered to have already experienced deterioration in terms of offensive odor conditions due to impacts from fixed or other sources.
Sites where pollution or other environmental harm is already advancing	Identify conditions prior to project implementation in locations that are considered to already be generating offensive odors due to other nearby sources. This will allow project proponents to distinguish project impacts from other impacts.

4) Survey period and timing concepts

Offensive odor conditions are profoundly affected by meteorological conditions related to advection and diffusion. When deciding on a survey period and timing, project proponents must select a period during which offensive odor issues are likely to arise, considering meteorological conditions as well as seasonal fluctuations in the concentration of odorous substances. Summer, for example, is a time when offensive odors are more readily generated and when people tend to have their windows open; while winter is when ground inversion layers tend to form, making it difficult for odorous substances to disperse. Project proponents also need to consider periods when residences or other targets will be downwind.

1.2.3 Forecasts

1) Forecast method concepts

Table III.1.2-8 shows examples of forecast methods for offensive odors. If project proponents are conducting a forecast based on similar case examples, project proponents need to consider the similarities and differences with their target project and clearly indicate the reasons for their selection of that case.

Table III.1.2-8. Examples of forecast methods for offensive odors

Method		Overview	Forecast conditions
Analyzing similar case examples	Odor intensity distance attenuation curve	• Measures odor intensity downwind from similar facilities and charts the correlation between downwind distance and odor intensity (using a curve, for example), and then uses it to estimate odor intensity from target project sources. • To get odor index forecasts, convert the odor intensity attenuation curve to an odor concentration attenuation curve and use the odor concentration to calculate the odor index.	・Odor intensity and other data from similar existing case examples
	Odor concentration diffusion dilution rate	• Measures odor concentration and downwind odor concentration from sources at similar facilities to find odor concentration diffusion dilution rate. Use it to find odor concentration for target project sources and use that concentration to calculate the odor index.	・Odor concentration and other data from similar existing case examples

	Creating statistical models	• Uses source data, ambient odor data, and survey results on meteorological conditions and other factors to create a statistical model that explains the ambient odor data. It is then applied to sources, meteorological conditions, and other project-related factors to forecast odor concentration, which can in turn be used to calculate odor index.	・Data on odor concentration, meteorological conditions, generation intensity, etc. from similar existing case examples ・Data on project source conditions, meteorological conditions, etc.
Calculations based on atmospheric diffusion models		• Runs theoretical calculations based on an atmospheric diffusion model and then uses them to forecast the concentration of offensive odor substances and odor concentration. • Assesses short-term offensive odor values, so must be supplemented based on variations in sample collection times.	・Wind speed/direction, atmospheric turbulence, and other meteorological data (long-term) ・Concentration of odorous substances or TOER (OER) and amount of emission gas ・Position and height (effective smokestack height) of emissions sources
Model testing	Wind tunnel experiments	• This forecast method uses wind tunnel experiments to find maximum concentration values, range, etc. for odorous substances.	・Topographical data, data on natural features
	Outdoor experiments	• This forecast method uses a tracer gas to test on-site diffusion.	
Rough rule-of-thumb forecasts using TOER		• This is simplified forecasting for TORE (or OER) gained empirically from project size and type plus TOER/OER coverage. • Effective for setting survey scope	・Rules of thumb (empirical assumptions)

Source: Prepared based on the *Manual on Nagano Prefecture Environmental Impact Assessment Technique Guidelines*, Environmental Division, Nagano Prefecture (2016)

2) Forecast area/site concepts

In general, the forecast area needs to include a range within which offensive odors due to project implementation will rise to a certain level or higher as well as encompass the survey area. This range can change based on project size/details, and must be considered in light of forecast uncertainty and regional characteristics—so err on the side of caution by making it larger than project proponents might need. Note that project proponents may also be able to use a forecast area that is smaller than their survey area in situations where project proponents have determined from their survey results that certain areas do not need to be subject to forecasts.

As with forecasts of atmospheric pollutants from fixed sources, representative meteorological conditions can be used to run trial calculations with the plume model (a general-purpose diffusion model), and project proponents can use a range that includes sites where maximum ground concentration will occur as a guideline for the forecast area.

3) Forecast period concepts

The forecast period should be the period during which project proponents anticipate offensive odor impacts during construction (e.g. based on the type of construction being carried out) and the post-service period where project facilities will reach steady-state operation. Note that as with the survey period, they need to consider meteorological conditions, the arrangement of residences, and so on in order to determine the period during which offensive odors will have greater impact.

1.2.4 Environmental mitigation measures

1) Consideration procedures

(1) Examining environmental mitigation measure policies

When considering policies for environmental mitigation measures targeting offensive odors, possible areas of focus include (a) targets requiring particular consideration in terms of environmental mitigation measures given project and regional characteristics (for example, areas where there are schools or hospitals, or areas where environmental conditions are already significantly compromised or at risk) and (b) environmental mitigation measure plans that are possible to carry out (source countermeasures or diffusion process countermeasures).

2) Environmental mitigation measure details

Table III.1.2-9 shows representative examples of environmental mitigation measures for offensive odors that are considered feasible for project proponents to implement.

Table III.1.2-9. Examples of environmental mitigation measures for offensive odors

For fixed sources

Target project status	Example environmental mitigation measures	Details	
		Source countermeasure	Source countermeasure
During construction	Setting up temporary enclosures around construction areas		○
	Controlling the volatilization of odorous substances, setting up deodorizing equipment	○	
	Setting up odor removal facilities, spraying deodorizing agents, using soil for cover		○
Once facilities are in service	Reconsidering site location (avoiding dense residential areas)		○
	Monitoring operational status/inspecting, maintaining, and managing facilities	○	
	Setting up planting strips (buffer zones) near the project implementation area		○
	Reconsidering the position of odor emissions points		○
	Controlling the leakage of odors from structures	○	
	Controlling the volatilization of odorous substances, setting up deodorizing equipment	○	
	Setting up odor removal facilities, spraying deodorizing agents, using soil for cover		○

1.2.5 Evaluations

In addition to evaluations that look at environmental impact avoidance and reduction, evaluations are also conducted to make sure that the selected assessment items are consistent with any standards or targets set forth in environmental conservation policies issued by national or local governments.

1) Evaluation of avoidance and/or reduction

Evaluations of avoidance or reduction describe and assess project proponents' efforts to avoid or reduce environmental impacts as well as the considerations they make towards that end. Some of the methods used to perform these evaluations include comparing multiple environmental mitigation measure proposals and looking at whether proponents are incorporating feasible and better technologies. Other methods assess whether the project will leave the environment worse off than it currently is.

2) Evaluation of consistency with standards and/or targets

Table III.1.2-10 lists examples of offensive odor standards and targets issued by the national government and local government agencies.

Table III.1.2-10. Examples of offensive odor standards and targets

National government	Regulatory standards based on the Offensive Odor Control Act
Local government agencies	Standards based on anti-pollution ordinances and ordinances to protect living environments Standards and targets from environmental basic plans and environmental management plans

Evaluations of consistency with standards and targets assess whether target project implementation is in line with environmental conservation policies formulated by national or local governments. Start by finding out the relative positioning of reference standards and targets in terms of those policies and then clearly define the concepts guiding the way those standards and targets will be used in their evaluations.

Also note that when comparing standards and targets to forecast results, it is important to conduct evaluations not only from the perspective of whether project proponents' forecast results will conform to standards and targets, but also looking at whether there is a risk that the degree of impact from the target project will hinder environmental conservation in light of those standards and targets.

1.2.6 Follow-up surveys

Because environmental impact assessments are carried out before projects are implemented, follow-up surveys are used to compensate for the uncertainty of their results. In cases where there is a large degree of uncertainty in forecasts or where environmental mitigation measures are carried out without sufficient understanding of their effects, consider whether a follow-up survey is needed based on the severity of environmental impacts. Project proponents must also look at adding or revising environmental mitigation measures as needed based on the results of follow-up surveys.

When conducting follow-up surveys, project proponents will of course need to identify the status of odorous substance generation resulting from the target project, but they also need to check to make sure that the status of offensive odor sources in the areas around the project implementation area and changes in social conditions are still in line with what they predicted during forecasts.

When conducting surveys, the survey period should ideally take into account characteristics of the target region, forecast/evaluation times, and so on in line with the temporal fluctuations in odorous substance sources (according to the time, day of the week, and season).

1.3 Noise and Infrasound[6]

1.3.1 Selection of environmental impact assessment items and survey/forecast/evaluation methods

1) Understanding of project characteristics

Table III.1.3-1 shows examples of project characteristics to list under noise.

Common sources of infrasound include overpasses, dam discharge, tunnel exits, and large boilers, but it is difficult to determine whether these will become sources of infrasound during the project planning stage. For this reason, project proponents should ideally refer to case examples of past complaints regarding infrasound and see whether they have similar characteristics to the target project.

Table III.1.3-1. Examples of project characteristics related to noise

Impact factor	Example items

---

[6] Infrasound: While the definition of "low-frequency noise" varies from country to country, in Japan, the term has been customarily used for "generally 100 Hz or lower". The International Electrotechnical Commission (IEC) 61400 Standards series defines sound of 20 Hz or lower as infrasound, and that between 20 Hz and 100 Hz as low-frequency noise. Based on this, JIS C 1400-0:2005 (Wind Turbine Generator Systems - Part 0: Glossary of Terms for Wind Turbine Generator Systems) carries the same definition. Accordingly, competent ministry ordinances prescribing technical guidelines for individual business types under the Environmental Impact Assessment Act are consistent with international definitions, and regulate noise (including noise of a frequency of 20–100 Hz), and infrasound (noise of a frequency of 20 Hz or lower). The term "low-frequency noise" is not used. This guide therefore refers to noise of 20 Hz or lower as "infrasound", and noise outside of this frequency range (including noise of a frequency of 20–100Hz) as "noise".

Construction	・ Construction details, methods, time period ・ Construction location, scope ・ Types and number of facilities and equipment used in construction, operating location, operating period, etc. ・ Number of construction vehicles in operation, type (large/small), period, route ・ Plans for temporary structures, soil pits, areas where soil generated from construction will be taken in and out, etc. ・ Propagation process
Existence/operation of facilities	・ Facility description, location, size ・ Facility service period ・ Type/size of sources ・ Amount of traffic congestion generated by the facilities, types of vehicles (large/small) ・ Routes for traffic congestion generated ・ Propagation process

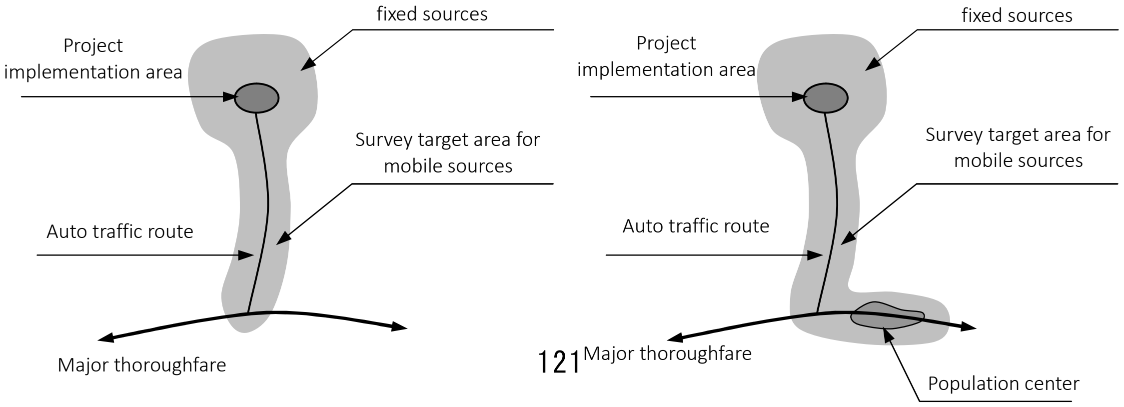
2) Understanding of regional characteristics

(1) Scope

When setting the survey target area, project proponents need to consider the range that they anticipate being impacted by mobile sources (such as motor vehicles) in addition to the range that project proponents anticipate being impacted by sources in the project implementation area in order to understand regional characteristics related to noise. Also note that their survey target area may differ from the project implementation area depending on the kinds of sources that are generating impacts. As an example, table III.1.3-2 lists concepts for determining survey target areas based on impact factors, while figure III.1.3-1 shows examples of survey target areas involving mobile sources.

Table III.1.3-2. Concepts for using impact factors to determine survey target area

Impact factor	Target survey area concepts
Fixed sources	When sources of noise are fixed (such as production plants) or when mobile sources will be limited to a specific area during construction (as in the case of construction equipment), the scope of the survey target area should include the area in which project proponents anticipate a certain amount of impact from noise due to those sources. Targets should also take into consideration the scope of impact from past case examples as well as various conditions such as the topography around the sources, surface structures, and so on.
Mobile sources	When sources of noise are mobile (such as motor vehicles and trains), the survey target area should include the area where project proponents anticipate a certain amount of impact from those mobile sources themselves as well as along their routes. Also take into consideration the environmental conditions in the surrounding area.



(A) Extending to an important main thoroughfare (B) Extending to an area particularly vulnerable to impacts

Figure III.1.3-1. Examples of survey target areas involving mobile sources

(2) Listing up natural and social conditions in the region

Tables III.1.3-3 and III.1.3-4 show examples of natural and social conditions to list for the region. Most of the existing documentation on noise has data on isolated points at low density, so on-site surveys need to supplement this information with data on regional characteristics between these points. Project proponents can find out the characteristics of daily life in the region and how roads are being used, for example, by looking at on-site surveys on the status of sources as well as of land and road usage. It is important that they are able understand the characteristics of daily life in the region as well as the status of road usage and noise generation, and also that they actually experience (listen to) noise being generated in the area.

Ideally, when looking at the measurement points used in existing documentation, project proponents should also use on-site surveys to identify the topography, natural features, and condition of sources in the surrounding area. It is also a good idea to check for information on complaints related to infrasound, and low-frequency noise.

Table III.1.3-3. Examples of natural conditions related to noise and infrasound

Classification	Description of example items
Air quality conditions	(a) Noise conditions Noise measurements related to traffic, railways, and aircraft are typically taken by national, prefectural, and municipal governments. Collect and organize this measurement data. Target measurements sites should basically be those closest to the project implementation area, but it is also important to understand the characteristics of the survey target area by collecting data from multiple measurement sites nearby. For each data source, make sure to collect and organize the latest data in consideration of traffic volume and other fluctuations throughout the year. Check local government complaint statistics for information on low-frequency noise. (b) Infrasound conditions Except in cases where there is a clear source of infrasound, it is not possible to obtain information on infrasound conditions.
Topographical conditions	Check for topographical conditions that could impact the propagation of noise, such as whether the terrain is flat of mountainous.
Status of animal habitats and/or ecosystems	Situations in which there are concerns that noise generation may impact animals or ecosystems include those in which the noise may trigger aversive behavior in animals. In these cases, project proponents need to look at the interrelationships between noise and animals/ecosystems and select survey ranges and methods accordingly.

Status of places for activities with nature	Situations in which there are concerns that noise generation may impact places for activities with nature include areas where impacts from construction noise are expected and there are campgrounds, for instance, whose usage characteristics may change as a result of that noise. In these cases, project proponents need to look at the interrelationships between noise and conditions in places for activities with nature and select survey ranges and methods accordingly.

Table III.1.3-4. Examples of social conditions related to noise and infrasound

<table>
<tr><th>Classification</th><th>Description of example items</th></tr>
<tr><td>Population and industrial features</td><td>(a) Population features
Identify the size and distribution of the population in the survey target area.

(b) Industrial features
When looking at industrial activity in the survey target area and the status of industrial activities that generate noise, get a statistical summary of the conditions and identify the location of key facilities. If there are industries that project proponents anticipate being vulnerable to impacts from noise, identify the location of their key facilities as well.

Examples: Stock farms, poultry farms, etc.</td></tr>
<tr><td>Land usage conditions</td><td>(a) Land usage
Project proponents can typically get an understanding of land usage conditions by looking at a land usage map. In some cases, project proponents will also need to make use of vegetation maps, aerial photos, and other general documents and/or on-site surveys.

(b) Zoning designations
Urban planning maps are the primary source for identifying the status of zoning designations in the survey target area. Project proponents also need to refer to general plans and other documents issued by local governments in when looking at future impacts so that they understand the direction of upcoming land usage trends.

(c) Status of aboveground structures
Check to see if there are conditions that would impact noise propagation. Project proponents can usually get a general idea of the situation based on topographical and residential maps.</td></tr>
<tr><td>Traffic conditions</td><td>(a) Motor vehicle traffic volume
When there will be construction work or the existence/use of land or structures and project proponents are looking at whether to select noise impacts from motor vehicle traffic as a target for environmental impact assessment, identify traffic volume conditions along target roadways.

Motor vehicle traffic volume conditions can be found by looking at traffic volume measurements along major roadways found in traffic censuses (nationwide road traffic survey), and prefectures and municipalities sometimes measure traffic volume as well. Collect and organize the information project proponents find in these documents. The information items project proponents collect during the item/method selection stage should include 24-hour traffic volume, 12-hour traffic volume, percentage of large vehicles, and level of traffic congestion.

Note that if documentation does not exist for target roadways, project proponents should ideally conduct an on-site survey to get a general idea of traffic conditions. They also need consider the possibility of future changes in traffic volume by looking at road plans as well as development plans in surrounding areas.

(b) Railways
If railways already run through the survey area and may be generating noise impacts, identify the type, location, and service frequency of the trains.

(c) Airports
If aircraft are taking off and landing within the survey area and may be generating noise impacts, identify their type, location, and number of flights as well as their flight paths.</td></tr>
<tr><td>Status of targets considered particularly vulnerable</td><td>(a) Distribution of facilities considered particularly vulnerable to impacts
Identify facilities likely to be particularly vulnerable to impacts from noise in addition to general land usage conditions in the area.

<table><tr><th>Classification</th><th>Example facilities</th></tr></table></td></tr>
</table>

<table>
<tr><td>to impacts</td><td>
<table>
<tr><td>Educational facilities</td><td>Nursery schools, kindergartens, elementary schools, junior high schools, high schools, universities, vocational schools, and other schools</td></tr>
<tr><td>Medical facilities</td><td>Hospitals, clinics offering residential services, long-term care facilities, etc.</td></tr>
<tr><td>Other public facilities</td><td>Libraries, foster homes, social services facilities, etc.</td></tr>
<tr><td>Parks</td><td>Children’s playgrounds, city parks, etc.</td></tr>
</table>

(b) General distribution of residential areas
In addition to looking at the status of zoning designations stemming from land usage conditions and urban planning laws, project proponents should ideally use on-site surveys to get an up-to-date picture of residential distribution. Particularly when it comes to noise, they need to have information on residential height (low, mid-rise, or high-rise).

Project proponents should also understand the possibility of future residential development by looking at general plans and other documents indicating, for example, land usage incentive policies by various local government agencies.</td></tr>
<tr><td>Status of legally-designated areas and regulations</td><td>Identify the environmental standards, regulatory standards, target values, and designated regions set forth in relevant laws and regulations.
• Basic Environment Law (Environmental Standards on Noise)
• Noise Regulation Act
• Noise countermeasure guidelines for new construction or major renovations of conventional rail lines
• Law on the Prevention of Disturbances from Aircraft Noise in the Vicinity of Public Airports
• Act on Special Measures concerning Countermeasures against Aircraft Noise around Specified Airports
• Act on Improvement of Living Environment of Areas Around Defense Facilities
• Pollution prevention plans
• Local ordinances to prevent pollution, protect living environments, etc.
• Local environmental basic plans</td></tr>
</table>

3) Selection of environmental impact assessment items

(1) Listing up impact factors and environmental components

Tables III.1.3-5 and III.1.3-6 list impact factors related to noise and infrasound, looking at the sources of noise and infrasound as well as conditions for each source.

Table III.1.3-5. Key sources of noise by type and main conditions impacting noise level

Type	Main conditions impacting noise level
Road traffic noise	Road location, road structure, number of lanes, road surface conditions, time-specific traffic volume, percentage of large vehicles, average traveling speed, soundproofing measures
Railway noise	Track location, track structure, train car type, traveling frequency, traveling speed, soundproofing measures
Aircraft noise	Type of aircraft, generated noise level, number of takeoffs and landings, airfield/airport usage time, flight path, takeoff/landing angles, usage status of areas around the airfield/airport, soundproofing measures
Noise from production plants or other workplaces	Type, location, and size of production plant/workplace, noise generation times, noise level in standard locations, sound source power level, soundproofing measures
Construction noise	Type, location, and size of sources, construction equipment usage times, noise generation times, conditions at the construction site, soundproofing measures
Wind power generation facilities	Type, location, and number of wind turbines, apparent sound power level of sound sources, soundproofing measures

Source: Prepared based on *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

Table III.1.3-6. Key sources of infrasound

Type	Source
Production plants	Compressors, ventilators, melting furnaces, boilers, etc. Vibration from factory buildings, etc.
Transportation	Aircraft, marine vessels, trains (passing through tunnels), bridges (roadways), etc.
Other	Blasting, dam discharge

Source: Prepared based on *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

(2) Selecting environmental impact assessment items

Select environmental impact assessment items based on the relationships between impact factors and environmental components.

Points to be considered

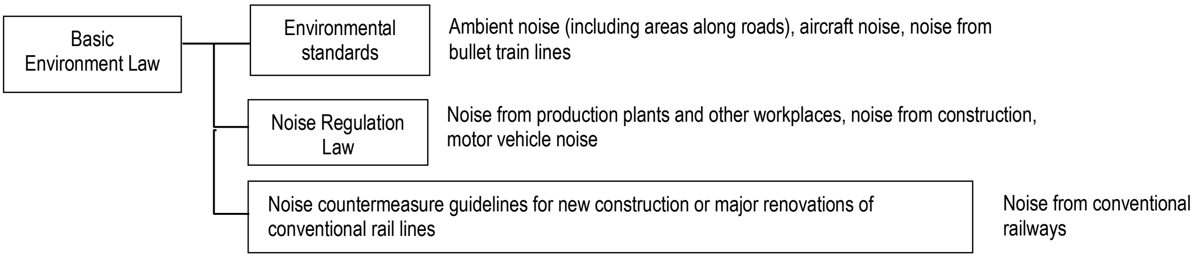
In situations where it becomes clear that (1) there are no environmental impacts related to the environmental impact assessment items or the level of environmental impact is extremely small; or (2) the project implementation area and its surroundings do not include areas or targets subject to environmental impacts related to those items for the given period, it is possible that none of the items will be selected for the environmental impact assessment. In cases like these, be sure to include information in the Scoping Document and other documents under "target project details" and "general conditions in the area" that provides a rationale for their decision.

Note that "areas or targets subject to environmental impacts" in (2) above refers to areas connected to human living environments as well as the presence of natural environments subject to the generation of noise and infrasound. It is clear that targets do not exist "for the given period" when they are not in existence during the life of the project or while it is in service, or the project construction period at the very least—as indicated by land usage regulations, land usage incentive policies, and the like. This corresponds, for example, to localized noise/infrasound impacts in a construction zone where there are no residents or natural environments requiring consideration. Note that noise in mountainous areas or other locations where there are no residences may still affect animals, so this needs to be considered in the selection of items as well.

4) Selection of survey, forecast, and evaluation methods

(1) Method selection concepts

As Figure III.1.3-2 shows, noise is regulated by environmental standards on ambient noise, aircraft noise, and so on as well as regulatory standards under the Noise Regulation Act. In some cases, laws and regulations also stipulate survey and evaluation methods. In those situations, project proponents should first look into survey and evaluation methods based on those laws, but when they are conducting environmental impact assessments, it is important to carry out surveys, forecasts, and evaluations using methods that are appropriate for their regional and project characteristics rather than limiting them to the legally-designated methods in every case. Surveys, forecasts, and evaluations also need to be done while referencing existing expert knowledge when the laws and regulations do not specify standards and measurement methods, as is the case with infrasound.



Note: These are just the major laws and regulations stipulating noise measurement and/or evaluation methods.

Figure III.1.3-2. Major laws and regulations on noise

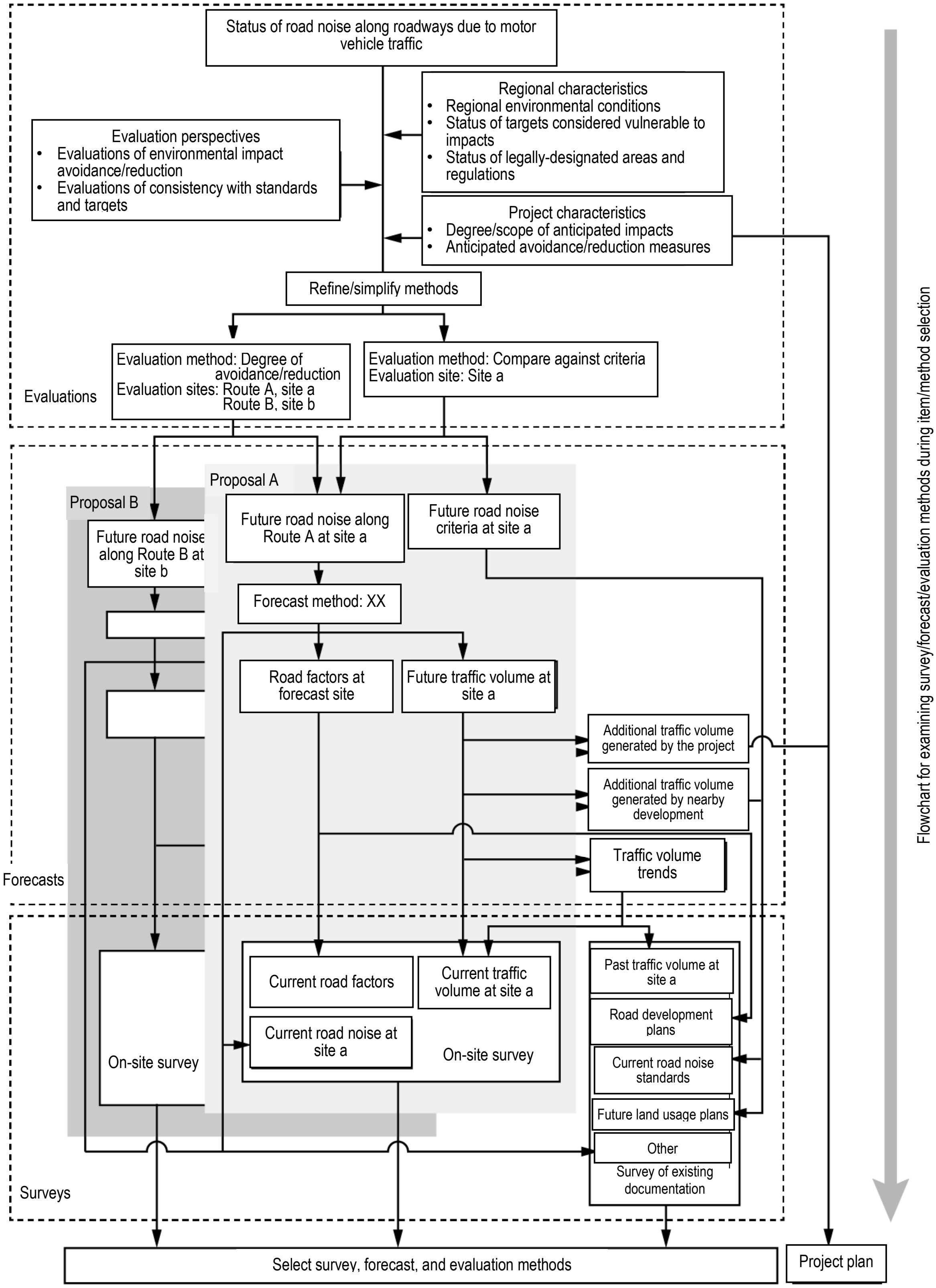


Figure III.1.3-3. Sample flowchart for determining noise survey, forecast, and evaluation methods

(2) Refining and simplifying survey and forecast methods

Refining survey and forecast methods for noise and infrasound may involve conducting detailed on-site surveys in order to collect information on the conditions needed to examine forecasts and environmental mitigation measures or densely distributing survey and forecast sites. Simplifying survey and forecast methods may involve using existing documentation to determine the conditions needed for forecasts or adopting forecast methods that predict the degree of impact using comparisons with similar case examples.

The following are some examples that will help project proponents determine whether to refine or simplify survey/forecast methods.

Examples of situations when more detailed methods should be considered

1. When the degree of environmental impact is likely to be significant
2. When the region is vulnerable to environmental impacts or there are vulnerable targets
   - When there are schools, hospitals, residential districts, or other areas with facilities that require particular consideration in terms of human health or environmental conservation
3. When the region is legally designated for environmental conservation or when there are legally-designated targets
   - Facilities along roadways designated under the Act on Improvement of Areas Along Trunk Roads
4. When the regional environment is already significantly compromised or at high risk
   - Regions that are not protected by environmental standards on noise
   - Areas where noise exceeds motor vehicle noise request limits[7]
5. When project or regional characteristics will likely make it difficult to conduct forecasts using general-purpose methods
   - Areas with complex propagation conditions due to unique topography or other characteristics
   - When it is necessary to understand area conditions vertically or across a broad region
   - When structural or other characteristics create complex source or propagation conditions
6. When local governments or project proponents have specific priorities when it comes to environmental conservation
   - When local governments or project proponents have determined that environmental

---

[7] The noise request limit value is defined in the following stipulation of the Noise Regulation Law: “motor vehicle noise in excess of the limits established by the ordinance of the Prime Minister's Office cause undue damage to the living environment surrounding roads within designated areas, the prefectural governor may request the prefectural public safety commission to implement measures pursuant to the provisions of the Road Traffic Law.”

conservation must be prioritized in light of regional characteristics, project characteristics and/or environmental conservation policies in the project

Examples of situations when simplifying methods should be considered

1. When it is clear that the degree of environmental impact will be minimal
    - When project plan details make it possible to explain that the degree of environmental impact will be minimal, project proponents may be able to use that as a rationale for simplifying project their forecasts.
2. When it is clear that there will not be any regions subject to environmental impact or any targets for a certain period of time
    - When it is clear that there are no residences, facilities, or other targets in the area at risk for impacts from noise or infrasound, either currently in the future, project proponents may be able to use results from proven environmental mitigation methods for example, for their forecasts
3. When it is clear from similar case examples that environmental impacts will be minimal
    - When the degree of impact can be estimated from surveys and other case examples from similar projects, project proponents may be able to use that data for forecasts.

1.3.2 Surveys

1) Selection of survey items

Survey items will likely include noise conditions, ground conditions, and so on, but it is important that project proponents select survey items while sufficiently considering their ability to appropriately grasp the noise impacts generated from project implementation in light of project characteristics/scope and regional characteristics so that they can obtain the information needed to conduct forecasts and evaluations. At the same time, in order to examine their forecast and evaluation methods in detail and get the information project proponents need for them, they will need to consider implementing surveys like the ones shown in Table III.1.3-7.

Table III.1.3-7. Examples of surveys used to collect information needed for forecasts and surveys

Survey item	Information required for forecasts and surveys
Noise levels from similar projects	Source characteristics (e.g. power level)
Traffic volume	Estimates of future traffic volume
Current noise levels	Extent of changes from current status

Certain areas already have sources producing significant noise, and the current measured noise values are heavily impacted by noise from those specific sources. In situations like these, it may be necessary to conduct a survey in order to understand the characteristics of the current noise.

When measuring current noise status, identify noise level distribution characteristics using time-ratio(percentile) noise level (L_{AN})[8], which will allow project proponents to obtain critical information and hints about noise generation factors at the measurement site. Also, by checking the changes in maximum values (L_{Amax})[9] and 5% time-ratio noise level (L_{A5}) over time, project proponents can sometimes estimate whether there are excluded impact-producing sounds in equivalent noise levels (L_{Aeq})[10]. By measuring 90% time-ratio noise level (L_{A90}) and 95% time-ratio noise level (L_{A95}), project proponents can sometimes estimate noise level corresponding to residual noise[11]. Therefore, when measuring noise, they should ideally identify maximum and time-ratio noise levels in addition to equivalent noise levels.

Points to be considered: Noise impacts from existing sources

Areas already subject to impacts from a variety of existing noise sources are likely to have high total noise levels and deteriorated environmental conditions. For this reason, they require a higher degree of consideration than other regions from the perspective of environmental impact avoidance and reduction.

2) Survey method concepts

With surveys, it is necessary to select the survey method project proponents need for forecasting once project proponents have identified evaluation targets and methods. Particularly when it comes to noise-related evaluation indicators, it is important to take into consideration differences in different types of sources as well as source characteristics in order to determine an appropriate survey method (see table III.1.3-8.

Note also that surveys are not limited to on-site surveys and surveys of existing documentation. As specified in noise-related environmental standards, project proponents should ideally make reasonable use of estimates as well as actual measurements in order to understand current status.

Points to be considered: Using estimates to understand current status

In principle, surveys on road noise status should ideally be on-site surveys, but there are cases where an on-site survey would be difficult (such as when road noise needs to be surveyed in the vertical direction), or where an on-site survey can be conducted efficiently by combining it with estimates in order to assess noise over a wide area. Also note that environmental standards on noise stipulate that in cases where the required time cannot be secured for actual measurements, traffic volume and other conditions can be used to estimate noise level in place of actual measurements.

---

[8] Time-ratio noise level (L_{AN}): The indicator that indicates noise level that exceeds a certain value for n% of the measurement period is called the time-ratio noise level and is expressed as L_{AN}. Because it is a statistical indicator, it cannot be used to for compound noises from different sources, but it is an important indicator for understanding the statistical characteristics of noises that cannot be understood with L_{Aeq} alone.

[9] Maximum value (L_{Amax}): Maximum noise level at a given time is expressed as L_{Amax}. When the source of noise is specified, it can be used as an indicator of sleep disturbance, for example.

[10] Equivalent noise level (L_{Aeq}): This is a time-averaged value of the noise energy that fluctuates over a given period of time. Because it is a physical indicator, it offers an abundance of operational logic, and can be used to combine noise from different sources or, conversely, find the relative contribution from specific sources. It also does a good job of reflecting physical/sensory intensity, and is widely used as a method for assessing noise level on an international scale.

[11] Residual noise: Residual noise is the total noise that remains at a certain location over a certain time once noises from specific sources (identified noises) are subtracted.

The following are examples of survey methods that are in line with laws and regulations and allow project proponents to perform estimates in addition to on-site surveys.

・Noise in areas along roadways

When evaluating noise over entire areas along roadways, it is recommended that project proponents estimate noise using calculations based on a variety of estimation models. The Acoustical Society of Japan, for example, offers the ASJ RTN-Model, which indicates a calibration method that corrects for grazing angle and space ratio between rows of proximate structures in order to estimate noise in background areas.

Manual for Evaluating Environmental Standards on Noise: Areas along Roadways, Ministry of the Environment (2015)

"The ASJ RTN-Model 2013 Predictive Model for Traffic Noise", Journal of the Acoustical Society of Japan Vol. 70 No. 4, Research Committee on Traffic Noise, Acoustical Society of Japan (2014)

・Noise from regular train lines

Measurement methods typically target all trains (going in both directions) passing through on a given train line, measuring single noise exposure level (L_{AE}) and maximum noise level ($L_{A,Smax}$) for each train that passes in line with a frequency correction circuit in line with characteristics A. Note, however, that the noise countermeasure guidelines for new construction or major renovations of conventional rail lines (Kandai No. 174, December 20, 1995) allow for the use of weighted addition by property reducing the number of trains that are measured while being cautious of fluctuations in noise level due to travel lines (e.g. each direction), type of train, car composition, running period (as trains sometimes slow down when they are crowded), and similar factors. The assumption here is that variation (standard deviation) in train noise at measurement sites is understood.

Measurement Manual for Regular Train Noise, Ministry of the Environment (2015)

・Aircraft noise

In addition to evaluation values calculated over a year for long-term standard periods, project proponents can use the results obtained from short-term measurements to calculate estimated values for equivalent noise levels time-adjusted according to annual averages.

Reference materials also introduce two methods for estimating equivalent noise levels time-adjusted according to annual averages: one that uses the results from nearby year-long measurements and one that uses flight information from the target airport/airfield.

Aircraft Noise Measurement and Evaluation Manual, Ministry of the Environment (2015)

Table III.1.3-8 Evaluation indicators based on noise laws and regulations

Standard / Type of source		Environmental standard	Regulatory standard (request limit)	Guidelines, ordinances, etc.	Notes
Ambient noise		L_{Aeq}	—	—	1
Motor vehicle traffic		L_{Aeq}	L_{Aeq}	—	1, 2
Train noise	Bullet trains	L_{Amax}	—	—	3
	Regular trains	—	—	L_{Aeq}	4
Aircraft noise		L_{den}	—	—	5
Noise from production plants and other workplaces		—	L_{A5} and others	—	6, 8
Noise from construction		—	L_{A5} and others	—	7, 8
Noise from late-night business operations, PA systems, etc.		—	—	L_{A5} and others	8

Notes:

1) *Environmental Standards on Noise* (Notification No. 64 of the Environmental Agency, September 30, 1998)
2) *Ministerial Ordinance on Traffic Noise Limits in Areas Designated under Article 17-1 of the Noise Regulation Law* (Ministerial Ordinance issued by the Prime Minister's Office No. 15 of March 2, 2000)
3) *Environmental Standards on Noise from Bullet Train Lines* (Notification No. 46 of the Environmental Agency, July 29, 1975)

4) Noise countermeasure guidelines for new construction or major renovations of conventional rail lines (Kandai No. 174, December 20, 1995)
5) *Environmental Standards for Aircraft Noise* (Notification No. 154 of the Environmental Agency, December 27, 1973)
6) *Standards Regulating Noise Generated from Designated Factories* (Notification No. 1 of the Ministry of Health, Labour and Welfare; the Ministry of Agriculture, Forestry and Fisheries; the Ministry of Economy, Trade and Industry, and the Ministry of Transport, November 27, 1968) and regulations issued by prefectural governors
7) *Standards Regulating Noise Generated from Designated Construction* (Notification No. 1 of the Ministry of Health, Labour and Welfare and the Ministry of Construction, November 27, 1968) and regulations issued by prefectural governors
8) May be stipulated in local government ordinances.

3) Survey area/site concepts

(1) Survey area

The range of the survey area must include sites that will experience maximum impacts from project implementation based on project characteristics (such as the type and location of sources), topography and other natural features, and social conditions (such as land usage). Project proponents must also take into consideration the status of targets thought to be vulnerable to environmental impacts.

In general, the survey area is frequently set as the project implementation area or an area at a certain distance from the edge of a roadway. Determine the survey area while taking into consideration project characteristics, noise propagation characteristics, and so on, including a range within which noise levels will change to a certain extent due to project implementation. In cases where there is a large degree of uncertainty about the range in which there is a certain level of change (because the propagation distance is so great, for example), project proponents may want to err on the side of caution by making it larger than they might need.

Note that when considering the impact of moving construction vehicles, if the destination is clear (as in the case of locations where soil generated from construction is being reused) and efficient travel routes for construction vehicles are therefore limited between the project implementation area and the reuse sites, there are cases where project proponents can anticipate a certain degree of change in traffic noise level for the entire route between the project implementation area and the reuse sites. In situations like these, the survey area range should include sites that will experience maximum impacts from project implementation. Figure III.1-3.1 provides methods for determining areas leading up to main thoroughfares and those particularly vulnerable to impacts (e.g. when there are population centers along major thoroughfares).

(2) Survey sites

Noise surveys are generally conducted at fixed points, therefore establish survey sites are needed. Table III.1.3-9 presents concepts for determining survey sites when conducting on-site surveys.

When project proponents are actually conducting on-site surveys, they need to confirm safety during measurements and that the impact from nearby designated sources is minimal; it is also possible to properly evaluate environmental changes from the current status by selecting sites that match forecast sites as much as possible.

Note that if project proponents anticipate conducting a follow-up survey, they should ideally consider beforehand the possibility of doing so at the sites project proponents select as well.

The *Environmental Standards on Noise* (Notification No. 64 of the Environmental Agency, 1998) stipulate standard values for spaces adjacent to main thoroughfares as well as indoor standards in cases where daily activities in areas along main thoroughfares are recognized as taking place primarily with the windows closed. Therefore, project proponents need to designate appropriate survey sites in full consideration of these concepts when conducting surveys that conform to environmental standards on noise.

Table III.1.3-9. Concepts for determining noise survey sites

Site classification	Site determination concepts
Sites representative of the area	Set sites that project proponents believe to be representative of the regional characteristics of the area. Select locations where there is little impact from specific nearby sources.
Sites at risk for particularly major impacts	Set sites that project proponents expect will experience particularly major project impacts based on project and regional characteristics. If there are mid-rise or high-rise residences adjacent to a major road or similar source, for example, consider selecting survey sites in the vertical direction.
Sites with targets requiring particularly careful consideration of environmental conservation	If project proponents set forecast/evaluation sites that include residences or facilities requiring particularly careful consideration of environmental conservation (such as schools or hospitals), and they expect that conditions there will be different than the sites representative of the area due to impacts from roads or other sources, select these locations as survey sites. Note that project proponents need to select survey sites once they determine whether there are sources of noise established at these facilities.
Sites where environmental conditions are already significantly compromised	Select sites that are considered to have already experienced deterioration due to noise/infrasound conditions as a result of impacts from specific sources—typically roads or train lines.
Sites where impacts from specific sources can be identified	In cases where measurements are being taken in similar case examples, fully confirm similarity in terms of project details and facility size as well as propagation conditions from the source before selecting sites that allow project proponents to identify the specific noise conditions that they will use as forecast targets.
Sites designated in laws or regulations	Survey sites are sometimes designated in laws and regulations, as with noise from regular train lines, so if project proponents are conducting evaluations to check for consistency with standards and targets or if they anticipate conducting follow-up surveys, select the sites designated in those laws and regulations. Examples: Noise from regular train lines→12.5 m from the center of the nearest track Noise from production plants or other workplaces→at the site boundary

Points to be considered: Survey site concepts in environmental regulations

The Environmental Standards on Noise set forth different concepts for selecting survey sites in general areas and areas facing roadways, so these differences need to be taken into consideration.

・General areas

Set sites where project proponents believe it is possible to evaluate average noise level for the region. These sites should be representative of noise in the survey area and free from localized impacts from specific sources. For this reason, it is not necessary to always select sites in areas around residences or other structures; even if the site is in an empty lot, for example, there is no reason project proponents can't select it as a site if they think the noise there will be representative of the area.

・Areas along roadways

When selecting survey sites, consider the distribution of residences and other structures in the evaluation zone, and then select sites where project proponents can measure the noise (noise adjacent to roadways) at locations considered to be the closest point of residences and other structures to the road. When performing distance attenuation corrections using background measurement results, for example, project proponents should ideally select sites where they can measure noise (background noise) at locations that correspond to the location of houses and other structures within the background areas of the evaluation zone. Consider the possibility of future residential locations as well when measuring noise adjacent to roads.

Manual for Evaluating Environmental Standards on Noise: General Environments, Ministry of the Environment (2015)
Manual for Evaluating Environmental Standards on Noise: Areas along Roadways, Ministry of the Environment (2015)

4) Survey period and timing concepts

It is essential that the survey period and timing are appropriate and allow project proponents to efficiently achieve the survey goals.

When the sources have an operational plan (such as trains or aircraft), or when their operation is otherwise under human control (as in the case of production plants), it is possible to conduct efficient and effective surveys by studying those schedules in advance and setting both survey period and timing accordingly.

Because traffic noise is a source created by the motion of an unspecified number of vehicles, when setting survey period/timing project proponents need to identify in advance traffic volume, types of vehicles, traveling speed, and other usage characteristics as well as consider temporal fluctuations based on the season, day of the week, and time of day.

Points to be considered: Setting a survey period that takes road usage characteristics into account

Environmental standards call for the selection of days that represent average noise conditions throughout the entire year. In the case of traffic noise, the survey period/timing is usually set as a 24-hour weekday timeframe. However, there are sometimes road that are primarily used for sightseeing; in these cases, project proponents should ideally conduct their survey during a season, day of the week, and timeframe that makes sense for the target facilities and behavioral characteristics.

1.3.3 Forecasts

1) Forecast method concepts

Forecasts should basically be carried out for the evaluation indicators stipulated in laws and regulations (see table III.1.3-8). When locations are specified in the standards and/or targets set forth in environmental basic plans or ordinances issued by local governments, the forecasts need to use the evaluation indicators required to assess conformity with those standards and/or targets.

Points to be considered: Forecasts for evaluation indicators not based on laws and regulations

When conducting quantitative forecasts for targets for which laws and regulations do not specify evaluation indicators or when project proponents anticipate that evaluation indicators based on laws and regulations will be insufficient for their forecasts, project proponents need to consider using the proper evaluation indicators for their situation.

・When laws and regulations do not specify evaluation indicators: Example concepts
Infrasound: Evaluate while referring to the G characteristic sound pressure level and other indicators stipulated in ISO7196 (1995)
Low-frequency noise (20–100 Hz): Evaluate while referring to expert information found in past research

・When project proponents anticipate that evaluation indicators based on laws and regulations will be insufficient: Example concepts
When construction occurs over a long period of time or multiple projects occur during the same period and across a large scale, it is likely that project proponents will be unable to sufficiently evaluate impacts on the surrounding environment by using the concepts found in the Regulatory Standards for Noise Generated by Specified Construction Projects (see note). Project proponents should therefore conduct their forecasts according to the equivalent noise level in order to compare it against environmental standards.

When the project is adjacent to a school, project proponents may be able to conduct their evaluations in line with the Standards for Healthy School Environments.

Note: The Noise Regulation Act does not apply the same regulatory methods to temporary noise sources that are not permanent (such as construction) as it does to production plants and other workplaces. Basically, significant noise generated from specific construction projects is regulated on a per-project basis. With the basic items, however, it does indicate that when there is a chance that impacts from construction will be sustained over a long period of time, whether there have been efforts to maintain conformity with applicable environmental standards (when basic items are stipulated in environmental standards related to target environmental components) must be taken into consideration.

Tables III.1.3-10 through III.1.3.15 show examples of forecast methods for noise.

Select forecast methods for noise while referring to theoretical propagation calculation formulas, empirical regression formulas, model testing, and similar case examples while also considering project details in light of other appropriate methods. Academic societies and other groups offer highly versatile noise forecasting formulas for a variety of sources (motor vehicles, trains, aircraft, production plants/workplaces, etc.), but even if project proponents use these forecasting methods, they need to sufficiently consider their application conditions and degree of uncertainty rather than blindly applying formulas. Note also they must sufficiently understand physical significance of address equivalent noise level, time-ratio noise level, and maximum noise level value for their forecast items, addressing forecast uncertainty by clarifying it as needed.

Table III.1.3-10 Examples of noise forecast methods (traffic noise)

Name	Description and features

(1) Formula proposed by the Acoustical Society of Japan) (ASJ RTN-Model 2013)	This forecast formula finds the change in noise level over time as a single motor vehicle drives past (unit pattern) and the time integration value, then uses those results to find an energetic time average value for the forecast point, taking into consideration traffic conditions. The previous 2008 model was revised based on reduced noise levels due to the power levels of hybrid and electric vehicles as well as double-layered draining pavement; it also incorporates insights from diffraction attenuation calculation methods for soundproofing walls, forecast calculation methods for smartcard (ETC) points, forecast calculation methods for ditches and semi-underground areas, forecast calculation methods for behind structures, etc.
(2) Model testing	Model testing involves creating a 1/n-scale model of actual structures in order to find sound propagation characteristics using sources whose frequency is n times that of the actual source. It allows for the direct measurement of propagation characteristics in three dimensions. It is important that the model testing conforms to the law of scale in terms of the acoustics of the model and reality, so the sound absorption coefficient and transparency loss of the model materials used to create the boundary surface must be taken into consideration along with the impacts of sound source direction and atmospheric absorption.
(3) Acoustic numerical analysis	The most common acoustic numerical analysis methods are the Boundary Element Method (BEM) and the Finite Difference Time Domain (FDTD) method, which are based on soundwave theory, and the acoustic ray method, which is based on geometrical acoustics theory. Methods like BEM and FDTD allow project proponents to calculate reflection and diffraction effects for individual frequencies using a variety of reflection coefficient characteristics and complex geometries for boundary surfaces. When flat road surfaces with parallel walls are jointly constructed with overpasses, these methods can be used to analyze sound fields with complex boundary conditions (such as cases where there is a long overhang on a semi-underground road structure). The acoustic ray method, on the other hand, considers the trajectory of sound (sound rays) emitted at a fixed angle interval in all directions from the sound source as the propagation of sound energy, using the density of the sound rays and other factors to find sound pressure level. It can be used to analyze multidimensional, multiply reflected sound from boundary surfaces with complex geometries.

Sources:

(1) "The ASJ RTN-Model 2013 Predictive Model for Traffic Noise", Journal of the Acoustical Society of Japan Vol. 70 No. 4, Research Committee on Traffic Noise, Acoustical Society of Japan (2014)

(2) (3) *Environmental Impact Assessment Techniques for Roadways (FY2012 edition)*, MLIT National Institute for Land and Infrastructure Management (2013); MLIT National Institute for Land and Infrastructure Management Document No. 714/Public Works Research Institute Document No. 4254)

Table III.1.3-11 Examples of noise forecast methods (railway noise)

Name	Description and features	Applicable scope
(1) Formula proposed by Ishii et al at the University of Tokyo	This method is used to forecast peak noise level. It includes motorized fan noises as rolling noise, establishing structural noise as long-ray sound sources with limited directivity. It uses sound source power levels based on measurement results taken in FY77–78, but various private railway companies have conducted similar case example studies and developed unique sound source power levels, giving it wide applicability. This formula can be applied by setting power levels based on measurement	• Tracks must be straight and flat • For long rails with welded rail joints • Train speed must be between 50 and 120 km/h, with no speed changes within the focal section • Structures must be reinforced concrete/rigid-frame overpasses (cannot be used for steel bridges) • Train cars must be mid- or short-distance commuter trains (cannot be used for trains pulled by electric locomotives, internal combustion trains, or trains that are particularly short) • Must have a track ballast • Tracks must be well-maintained

	results from similar case examples. However, the accuracy of this method must be confirmed by recreating current conditions.	• Train cars must be well-maintained and wheels must have no significant flats
(2) Formula proposed by Morifuji et al at the Railway Technical Research Institute	This formula is based on the one proposed by Ishii et al at the University of Tokyo (1), but has been corrected based on the latest source condition data and adjusted so that it can be applied to non-elevated structures as well. This formula separately models rolling noise, structural noise, and vehicle equipment noise (motor fan noise) from sound sources, and then combines them once propagation calculations are done. Forecast quantities are peak noise level and single-noise exposure level, with single-noise exposure level and the number of passing trains during the evaluation time used to find equivalent noise level for that evaluation time.	• Trains must be traveling at a fixed speed between 50 and 150 km/h • Sound collection points must be between 10 and 100 meters from the track • Structures must be reinforced concrete/rigid-frame overpasses (cannot be used for steel bridges). Structural noise is can be ignored for banked, flat structures. • Tracks must be flat and straight, with a long-rail construction. The rail surface must be free of significant unevenness. Tracks must have a track ballast or be slab tracks. • Trains cannot be excessively short. • Designed for use with electric trains. Diesel railcars and locomotive railcars emit engine noise, but there are few measurement examples and quantitative evaluation forecasts cannot be made, so these forecasts will overlook engine noise. • Wheels must be of normal construction, and the surface must be free of significant flats or corrugation.
(3) Formula proposed by Nagakura et al at the Railway Technical Research Institute	This formula proposes a method for calculating single-noise exposure level for passing trains by setting up point sources for each bullet train car. It classifies noises produced by passing bullet trains into undercarriage noises (rolling noise, gear noise, aerodynamic noise), structural noise (only when there are concrete bridges), aerodynamic noise above the train (including aerodynamic noise at the nose), and power collection system noise (aerodynamic noise, spark noises), establishing a sound source power level for each. It essentially finds temporal changes in the noise at sound collection points when a single point source is moving (unit patterns) and those time integration values.	• Train cars must be Series 0, Series 100, Series 100N, Series 300, Series 500, Series 700, Series 200, Series E1, Series E2, Series E4, Series 400, or Series E3 (note: these are the trains that were running when the formula was proposed, and include those that are no longer in service) • Trains must be running at a steady speed, with the maximum speed of each car type starting at 150 km/h • Tracks must be ballast, slab tracks, or one of several types of vibration-damping tracks • Structures must be concrete overpasses, embankments, flat • Soundproofing walls must be erect soundproofing walls with no soundproofing wall height limit; soundproofing material effects are taken into consideration • Noise evaluation points must be between 12.5 and 50 meters horizontal distance from the center of the track in the vertical direction and lower than the top of the soundproofing wall

Sources:

(1) Ishii, K., Koyasu, M., Cho, Y., and Koba, H. “Draft proposal of the prediction of noise from elevated railways”, *Noise Control* Vol. 4 No. 2 (1980)

(2) Morifuji, Y., Nagakura, K., Tachikawa, H., and Ogata, S. “A predictive forecasting and evaluation method for railway noise”, *Noise Control* Vol. 20 No. 3 (1996)

Kitagawa, T., Nagakura, K., and Ogata, S. “A noise prediction method for railways”. *Railway Technical Research Institute Report* Vol. 12, No. 12 (1998)

Environmental Assessment Techniques, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

(3) Nagakura, K. and Zenda, Y. “A noise prediction model for bullet trains”, *Railway Technical Research Institute Report* Vol. 14, No. 9 (2000)

Table III.1.3-12 Examples of noise forecast methods (aircraft noise)

Name	Description and features
(1) Model from the Ministry of Land, Infrastructure, Transport and Tourism	The revision to environmental standards on aircraft noise enabled the use of L_{den} as a noise evaluation indicator and added considerations of the operation of auxiliary power units (APU) in parked aircraft, engine test runs, taxiing, and other situations where the noise contribution from aircraft operation on the ground is important. Models taking these factors into account were developed by the Aviation Environment Research Center run by the Airport Environmental Development Association and others. Below is an overview of the model developed by the Aviation Environment Research Center. • Noise generated in the course of aircraft operation is calculated using a method called the segment model. The segment model breaks up flight paths into multiple segments of limited length, treating each individual segment as a regular, straight-line course. Calculations of noise exposure across the entire route are then done by making corrections for the limited segments. • Basic noise data is on distance and single-noise exposure level for each aircraft model and thrust. This data must be prepared for takeoff and landing (including reverse), taxiing, APU, and engine test runs. • In addition, performance data that indicates changes in aircraft height, thrust, and speed during operation is expressed as a distance function according to the flight path. This data must be prepared for each aircraft model, flight configuration, and weight. • It is then necessary to determine the number of takeoffs and landings by aircraft model, flight configuration, flight path, and time; the number of operations by weight (for take-offs only); the number of taxi operations by aircraft model, flight path, and time period; and the length of APU and engine trial run operations by aircraft model, operating position, output characteristics, and time period.
(2) INM model from the US Federal Aviation Administration	Noise evaluation levels prepared under INM 7.0 are applied to private fixed-wing aircraft, private rotary-wing aircraft, and military aircraft (fixed-wing), making it possible to forecast aircraft noise in areas around airports. The 2007 revisions to the Environmental Standards on Aircraft Noise, however, do not allow for the use of INM calculation methods in ground noise forecasts. Calculation conditions • Basic data (NPD data, performance data) is provided for operating conditions standardized by manufacturing companies and the FAA. • This model also requires that calculation conditions be set for (1) target aircraft information (runway direction and length, altitude, weather); (2) type and take-off weight of the operating aircraft; (3) number of take-offs and landings, runway usage rate; (4) flight path settings; and flight path distribution.

Sources:

(1) Sugawara, M., Nakazawa, T., and Yoshioka, H. “Developing an airport noise model using L_{den} as a noise index” *Aviation Environment Research* No. 19, Aviation Environment Research Center, Airport Environmental Development Association (2015)

(2) Yoshioka, H. “Aircraft noise prediction”, *Noise Control* Vol. 35 No. 2 (2011)

Table III.1.3-13 Examples of noise forecast methods (production plant and other workplace noise)

Classification	Description and features
I. Calculations for noise propagation inside structures	(1) Calculates average indoor sound pressure level for indoor noise sources in the same room Factors like noise source power level, total indoor surface area, and average sound absorption rate are used to calculate average indoor sound pressure level (2) Calculates average indoor sound pressure level for sources in neighboring rooms When there is an adjacent room (sound receiving room), partition surface area and transmission loss, total indoor surface area of the adjacent room, and average sound absorption rate are used to calculate average indoor sound pressure level in the adjacent room
II. Calculations for noise propagation inside to outside	Calculates noise level values at outdoor sites at a distance from exterior walls, taking into consideration average indoor sound pressure level adjacent to the exterior wall and the area/transmission loss of target exterior wall portions as well as attenuation due to a variety of factors including distance attenuation and diffraction attenuation due to walls and the like

Sources:

Living Environment Impact Survey Guidelines for Waste Treatment Facilities, Waste Management and Recycling Department, Minister's Secretariat, Ministry of the Environment (2006)

Practical Noise Countermeasure Guidelines (Second Edition), Architectural Institute of Japan (Gihodo Shuppan 1994)

New Pollution Control Technologies and Laws 2016 (Noise and Vibration), Pollution Control Technologies and Legal Editorial Committee (Maruzen Publishing)

Table III.1.3-14 Examples of noise forecast methods (outdoor noise from fixed sources)

Name	Description and features
ISO9613-2: 1996	Describes a calculation method for forecasting noise levels of sound from a variety of sources during propagation outdoors. Presupposes meteorological conditions favorable to sound propagation and separate calculations for different types of attenuation to find equivalent noise level at sound receiving locations. • This forecast method uses acoustic power level (amount of sound energy produced per unit of time) from noise sources to calculate noise attenuation for an individual octave bands of a given frequency and ultimately find overall equivalent noise level • Therefore, when identifying maximum environmental impact conditions, it is important to have information on acoustic power level for each octave band (for example, in cases where facilities are running at their rated output or maximum output) • This forecast method assumes meteorological conditions that are favorable to sound propagation, and it is possible to incorporate corrections for sound source directionality or weather requirements (correct for conditions other that those that are favorable to sound propagation). It is also possible to calculate frequency for each octave band between 63 and 8,000 Hz.

Source: ISO9613-2: 1996 Acoustics: Attenuation of sound during propagation outdoors, Part 2: General method of calculation

Table III.1.3-15 Examples of noise forecast methods (construction noise)

Name	Description and features
(1) Formula proposed by the Acoustical Society of Japan) (ASJ CN-Model 2007)	This forecasting model can be used for general construction projects or blasting work for tunnel construction projects. *For general construction projects* • Provides two types of forecast methods, one for different construction types that takes into account the maturity of construction plans at the forecast site, and one for different types of equipment (noise sources). The forecast range extends out to about 100 meters from the boundary line of the construction site. Meteorological conditions are standardized as no wind and without a particularly strong temperature gradient. • The method that forecasts by construction type combines construction equipment in light of work units and treats it as a single source of noise. This method is used when forecasting approximate noise during planning-stage environmental assessments or other situations where construction plans are not very developed and details such as the allocation of individual pieces of construction equipment has not yet been decided, even if the construction type can be predicted. This method uses energy as the basis of its forecast calculations. When finding the evaluation values stipulated in the Noise Regulation Act, it can be used to statistically estimate effective noise level from forecast calculation values. • The method that forecasts by equipment type treats individual pieces of construction equipment as sources of noise, then forecasts the noise propagation from them. This method is used for forecasts when construction plans have a high degree of maturity and when the allocation of individual pieces of construction equipment can be determined. When using this method to find the evaluation values stipulated in the Noise Regulation Act, calculate each evaluation value for the forecast site based on measured noise source data for that value in consideration of attenuation due to propagation. *For blasting work in tunnel construction projects* • Blast sounds have a tremendous amount of energy, and also contain many components in the low-frequency range. Therefore, though it is possible to apply the forecast method for general construction project noise for noise ranges generally at or above 100 Hz, it cannot be applied as-is to low-frequency components below that. This forecast model uses single-noise exposure level and the C characteristic single sound

	pressure exposure level as blast noise evaluation values. • The forecast range extends out about 500 meters from the tunnel opening. Meteorological conditions are standardized as no wind and without a particularly strong temperature gradient.
(2) Theoretical propagation formula for point sound sources	This method makes it possible to identify construction project noise at sound receiving sites using a theoretical propagation formula for point sound sources that uses the acoustic power level of construction equipment and the distance from the construction equipment (sound source) to the sound receiving sites. In cases where multiple pieces of construction equipment are being operated, it can be used to forecast by combining noise levels at the sound receiving point. Keep in mind that theoretical propagation formulas differ depending on the directionality of noise sources and the relative position of reflective surfaces, such as when the sound source is nondirectional and in space (free space) or when it is nondirectional and above the surface of the ground (semi-free space). Also note that with propagation over long distances, project proponents may be able to get noise reduction greater than the calculated values (overdamping) due to the impact of atmospheric absorption, tress or structures, topography, temperature, or wind.

Sources:
(1) "The ASJ CN-Model 2007 Predictive Model for Construction Noise", *Journal of the Acoustical Society of Japan* Vol. 64 No. 4, Research Committee on Traffic Noise, Acoustical Society of Japan (2008)
(2) *New Pollution Control Technologies and Laws 2015 (Noise and Vibration),* Pollution Control Technologies and Legal Editorial Committee (Maruzen Publishing 2015)

(1) Forecast conditions: Concepts

Primary units and other conditions used in forecasts require that project proponents not only consult document used in past environmental impact assessments, but also that they check for new data and incorporate it as needed. Pay particular attention when it comes to primary units for things like acoustic power level for construction equipment, as this data is constantly changing as new equipment gets developed.

Also, when conducting forecasts using excerpts or analyses from existing case examples, take into account uncertainty as well as propagation characteristics, frequency characteristics, and the similarity of these conditions as applied to their own forecast conditions, describing them as clearly as possible.

a) Examining primary units

Primary units (such as acoustic power level) form the basis of noise prediction and can be roughly divided into two categories: primary units set for practical purposes and primary units set based on countermeasure targets. Project proponents also need to check to make sure that their primary units are consistent with those set conditions and evaluation indicators.

Primary units set based on countermeasure targets need to be examined in terms of the feasibility of the countermeasures. If feasibility cannot be confirmed, project proponents need to clearly provide details on the uncertainty involved as well as its extent.

With motor vehicle traffic, forecasts typically look at two types of vehicles (large and small), but in cases where large dump trucks, trailers, and other construction equipment is being used, primary units need to be set in accordance with the reality of the situation (e.g. in consideration of the high noise levels generated by extra-large equipment).

Points to be considered: Conditions for determining primary units

Particularly when project proponents are working with the acoustic power level of construction equipment, it is important to look carefully at how operating conditions are set up, carefully checking maximum values, time-ratio noise level, equivalent noise level, and the like.

b) Propagation characteristics

There are a variety of factors that determine the propagation characteristics of noise in addition to distance, among them meteorological conditions, sound insulation from structures, and surface topography. In recent years, calculation methods have begun to take into consideration the impact of atmospheric sound absorption, diffraction effects due to obstacles, and reflection from the ground surface.

When conducting forecasts, consider the accuracy of the propagation process as a whole and incorporate these factors as needed.

c) Frequency characteristics

Noise is the vibration or air at various frequencies. If project proponents anticipate using sound insulation, absorption, and/or diffraction as environmental mitigation measures, they need to consider frequency characteristics.

d) Other

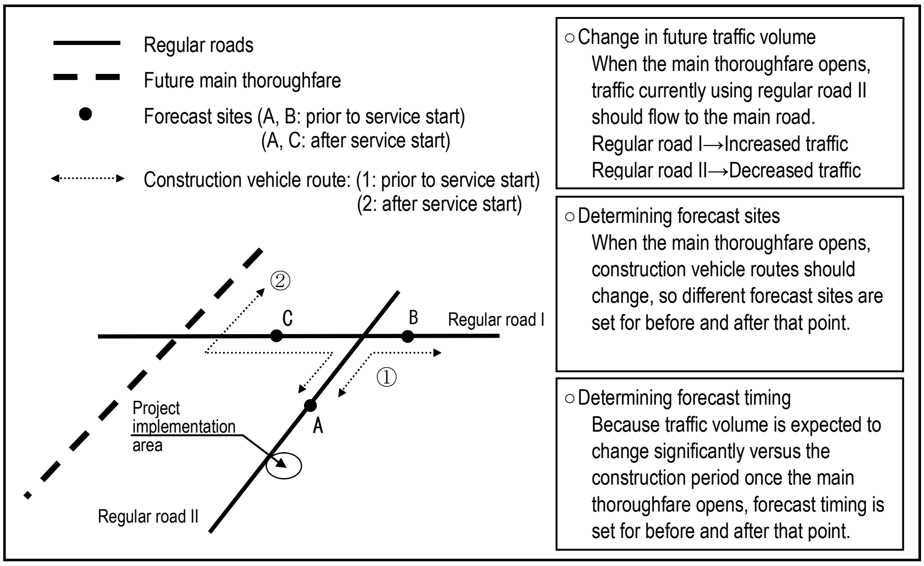
Future traffic volume

Future traffic volume used for environmental impact assessments is frequently set using growth rate, which is obtained (1) using road development plans and based on current traffic volume or (2) using a traffic distribution simulation method based on transportation networks and an origin-designation matrix for the target year—data which is in turn sourced from road development plans issued by the national or local governments. Make sure to take into consideration the project and regional characteristics listed in Table III.1.3-16 in order to determine an appropriate method.

When formulating estimates, carefully consider future transportation network construction, taking into account not just new construction and renovation plans for roads and railways, but also any project currently underway and how far along they are. This will allow project proponents to determine a more suitable transportation network. Particularly in cases where there will be major changes in the transportation network at some future point in time (such as when highways go into service), make sure to sufficiently consider their traffic volume and other settings. Figure III.1.3-4 shows some examples of those concepts.

Table III.1.3-16. Project and regional characteristics associated with future traffic volume

Project characteristics	• Construction plan • Roadway facility plans • Designed traffic volume (for roadway projects)
Regional characteristics	• New construction or renovation status of roads and railways • Large-scale development in surrounding areas • Changes in regional traffic volume throughout the year or over time



○ Change in future traffic volume
When the main thoroughfare opens, traffic currently using regular road II should flow to the main road.
Regular road I→Increased traffic
Regular road II→Decreased traffic

○ Determining forecast sites
When the main thoroughfare opens, construction vehicle routes should change, so different forecast sites are set for before and after that point.

○ Determining forecast timing
Because traffic volume is expected to change significantly versus the construction period once the main thoroughfare opens, forecast timing is set for before and after that point.

Figure III.1.3-4. Sample approaches to changes in future traffic volume due to new road construction

Travel speed

The forecast condition of travel speed is typically set using speed limits and design speed. Note, however, that in cases where regulation speed is slower than the speed limit or design speed or situations where congestion is likely to occur, project proponents should ideally clarify the uncertainty involved in the fact that actual speed will be different than the traveling speed used as a forecast condition. In addition to traveling speed they will also need to clarify traveling conditions (if vehicles are traveling at constant or non-constant speed).

Note that in cases where traffic volume is extremely low overnight, for example, and vehicles are likely to travel faster than regulation speed, the project proponent must describe environmental mitigation measures according to their position; in other words, urging the relevant agencies to crack down on speed regulations or ensuring that construction vehicle drivers thoroughly comply with speed regulations.

Attenuation due to homes

Environmental standards related to noise stipulate those standards from the perspective of preventing that noise from interfering with conversations or sleep, and are set for outdoor areas in line with structural soundproofing performance. However, in situations where it is recognized that people will primarily go about their lives with the windows closed when those windows face areas susceptible to noise impacts (such as in individual homes adjacent to a major thoroughfare), it is possible to evaluate noise according to standards for interior permeation. These standards can sometimes be applied in regions where soundproofing assistance is provided under the Act on the Improvement of Areas along Main Thoroughfares. In this case, it will be necessary to determine the attenuation effects due to homes.

(2) Forecast uncertainty

Forecast uncertainty comes from various factors, including uncertainty caused by forecast conditions, uncertainty due to factors related to forecast methods, and uncertainty due to the fact that there is insufficient insight into what results environmental mitigation measures will produce. While project proponents should ideally make effective use of existing scientific knowledge and similar case examples in order to eliminate these forms of uncertainty as much as possible, keep in mind that there are uncertainties that project proponents cannot control—such as future traffic volume and traveling speed for road projects or aircraft type and flight path for airport development projects.

Points to be considered: Uncertainty in forecast conditions related to traffic

There are a variety of traffic-related indicators used just for forecast conditions—including traffic volume, temporal fluctuation rates, and percentage of large vehicles—and each of them comes with their own degree of uncertainty.

In the field of transportation planning, there are many different models used to make detailed traffic volume estimates, but the estimated traffic figures used for forecasts in environmental impact assessments typically use planned traffic volume on a daily basis. Temporal fluctuation rates and percentage of large vehicles are based on survey results from existing nearby roads and the like. Keep in mind that of these forecast conditions has a degree of uncertainty.

2) Forecast area/site concepts

In most cases, forecast area needs to include a range within which noise due to project implementation will rise to a certain level or higher, and will typically include the survey area. This range can change based on project size/details, but take forecast uncertainty and regional characteristics into consideration and err on the side of caution by making it larger than project proponents might need. Note also that in situations where survey results indicate that there are areas that do not need to be targeted for forecasts and evaluations, project proponents can eliminate these surveyed areas from their forecast area.

It is easy to identify source conditions in the case of production plants or other fixed sources, so in these cases project proponents can set their range using trial calculations run using the forecast methods shown in table III.1.3-13. If there will be motor vehicles or other mobile sources, a basic guideline is to use a range of between several tens and several hundred meters from the roadside as their forecast area, since the impact from these noise sources on the surrounding area is relatively limited. Environmental standards on noise also include stipulations for general areas, areas facing roads, and spaces adjacent to main thoroughfares, so they can refer to these concepts when setting their forecast area as well.

The vertical height of noise forecast sites is also normally set to 1.2 meters in many cases, but if there are high-rise structures nearby, consider setting sites at a height that takes into account the height at which people are actually going about their daily lives.

Points to be considered: Considering height when determining sites

Environmental standards on noise are ideally designed to protect living environments from environmental conditions related to noise and maintained for the sake of human health. They also state that when performing evaluations on the level of individual structures, the noise level that would impact people in individual residences should be used as a basis for evaluations, which should be done according to the face of residential buildings most susceptible to impacts. Because height must therefore be accounted for from the perspective of human health impacts, be sure to incorporate height considerations when determining forecast sites if there are mid-rise or high-rise buildings in the area.

3) Forecast period concepts

a) During construction

In addition to identifying changes in construction volume over time throughout the entire course of the project plan and changes in construction zones, forecasts during construction should take the following factors into account. For forecasts related to the operation of construction equipment, set the forecast period as the period during which construction equipment is located closest to the forecast site or the period where the type of construction being carried out generates the maximum noise level. For forecasts involving construction vehicles, set the forecast period as the period during which the greatest number of construction vehicles are running.

When construction will be taking place over an extremely long period of time and there are likely to be changes in forecast conditions (such as changes in the routes that construction vehicles travel during construction), consider conducting forecasts during a mid-term period as well.

b) Once facilities are in service

Once project facilities are in service, set the forecast period for the steady state during which facilities are operating or vehicles are traveling. Note that if the project is being implemented in stages over a long period of time or if there will be major changes in environmental conditions partway through, project proponents will need to identify those changes over the course of year and conduct forecasts during an appropriate period.

c) Other

For projects involving the establishment of final waste disposal sites or replacing thermal power plants, it is likely that the construction period will overlap the service period. In these situations, consider environmental impacts both for construction implementation and facility service, identify points in time where impacts are likely to be greatest, and set a forecast timing accordingly.

1.3.4 Environmental mitigation measures

1) Consideration procedures

(1) Examining environmental mitigation measure policies

When it comes to noise, policies are frequently dictated by environmental standards, regulatory standards, and the like. The policy towards environmental mitigation measures can include the meeting of those standards, but it is also fairly likely that project proponents will need to establish policies outside of the achievement of standards once project proponents consider project and regional characteristics. Also, when local environmental basic plans include targets aligned with regional characteristics or consideration policies are spelled out, those need to be properly considered as well.

The regional characteristics project proponents need to consider when looking at environmental mitigation measures include whether there are exclusive residential districts or other facilities that are in particular need of peace and quiet, and what the current environmental status is. Project characteristics that need to be considered include noise generation characteristics (time, frequency, etc.) as well as construction plans (construction period, construction methods, etc.). For example, if a project such as damn construction over a period of ten to twenty years will have environmental impacts, project proponents may want to set targets that are relatively strict compared to those that would be set for a project that will be completed in a year or two. Taking these regional and project characteristics into account is part of examining environmental mitigation measures.

With noise, there are times when project proponents will implement environmental mitigation measures (such as setting up soundproofing walls) in order to meet established standards. In cases like these, it is important to clarify the concepts they are using for forecast conditions and the like, and to track their investigation process so project proponents can efficiently consider future evaluations and follow-up surveys.

(2) Checking for impacts on other environmental components

Environmental mitigation measures against noise may have an impact on other environmental components. Erecting a soundproofing wall as environmental mitigation measure against noise may, for example, block sunlight or have an impact on the landscape. In these situations, it is important to sufficiently consider impacts on other environmental components when looking at environmental mitigation measures, taking reflected sound into account and perhaps setting up a soundproofing wall that allows light through.

2) Environmental mitigation measure details

Countermeasures to protect against noise can be roughly divided into (1) source countermeasures, (2) propagation path countermeasures, and (3) sound-receiving location countermeasures. The basic idea with environmental impact assessments is for project proponents to avoid or reduce environmental impacts through countermeasures that address sources and propagation pathways within the project implementation area as part of avoiding/reducing environmental impacts resulting from project implementation within practicable bounds.

Table III.1.3-17. Examples of environmental mitigation measures for noise (road traffic)

Example environmental mitigation measures		Countermeasure overview	Other environmental components at risk for impacts as a result of implementation	Methods for identifying results
Sound-insulating walls	Regular sound-insulating walls	These walls use shielding effects to reduce noise. They can be built on narrow sites and are easy to construct.	The higher sound-insulating walls are, the more problems they cause for the landscape, sunlight blockage, and so on	Use the ASJ RTN-Model.
	Sound-insulating walls with high-tech edges	Using overhang-type sound-insulating walls that bend at the very top or installing sound-absorbing pieces or protrusions at the tips of sound-insulating walls creates sound-insulating walls with high-tech edges for greater diffraction attenuation. This reduces the impact on other environmental components and is effective in situations where the height of sound-insulating walls is restricted.	Sunlight blockage and landscape impacts are less than those associated with regular sound-insulating walls	Use the ASJ RTN-Model. Note, however, that calculations will have to use a hypothetical straight wall for the overhang-type sound-insulating walls if the shape of the high-tech edges is not defined. In this case, project proponents can expect greater noise reduction effects than the calculated values.
	Low sound-insulating walls	Low sound-insulating walls are between a meter and a meter and a half in height. Because they need to preserve roadside access along flat urban roads, they are not continuous and have numerous openings.	Virtually no impact on other environmental components	Use the ASJ RTN-Model. Note that in cases where noise level behind the low sound-insulating wall is different at every site due to the existence of openings, project proponents can use the average energy value for equivalent noise level (L_{Aeq}) for the evaluated section.
Sound-insulating embankments		These are embankments used to shield noise. They require more land than sound-insulating walls and their height is limited based on width restrictions, so they are sometimes used in conjunction with sound-insulating walls.	As with sound-insulating walls, embankments can block sunlight and impact the landscape. Mitigate impacts on the landscape project proponents are shielding with the embankment by planting trees on it.	Use the ASJ RTN-Model.
Draining pavement		Draining pavement is designed to reduce tire/road surface noise (mainly air-pumping sounds) while creating sound-absorbing effects that target the propagation process.	Virtually no impact on other environmental components	Use the ASJ RTN-Model.

	However, these noise-reduction effects wear off over time as gaps in the pavement become clogged.		
Double-layered draining pavement	This type of pavement uses two single draining pavement layers of different particle sizes (an upper and lower layer) to create an even finer pavement surface	Virtually no impact on other environmental components	Currently under academic study
Sound-absorbing treatment	In places where there is joint construction of overpasses and surface roads, this method is used to counter sound reflected from the bottom of the overpass (located in the multilayered portion) as well as sound reflected from the sides of the dug-out road and tunnel openings. It is effective when reflected sound makes up a significant portion of the noise level alongside roads.	Virtually no impact on other environmental components	Use the ASJ RTN-Model. For sound absorption rate, use an average oblique incidence absorption coefficient.
Setting up roadside greenbelts	This countermeasure involves securing ten or twenty meters of land from the edge of the road from the road site to construct greenbelts, sidewalks, bypasses, etc., which typically produces environmental improvement effects due to distance-based attenuation. It also contributes the better local services along the road.	Take steps to mitigate air quality, vibration, low-frequency noise, and blocked sunlight impacts and create a pleasant landscape. Also find ways to create habitats for plants and animals by using greenbelts for ongoing tree-planting efforts.	Use the ASJ RTN-Model.
Using vegetation to shield roadways	Visually shielding the motor vehicles that are the source of noise can also have a psychological noise-reduction effect on pedestrians and roadside residents	Keep the air clean by encouraging the diffusion of emissions gases, and by generating adsorption effects to absorb nitrogen oxides (NOx) and suspended particulate matter (SPM). Also take steps to create a pleasant landscape.	The noise-reducing effects of this method due to shielding depend on the type and density of the vegetation used, and though they cannot be quantified, similar surface overdamping effects can be expected as those produced by rice paddies or farmland.
Soundproofing countermeasures for structures	Upgrade windows and walls and install HVAC equipment	No impact on other environmental components	To find noise level propagation into interiors, follow the Environmental Standards on Noise, which typically involves using the noise level coming into the surfaces of structures vulnerable to noise impacts and then subtracting the structural soundproofing performance of that surface
Installation of sound-absorbing louvres	This is one of the noise countermeasures used for roads that utilize a semi-underground construction (when roads are dug into the ground and have horizontal overhang structures that protrude out). It involves installing slit or lattice-shaped sound-absorbing panel around openings to reduce the propagation of noise outside the road.	Impacts on air quality need to be examined individually in light of planned installation design.	If project proponents use the simple calculation method provided by the directional point source model, they can determine effects by factoring in a correctional value for the effects of installing the sound-absorbing louvers. Note, that this requires that project proponents separately examine each correctional value project proponents set based on the equipment they intend to install.

Source: *Environmental Impact Assessment Techniques for Roadways (FY2012 edition)*, MLIT National Institute for Land and Infrastructure Management (2013); MLIT National Institute for Land and Infrastructure Management Document No. 714/Public Works Research Institute Document No. 4254)

Table III.1.3-18. Examples of environmental mitigation measures for noise (railways)

Bullet train lines

Line	Tokaido Shinkansen		Sanyo Shinkansen		Tohoku Shinkansen	Joetsu Shinkansen
Type	Tokyo to Shin-Osaka (at the time of	Tokyo to Shin-Osaka (current)	Shin-Osaka to Okayama	Okayama to Hakata	Ueno to Morioka	Omiya to Niigata

	construction)					
Train tracks	• Long rails • Turnout with moveable nose • 53 kg/m rails • Heavier PC ties • Thicker track bed	• 53, 60 kg/m rails • Ballast mats • Rail reprofiling	• Long rails • ◎ Adoption of 60kg/m rails throughout • Rail reprofiling	• Long rails • 60kg/m rails • Rail reprofiling • ◎ Ballast mats • ◎Anti-vibration slab	• Long rails • 60kg/m rails • Anti-vibration slab • ◎ Rail reprofiling	• Long rails • 60kg/m rails • Anti-vibration slab • ◎ Rail reprofiling
Structures		• Soundproofing work on rail girders	• ◎ Avoidance of rail girders wherever possible	• Avoidance of rail girders wherever possible • ◎ Development of damping materials (composite girders) • ◎ Tunnel buffer work	• Avoidance of rail girders wherever possible • Tunnel buffer work	• Avoidance of rail girders wherever possible
Soundproofing walls	• Partial adoption of direct soundproofing walls (block) (H=1.0 m)	• Flexible board soundproofing walls (H=2.0 m) • Latest soundproofing walls	• ◎ Direct soundproofing walls (concrete, H=2.0 m) • Sound-absorbing materials	• Direct soundproofing walls (concrete, H=2.0 m) • ◎Development of Reverse-L soundproofing walls (PC board) • Latest soundproofing walls • Sound-absorbing materials	• Direct soundproofing walls (concrete, H=2.0 m) • ◎ Development of Reverse-L soundproofing walls (cast-in-place concrete) • ◎ Sound-absorbing materials	• Direct soundproofing walls (concrete, H=2.0 m) • ◎ Development of Reverse-L soundproofing walls (cast-in-place concrete)
Overhead wiring	• Composite compound catenary	• Heavy compound catenary • Overhead wiring with minimal space between hangers	• ◎ Heavy compound catenary adopted throughout	• Heavy compound catenary	• Heavy compound catenary • ◎ Overhead wiring with minimal space between hangers	• Heavy compound catenary • ◎ Overhead wiring with minimal space between hangers
Vehicles	• Compact pantographs • Fixed sliding detector • Track-sweeping device	• Improved pantograph insulator shape • Improved pantograph	• Compact pantographs • Fixed sliding detector • Track-sweeping device	• Compact pantographs • Fixed sliding detector • Track-sweeping device • Improved pantograph	• Fixed sliding detector • Track-sweeping device • ◎ Improved pantograph • ◎ Extended car skirt • Half the number of pantographs • High-voltage bus pull	• Fixed sliding detector • Track-sweeping device • ◎ Improved pantographs • ◎Extended car skirt

Note: Items marked ◎ were newly implemented countermeasures until the start of service

Source: Uwabe, T. "Environmental standards and countermeasures for shinkansen railway noise", *Noise Control* Vol. 19 No. 2 (1995)

Table III.1.3-19. Examples of environmental mitigation measures for noise (production plants and other workplaces)

Classification	Countermeasures

Source countermeasures	• Methods for changing the structure/materials of noise sources • Installing anti-vibration, soundproofing, and silencing equipment • Installing soundproofing covers, soundproofing partitions, or soundproof rooms
Indoor source propagation countermeasures	• Countermeasures that use interior sound-insulating or sound-absorbing materials
Countermeasures against propagation outdoors	• Countermeasures that address structural composition (including entryways) • Countermeasures that distribute structures to shield noise
Setting up planting strips (buffer zones)	• Countermeasures that ensure distance-based attenuation from sources • Countermeasures that use large, dense, well-shaped trees

Source: Prepared based on *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

Table III.1.3-20. Examples of environmental mitigation measures for noise (construction)

Classification		Overview
Hard countermeasures	Source countermeasures	• Make an effort to use low-noise construction equipment • Make an effort to use the latest applicable soundproofing methods • Adopt low-emissions vehicles whenever possible
	Anti-propagation	• Install soundproofing sheets when residential areas are adjacent to the construction site
	At the sound receiving side	• Carry on proofing measures at the sound-receiving side when reduction targets are not met despite the implementation of both source and anti—propagation countermeasures
Soft countermeasures	Operation of construction equipment	• Make efficient use of construction equipment in order to reduce the total number of runs • Adjust the construction plan so that construction equipment is not all operating at the same time (level out the work) • Use construction equipment appropriate to the scale of the project • Keep construction equipment well-maintained, prohibit idling except when necessary, check fuel properties, and conduct proper operational management • When using specific kinds of equipment (such as backhoes or bulldozers), keep actual operating times to eight hours a day, take Sundays off, and otherwise comply with the regulations on special construction work defined in the Noise Regulation Law and other legislation • When carrying out construction work at night, do so for as little time as possible and try to finish quickly
	Movement of construction vehicles	• Create manuals indicating travel routes, travel periods, travel times, and other key considerations as well as penalties for violations in order to mitigate the impact of noise along construction roads • Instruct employees to leave their commuter vehicles at the site and not drive them through neighboring residential areas • Running times for large construction vehicles should generally be limited to between 8 AM and 6 PM, avoiding regular traffic congestion times whenever possible. School routes should also be avoided during commuting times. • To prevent lines of concrete mixers standing by on nearby roads, adjust concrete pouring work times and deliveries to wet-concrete plants while also setting up parking areas on the construction site so that the mixers can wait on-site if necessary • Limit warning sounds and other audible signals emitted from construction vehicles to an absolute minimum, ensuring that contractors and drivers are thoroughly aware of the rules • When transporting construction materials on and off site, get a detailed understanding of their size, usage period, usage location, volume, and other characteristics, and then select the right construction vehicles in order to reduce their number. This will reduce impacts along construction roads as much as possible.

Source: *Environmental Conservation Techniques for Construction*, Japanese Geotechnical Society (Maruzen 2009)

Table III.1.3-21. Examples of environmental mitigation measures for noise and infrasound

Classification	Countermeasures	Notes

Source countermeasures	In the acoustic radiation field	• Prevent pulsation or pressure changes • Increase rigidity (use sound-absorbing alloys) • Treatment with damping material • Vibration isolation (rubber cushions, springs) • Tuned Mass Damper (TMD) (a mechanical damping device)*	• Transmission loss according to the law of mass cannot be expected • Rigidity principles could use further consideration • Soundproofing materials are unlikely to be effective at around 1–100 Hz • Requires full-scale soundproofing (sound absorption, sound insulation, vibration reduction, and damping) design
	At the source	• High-rigidity soundproofing enclosures • Use of inflatable-, resonance-, or interference-type silencers* • Introducing active noise control technologies*	
Propagation path countermeasures		• Introducing resonance- or interference-type sound barriers/sound-insulating walls • Introducing active noise control technologies*	• Very little effect can be expected from the sound-insulation enclosures/walls typically used for roadways and railways • Requires full-scale soundproofing (sound absorption, sound insulation, vibration reduction, and damping) design
Countermeasures at the sound receiving side		• Eliminate the generation of stationary waves inside residences • Make changes to the thickness of multipaned class • Close gaps between the various components of residential structures • Upgrade to the latest roof tile wire	• Almost all sound-receiving side countermeasures are difficult to implement, so prioritize source countermeasures whenever possible

Note: Items marked with an asterisk (*) are effective environmental mitigation measures against infrasound as well
Source: Prepared based on Shioda, Masazumi. "Basic knowledge and practical examples of low-frequency noise (2)", *Facilities and Management* Vol. 45 No. 9 (2011)

1.3.5 Evaluations

In addition to evaluations that look at environmental impact avoidance and reduction, evaluations are also conducted to make sure that the selected assessment items are consistent with any standards or targets set forth in environmental conservation policies issued by national or local governments.

1) Evaluating avoidance and/or reduction

Evaluations of avoidance or reduction describe and assess project proponents' efforts to avoid or reduce environmental impacts as well as the considerations they make towards that end. Some of the methods used to perform these evaluations include comparing multiple environmental mitigation measure proposals and looking at whether proponents are incorporating feasible and better technologies. Other methods assess whether the project will leave the environment worse off than it currently is, or evaluate whether rattling from fixtures or fittings will generate infrasound based on a comparison against past expert knowledge.

2) Evaluating consistency with standards and/or targets

Table III.1.3-22 lists examples of noise standards and targets issued by the national government and local government agencies.

Table III.1.3-22. Examples of noise standards and targets

National and local governments	Environmental standards on noise based on the Basic Environment Law Regulatory standards based on the Noise Regulation Act
Local governments	Standards based on anti-pollution ordinances and ordinances to protect living environments Standards and targets from environmental basic plans and environmental management plans

Evaluating consistency with standards and/or targets means assessing whether project implementation is in line with the environmental conservation policies formulated by the national government or local government agencies. As with environmental standard zoning for bullet trains, these standards include government procedures to be taken after environmental impact assessment procedures are complete. There are also times when environmental basic plans formulated by local governments set forth their own unique standards and targets. When conducting evaluations, start by finding out the relative positioning of reference standards and targets in terms of those environmental conservation policies and then define which source noises are subject to evaluation in light of standard and target values, under which conditions they will be evaluated, and which evaluation indicators project proponents will use to do so.

Also note that when comparing standards and targets to forecast results, it is important to clarify the degree of impact the target project will have, specifying both noise generated by the project and noise from other sources.

If project proponents expect effects from environmental mitigation measures conducted by parties other than the project proponent in situations where environmental standards cannot be maintained given current noise conditions, they must include a detailed description of the prospects for those measures.

Once these points have been clearly explained, it is important to conduct evaluations not only from the perspective of whether their forecast results will conform to standards and targets, but also looking at whether there is a risk that the degree of impact from the target project will hinder environmental conservation in light of those standards and targets.

Points to be considered: Environmental standards and request limits/regulatory standards

Environmental standards are government-issued targets that stipulate ideal criteria under which environmental conservation should be maintained. They do not function to prevent health hazards (as do permissible noise limits to protect human hearing), and they are not meant as maximum bearable conditions (as in tolerable limits). Instead, they are ideals designed to be achieved and upheld through a wide variety of government policies. A request limit, on the other hand, is an indicator used to determine the necessity of countermeasures; regulatory standards are standards set for the purpose of preserving living environments and protecting human health. They are considered one of the many strategies implemented in order to meet environmental standards.

When referring to environmental standards in preparing environmental impact assessments, project proponents must conduct appropriate evaluations not only from the perspective of whether their forecast results conform to those standards, but also with the understanding that they are expected to take steps to avoid or reduce project impacts within practicable bounds in order to keep the components that make up the natural environment in good condition.

Points to be considered: Soundproofing construction

When standard values for noise cannot be achieved even with maximum implementation of environmental mitigation measures, soundproofing construction is sometimes carried out on the sound receiving side. The significance of soundproofing construction itself is legally defined and cannot be denied, but when it comes to considering environmental mitigation measures for environmental impact assessments, the priority is on avoiding or reducing environmental impacts from projects. For this reason, project proponents need to clearly track the investigation process by which project proponents arrived at soundproofing construction as well as clearline environmental mitigation measures within a practicable scope.

Once the environmental impact assessment process is complete or even once the project has begun, project proponents should ideally clarify their towards ongoing consideration of soundproofing construction and other measures, since superior environmental considerations are sometimes made possible by the development of environmental conservation technologies, for example.

Note that in cases where runways will be extended at existing airports or there will be a significant increase in traffic volume on existing roads as a result of new road construction, it may be extremely difficult for project proponents to implement practicable environmental mitigation measures for noise sources or propagation paths. Obviously in these situations, project proponents will need to improve the local nose environment by actively applying soundproofing aids based on the laws and regulations below as required.

Some examples of laws regulating soundproofing construction are shown below.
- Act on the Improvement of Areas along Main Thoroughfares
- Law on the Prevention of Disturbances from Aircraft Noise in the Vicinity of Public Airports
- Act on Improvement of Living Environment of Areas Around Defense Facilities

Points to be considered: Concepts applied to temporary impacts

Like vibration, noise and infrasound are different from other environmental components in that their impacts are temporary and do not remain in the environment. For this reason, their evaluations must take into account impact frequency, duration, and generation time periods. Try to stay flexible in examinations; considering, for example, the relationship between the amount of blasting material and blasting frequency during a tunneling project, or the relationship between using larger construction equipment and shortening construction time during a construction project.

1.3.6 Follow-up surveys

Because environmental impact assessments are carried out before projects are implemented, follow-up surveys are used to compensate for the uncertainty of their results. In cases where there is a large degree of uncertainty in forecasts or where environmental mitigation measures are carried out without sufficient understanding of their effects, consider whether a follow-up survey is needed based on the severity of environmental impacts. Project proponents must also look at adding or revising environmental mitigation measures as needed based on the results of follow-up surveys.

When conducting follow-up surveys, project proponents will of course need to identify the status of noise and infrasound resulting from the target project, but project proponents also need to check for factors triggering any differences that arise versus forecast results—for example, the development status of nearby roads, traffic volume, and the results of environmental mitigation measures.

It is also necessary to make use of the results of surveys conducted by local governments or other parties aside from the project proponent, including noise measurement results, complaint surveys, and traffic censuses. For follow-up surveys conducted immediately after project implementation, for example, once the project proponent has conducted a detailed survey and it is clear that no significant impacts have been incurred, using monitoring for efficient, long-term follow-up surveys should be considered.

Points to be considered: Additional environmental mitigation measures

Compared to other impacts, it is relatively easy to implement additional environmental mitigation measures for noise once project facilities are in service. In the case of new airport construction, however, additional environmental mitigation measures are difficult to implement once services has started—so it is naturally extremely important in these cases to carefully consider countermeasures prior to project implementation.

Note that when considering additional environmental mitigation measures, project proponents should not only look at physical measures such as erecting soundproofing walls, but also work with relevant agencies to examine and adopt a broad range of effective and efficient strategies for ensuring smooth traffic flow.

1.4 Vibration

1.4.1 *Selection of environmental impact assessment items and survey/forecast/evaluation methods*

1) Understanding of project concepts

Table III.1.4-1 shows examples of project characteristics to list under vibration.

Table III.1.4-1. Examples of project characteristics related to vibration

Impact factor	Example items
Construction	• Construction details, methods, time period • Construction location, scope • Types and number of facilities and equipment used in construction, operating location, operating period, etc. • Number of construction vehicles in operation, type (large/small), period, route • Plans for temporary structures, soil pits, areas where soil generated from construction will be taken in and out, etc. • Propagation process
Existence/operation of facilities	• Facility description, location, size • Facility service period • Type/size of sources • Amount of traffic congestion generated by the facilities, types of vehicles (large/small) • Routes for traffic congestion generated • Propagation process

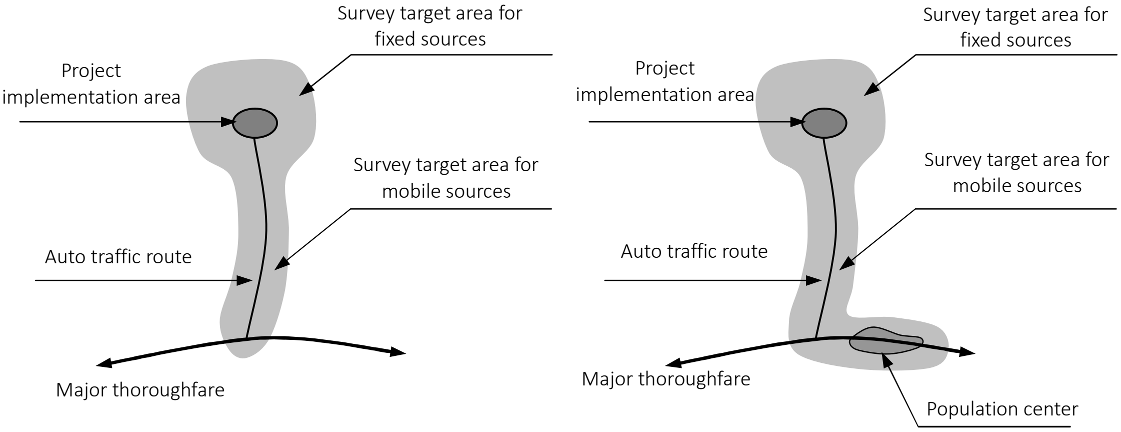
2) Understanding of regional characteristics

(1) Scope

When setting the survey target area, project proponents need to consider the range that project proponents anticipate being impacted by mobile sources (such as motor vehicles) in addition to the range that they anticipate being impacted by sources in the project implementation area in order to understand regional characteristics related to vibration. Also note that their survey target area may differ from the project implementation area depending on the kinds of sources that are generating impacts. As an example, table III.1.4-2 lists concepts for determining survey target areas based on impact factors, while figure III.1.4-1 shows examples of survey target areas involving mobile sources.

Table III.1.4-2. Concepts for using impact factors to determine survey target area

Impact factor	Target survey area concepts
Fixed sources	When sources of vibration are fixed (such as production plants) or when mobile sources will be limited to a specific area during construction (as in the case of construction equipment), the scope of the survey target area should include the area in which project proponents anticipate a certain amount of impact from vibration due to those sources. Targets should also take into consideration the scope of impact from past case examples as well as various conditions such as the topography around the sources.
Mobile sources	When sources of vibration are mobile (such as motor vehicles and trains), the survey target area should include the area where project proponents anticipate a certain amount of impact from those mobile sources themselves as well as along their routes. Also take into consideration the environmental conditions in the surrounding area.



(A) Extending to an important main thoroughfare

(B) Extending to an area particularly vulnerable to impacts

Figure III.1.4-1. Examples of survey target areas involving mobile sources

(2) Listing up natural and social conditions in the region

Tables III.1.4-3 and III.1.4-4 show examples of natural and social conditions to list for the region. Most of the existing documentation on vibration has data on isolated points at low density, so on-site surveys need to supplement this information with data on regional characteristics between these points. Project proponents can find out the characteristics of daily life in the region and how roads are being used, for example, by looking at on-site surveys on the status of sources as well as of land and road usage. It is important that project proponents are able to understand the characteristics of daily life in the region as well as the status of road usage and vibration generation, and also that project proponents actually experience (physically feel) vibrations being generated in the area.

Ideally, when looking at the measurement points used in existing documentation, project proponents should also use on-site surveys to identify the topography, natural features, and condition of sources in the surrounding area.

Table III.1.4-3. Examples of natural conditions related to vibration

Classification	Description of example items
Air quality conditions	As with noise, though documentation on vibration conditions exists, it is rarely possible to get information on environmental vibration not tied to the status of specific vibration sources from existing documentation. For this reason, project proponents will need to conduct on-site surveys in order to identify relevant regional characteristics and understand vibration in the target area.
Topographical, geological, and ground conditions	The propagation characteristics of vibration are dependent upon ground characteristics (filling soil, clay layers, loamy layers, gravel layers, hardened layers, etc.) and on ground conditions susceptible to vibration impacts (whether the ground is soft). To identify these characteristics, use existing documentation (such as subsurface geological maps) to organize information on the topographical, geological, and ground conditions in the target area.
Status of animal habitats and/or ecosystems	Situations in which there are concerns that vibration generation may impact animals or ecosystems include those in which vibrations may trigger aversive behavior in animals. In these cases, project proponents need to look at the interrelationships between vibration and animals/ecosystems and select survey ranges and methods accordingly.

Status of places for activities with nature	Situations in which there are concerns that vibration generation may impact places for activities with nature include areas where impacts from vibration are expected and there are campgrounds, for instance, whose usage characteristics may change as a result of that vibration. In these cases, project proponents need to look at the interrelationships between vibration during construction and conditions in places for activities with nature and select survey ranges and methods accordingly.

Table III.1.4-4. Examples of social conditions related to vibration

Classification	Description of example items
Population and industrial features	(a) Population features Identify the size and distribution of the population in the survey target area. (b) Industrial features When looking at industrial activity in the survey target area and the status of industrial activities that generate vibration, get a statistical summary of the conditions and identify the location of key facilities. If there are industries that project proponents anticipate being vulnerable to impacts from vibration, identify the location of their key facilities as well. **Example:** Precision processing work
Land usage conditions	(a) Land usage Project proponents can typically get an understanding of land usage conditions by looking at a land usage map. In some cases, they will also need to make use of vegetation maps, aerial photos, and other general documents and/or on-site surveys. (b) Zoning designations Urban planning maps are the primary source for identifying the status of zoning designations in the survey target area. Project proponents also need to refer to general plans and other documents issued by local governments in when looking at future impacts so that they understand the direction of upcoming land usage trends. (c) Status of underground structures Check to see if there are conditions that would impact vibration propagation to underground structures. Project proponents can usually get a general idea of the situation based on topographical and residential maps.
Traffic conditions	(a) Motor vehicle traffic volume When there will be construction work or the existence/use of land or structures and project proponents are looking at whether to select vibration impacts from motor vehicle traffic as a target for environmental impact assessment, identify traffic volume conditions along target roadways. Motor vehicle traffic volume conditions can be found by looking at traffic volume measurements along major roadways found in traffic censuses (nationwide road traffic survey), and prefectures and municipalities sometimes measure traffic volume as well. Collect and organize the information project proponents find in these documents. The information items project proponents collect during the item/method selection stage should include 24-hour traffic volume, 12-hour traffic volume, percentage of large vehicles, and level of traffic congestion. Note that if documentation does not exist for target roadways, project proponents should ideally conduct an on-site survey to get a general idea of traffic conditions. They also need consider the possibility of future changes in traffic volume by looking at road plans as well as development plans in surrounding areas. (b) Railways If railways already run through the survey area and may be generating vibration impacts, identify the type, location, and service frequency of the trains.

<table>
<tr>
<td>Status of targets considered particularly vulnerable to impacts</td>
<td>(a) Distribution of facilities considered particularly vulnerable to impacts
Identify facilities likely to be particularly vulnerable to impacts from vibration in addition to general land usage conditions in the area.
<table>
<tr><th>Classification</th><th>Example facilities</th></tr>
<tr><td>Educational facilities</td><td>Nursery schools, kindergartens, elementary schools, junior high schools, high schools, universities, vocational schools, and other schools</td></tr>
<tr><td>Medical facilities</td><td>Hospitals, clinics offering residential services, long-term care facilities, etc.</td></tr>
<tr><td>Other public facilities</td><td>Libraries, foster homes, social services facilities, etc.</td></tr>
<tr><td>Parks</td><td>Children’s playgrounds, city parks, etc.</td></tr>
</table>
(b) General distribution of residential areas
In addition to looking at the status of zoning designations stemming from land usage conditions and urban planning laws, project proponents should ideally use on-site surveys to get an up-to-date picture of residential distribution. Particularly when it comes to vibration, they need to have information on residential structures (wooden construction, reinforced concrete, etc.).

Project proponents should also understand the possibility of future residential development by looking at general plans and other documents indicating, for example, land usage incentive policies by various local government agencies.</td>
</tr>
<tr>
<td>Status of legally-designated areas and regulations</td>
<td>Identify the environmental standards, regulatory standards, target values, and designated regions set forth in relevant laws and regulations.
• Vibration Regulation Act
• Act on the Improvement of Areas along Main Thoroughfares
• Urgent Measures against Vibration from Bullet Train Lines for Environmental Conservation (recommendation)
• Pollution prevention plans
• Local ordinances to prevent pollution, protect living environments, etc.
• Local environmental basic plans</td>
</tr>
</table>

3) Selection of environmental impact assessment items

(1) Listing up impact factors and environmental components

Table III.1.4-5 lists impact factors related to vibration, looking at the sources of vibration as well as conditions for each source.

Table III.1.4-5. Key sources of vibration by type and main conditions impacting vibration level

Type	Main conditions impacting vibration level
Road traffic vibration	Road location, road structure, number of lanes, road surface conditions, time-specific traffic volume, percentage of large vehicles, average traveling speed, anti-vibration measures
Railway vibration	Track location, track structure, train car type, traveling frequency, traveling speed, anti-vibration measures
Vibration from production plants or other workplaces	Type, location, and size of production plant/workplace, vibration generation times, anti-vibration measures
Construction vibration	Type, location, and size of sources, construction equipment usage times, vibration generation times, conditions at the construction site, anti-vibration measures

Source: Prepared based on *Environmental Assessment Techniques*, Center for Environmental Information Science (1999)

(2) Selecting environmental impact assessment items

Select environmental impact assessment items based on the relationships between impact factors and environmental components.

Points to be considered

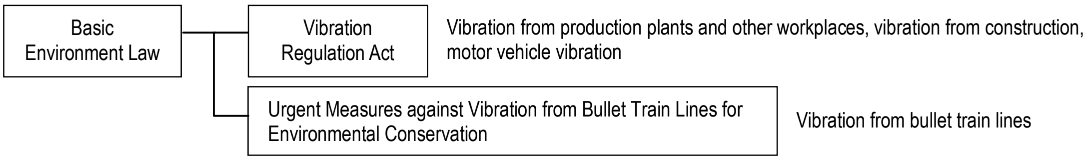
In situations where it becomes clear that (1) there are no environmental impacts related to the environmental impact assessment items or the level of environmental impact is extremely small; or (2) the project implementation area and its surroundings do not include areas or targets subject to environmental impacts related to those items for the given period, it is possible that none of the items will be selected for the environmental impact assessment. In cases like these, be sure to include information in the Scoping Document and other documents under “target project details” and “general conditions in the area” that provides a rationale for a decision.

Note that “areas or targets subject to environmental impacts” in (2) above refers to areas connected to human living environments as well as the presence of natural environments subject to the generation of vibration. It is clear that targets do not exist “for the given period” when they are not in existence during the life of the project or while it is in service, or the project construction period at the very least—as indicated by land usage regulations, land usage incentive policies, and the like. This corresponds, for example, to localized vibration impacts in a construction zone where there are no residents or natural environments requiring consideration. Note that vibration in mountainous areas or other locations where there are no residences may still affect animals, so this needs to be considered in selection of items as well.

4) Selection of survey, forecast, and evaluation methods

(1) Method selection concepts

As Figure III.1.4-2 and table 1.4-7 show, laws and regulations also stipulate survey and evaluation methods for vibration, as in the case of vibration from bullet train railways and production plants/workplaces. In these situations, project proponents should first look into the methods based on those laws, but when project proponents are conducting environmental impact assessments, it is important to carry on surveys, forecasts, and evaluations using methods that are appropriate for their regional and project characteristics rather than limiting their selection to the legally-designated methods in every case. If there are no legal standards in place (as with vibration from regular railways), project proponents still need to move ahead with their survey, forecast, and evaluation methods while referencing existing expert knowledge.



Note: These are just the major laws and regulations stipulating vibration measurement and/or evaluation methods.

Figure III.1.4-2. Major laws and regulations on vibration

(2) Refining and simplifying survey and forecast methods

Refining survey and forecast methods for vibration may involve conducting detailed on-site surveys on the conditions needed to examine forecasts and environmental mitigation measures or densely distributing survey and forecast sites. Simplifying survey and forecast methods may involve using existing documentation to determine the conditions needed for forecasts or adopting forecast methods that predict the degree of impact using comparisons with similar case examples.

The following are some examples that will help project proponents determine whether to refine or simplify survey/forecast methods.

Examples of situations when more detailed methods should be considered

1. When the degree of environmental impact is likely to be significant
2. When the region is vulnerable to environmental impacts or there are vulnerable targets
    - When there are schools, hospitals, residential districts, or other areas with facilities that require particular consideration in terms of human health or environmental conservation
    - When there are areas vulnerable to vibration impacts, such as reclaimed land or other soft ground
3. When the region is legally-designated for environmental conservation or when there are legally-designated targets
4. When the regional environment is already significantly compromised or at high risk
    - Areas where vibration exceeds motor vehicle vibration request limits[12]
5. When project or regional characteristics will likely make it difficult to conduct forecasts using general-purpose methods
    - Areas with complex propagation conditions due to topography or ground characteristics
6. When local governments or project proponents have specific priorities when it comes to environmental conservation
    - When local governments or project proponents have determined that environmental conservation must be prioritized in light of regional characteristics, project characteristics and/or environmental conservation policies in the project

Examples of situations when simplifying methods should be considered

1. When it is clear that the degree of environmental impact will be minimal
    - When project plan details make it possible to explain that the degree of environmental impact will be minimal, project proponents may be able to use that as a rationale for simplifying project their forecasts.
2. When it is clear that there will not be any regions subject to environmental impact or any targets for a certain period of time
    - When it is clear that there are no residences, facilities, or other targets in the area at risk for impacts from vibration, either currently in the future, project proponents may

---

[12] The vibration request limit value is defined in the following stipulation of the Vibration Regulation Act: “motor vehicle vibration in excess of the limits established by the ordinance of the Prime Minister's Office cause undue damage to the living environment surrounding roads within designated areas, the prefectural governor may request the prefectural public safety commission to implement measures pursuant to the provisions of the Road Traffic Law.”

be able to use results from environmental mitigation methods or other performance records for example, for their forecasts

3. When it is clear from similar case examples that environmental impacts will be minimal
    - When the degree of impact can be estimated from surveys and other case examples from similar projects, project proponents may be able to use that data for forecasts.

1.4.2 Surveys

1) Selection of survey items

Survey items will likely include vibration conditions, ground conditions, and so on, but select survey items while sufficiently considering ability to appropriately grasp the degree of vibrational impact generated from project implementation in light of project characteristics/scope and regional characteristics so that project proponents can obtain the information project proponents need to conduct forecasts and evaluations. At the same time, in order to examine forecast and evaluation methods taken in detail and get the information needed, it will need to consider implementing surveys like the ones shown in Table III.1.4-6.

Table III.1.4-6. Examples of survey items used to collect information needed for forecasts and surveys

Survey item	Required information
Vibration levels from similar projects	Understanding source characteristics
Traffic volume	Estimates of future traffic volume
Dominant ground vibration frequency[13]	Estimates of traffic vibration
Current vibration levels	Extent of changes from current status

2) Survey method concepts

With surveys, project proponents need to select the survey method project proponents need for forecasting once project proponents have identified evaluation targets and methods. Particularly when it comes to vibration-related evaluation indicators, it is important to take into consideration differences in different types of sources (see table III.1.4-7).

Note that vibration surveys, forecasts, and evaluations are typically conducted outdoors, but keep in mind that there are situations where vibrations will change as a result of propagation processes within homes.

Table III.1.4-7 Evaluation indicators based on vibration laws and regulations

Standard Type	Regulatory standard (request limit)	Guidelines, ordinances, etc.	Notes

---

[13] Dominant ground vibration frequency: In most environmental impact assessments, dominant ground vibration frequency indicates peak ground vibration when vehicles pass by. In the formula that is widely used in traffic vibration forecasts to estimate the upper-end value for the 80-percent range of vibration level (a formula proposed by the former Public Works Research Institute, Ministry of Construction), dominant ground vibration frequency is used as an indicator to express ground conditions.

Traffic vibration		L_{V10}	—	1
Train vibration	Bullet trains	—	L_{Vmax}	2
	Regular trains	—	—	—
Vibration from production plants and other workplaces		L_{Vmax}, L_{V10}, and others	—	3, 4
Vibration from construction		L_{Vmax}, L_{V10}, and others	—	1, 4

Notes:

1) Enforcement Regulations for the Vibration Regulation Act (Ministerial Ordinance issued by the Prime Minister's Office No. 58 of November 10, 1976)
2) Urgent Measures against Vibration from Bullet Train Lines for Environmental Conservation (recommendation) (Kandai-Toku No. 32 of March 12, 1976)
3) *Environmental Standards on Vibration from Designated Production Plants* (Notification No. 90 of the Environmental Agency, November 10, 1976) and regulations issued by prefectural governors
4) May be stipulated in local government ordinances.

3) Survey area/site concepts

(1) Survey area

The range of the survey area must include sites that will experience maximum impacts from project implementation based on project characteristics (such vibration characteristics) and regional conditions (such as topography and land usage). Project proponents must also take into consideration whether there are areas thought to be vulnerable to environmental impacts.

In general, the survey area is frequently set as the project implementation area or an area at a certain distance from the edge of a roadway. Determine the survey area while taking into consideration project characteristics, vibration propagation characteristics, and so on, including a range within which vibration levels will change to a certain extent due to project implementation. In cases where there is a large degree of uncertainty about the range in which there is a certain level of change (because the propagation distance is so great, for example), project proponents may want to err on the side of caution by making it larger than they might need.

Note that when considering the impact of moving construction vehicles, if the destination is clear (as in the case of locations where soil generated from construction is being reused) and efficient travel routes for construction vehicles are therefore limited between the project implementation area and the reuse sites, there are cases where project proponents can anticipate a certain degree of change in traffic vibration level for the entire route between the project implementation area and the reuse sites. In situations like these, the survey area range should include sites that will experience maximum impacts from project implementation. Figure III.1-4-1 provides methods for determining areas leading up to main thoroughfares and those particularly vulnerable to impacts (e.g. when there are population centers along major thoroughfares).

(2) Survey sites

Vibration surveys are generally conducted at fixed points, so project proponents will need to establish survey sites. Table III.1.4-8 presents concepts for determining survey sites when conducting on-site surveys.

When they are actually conducting on-site surveys, project proponents need to confirm safety during measurements and that the impact from nearby designated sources is minimal; it is also possible to properly evaluate environmental changes from the current status by selecting sites that match forecast sites as much as possible.

Note that if project proponents anticipate conducting a follow-up survey, they should ideally consider beforehand the possibility of doing so at the sites they select as well.

Table III.1.4-8. Concepts for determining vibration survey sites

Site classification	Site determination concepts
Sites representative of the area	Set sites that project proponents believe to be representative of the regional characteristics of the area. Select locations where there is little impact from specific nearby sources.
Sites at risk for particularly major impacts	Set sites that project proponents expect will experience particularly major project impacts based on project and regional characteristics.
Sites with targets requiring particularly careful consideration of environmental conservation	If project proponents set forecast/evaluation sites that include residences or facilities requiring particularly careful consideration of environmental conservation (such as schools or hospitals), and they expect that conditions there will be different than the sites representative of the area due to impacts from roads or other sources, select these locations as survey sites. Note that they need to select survey sites once they determine whether there are sources of vibration established at these facilities.
Sites where environmental conditions are already significantly compromised	Select sites that are considered to have already experienced deterioration due to vibration conditions as a result of impacts from specific sources—typically roads or train lines.
Sites where impacts from specific sources can be identified	In cases where measurements are being taken in similar case examples, fully confirm similarity in terms of project details and facility size as well as propagation conditions from the source before selecting sites that allow project proponents to identify the specific vibration conditions that they will use as forecast targets.
Sites designated in laws or regulations	Survey sites are sometimes designated in laws and regulations (on vibration from production plants/workplaces, for example), so if project proponents are conducting evaluations to check for consistency with standards and targets or if they anticipate conducting follow-up surveys, select the sites designated in those laws and regulations. Examples: Vibration from production plants/workplaces→at the site boundary

4) Survey period and timing concepts

It is essential that the survey period and timing are appropriate and allow project proponents to efficiently achieve their survey goals.

When the sources have an operational plan (such as trains), or when their operation is otherwise under human control (as in the case of production plants), it is possible to conduct efficient and effective surveys by studying those schedules in advance and setting the survey period and timing accordingly.

Because traffic vibration is a source created by the motion of an unspecified number of vehicles, when setting survey period/timing project proponents need to identify in advance traffic volume, types of vehicles, traveling speed, and other usage characteristics as well as consider temporal fluctuations based on the season, day of the week, and time of day.

1.4.3 Forecasts

1) Forecast method concepts

Forecasts should basically be carried out for the evaluation indicators stipulated in laws and regulations (see table III.1.4-7), but project proponents should ideally look into evaluation indicators other than those based on laws and regulations as needed.

When locations are specified in the standards and/or targets set forth in environmental basic plans or ordinances issued by local governments, forecasts need to use the evaluation indicators required to assess conformity with those standards and/or targets.

Points to be considered: Forecasts for evaluation indicators not based on laws and regulations

When conducting quantitative forecasts for regular railway vibration (for which laws and regulations do not specify evaluation indicators) or when project proponents anticipate that evaluation indicators based on laws and regulations will be insufficient for their forecasts, project proponents need to consider using the proper evaluation indicators for their situation.

・When laws and regulations do not specify evaluation indicators: Example concepts
Vibration from regular train lines: Base decisions on vibration from bullet train railways with similar source characteristics

Tables III.1.4-9 through III.1.4-11 show examples of forecast methods for vibration. Select forecast methods for vibration while referring to theoretical propagation calculation formulas, empirical regression formulas, and similar case examples while also considering project details in light of other appropriate methods. Academic societies and other groups offer highly versatile vibration forecasting formulas for a variety of sources (motor vehicles, trains, aircraft, production plants/workplaces, etc.), but even if project proponents use these forecasting methods, they need to sufficiently consider their application conditions and degree of uncertainty rather than blindly applying formulas.

Table III.1.4-9 Examples of vibration forecast methods (traffic vibration)

Name	Description and features
(1) Formula for forecasting the upper limit of the 80 range for vibration level	This model addresses vibration level at standard forecast points on flat roads. It uses regression analysis to create a formula for forecasting vibration level based on traffic volume, number of lanes, vehicle speed, flatness of the road, and data on ground characteristics. This information is then used to create correction items that reflect the impacts of the road structure and distance from the road into the forecast formula. Applied conditions are listed below. ・Equivalent traffic volume: 10–1,000 vehicles/lane/500 sec ・Traveling speed: 20–140 km/h

	・Number of lanes: 2–8 (non-elevated), 2–6 (elevated) ・Road flatness: Road flatness standard deviation 1–8 mm (non-elevated), maximum change in height from expansion joint within a ±5-meter range 1–30 mm (elevated) ・Embankment height: 2–17 m ・Cut height: 2–18 m ・Ditch height: 2–6 m
(2) INCE/J RTV-Model 2003 by the Institute of Noise Engineering, Japan	This is a traffic vibration forecast formula that is based on the frequency characteristics in ISO2631-1: 1985 and takes into consideration ground and road surface characteristics. It defines the forecast value as equivalent vibration level (L_{Veq}). It also takes into consideration the fact that administrators use the upper limit of the 80% range for vibration level (L_{V10}) as their evaluation value, and provides a formula for converting L_{Veq} into L_{V10}. ・Road structure: Flat road ・Traffic volume: 36–930 vehicles/lane/hour ・Traveling speed: 20–80 km/h ・Forecast range: Within 50 meters of the roadside ・Ground: loamy, gravel, alluvial (even if the ground is layered, it can be treated as having semi-unlimited elasticity) ・Road surface flatness: 1.24–6.0 mm (standard deviation) ・Equivalent total thickness of roadbed pavement: 18.5–60 cm ・Number of lanes: 1–8
(3) Prediction model for flat roadways	This formula was designed to handle the ground in Tokyo. The main differences between this formula and the formula in (1) is that it clearly classifies roads by ground type and incorporates pavement structure. However, it only targets flat roads on Tokyo ground. Applied conditions are as follows. ・Ground: Loamy, gravel, alluvial ・Number of lanes: Up to 6 ・Road surface flatness: 1–6 mm ・Equivalent converted total flatness: 10–60 cm ・Traveling speed: 20–70 km/h ・Number of vehicles: (35 every 10 min to 350 every min) per lane ・Forecast range: Up to 30 meters out perpendicular to the road

Sources:

(1) *Environmental Impact Assessment Techniques for Roadways (FY2012 edition)*, MLIT National Institute for Land and Infrastructure Management (2013); MLIT National Institute for Land and Infrastructure Management Document No. 714/Public Works Research Institute Document No. 4254)

(2) "The Road Traffic Vibration Prediction Model (INCE/J RTV-Model 2003)" by the Technical Subcommittee of the Institute of Noise Control Engineering, Japan. *Noise Control* Vol. 28 No. 3 (2004)

(3) Yokota, A. "Predicting Traffic Vibration", *Noise Control* Vol. 18 No. 6 (1994)

Table III.1.4-10 Examples of vibration forecast methods (railway vibration)

Name	Description and features
(1) Proposed formula and improved formula from the Teito Rapid Transit Authority	This forecast formula was created laminated diluvium ground in the wards of Tokyo based on measured results of soil quality with good internal attenuation. Its applicable scope is essentially locations whose soil quality is similar to that of the wards of Tokyo. When forecasting for alluvial soil in the Tokyo words, the model proposes adding 5 dB to the constant K value for each track. Also, because the forecast values are given as averages, project proponents will need to use a number higher than the forecast value if project proponents are focusing on peak vibration. As a rough guideline, the model proposes adding 5 dB to get peak value. Other applied scope information for each model is as follows: *Forecast formula for multi-track box tunnels*

	Minimum distance between the tunnel and forecast site (X): 3 m < X < 50 m Tunnel weight (Y): 30 t/m < Y < 150 t/m Train speed (Z): 30 km/h < Z < 75 km/h *Forecast formula for multi-track shielded tunnels* Minimum distance between the tunnel and forecast site (X): 8 m < X < 50 m Tunnel weight (Y): 30 t/m < Y < 70 t/m Train speed (Z): 30 km/h < Z < 75 km/h *Forecast formula for single-track shielded tunnels* Minimum distance between the tunnel and forecast site (X): 8 m < X < 50 m Tunnel weight (Y): 15 t/m < Y < 30 t/m Train speed (Z): 30 km/h < Z < 75 km/h Note that this is a basic formula proposal and that various corrections are made based on differences in track structure and other factors.
(2) The Tokyo model	This model was presented in Environmental Forecast Surveys for Elevated Railways, a survey of elevated and similar sites that the Tokyo Bureau of Construction conducted in 1980. It proposes two types of damping: damping that results from the weakening of energy per unit of space in distance-based attenuation, and internal damping that results as vibrational energy is converted to heat energy via friction inside a medium during the propagation process. These forecasts required vibrational level at standard sites, but there is a method for calculating it that uses a relative equation between speed and vibrational level prepared from measurement surveys for individual structural types at similar sites.
(3) The Osaka model	This formula comes from a 1980 Survey Report on the Development of Predictive Model for Railway Noise/Vibration and Propagation according to Land Usage Conditions Along Railways, which was conducted by the Special Pollution Section at the Pollution Office in the Osaka Prefectural Department of Living Environments. The results of this survey on how vibration propagates depending on the way land is used along railways within Osaka Prefecture resulted in the formulation of region-specific parameters. These can be considered in light of train speed, distance-based attenuation, and structural types, but ground characteristics cannot be factored in. Still, because it does not require specifying vibration level at standard sites the way the Tokyo model does, vibration can be forecast at a variety of sites according to structural types as long as distance and speed are entered into the formula.
(4) Forecast models based on measured results from similar lines	There are also examples of forecast formulas that analyze the relationship between train speed and distance from the vibration source on existing tracks for each of the main types of structures.

Sources:
(1) Teito Rapid Transit Authority documents
(2) (3) *Technical Manual on Ground Environment Vibration Countermeasures*. Ground Environment Vibration Research Group, Calamity Science Institute (2013)

Table III.1.4-11 Examples of vibration forecast methods (vibration from production plants/workplaces and construction)

Name	Description and features
Theoretical formula for propagation	If we assume that the ground has semi-unlimited, homogenous elasticity, the waves that spread out from a single point will undergo what is called geometric damping—which indicates the relationship between two terms: attenuation inversely proportional to distance to the nth power and an internal constant for the soil.

Source: Shoida, Masazumi, *Forecasting Methods for Vibration Pollution* (Inoue Shoin 1986)
Environmental Impact Assessment Techniques for Roadways (FY2012 edition), MLIT National Institute for Land and Infrastructure Management (2013); MLIT National Institute for Land and Infrastructure Management Document No. 714/Public Works Research Institute Document No. 4254)

(1) Forecast conditions: Concepts

Primary units and other conditions used in forecasts require that project proponents not only consult document used in past environmental impact assessments, but also that they check for new data and incorporate it as needed. Pay particular attention when it comes to primary units for things like reference point vibration level for construction equipment, as this data is constantly changing as new equipment gets developed.

Also, when conducting forecasts using excerpts or analyses from existing case examples, take into account uncertainty as well as propagation characteristics, frequency characteristics, and the similarity of these conditions as applied to own forecast conditions, describing them as clearly as possible. If project proponents do conduct forecasts using excerpts from case examples, it is important that they make an effort to provide multiple case examples so that it is as clear as possible why the cases they chose are suitable for the project.

a) Examining primary units

Primary units (such as standard point vibration level) form the basis of vibration prediction and can be roughly divided into two categories: primary units set for practical purposes and primary units set based on countermeasure targets. Project proponents also need to check to make sure that primary units like standard point vibration level are consistent with those set conditions and evaluation indicators.

If project proponents are using primary units set based on actual measurements, make sure to clearly indicate the measurement conditions and similarities. Note that it is actually impossible to have conditions that are exactly the same as forecasts, so identify the uncertainties arising from forecast conditions before using them.

Primary units set based on countermeasure targets need to be examined in terms of the feasibility of the countermeasures. If feasibility cannot be confirmed, project proponents need to clearly provide details on the uncertainty involved as well as its extent.

With motor vehicle traffic, forecasts typically look at two types of vehicles (large and small), but in cases where large dump trucks, trailers, and other construction equipment is being used, primary units need to be set in accordance with the reality of the situation (e.g. in consideration of the high vibration levels generated by extra-large equipment). When setting primary units like these—particularly standard point vibration level for construction equipment, project proponents need to check on detailed conditions, such as the kinds of operating conditions that are in place, whether maximum value or time-ratio vibration level are used, and so on.

b) Propagation characteristics

Among the major factors that determine propagation characteristics for vibration are distance and the type of ground. The former is called geometric damping, while the latter is called internal damping. Theoretical attenuation formulas exist for both. If project proponents are using a theoretical attenuation formula, they need to clearly indicate the propagating frequency (surface waves, seismic waves) and how they are treating ground characteristics, as these will impact their results.

Several forecasting formulas are provided below for a variety of assumed conditions. These can be used to predict vibration from multiple unspecified mobile sources (as with traffic vibration) or underground vibration with complex propagation characteristics, as when vibration sources are in the ground. When project proponents use a forecasting formula, project proponents need to clearly explain why it is suitable for the situation project proponents are applying it to—for example, by comparing their project against a similar case example in which the calculation formula was applied. Particularly when it comes to in-ground vibration sources like road tunnels or subways, it will likely be difficult to implement environmental mitigation measures once the facilities are in service. This makes it critical that project proponents take propagation characteristic uncertainties into account as well.

c) Frequency characteristics

Vibration that propagates through the ground contains multiple frequency components. The higher the frequency, the faster the attenuation; and the faster the ground transmits it (as with hard ground), the less attenuation occurs. Ground substances also have their own unique vibration periods that will generate amplifying resonance when a vibration frequency matches their vibration frequency. When this occurs, distance has less effect on the amount of attenuation.

d) Other

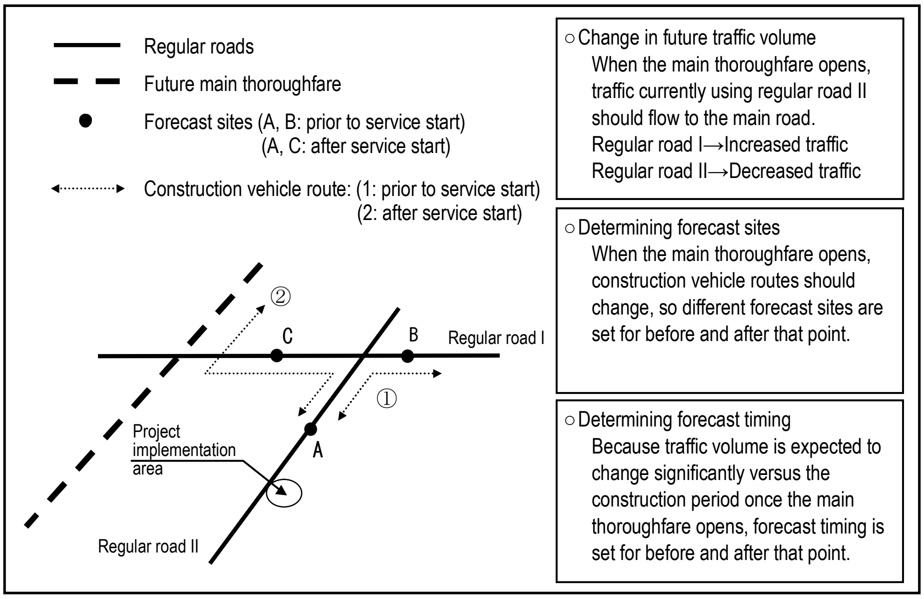
Future traffic volume

Future traffic volume used for environmental impact assessments is frequently set using growth rate, which is obtained (1) using road development plans and based on current traffic volume or (2) using traffic distribution simulation settings based on transportation networks and an origin-designation matrix for the target year—data which is in turn sourced from road development plans. Make sure to take into consideration the project and regional characteristics listed in Table III.1.4-12 in order to determine an appropriate method.

When formulating estimates, carefully consider future transportation network construction, taking into account not just new construction and renovation plans for roads and railways, but also any project currently underway and how far along they are. This will allow project proponents to determine a more suitable transportation network. Particularly in cases where there will be major changes in the transportation network at some future point in time (such as when highways go into service), make sure to sufficiently consider project proponents traffic volume and other settings. Figure III.1.4-3 shows some examples of those concepts.

Table III.1.4-12. Project and regional characteristics associated with future traffic volume

Project characteristics	• Construction plan • Roadway facility plans • Designed traffic volume (for roadway projects)
Regional characteristics	• New construction or renovation status of roads and railways • Large-scale development in surrounding areas • Changes in regional traffic volume throughout the year or over time



○ Change in future traffic volume
When the main thoroughfare opens, traffic currently using regular road II should flow to the main road.
Regular road I→Increased traffic
Regular road II→Decreased traffic

○ Determining forecast sites
When the main thoroughfare opens, construction vehicle routes should change, so different forecast sites are set for before and after that point.

○ Determining forecast timing
Because traffic volume is expected to change significantly versus the construction period once the main thoroughfare opens, forecast timing is set for before and after that point.

Figure III.1.4-3. Sample approaches to changes in future traffic volume due to new road construction

Travel speed

The forecast condition of travel speed is typically set using speed limits and design speed. Note, however, that in cases where regulation speed is slower than the speed limit or design speed or situations where congestion is likely to occur, project proponents should ideally clarify the uncertainty involved in the fact that actual speed will be different than the traveling speed used as a forecast condition.

Note that in cases where traffic volume is extremely low overnight, for example, and vehicles are likely to travel faster than regulation speed, the project proponent must describe environmental mitigation measures according to their position; in other words, urging the relevant agencies to crack down on speed regulations or ensuring that construction vehicle drivers thoroughly comply with speed regulations.

Differences in vibration level inside and outside homes

Vibration can change as a result of the propagation process through homes, and there are numerous differences in vibration levels in the ground surface around homes and within them depending on how the residences are constructed. If project proponents have positioned their forecast site outside and are evaluating sensitivity threshold[14] (the limit at which people start to feel vibration), keep in mind the possibility that vibration inside homes may exceed that limit.

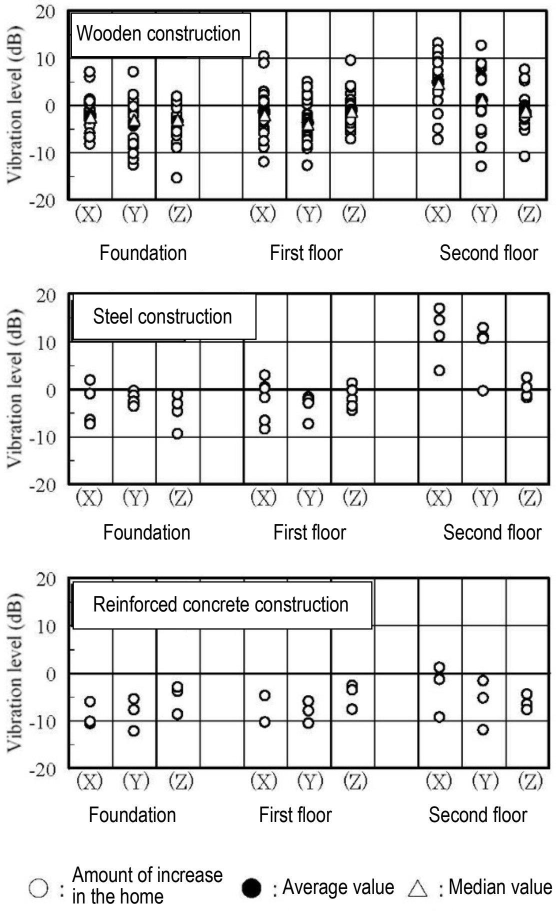
---

[14] Vibration sensitivity threshold: The vibration level used in the Vibration Regulation Act adds a vibration sensitivity correction for vibration acceleration level perpendicular to the human body. The human vibration sensitivity threshold is about 60 dB for the level at which 50% of people will feel the vibration, and about 55 dB for the level at which about 10% of people will feel it. However, keep in mind that depending on the frequency, people may still feel vibration levels (overall values) below the sensitivity threshold.

Points to be considered: Survey on differences in vibration level inside and outside of homes

Figures III.1.4-4 and III.1.4-5 show the results of a study that tracked differences in vibration level inside and outside 30 structures according to the type of source emitting the vibration. (There were four one-story wooden structures, 18 two-story wooden structures, one one-story steel structure, four two-story steel structures, and three two-story reinforced concrete structures involved in the study.)

The results indicate that vibration inside structures has different characteristics than vibration in the ground around them. The vibration increased or decreased depending on the vibrational characteristics of the structures, but there was significant variation in those characteristics depending on the structure of the homes and other factors—making it difficult to determine a representative, mean-characteristic value. Variation was also seen in the difference in vibration level inside and outside; this was within the range of plus or minus 20-20 dB in the collected data. The study indicated, therefore, that vibration at site boundaries is very likely to have different characteristics than vibrations in indoor living environments (the vibration that residents experience).



(Top: 22 wooden structures Middle: 5 steel structures Bottom: 3 reinforced concrete structures)

Figure III.1.4-4. Differences in vibration level in residential foundations and interior measurement sites

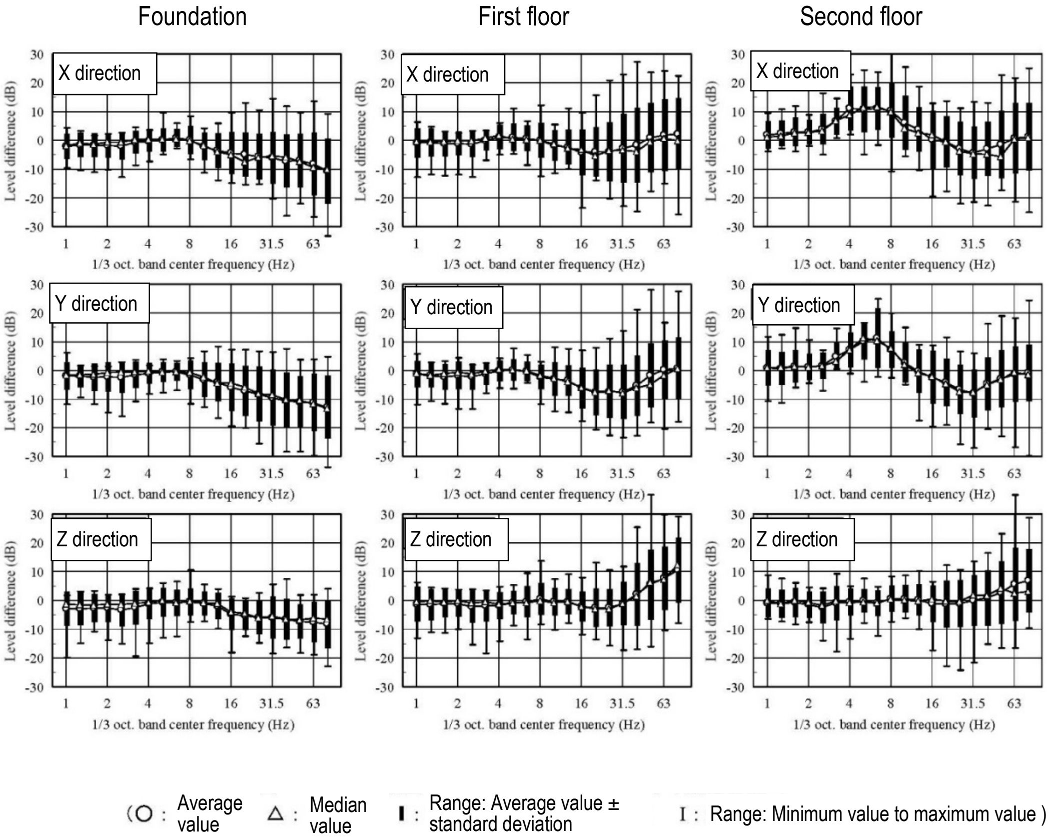


Figure III.1.4-5. Changes in vibration by frequency in 22 wooden homes

Source: *2007 Report on the Results of Work Contracted under the Ministry of the Environment: Surveys Examining Vibration Evaluation and Regulatory Methods.* Institute of Noise Control Engineering of Japan (2008)

(2) Forecast uncertainty

Forecast uncertainty comes from various factors, including uncertainty caused by forecast conditions, uncertainty due to factors related to forecast methods, and uncertainty due to the fact that there is insufficient insight into what results environmental mitigation measures will produce. While project proponents should ideally make effective use of existing scientific knowledge and similar case examples in order to eliminate these forms of uncertainty as much as possible, keep in mind that there are uncertainties that project proponents cannot control—such as future traffic volume and traveling speed for road projects. There are various forms of uncertainty involved with vibration, particularly in the process it goes through after being emitted from the source and before hitting the ground, structures, or the human body.

2) Forecast area/site concepts

In most cases, forecast area needs to include a range within which vibration due to project implementation will rise to a certain level or higher, and will typically include the survey area. This range can change based on project size/details, but take forecast uncertainty and regional characteristics into consideration and err on the side of caution by making it larger than project proponents might need. Note also that in situations where survey results indicate that there are areas that do not need to be targeted for forecasts and evaluations, project proponents can eliminate these surveyed areas from their forecast area.

It is easy to identify source conditions in the case of production plants or other fixed sources, so in these cases project proponents can set their range using the forecast methods shown in table III.1.4-11. If there will be motor vehicles or other mobile sources, a basic guideline is to use a range of between several tens and several hundred meters from the roadside as their forecast area, since their impact on the surrounding area is relatively limited.

3) Forecast period concepts

a) During construction

In addition to identifying changes in construction volume over time throughout the entire course of the project plan and changes in construction zones, forecasts during construction should take the following factors into account. For forecasts related to the operation of construction equipment, set the forecast period as the period during which construction equipment is located closest to the forecast site or the period where the type of construction being carried out generates the maximum vibration level. For forecasts involving construction vehicles, set the forecast period as the period during which the greatest number of construction vehicles are running.

When construction will be taking place over an extremely long period of time and there are likely to be changes in forecast conditions (such as changes in the routes that construction vehicles travel during construction), consider conducting forecasts during a mid-term period as well.

b) Once facilities are in service

Once project facilities are in service, set the forecast period for the steady state during which facilities are operating or vehicles are traveling. Note that if the project is being implemented in stages over a long period of time or if there will be major changes in environmental conditions partway through, project proponents will need to identify those changes over the course of year and conduct forecasts during an appropriate period.

c) Other

For projects involving the establishment of final waste disposal sites or replacing thermal power plants, it is likely that the construction period will overlap the service period. In these situations, consider environmental impacts both for construction implementation and facility service, identify points in time where impacts are likely to be greatest, and set project forecast timing accordingly.

1.4.4 Environmental mitigation measures

1) Consideration procedures

(1) Examining environmental mitigation measure policies

When it comes to vibration, policies are frequently dictated by environmental standards, regulatory standards, and the like. The policy towards environmental mitigation measures can include the meeting of standards, but it is also fairly likely that it is necessary to establish policies outside of the achievement of standards once project proponents consider project and regional characteristics. Also, when local environmental basic plans include targets aligned with regional characteristics or consideration policies are spelled out, those need to be properly considered as well.

The regional characteristics needed to consider when looking at environmental mitigation measures include whether there are exclusive residential districts or other facilities that are particularly vulnerable to vibration impacts, and what the current environmental status is. Project characteristics that need to be considered include vibration generation characteristics (time, frequency, etc.) as well as construction plans (construction period, construction methods, etc.). Taking these regional and project characteristics into account is part of examining environmental mitigation measures.

(2) Checking for impacts on other environmental components

When ground improvements have taken place, there may be impacts on the topography, natural features, animals, or plants. In these situations, it is important to sufficiently consider impacts on other environmental components when looking at appropriate methods and environmental mitigation measures.

2) Environmental mitigation measure details

Countermeasures to protect against vibration can be roughly divided into (1) source countermeasures, (2) propagation path countermeasures, and (3) vibration-receiving location countermeasures. The basic idea with environmental impact assessments is for project proponents to avoid or reduce environmental impacts through countermeasures that address sources and propagation pathways within the project implementation area as part of avoiding/reducing environmental impacts resulting from project implementation within practicable bounds. Those characteristics are shown in table III.1.4-13, while examples of specific mitigation measures for each type of vibration are shown in tables III.1.4-14 through III.1.4-18.

Table III.1.4-13. Characteristics of countermeasures against traffic vibration

No.	Countermeasure	Specific methods	Characteristics
1	Structural improvements to motor vehicles	Improvements to motor vehicles themselves, such as better suspension springs, the use of shock absorbers, etc.	Because these countermeasures also result in improved ride comfort and overlap with shipment countermeasures, structural improvements are immensely beneficial.
2	Implementing traffic restrictions	Speed limits, designated sections for large vehicles, crackdown son overloaded vehicles, etc.	These countermeasures are effective and easy to implement. They are also effective as required countermeasures for traffic management.
3	Ensuring levelness of road surfaces	Overlays, resurfacing, surface treatments, etc.	These countermeasures have reliable effects, making them ideal for implementation by road administrators. They are also greatly appreciated by the residents who live near the roads.
4	Improving pavement structure	Thicker concrete slabs Higher T_A value	Cement/concrete pavement is an effective countermeasure against vibration. Asphalt pavement is not guaranteed to be effective.
5	Reducing level differences	Reducing level differences at bridge mounts, pavement joints, areas of damaged pavement, etc.	The effects of reducing level changes (e.g. via smoothing) can be extremely good. This is an ideal countermeasure for road administrators to implement.
6	Mitigations related to embankment structure	Adopting appropriate road structures	Ideally, the most suitable road structures should be adopted in light of various factors (including economic factors) that are unrelated to traffic vibration.
7	Installing roadside greenbelts	Creating space between roads and residential areas	This countermeasure produces reliable distance-based attenuation effects. It is difficult to secure the land needed along existing roads, however.
8	Vibration isolation trenches, anti-vibration walls	Underground walls made from urethane or Styrofoam	Although this concept has been around for a long time, it requires underground walls that are quite deep, so it comes with logistical difficulties in terms of construction work and maintenance.
9	Mitigations related to ground improvements	Replacement with quality material, sand piles, sand drains, etc.	It is possible to apply stability treatments to the ground, but impossible from a practical standpoint when there are homes along the road.

Source: Kiyomizu, H., Adachi, K., Suji S., and Nemoto, M. *Road Environments* (Sankaido 1987)

Table III.1.4-14. Examples of environmental mitigation measures for vibration (road traffic)

No.	Countermeasure	Specific methods	Vibration mitigation effects
1	Improving road surface flatness	・Overlays ・Repaving	Reducing the standard deviation of surface unevenness (σ) by 1 mm reduces L_{10} by about 4 dB.
2	Traffic regulations	・Reducing travel speed ・Restricting traffic volume ・Restricting travel lanes	Moving traffic towards the center by one lane reduces vibration level at the edges of roadways by 2–3.5 dB if it is less than 60 dB, and by 6.5–7 dB if it is more than 60 dB.
3	Installing roadside greenbelts	・Putting space between roads and residential areas	Installing a 20-meter wide roadside greenbelt reduces vibration level at the edge of the road by 5–12 dB on sandy ground or by 3–6 dB on clay ground. The extent of these reductions depends on the L_{10} value at the edge of the road.
4	Improving soft ground	・Chemico-pile method ・Sand compaction	Installing chemico-pile with a diameter of 40 cm and a depth of 12 cm at a 90-cm pitch reduced vibration by a third to a half when no road surface acceleration

		method ・Sand drain method and others	was installed.
5	Underground walls	・Underground walls made from urethane or Styrofoam	An underground Styrofoam wall 80 cm wide at a depth of 3.6 meters has reduced vibration by 2–12 dB in an area up to 35–45 meters behind the wall.

Source: Yokoyama, K. "Examples of Traffic Vibration Countermeasures". *Noise Control* Vol. 13 No. 3 (1989)

Table III.1.4-15. Examples of environmental mitigation measures for vibration (railways)

Classification	Characteristics	Examples
Source countermeasures	Examples of source countermeasures include structural countermeasures for train cars (car and wheel maintenance), structural measures for tracks (installing long rails or laying ballasts), and general structural measures.	• Long rail sections with welded joints reduce vibration between a third and a half compared to jointed rail sections. • Improved rail construction using ballast mats reduces vibration by a fifth compared to conventional rail construction and should also lower ground vibration.
Countermeasures to block propagation pathways	Vibration insulation measures involve methods of preventing vibration from propagating by digging trenches between the structure and the problem site or between buildings. However, there are cases where the type of frequency makes them ineffective.	• There are cases where urethane foam was used to line tunnel walls during underground rail construction, which in experiments had a VL effect of around 6 dB. • Air trenches 20 cm wide can also be built along the walls of buildings facing tunnels, and the earth between the building and the tunnel can be replaced with sand.
Obstacle prevention measures	When there are still impacts on residents even after source countermeasures have been taken, project proponents can consider relocating buildings or taking anti-vibration measures on homes.	• In cases where buildings are constructed directly on top of tunnels, support beams can be constructed between the building pillars and the tunnel, and spaces between the tunnel and the building can be can be filled with sand and urethane foam.

Source: *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

Table III.1.4-16. Examples of environmental mitigation measures for vibration (railways)

Classification		Features
Train car countermeasures		• Because railway surface equipment is so long, measures to counteract vibration in train cars is extremely effective if it can be done. • Train car vibration countermeasures include making cars more lightweight (which is becoming increasingly practical), though the current high-speed bullet trains have likely already been lightened as much as possible.
Track counter measure s	Adding base springs	• Base spring coefficient rail connection devices primarily target sections of slab track (tracks that use pretested concrete slabs). There are also ballasted elasticity ties and ballast mats, which are used on sections of ballasted track (tracks where ties and rails are laid over gravel or stone). • Base spring coefficient rail connection devices are track pads placed between the rails and ties or between track slabs that have a lower spring coefficient than normal. They have been shown in past experiments to reduce vibration in high-frequency zones of 63 Hz or more. • Ballasted elasticity ties have elastic material placed under concrete ties. Ballast mats have mats made of elastic material placed under crushed stone on the track bed. In construction examples for the bullet train, these countermeasures had an anti-vibration effect of between 0 and 4 dB depending on where they were installed, for an average effect of about 2 dB over a 12.5- to 25-meter section. • Bullet trains sometimes use an anti-vibration track structure (such as directly-linked anti-vibration tracks or long tracks), and these strategies are widely applied to subways and regular railways as well. • Note, however, that railway support spring coefficients have a major impact on train running stability, so it is difficult to use an extremely low spring coefficient for high-speed trains.

	Smoothing out rail unevenness	• Unevenness along the railhead surface arises from rail manufacturing processes as well as the friction that trains produce as they travel along them. Because it creates a forced displacement effect against the train cars, vibration is generated to the extent that unevenness conditions or surface conditions deliver impacts along the line. Examples of measures to counteract vibration caused by unevenness along railheads include reprofiling the railhead surface and changing out the rails to eliminate unevenness and taking steps to reduce vibration in a frequency band that addresses the wavelength of the unevenness.

Source: Yokoyama, H. “Characteristics of Vibration arising from Rail Systems” *Noise Control* Vol 35 No. 2 (2011)

Table III.1.4-17. Examples of environmental mitigation measures for vibration (production plants/workplaces)

Classification	Features
Source countermeasures	• If there is a way to carry out work using equipment that has the same function but lower vibration, switching out the equipment is the most effective way to eliminate sources of vibration. • Maintenance and improvement can also decrease the exciting force generated by equipment, as can operational practices intended to reduce it as much as possible. The directionality of the exciting force can also be considered. • Even when equipment is running properly, stronger and weaker vibration may still be generated due to compound effects with other equipment.
Ground propagation route countermeasures	• When waves are propagating through a medium, vibration is generally reduced while increasing distance (distance-based attenuation). During propagation, it is also possible to create barriers that will reduce it—such as constructing insulating layers like anti-vibration ditches or anti-vibration walls.
Receiving-side countermeasures	• When vibration that is transmitted from housing foundations can the structure of homes or cause movement in structural members (windowpanes, sliding doors, etc.), and vibration can sometimes be detected through the observance of noise or the movement of objects. Taking steps to reduce vibration propagation or prevent resonance/shaking in structural members are merely addressing the symptoms of the vibration, but they are important, nonetheless.

Source: *Environmental Assessment Techniques*, Center for Environmental Information Science (Chuohoki Publishing Co., Ltd. 1999)

Table III.1.4-18. Examples of environmental mitigation measures for vibration (construction)

Vibration source countermeasures (hard countermeasures)	• Adopting low-vibration construction methods • Adopting low-vibration construction equipment • Lay steel plates along construction roads (in the construction zone) • Pave construction roads (in the construction zone) • Repair construction vehicle approach paths (in the construction zone) • Adopt compact construction equipment near residential areas • Perform crushing work using low-vibration hydraulic crushers or similar equipment	Vibration source countermeasures (soft countermeasures)	• Inform everyone of reduced speed through signage and speed warning devices • Use signs to restrict backhoe output • Educate construction equipment operators • Always use the same construction equipment operators • Use vibration monitoring to issue real-time warnings to construction equipment operators • Bypass locations where the passage of construction equipment would generate significant vibration
Propagation route countermeasures (hard countermeasures)	• Install linked underground walls or stress-insulating walls (such as steel sheet pile) • Adopt the latest vibration propagation prevention methods	Adjusting construction details (soft countermeasures)	• Restrict construction equipment operating times (use later start times or voluntarily restrict vibration-producing work on Saturdays) • Adjust scheduled concrete-pouring days in different

			construction zones
Receiving-side countermeasures (hard countermeasures	• Reinforcing anti-vibration features of structures subject to vibration	Communication with residents (soft countermeasures)	• Notify residents of constructions using bulletins or flyers • Greet residents or make rounds or other visits to support face-to-face communication • Hold construction information sessions • Host construction tours
Receiving-side countermeasures (soft countermeasures	• Temporarily evacuating those subject to vibration		

Source: *Handbook for Local Governments on Countermeasures against Construction Vibration*. Office of Odor, Noise and Vibration, Environmental Management Bureau, Ministry of the Environment (2012)

1.4.5 Evaluations

In addition to evaluations that look at environmental impact avoidance and reduction, evaluations are also conducted to make sure that they are consistent with any standards or targets set forth in environmental conservation policies issued by national or local governments.

1) Evaluation of avoidance and/or reduction

Evaluations of avoidance or reduction describe and assess project proponents' efforts to avoid or reduce environmental impacts as well as the considerations they make towards that end. Some of the methods used to perform these evaluations include comparing multiple environmental mitigation measure proposals and looking at whether proponents are incorporating feasible and better technologies. Other methods assess whether the project will leave the environment worse off than it currently is, or evaluate by comparing vibration threshold levels[15].

2) Evaluation of consistency with standards and/or targets

Table III.1.4-19 lists examples of vibration standards and targets issued by the national government and local government agencies.

Table III.1.4-19. Examples of vibration standards and targets

National and local governments	Regulatory standards based on the Vibration Regulation Act
Local governments	Standards based on anti-pollution ordinances and ordinances to protect living environments Standards and targets from environmental basic plans and environmental management plans

Evaluating consistency with standards and/or targets means assessing whether project implementation is in line with the environmental conservation policies formulated by the national government or local government agencies. Standards and targets related to vibration are frequently stipulated according to the type of vibration source, so when conducting evaluations, start by finding out the relative positioning of reference standards and targets in terms of those environmental conservation policies and then define which source vibrations are

---

[15] Vibration threshold levels: See p. III (air quality)-87

subject to evaluation in light of standard and target values, under which conditions they will be evaluated, and which evaluation indicators project proponents will use to do so.

Also note that when comparing standards and targets to forecast results, it is important to clarify the degree of impact the target project will have, specifying both vibration generated by the project and vibration from other sources. Once these points have been clearly explained, it is important to conduct evaluations not only from the perspective of whether the forecast results will conform to standards and targets, but also looking at whether there is a risk that the degree of impact from the target project will hinder environmental conservation in light of those standards and targets.

Points to be considered: Request limits and regulatory standards

Request limits are indicators used to determine the necessity of countermeasures, while regulatory standards are standards set for the purpose of preserving living environments and protecting human health.

In preparing environmental impact assessments, project proponents must conduct appropriate evaluations not only from the perspective of conformance with regulatory standards, but also with the understanding that they are expected to carry out environmental mitigation measures in order to avoid or reduce project impacts within practicable bounds and keep the components that make up the natural environment in good condition.

Points to be considered: Concepts applied to temporary impacts

Like noise and infrasound, vibration is different from other environmental components in that its impacts are temporary and do not remain in the environment. For this reason, their evaluations must take into account impact frequency, duration, and generation time periods. Try to stay flexible in the examinations; considering, for example, the relationship between the amount of blasting material and blasting frequency during a tunneling project, or the relationship between using larger construction equipment and shortening construction time during a construction project.

1.4.6 Follow-up surveys

Because environmental impact assessments are carried out before projects are implemented, follow-up surveys are used to compensate for the uncertainty of their results. In cases where there is a large degree of uncertainty in forecasts or where environmental mitigation measures are carried out without sufficient understanding of their effects, consider whether a follow-up survey is needed based on the severity of environmental impacts. Project proponents must also look at adding or revising environmental mitigation measures as needed based on the results of follow-up surveys.

When conducting follow-up surveys, project proponents will of course need to identify the status of vibration resulting from the target project, but also need to check for factors triggering any differences that arise versus forecast results—for example, the development status of nearby roads, traffic volume, and the results of environmental mitigation measures.

It is also necessary to make use of the results of surveys conducted by local governments or other parties aside from the project proponent, including vibration measurement results, complaint surveys, and traffic censuses. For follow-up surveys conducted immediately after project implementation, for example, once the project proponent has conducted a detailed survey and it is clear that no significant impacts have been incurred, using monitoring for efficient, long-term follow-up surveys should be considered.

Points to be considered: Additional environmental mitigation measures

It is often difficult to implement additional environmental mitigation measures for vibration once project facilities are in service, so it is naturally extremely important in these cases to carefully consider countermeasures prior to project implementation.

Note that when considering additional environmental mitigation measures, project proponents should not only look at physical measures such as repaving roads, but also work with relevant agencies to examine and adopt a broad range of effective and efficient strategies for ensuring smooth traffic flow.