**Mongolia**
**Air Pollution Reduction Department (APRD)**

# Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia

## Technical Manual 06
## PM10 and PM2.5 Measurement and PM Composition Analysis Manual

**September 2016**

**Japan International Cooperation Agency**
**SUURI-KEIKAKU CO., LTD.**

# Introduction

In this project JICA Experts have planned filter sampling of PM10 and PM2.5 of the ambient air at some sites in every season and analyze the components of the samples. JICA Experts will use the result for identification of PM sources throughout the year including winter season when the air pollution is severe and achieve information which will be useful for the policy making. Samplings and composition analysis of 120 points in total are scheduled in 3 years from 2014 to 2016. Considering the matters of power source and security, sampling points were selected from 10 local monitoring stations (6 stations of CLEM and 4 stations of APRD (AQDCC)) in UB City. And JICA Expert Team also used one local residence in northern gel area, Chingeltei from December 2014.

Mass concentration of PM10 and PM2.5 is calculated by comparing the mass weight of sampled filter from before to after sampling. Major chemical compositions of PM are various elements, carbon components, and water soluble ionic species. However, analysis instruments were not in Mongolian country, above samples of filter on which PM was collected were used for composition analysis in Japan.

Necessary operational procedure regarding measurement of PM10 and PM2.5 mass concentration was summarized in this manual. Also method of PM composition analysis was described for future reference in this manual.

Some persons in charge were trained during the technical cooperation project. However, person in charge has the potential to leave of absence or retire for individual situation. JICA Expert Team very much hopes that APRD will complete task of training of successors through the use of this manual in order to perform continuously the PM2.5 and PM10 measurement.

September, 2016

Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 in Mongolia

JICA Expert Team

# Photo

Thermo FRM 2000i Sampler

MCAS Slit Jet Air Sampler


Thermo FRM2000i Sampler

MCAS Slit Jet Air Sampler

Thermo FRM2000i Sampler

Filter weighing

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# 1 Filter weighing Manual

## METTLER TOLEDO　XP6

## １． Procedure of the Filter weighing

① Put filters in the climate chamber.
② Conditioning of the filters at 21.5℃±1.5℃ and 35%±5% during 24 hours
③ Switching On- Press «On/Off». The display appears
④ Perform calibration “Zero point”
⑤ Open the front door of micro balance and put the filter in the central position of weighing dish using tweezers, then close the front door of micro balance.

Note: Propagation of vibration has a bad effect on weighing filter, Single-handed work should be done.

⑥ After the stabilization, print measured value.
⑦ Open the front door of micro balance and take the filter from the central position of weighing dish using tweezers, and then put the filter in petri dish fodder.
⑧ Switching Off– Press «On/Off» until "Off" appears on the display.

Precaution Statement

- So a measured value is different by worker, that weighing should be done by the same worker.
- Don’t move without single-handed during weighing the filter.
- PTFE filter: Should take a part of a ring on filter by tweezers. If there is a hole in the filter, it is impossible to perform sampling using this filter.
- Quartz Filter: Should push a corner of the filter with tweezers and flout the filter, and then take the filter.

## ２． Troubleshooting and Maintenance

Refer operating instructions “METTLER TRADE Excellence ultra-micro balance XP” with regard to the troubleshooting and Maintenance.

## ３． Others

Refer the operating instructions “METTLER TRADE Excellence ultra-micro balance XP” with regard to detailed operation method and setting up the balance.

# 2 Climate Chamber Operation Manual

1. Switch On the earth leakage breaker of the product.
2. Check the water level of humidification water supply tank.
3. Drain the discharging water tank (once-daily checking).
4. Check the set temperature at 21.5℃ and set humidity at 35%
5. When start the product, press the RUN・STOP button on the control panel.
6. Wait during 2 hours until stabilization of the set temperature and set humidity.
7. If operation is abnormal, an alarm cord C640, C641 or C140 will be displayed. However, when temperature and humidity are stabilized, display of the alarm code is cleared.

Note: Refer the operating manual "ORION Precision Air Processer" with regard to the contents of the display.

8. When stop the product, press the RUN・STOP button on the control panel.
9. The digital humidity display is alternating between [COL ] and the measured value.
10. The RUN lamp (green) will go out, and after cool down operation is complete the product will automatically shut down.

Caution:

・When start the product, open the front window of the climate chamber to prevent high humidity in the climate chamber.

・When press the RUN・STOP button after shutting down, open the front window of the climate chamber to prevent high humidity in the climate chamber.

・When HEPA filter and water supply hose are clogged, temperature and humidity will be not stabilized. HEPA filter and humidifier should be cleaned once –yearly to protect the product.

# 3 MCAS-SJ Sampler  Filter Exchange Manual

## Common

Take out the Impactor parts from the sampler.
Put them on the clean paper.

## Quartz filter

Clean the pinset with alchohol and clean paper.

Loose the snap locks and take out ① & ② parts.

Take out the impaction filter holder from the ③Motor Housing.

Remove the cover of the impaction filter holder and the o-ring.

Move the filter to the Petrislide with the pinset.

Put the cover of the Petrislide and fix it with tape.

Clean the impaction filter holder with clean paper.

Clean the impaction filter holder with clean paper.

Clean the o-ring for the impaction filter holder with clean paper.

Remove ③ & ④ parts.

Remove the back up filter holder from the back up stage.

Remove the upper part of the back up filter holder.

To remove the upper part slowly, use the flat pinset.

Move the filters to the Petrislide with the pinset.

It is easy to pick up the filter with the mesh plate with a pinset and take out the mesh plate on the Petri slide.

Put the cover of the Petrislide and fix it with tape.

Clean the back up filter holder with clean paper.

Clean the mesh plate with clean paper.

Put two pieces of new filters on the back up filter holder.

Put one piece of new filter on the impaction filter holder.

Adjust to place the filters in the center of the back up filter holder.

Put the upper part of the back up filter holder and fix it tightly.

Put the back up filter holder with new filters on the back up stage (⑤).

Before putting it, confirm the red o-ring is placed on the back up stage properly.

Put back ③ & ④ parts.

Take care there is no gap between ④ & ⑤ parts.

Adjust to place the filter in the center of the impaction filter holder.

Put the o-ring on the filter.

Take care there is no gap between the o-ring and the filter.

Put back the cover of the impaction filter holder and tighten it.

Put the impaction filter holder with new filter on the motor housing (③).

Confirm the red o-ring is placed on the motor housing properly (③).

Clean ① & ② parts before putting them back. Loose the snap locks and remove ① part from ② part.

Clean ① part with clean paper.

Clean ② part (upper side) with clean paper.

Clean ② part (lower side) with clean paper.

Put back ① part to ② part and tighten the snap lock.

Put back ① & ② parts on the motor housing (③) and tighten the snap locks.

## PTFE filter

Clean the pinset with alchohol and clean paper.

Loose the snap locks and take out ① & ② parts.

Take out the impaction filter holder from the ③Motor Housing.

Remove the cover of the impaction filter holder and the o-ring.


Move the filter to the Petrislide with the pinset.


Put the cover of the Petrislide and fix it with tape.


Clean the impaction filter holder with clean paper.

Clean the o-ring for the impaction filter holder with clean paper.

Clean the mesh plate with clean paper.

Remove ③ & ④ parts.

Remove the back up filter holder from the back up stage.

Remove the upper part of the back up filter holder.

To remove the upper part slowly, use the flat pinset.

Move the filter to the Petrislide with the pinset.


It is easy to pick up the filter with the mesh plate with a pinset and take out the mesh plate on the Petri slide.

Put the cover of the Petrislide and fix it with tape.


Clean the back up filter holder with clean paper.

Clean the mesh plate with clean paper.

Put a new filter on the back up filter holder.

Put the upper part of the back up filter holder and fix it tightly.

Put the back up filter holder with new filters on the back up stage (⑤).

Before putting it, confirm the red o-ring is placed on the back up stage properly.

Put back ③ & ④ parts.

Take care there is no gap between ④ & ⑤ parts.

Put a new filter on the impaction filter holder.

Put the o-ring on the filter.

Put back the cover of the impaction filter holder and tighten it. Put the impaction filter holder with new filter on the motor housing (③).

Confirm the red o-ring is placed on the motor housing properly (③).

Clean ① & ② parts before putting them back. Loose the snap locks and remove ① part from ② part.

Clean ① part with clean paper.

Clean ② part (upper side) with clean paper.

Clean ② part (lower side) with clean paper. Then put back ① part to ② part and tighten the snap lock.

Put back ① part to ② part and tighten the snap lock.

Put back ① & ② parts on the motor housing (③) and tighten the snap locks.

## Common

Keep the collected filter samples in non-contaminated condition.


Wrap up and keep cool.

# 4 Slit Jet Air Sampler

# Operation Manual

（MCAS-SJ-M4-S1）

This manual is translated “Slit Jet Air Sampler Operation Manual (MCAS-SJ-M4-S1)” into Mongolian language. JICA Expert used this manual for C/Ps training, and C/Ps have referred to this manual as needed. “Slit Jet Air Sampler Operation Manual (MCAS-SJ-M4-S1)” is copyrighted by Murata Keisokuki Service Cooperation, and to publish this manual is to provide competitors with an opportunity to obtain reference material. Therefore, despite one of the PM10 and PM2.5 measurement and PM composition analysis manual, this manual is not able to be put down as a manual.

# 5 Ambient Air Sampler (FRM)

# Operation Manual

Model: 2000i

This manual is translated “Ambient Air Sampler (FRM) Model: 2000i Quick Guide” into Mongolian language. JICA Expert used this manual for C/Ps training, and C/Ps have referred to this manual as needed. “Ambient Air Sampler (FRM) Model: 2000i Quick Guide” is copyrighted by Thermo Fisher Scientific Inc., and to publish this manual is to provide competitors with an opportunity to obtain reference material. Therefore, despite one of the PM10 and PM2.5 measurement and PM composition analysis manual, this manual is not able to be put down as a manual.

# 6 PM Composition Analysis Manual

## PM Composition Analysis

Major chemical compositions of PM are various elements, carbon components, and water soluble ionic species.

### 1 Various Elements Analysis

By applying energy-dispersible X-ray fluorescence spectroscopy (EDXRF) to the Teflon filter sample after the weighing, concentrations of various elements; Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Se, Br, Rb, Sr, Mo, Sn, Sb, Ba, Pb are analyzed non-destructively.

The sample is irradiated by excitation X-ray chosen in proportion to the objective elements, and the energy spectrum of X-ray emitting from the sample is measured by the semiconductor detector. The element is identified from the energy of the photo-peak observed in the obtained spectrum, and the photo-peak intensity is determined quantitatively in comparison with the strength of the thin film standard samples of which surface concentration of the elements is known. The X-ray is irradiated by using the suitable secondary target in proportion to the objective elements. For X-ray irradiation, 7 secondary targets (Al, $CaF_2$, Fe, Ge, Mo, $CeO_2$ and $Al_2O_3$) are used, and the various elemental concentrations were obtained by analyzing the measured X-ray fluorescence spectrum. The example of measured spectra by using Mo-target was shown in Figure 1.

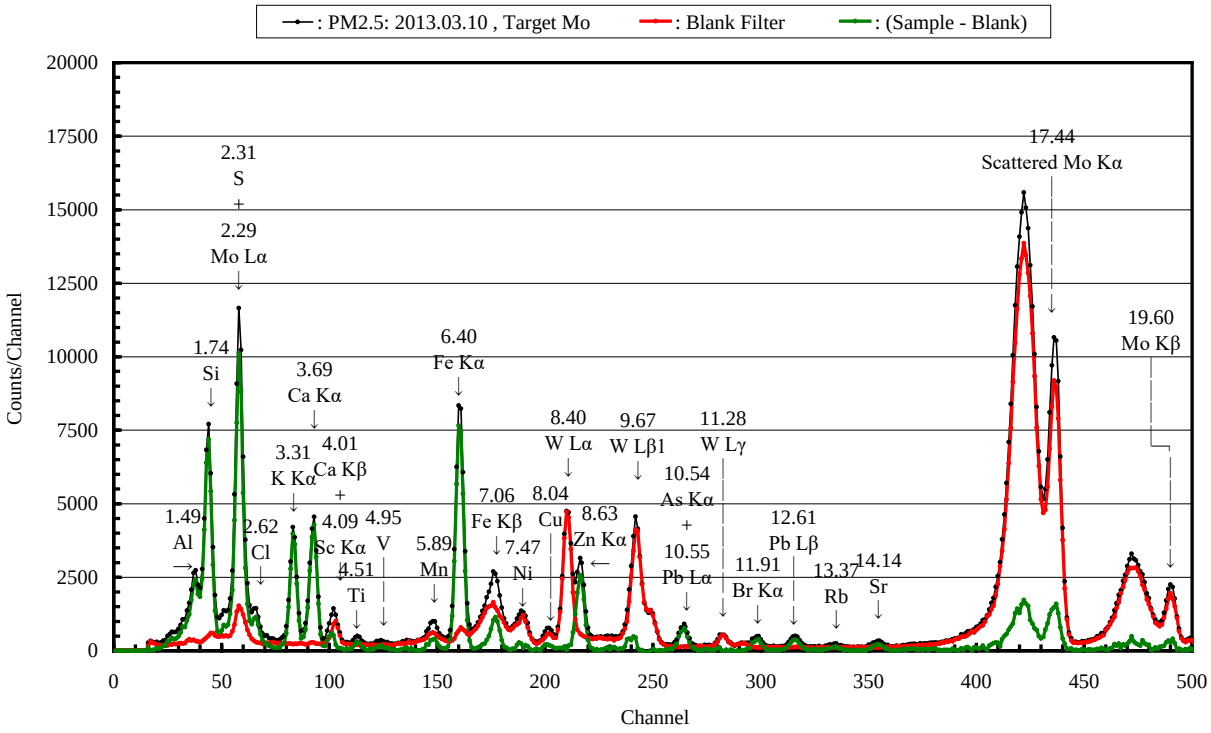


**Figure 1 Obtained X-ray Spectrum of PM2.5 Sample Irradiated by Excitation X-ray from Secondary Target Mo**

## 2 Carbon Analysis

The small piece (8 mmφ) of PM2.5 sample collected on the quartz fiber filter was analyzed for carbon components, OC and EC, by thermal optical reflectance method (TOR) using IMPROVE-A procedure. In this method, the organic carbon was classified into 4 fractions (OC1 to OC4) and the elemental carbon into 3 fractions (EC1 to EC3), according to the temperature differences of the analytical atmospheres. The estimated correction was applied by monitoring the sample surface of quantity of charred organic matter in pyrolysis by observing the change of the reflectivity. By mounting 2sheets of quartz fiber filter pre-heated at 900 degrees Celsius for 3 hours on the holder of the sampler, and 2 sample filters were obtained. The gaseous organic matter concentration was also grasped by analyzing the lower filter which adsorbed gaseous organic matter without PM. The relation of carbon fraction and measurement condition is shown in Table 1 and the definition of carbon components in Table 2. Obtained thermogram of $PM_{2.5}$ sample, measured by DRI model-2001 Thermal Optical Carbon Analyzer was shown in Figure 2.

**Table 1 Relationship between Each Carbon Fraction and Analysis Atmosphere and Temperature**

| Measurement Condition | | | |
|---|---|---|---|
| Carbon fraction | Sensor setting temperature | | Analysis-atmosphere |
| | IMPROVE | IMPROVE-A | |
| OC1 | 120℃ | 140℃ | He |
| OC2 | 240℃ | 280℃ | He |
| OC3 | 450℃ | 480℃ | He |
| OC4 | 550℃ | 580℃ | He |
| EC1 | 550℃ | 580℃ | 98%He+2%$O_2$ |
| EC2 | 700℃ | 740℃ | 98%He+2%$O_2$ |
| EC3 | 800℃ | 840℃ | 98%He+2%$O_2$ |

**Table 2 Definition of Carbon Components**

| |
|---|
| Total C : TC = OC1 + OC2 + OC3 + OC4 + EC1 +EC2 + EC3 |
| Organnic C : OC = OC1 + OC2 + OC3 + OC4 + OCpyro |
| Elemental C : EC = TC - OC |
| Volatile OC : VOC = OC1 |
| High Temperature OC : HTOC =OC - OC1 |
| High Temperature EC : HTEC = EC2 + EC3 - max(Ocpyro - EC1) |

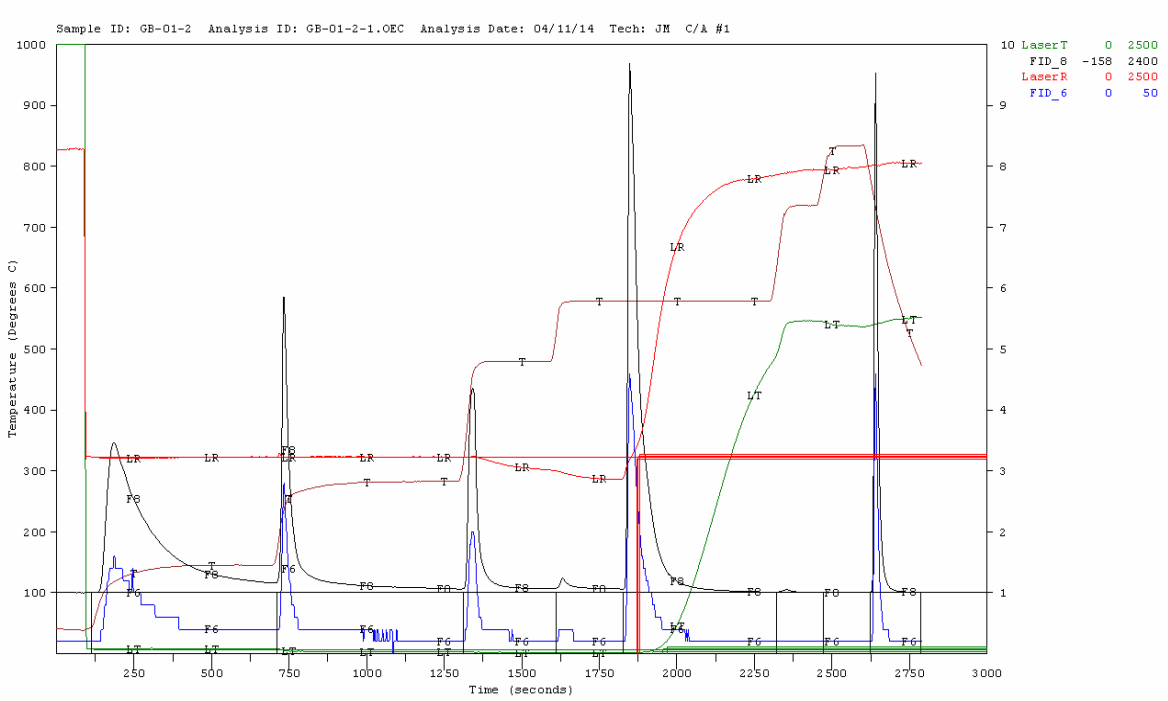


**Figure 2 Obtained Thermogram of PM2.5 Sample, Measured by Thermal Optical Carbon Analyzer**

## 3 Water-soluble ionic species

The water-soluble ionic species were analyzed by the ion chromatography (IC). The water-soluble ionic species were extracted ultrasonically from the half of PM2.5 sample collected on the quartz fiber filter with 10 ml of deionization distilled water. The filtrate was analyzed to determine the concentration of anion ($NO_3^-$, $SO_4^{2-}$, $CO_3^{2-}$ and $Cl^-$) and cation ($NH_4^+$, $Na^+$, $K^+$ and $Ca^{2+}$) by IC.

## 4 Result of the Chemical Composition Analysis

Chemical compositions contained in PM2.5 are mainly various elements, carbon components, and water soluble ionic species. Concentrations of various elements, carbon components and water soluble ionic species in PM2.5 were respectively measured by EDXRF method, thermal optical carbon reflectance method with IMPROVE-A method and ion chromatography method, and obtained results were tabulated in Table 3, Table 4 and Table 5, respectively.

The sample name shows name of city (UB), date (yyyymmdd), site (C for CLEM or A for AQDCC), and particle size range (F for PM2.5 or L for PM10) of the sample collected in order.

**Table 3 Concentration of various elements in PM2.5 measured by EDXRF method, samples collected in Jan. 2014**

(ug/m3)

| Sample / Element | UB20140117C5F | | UB20140118C5F | | UB20140120C7F | | UB20140121C7F | | UB20140123C2F | |
|---|---|---|---|---|---|---|---|---|---|---|
| PM(ug/m3) | 1029.5 | | 130.5 | | 174.2 | | 101.1 | | 146.4 | |
| SD(mg/cm2) | 0.182 | | 0.276 | | 0.369 | | 0.214 | | 0.230 | |
| Na | 1.6 | 18 | 0.25 | 9 | 0.19 | 17 | 0.14 | 24 | 0.34 | 11 |
| Mg | 0.9 | *** | 0.09 | *** | 0.10 | *** | 0.09 | *** | 0.12 | *** |
| Al | 0.4 | *** | 0.07 | *** | 0.05 | *** | 0.14 | *** | 0.07 | *** |
| Si | 0.4 | *** | 0.5 | 38 | 0.4 | 41 | 0.52 | 30 | 0.91 | 25 |
| P | 0.4 | *** | 0.04 | *** | 0.05 | *** | 0.04 | *** | 0.04 | *** |
| S | 49 | 4 | 4.1 | 6 | 7.8 | 5 | 4.4 | 5 | 4.4 | 4 |
| Cl | 8.8 | 7 | 1.6 | 8 | 0.81 | 15 | 0.88 | 11 | 1.14 | 7 |
| K | 0.89 | 3 | 0.17 | 3 | 0.20 | 3 | 0.16 | 5 | 0.27 | 24 |
| Ca | 0.49 | 3 | 0.33 | 2 | 0.31 | 2 | 0.43 | 3 | 0.64 | 14 |
| Ti | 0.085 | 9 | 0.021 | 7 | 0.023 | 8 | 0.017 | 17 | 0.05 | 48 |
| V | 0.01 | *** | 0.003 | 29 | 0.003 | 34 | 0.001 | *** | 0.006 | *** |
| Cr | 0.01 | *** | 0.001 | *** | 0.001 | *** | 0.002 | *** | 0.005 | *** |
| Mn | 0.1 | *** | 0.015 | 9 | 0.02 | 42 | 0.02 | 44 | 0.023 | 8 |
| Fe | 0.56 | 26 | 0.22 | 2 | 0.34 | 10 | 0.40 | 11 | 0.66 | 1 |
| Ni | 0.01 | *** | 0.001 | *** | 0.001 | *** | 0.001 | *** | 0.001 | *** |
| Cu | 0.1 | *** | 0.015 | 4 | 0.010 | *** | 0.02 | *** | 0.016 | 7 |
| Zn | 0.50 | 24 | 0.063 | 2 | 0.079 | 16 | 0.069 | 22 | 0.082 | 2 |
| As | 0.099 | 11 | 0.021 | 6 | 0.019 | 12 | 0.010 | 11 | 0.015 | 9 |
| Se | 0.32 | 9 | 0.026 | 10 | 0.024 | 19 | 0.023 | 17 | 0.036 | 9 |
| Br | 0.091 | 16 | 0.016 | 9 | 0.011 | 19 | 0.010 | 21 | 0.014 | 13 |
| Rb | 0.02 | *** | 0.002 | *** | 0.002 | *** | 0.002 | *** | 0.002 | *** |
| Sr | 0.02 | *** | 0.002 | *** | 0.003 | 18 | 0.002 | *** | 0.013 | 10 |
| Mo | 0.10 | *** | 0.008 | *** | 0.008 | *** | 0.008 | *** | 0.012 | *** |
| Sn | 0.09 | *** | 0.008 | *** | 0.007 | *** | 0.007 | *** | 0.010 | *** |
| Sb | 0.09 | *** | 0.009 | *** | 0.008 | *** | 0.008 | *** | 0.010 | *** |
| Ba | 0.3 | *** | 0.02 | *** | 0.02 | *** | 0.02 | *** | 0.03 | *** |
| Pb | 0.17 | 27 | 0.049 | 10 | 0.035 | 25 | 0.057 | 16 | 0.030 | 19 |

***: indicate below detecting limit, and figures error %.

*: no compensation on sample thickness and filter blank.

**Table 4 Concentration of carbon components in PM2.5 measured by thermal optical reflectance method (TOR) with IMPROVE-A procedure, samples collected in Jan. 2014.**

( unit: μg/$m^3$ )

| Sample | Reg. OC | VOC | HighT. OC | Reg. EC | High T. EC | TC | Cpyr-R |
|---|---|---|---|---|---|---|---|
| UB20140117C5F | 175 | 72 | 103 | 28 | 0.5 | 203 | 44 |
| UB20140118C5F | 59 | 23 | 36 | 12 | 0.8 | 71 | 16 |
| UB20140120C7F | 63 | 20 | 43 | 12 | 1.2 | 76 | 22 |
| UB20140121C7F | 33 | 8 | 25 | 10 | 1.0 | 43 | 10 |
| UB20140123C2F | 96 | 45 | 51 | 18 | 0.9 | 114 | 23 |
| Grand av.(%) | 83 | 31 | 52 | 17 | 1 | 100 | 23 |

**Table 5 Concentration of water soluble ionic species measured by IC method, samples collected in Jan. 2014.**

(ug/$m^3$)

| Sample Ion | UB20140117C5F | UB20140118C5F | UB20140120C7F | UB20140121C7F | UB20140123C2F |
|---|---|---|---|---|---|
| $CO_3^{2-}$ | 1.1 | - | - | 1.3 | - |
| $C^{l-}$ | 5.3 | 2.9 | 0.9 | 1.0 | 2.4 |
| $NO_3^-$ | 8.4 | 3.4 | 6.8 | 5.4 | 3.7 |
| $SO_4^{2-}$ | 23.2 | 9.1 | 15.3 | 8.0 | 12.2 |
| $Na^+$ | 0.4 | 0.1 | < 0.1 | 0.1 | 0.1 |
| $NH_4^+$ | 18.1 | 6.8 | 9.8 | 5.7 | 9.3 |
| $K^+$ | 0.3 | 0.5 | 0.1 | < 0.1 | 0.4 |
| $Ca^{2+}$ | 1.1 | < 0.1 | 0.3 | 0.3 | < 0.1 |

## 5 Major Source Category Analysis

Calculation procedure of reconstructed fine mass (RCFM) by major source category analysis is shown in Table 6. The sum of the major sources, $(NH_4)_2SO_4$, particulate organic matter (POM), EC, crustal particles (Soil), biomass aerosol, Sea salt, $NH_4NO_3$, and $NH_4Cl$, should provide a reasonable estimate of the ambient dry $PM_{2.5}$ mass concentration in the atmosphere. Therefore, whether there is no contradiction in filter weighing concentration and chemical composition measurement results can be judged by comparing $PM_{2.5}$ weighing concentration by the filter method with the RCFM concentration.

Concentrations of major sources calculated from chemical composition concentrations in $PM_{2.5}$ observed in UB were shown in Figure 3～Figure 7. In all cases, more than 80 % of $PM_{2.5}$ concentration measured by the filter method can be explained by the sum of the major source concentrations. These results indicated that there were no contradiction in the filter weighing and the analytical results of chemical composition in $PM_{2.5}$.

The contribution ratio of the source category was POM 60%, $(NH_4)_2SO_4$ 10%, EC 8%, $NH_4NO_3$ 4%, Soil 2%, $NH_4Cl$ 2%, and so on in order. Though POM is remarkably high in contribution ratio, on the hand, the contribution of crustal particle is low for the seasonal factor. As the high-dense VOC is condensed on POM observed in UB, clarification is necessary to find the cause, such as the seasonal factor, and the sources of the VOC should be analyzed.

**Table 6 Block diagram of RCFM calculation procedure by major emission source category analysis**

① : Measurement of PM2.5 concentration by the filter method

② : Measurement of chemical constituents in PM2.5

1) Carbon components by IMPROVE-A procedure; OC and EC

2) Water soluble ionic species by IC; $SO_4^{2-}$, $NO_3^-$,$NH_4^+$, and so on

3) Various major elements by EDXFA; Na,Al, Si, S, Cl, K, Ca, Ti, Fe, and so on.

③ : Calculation of RCFM by the following formula

$RCFM = 4.125[S]+POM+[EC]+[Soil]+1.4[KNON]+2.5[Na]+1.29[NO_3^-]+[NH_4Cl]$

$[Soil]=2.2[Al]+2.49[Si]+1.63[Ca]+2.42[Fe]+1.94[Ti]$

$[KNON]=[K]-0.6[Fe]$

$POM=1.4[OC]$

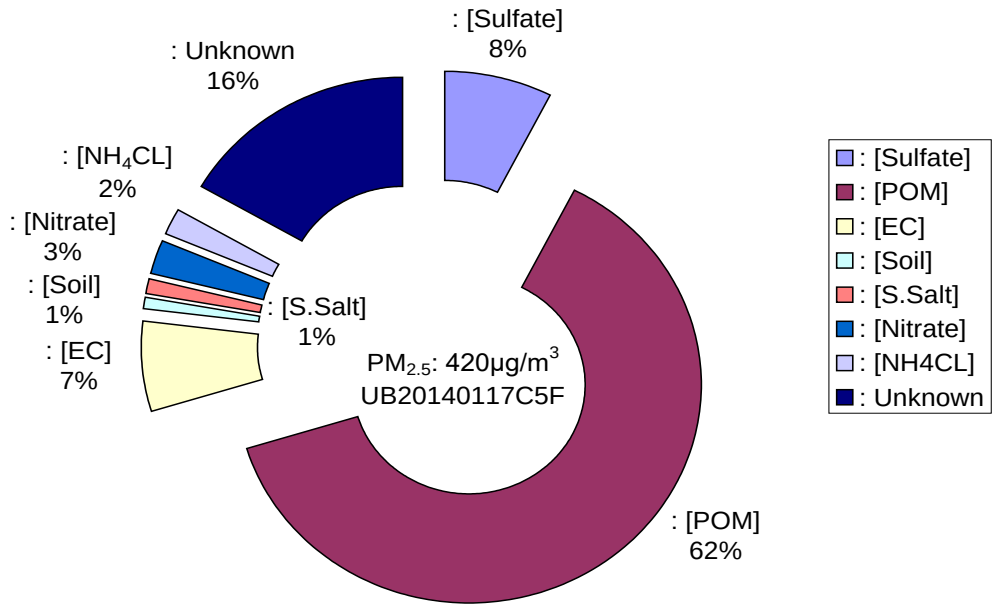


**Figure 3 Result of Reconstructed Fine Mass (RCFM) for the Sample UB20140117C5F**

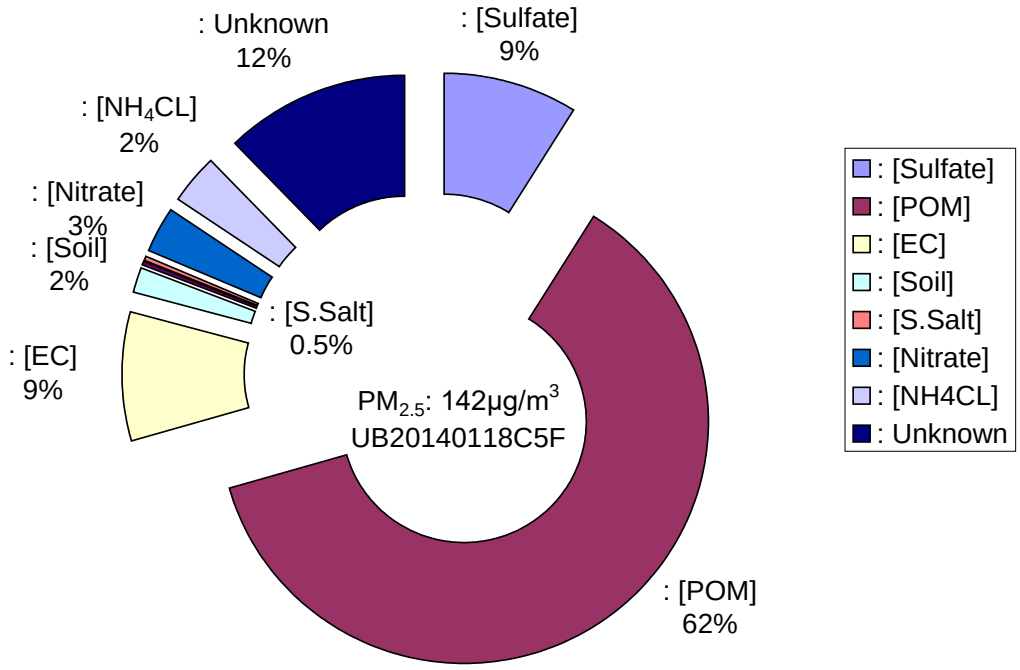


**Figure 4 Result of Reconstructed Fine Mass (RCFM) for the Sample UB20140118C5F**

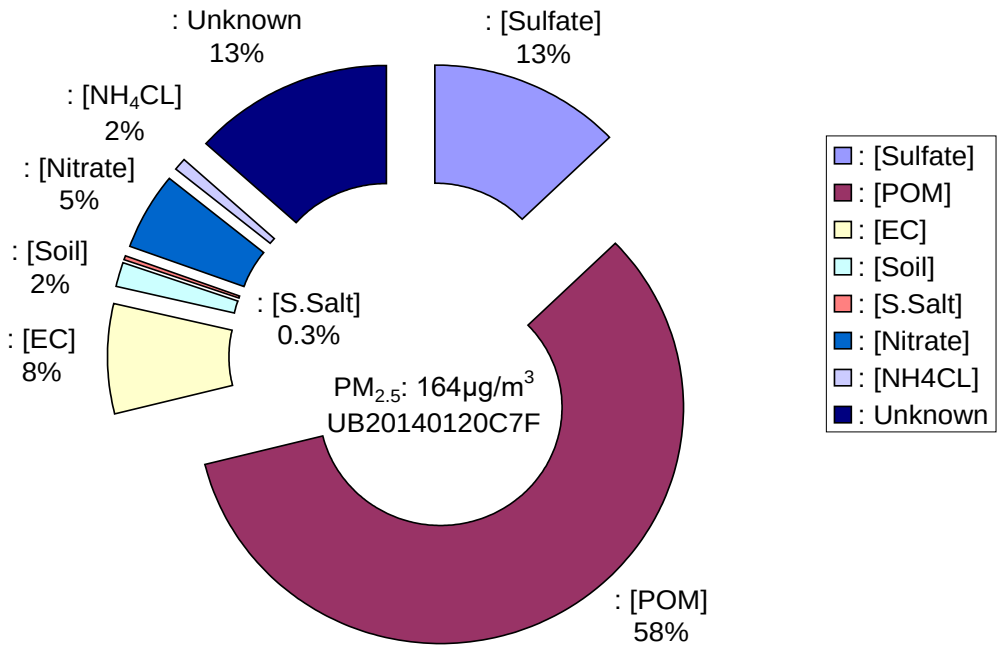


**Figure 5 Result of Reconstructed Fine Mass (RCFM) for the Sample UB20140120C7F**

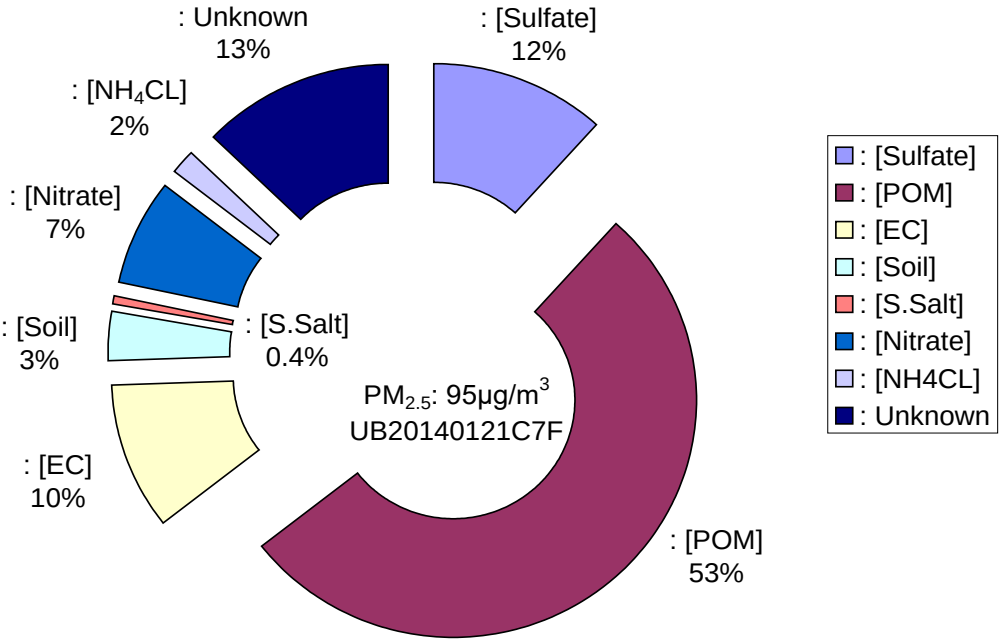


**Figure 6 Result of Reconstructed Fine Mass（RCFM） for the Sample** UB20140121C7F

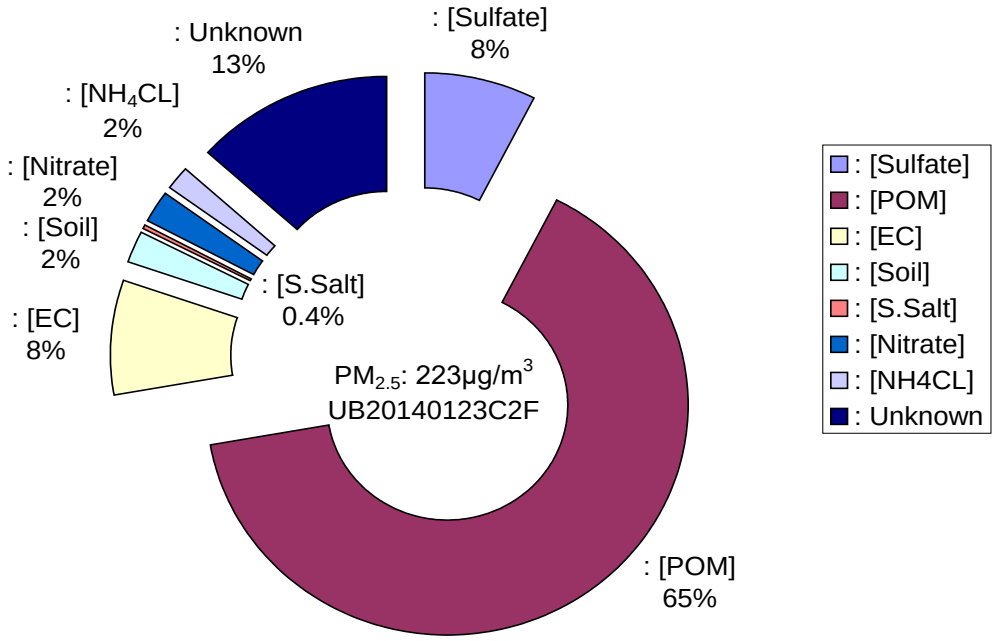


**Figure 7 Result of Reconstructed Fine Mass (RCFM) for the Sample UB20140123C2F**

**Mongolia**

**Air Pollution Reducing Department of Capital City (APRD)**

# Capacity Development Project for Air Pollution Control in Ulaanbaatar City Phase 2 Mongolia

## Technical Manual 07

## Manual for Development and Updating of Emission Inventory

**March 2017**

**Japan International Cooperation Agency (JICA)**

**SUURI-KEIKAKU CO., LTD.**

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# 1 Basic policy in estimating emission inventory

## 1.1 Estimation method

In general, emissions of air pollutants are estimated by the following basic formula for each source category. Details of emission estimation method are explained in each source.

Emission ＝ Emission factor × Activity data

Example

- SOx emission per the amount of fuel burnt, calculated based on sulfur content of fuel, the sulfur retained in the ash and the reduction achieved by emission control technology (fuel combustion)
- NOx emission per distance (exhaust gas emission from vehicles)

- The amount of fuel burnt (fuel combustion)
- The distance of vehicle travelled (exhsut gas emissions from vehicles)

### 1.1.1 Emission Factor

Emission factors are the average of emission of a pollutant per unit of activity data.

In this manual, First priority is given to applying the emission factor based on the measurement data in UB city. However, if no emission factor based on measurement data exists, use the emission factor described in manuals of Europe and the United States or Japan. As, an example of manual, there are “Guidelines for Developing Emission Inventory in East Asia”[1], “GAP Forum Manual”[2], “EMEP/EEA Guidebook”[3], “AP-42”[4], and “COPERT”[5] etc.

### 1.1.2 Activity Data

Activity data indicates the extent of activity causing emissions. Required data can be basically collected from statistics and surveys.

Use the measured data in UB city and statistic data as activity data in this manual.

## 1.2 Target Sources

In this manual, target Sources are power plant, HOB, CFWH, small stove for household, vehicle exhaust gas, fugitive road dust, and fugitive ash from ash pond of power plant.

## 1.3 Target Pollutants

This manual indicates that target pollutants are SO2, NOx, TSP, $PM_{10}$, and CO.

[1] http://www.acap.asia/publication/pdf/em_inventory/em_guideline.pdf
[2] https://www.sei-international.org/gapforum/emissions-manual.php
[3] https://www.eea.europa.eu/publications/emep-eea-guidebook-2016
[4] https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emission-factors
[5] http://emisia.com/products/copert

## 1.4 Target Area

This manual targets central 6 districts in UB city (Bayangol, Bayanzurkh, Songinokhairkhan, Sukhbaatar, Khan-Uul, and Chingeltei). Since these districts are much population and much fuel consumption, much amount of pollutants is emitted.

## 1.5 Temporal Change and Spatial Distribution

### 1.5.1 Temporal Change

In order to consider air pollution control measures and arrange input data for simulation model, it is necessary to set temporal change for emissions. After setting the emission per unit such as season, month, week, day of week, daytime/nighttime, and etc. according to the emission situation of sources, estimate the temporal change. Furthermore, if individual source information can be gathered by questionnaire survey, interview survey, and traffic count survey etc. and temporal change can be set with operation time of source and traffic count by time, more detailed temporal change of source can be grasped.

### 1.5.2 Spatial Distribution

In order to consider air pollution control measures and arrange input data for simulation models, it is necessary to distribute total emissions to more detailed spatial area. Regarding area source, more detailed emission distribution can be developed by narrowing down the range that pollutant can be emitted, this narrowing contributes to the accuracy improvement of simulation model.

On the other hand, regarding the sources that can collect individual information by questionnaire survey or interview survey such as power plant, HOB, and so on, emission inventories should be prepared as point sources. Also, regarding vehicle exhaust gas, after acquiring road network data and collecting individual information on sources by traffic count survey etc., emission inventory should be prepared as line source.

# 2 Power Plant

## 2.1 Developing and Updating Method for Emission inventory

The emissions by stacks are estimated. In the case of collected stack, the emission of each boiler is calculated and this summation is the emission from the collected stack. Calculation flow diagram of the emission from power plant is shown in Figure 2-1. Emission is calculated by using the following formula. Regarding temporal change, monthly operating pattern is calculated by using monthly coal consumption by boiler. When you want to grasp the more detailed operating condition, the method that operating pattern by time is calculated by using the continuous flow gas concentration measurement result with CEMS also exist.

$$E_i = AD_i \times EF_i$$

Ei: Emission from stack i (ton/year)

ADi: Annual coal consumption of boiler connected to stack i (ton/year)

EFi: Emission factor of stack i (kg/ton fuel)

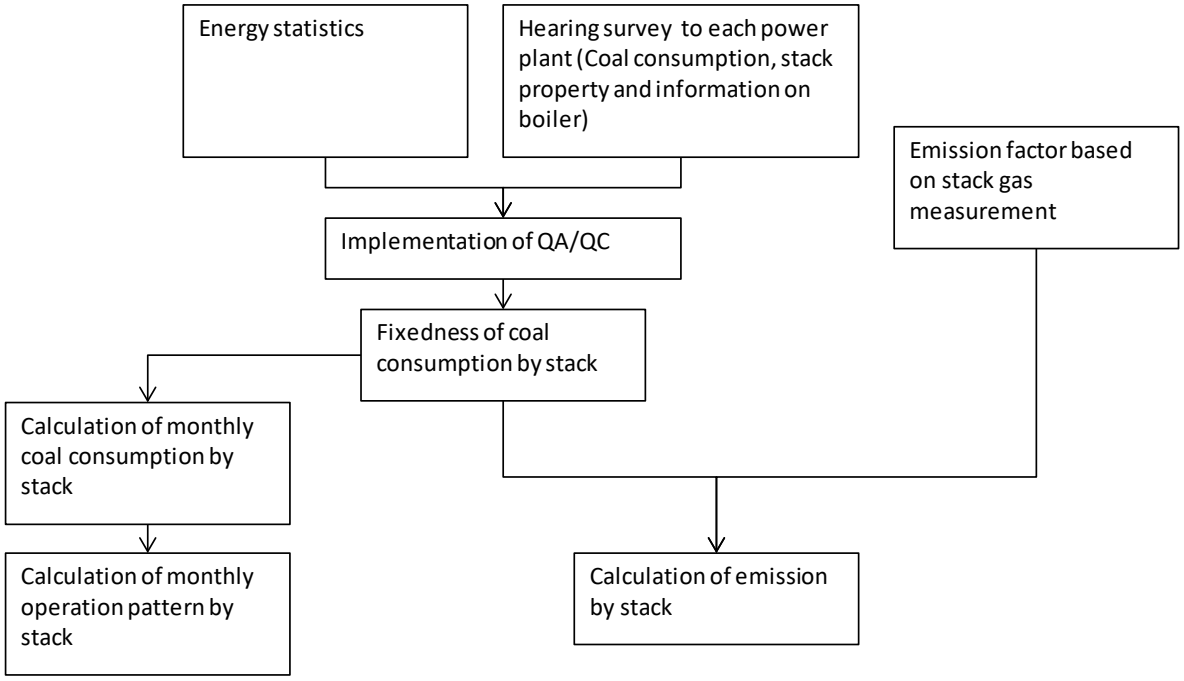


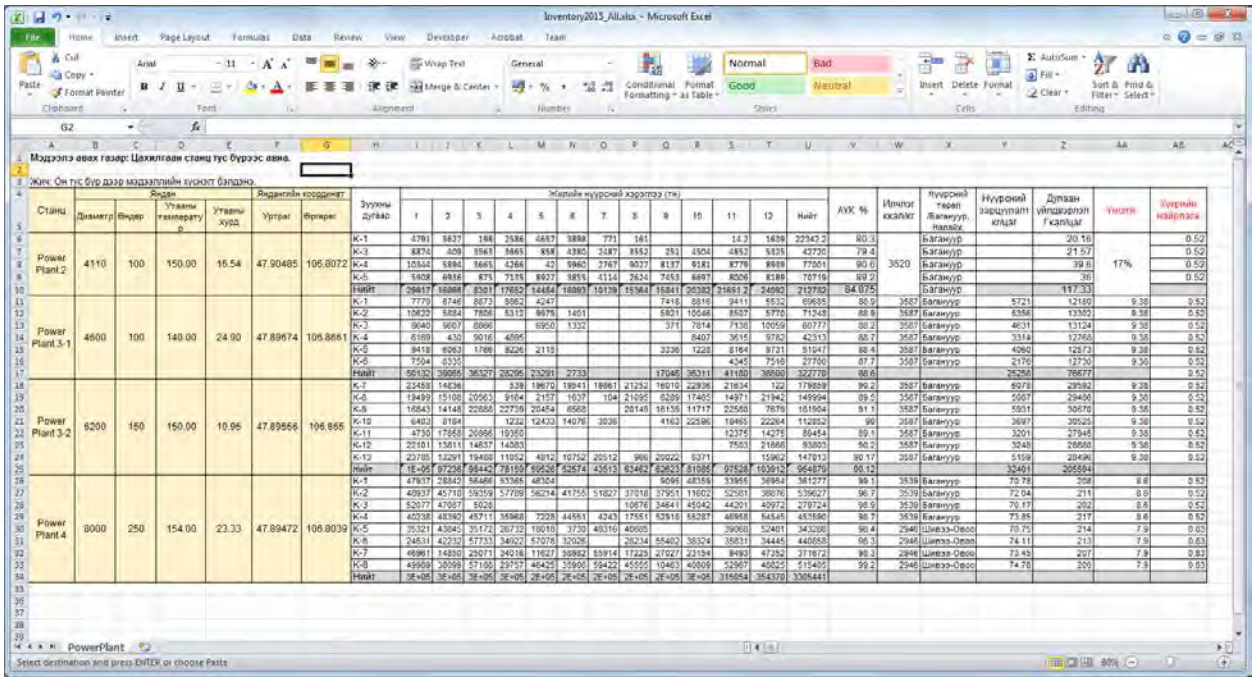

**Figure 2-1 Calculation Flow Diagram of the Emission from Power Plant**

### 2.1.1 Collecting and Organizing Information for Developing and Updating Emission Inventory

Contact the person in charge of each power plant about the request of the information for target year and write and send the letter to each power plant. Attach the template in the following figure and ask each power plant to provide the following information by electric file.

1) Stack height and diameter
2) Flow gas temperature and speed (or flow amount) nearby the exit of stack
3) Boiler operating condition (monthly coal consumption and boiler efficiency)
4) Property of coal (production, net calorific value, sulfur content, and ash content)

5) Necessary information for developing emission inventory such as flow gas concentration by pollutant



Inquiry list of each power plant is below. If the person in charge changes, you should update this list.

| Name | Person in charge | Post | Contact information (Cellar phone etc.) |
|---|---|---|---|
| Power Plant 2 | | | |
| Power Plant 3 | | | |
| Power Plant 4 | | | |
| Amgalan Heat Supply Facility | | | |

### 2.1.2 Collecting Information for Developing Emission Factor

Flow gas measurement of JICA project was conducted at each power plant in 2010 to 2011 and emission factor was developed for each measurement. These results were organized for each system of power plant and the following values are applied.

| Power Plant | SO2 | NOx | TSP | PM10 | CO | Production of fuel |
|---|---|---|---|---|---|---|
| CHP 2 (*1) | 3.31 | 0.97 | 23.37 | 21.40 | 41.35 | Baganuur coal |
| CHP 3-1 | 7.35 | 6.91 | 10.47 | 9.59 | 1.13 | Baganuur coal |
| CHP 3-2 | 1.64 | 0.88 | 5.13 | 4.69 | 0.23 | Baganuur coal |
| CHP 4 (*2) | 2.19 | 3.87 | 2.87 | 2.63 | 0.03 | Baganuur coal |

Unit: kg/ton
Source: APRD&JICA, 2013
*1: averaged value for once measurement of 35ton/h boiler and three times measurement of 75ton/h boiler from Jan. to Feb. in 2011.

These emission factors were developed based on the flow gas measurement conducted in 2010 to 2011 and facilities were improved in some power plant. Therefore, it is desirable that regular flow gas measurement and sharing the measurement result are proposed to power plant. Also, the value of flow gas measurement result is different depending on the load condition of boiler. Then, increasing the count of flow gas measurement and analysis of sulfur content in fuel should improve the accuracy of emission factors.

### 2.1.3 Developing and Updating Emission Inventory

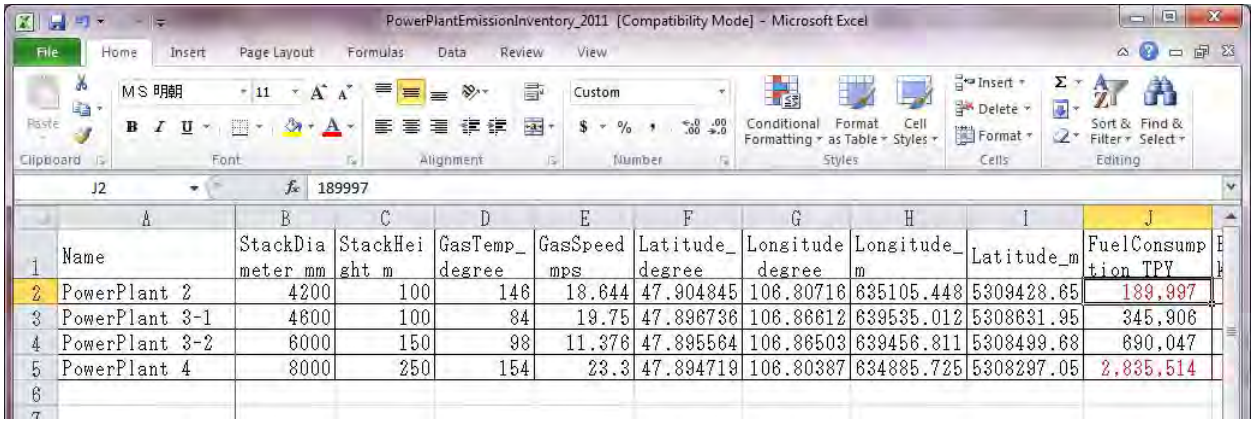
Use “PowerPlantEmissionInventory.xls” for developing and updating emission inventory of power plant. If new large scale heat supply facility is constructed, you should add the information of this facilities to this excel file.

Sum up the obtained fuel consumption by stacks and update the [FuelConsumption_TPY] column.

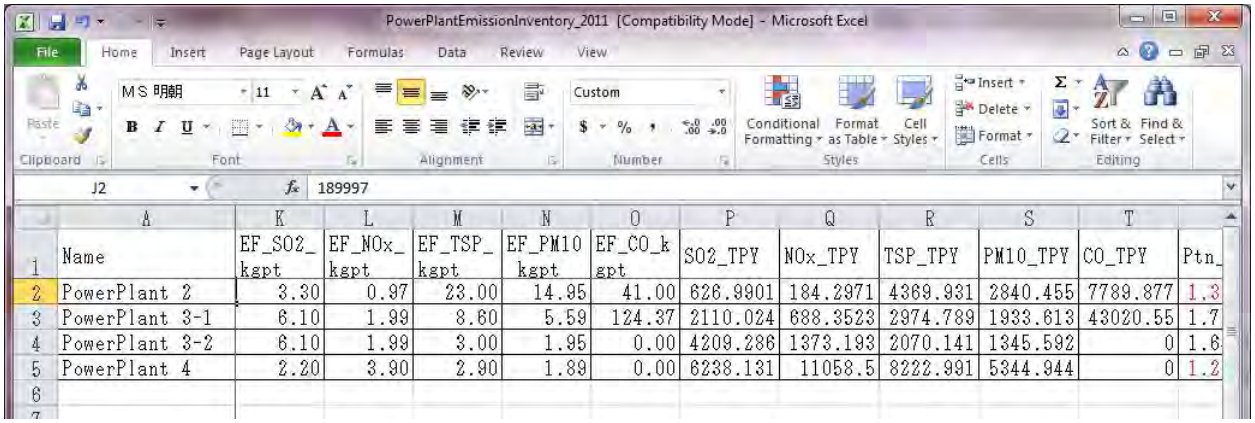
If you obtain the latest emission factor based on flow gas measurement, update the SO2 emission factor ([EF_SO2_kgpt] column) and so on.

Emission is automatically calculated by using fuel consumption and emission factor.

Coordinate of stack, stack height, diameter, flue gas temperature, flue gas speed and monthly operating pattern are used in dispersion simulation.

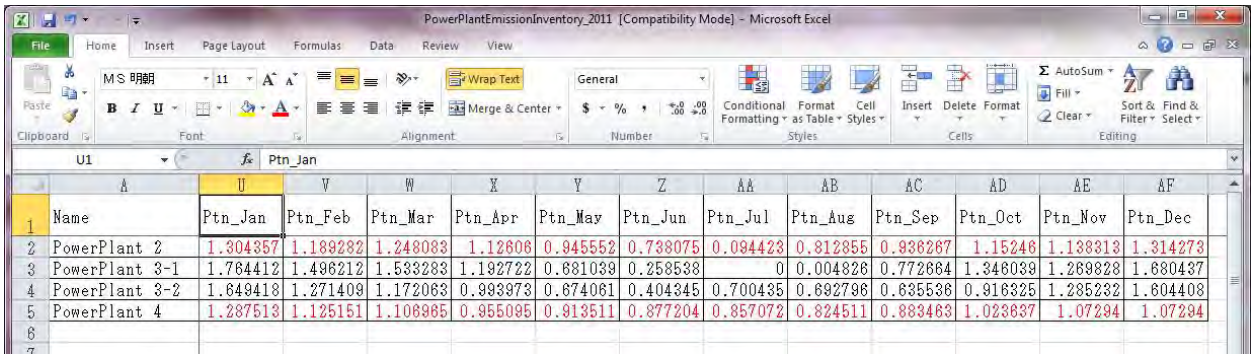



| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Name | StackDiameter_mm | StackHeight_m | GasTemp_degree | GasSpeed_mps | Latitude_degree | Longitude_degree | Longitude_m | Latitude_m | FuelConsumption_TPY |
| 2 | PowerPlant 2 | 4200 | 100 | 146 | 18.644 | 47.904845 | 106.80716 | 635105.448 | 5309428.65 | 189,997 |
| 3 | PowerPlant 3-1 | 4600 | 100 | 84 | 19.75 | 47.896736 | 106.86612 | 639535.012 | 5308631.95 | 345,906 |
| 4 | PowerPlant 3-2 | 6000 | 150 | 98 | 11.376 | 47.895564 | 106.86503 | 639456.811 | 5308499.68 | 690,047 |
| 5 | PowerPlant 4 | 8000 | 250 | 154 | 23.3 | 47.894719 | 106.80387 | 634885.725 | 5308297.05 | 2,885,514 |
| 6 | | | | | | | | | | |



PowerPlantEmissionInventory_2011 [Compatibility Mode] - Microsoft Excel

| | A | K | L | M | N | O | P | Q | R | S | T | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Name | EF_SO2_ kgpt | EF_NOx_ kgpt | EF_TSP_ kgpt | EF_PM10 kgpt | EF_CO_k gpt | SO2_TPY | NOx_TPY | TSP_TPY | PM10_TPY | CO_TPY | Ptn_ |
| 2 | PowerPlant 2 | 3.30 | 0.97 | 23.00 | 14.95 | 41.00 | 626.9901 | 184.2971 | 4369.931 | 2840.455 | 7789.877 | 1.3 |
| 3 | PowerPlant 3-1 | 6.10 | 1.99 | 8.60 | 5.59 | 124.37 | 2110.024 | 688.3523 | 2974.789 | 1933.613 | 43020.55 | 1.7 |
| 4 | PowerPlant 3-2 | 6.10 | 1.99 | 3.00 | 1.95 | 0.00 | 4209.286 | 1373.193 | 2070.141 | 1345.592 | 0 | 1.6 |
| 5 | PowerPlant 4 | 2.20 | 3.90 | 2.90 | 1.89 | 0.00 | 6238.131 | 11058.5 | 8222.991 | 5344.944 | 0 | 1.2 |
| 6 | | | | | | | | | | | | |

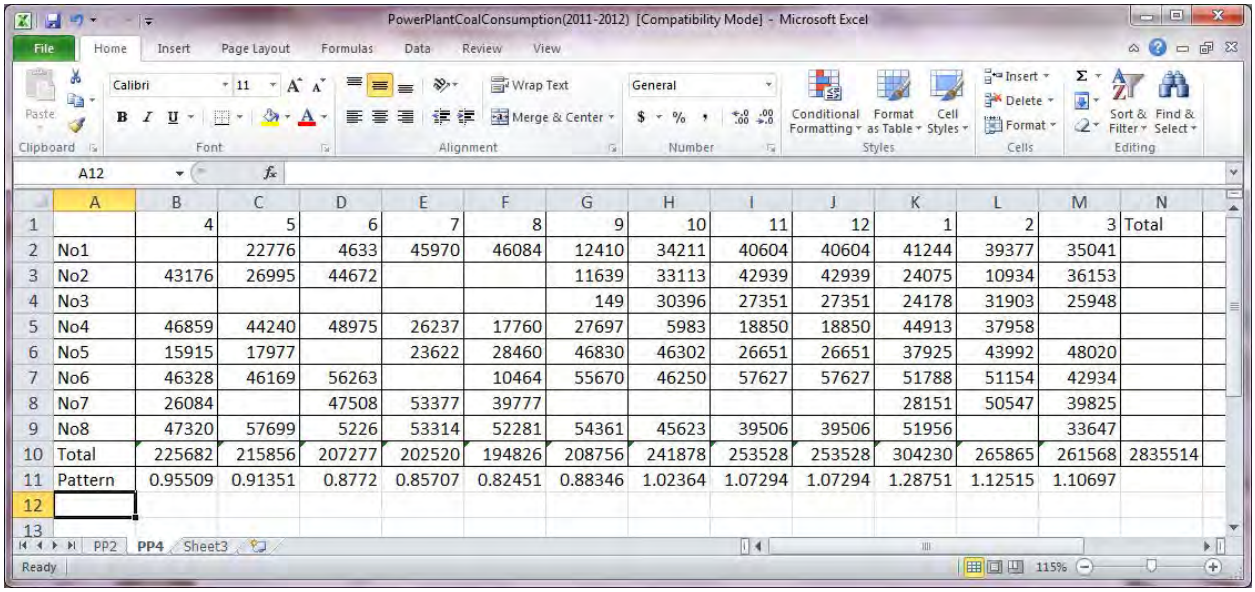


PowerPlantEmissionInventory_2011 [Compatibility Mode] - Microsoft Excel

| | A | U | V | W | X | Y | Z | AA | AB | AC | AD | AE | AF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Name | Ptn_Jan | Ptn_Feb | Ptn_Mar | Ptn_Apr | Ptn_May | Ptn_Jun | Ptn_Jul | Ptn_Aug | Ptn_Sep | Ptn_Oct | Ptn_Nov | Ptn_Dec |
| 2 | PowerPlant 2 | 1.304357 | 1.189282 | 1.248083 | 1.12606 | 0.945552 | 0.738075 | 0.094423 | 0.812855 | 0.936267 | 1.15246 | 1.138313 | 1.314273 |
| 3 | PowerPlant 3-1 | 1.764412 | 1.496212 | 1.533283 | 1.192722 | 0.681039 | 0.258538 | 0 | 0.004826 | 0.772664 | 1.346039 | 1.269828 | 1.680437 |
| 4 | PowerPlant 3-2 | 1.649418 | 1.271409 | 1.172063 | 0.993973 | 0.674061 | 0.404345 | 0.700435 | 0.692796 | 0.635536 | 0.916325 | 1.285232 | 1.604408 |
| 5 | PowerPlant 4 | 1.287513 | 1.125151 | 1.106965 | 0.955095 | 0.913511 | 0.877204 | 0.857072 | 0.824511 | 0.883463 | 1.023637 | 1.07294 | 1.07294 |
| 6 | | | | | | | | | | | | | |

Using the monthly fuel consumption of power plant, monthly operating pattern is calculated by the following formula.

Operating pattern in Janualy = Fuel consumption in January / Annual fuel consumption x 12



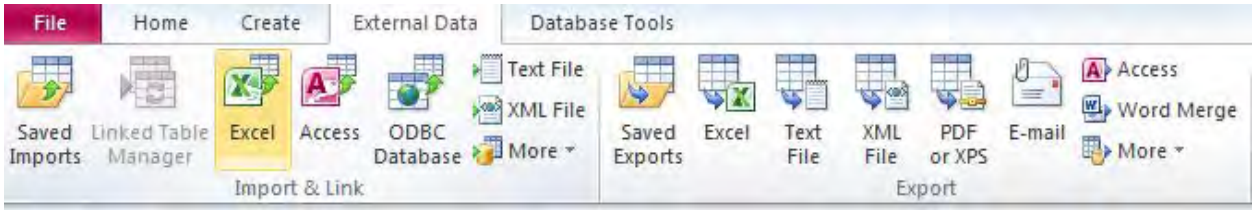
PowerPlantCoalConsumption(2011-2012) [Compatibility Mode] - Microsoft Excel

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 | Total |
| 2 | No1 | | 22776 | 4633 | 45970 | 46084 | 12410 | 34211 | 40604 | 40604 | 41244 | 39377 | 35041 | |
| 3 | No2 | 43176 | 26995 | 44672 | | | 11639 | 33113 | 42939 | 42939 | 24075 | 10934 | 36153 | |
| 4 | No3 | | | | | | 149 | 30396 | 27351 | 27351 | 24178 | 31903 | 25948 | |
| 5 | No4 | 46859 | 44240 | 48975 | 26237 | 17760 | 27697 | 5983 | 18850 | 18850 | 44913 | 37958 | | |
| 6 | No5 | 15915 | 17977 | | 23622 | 28460 | 46830 | 46302 | 26651 | 26651 | 37925 | 43992 | 48020 | |
| 7 | No6 | 46328 | 46169 | 56263 | | 10464 | 55670 | 46250 | 57627 | 57627 | 51788 | 51154 | 42934 | |
| 8 | No7 | 26084 | | 47508 | 53377 | 39777 | | | | | 28151 | 50547 | 39825 | |
| 9 | No8 | 47320 | 57699 | 5226 | 53314 | 52281 | 54361 | 45623 | 39506 | 39506 | 51956 | | 33647 | |
| 10 | Total | 225682 | 215856 | 207277 | 202520 | 194826 | 208756 | 241878 | 253528 | 253528 | 304230 | 265865 | 261568 | 2835514 |
| 11 | Pattern | 0.95509 | 0.91351 | 0.8772 | 0.85707 | 0.82451 | 0.88346 | 1.02364 | 1.07294 | 1.07294 | 1.28751 | 1.12515 | 1.10697 | |
| 12 | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | |

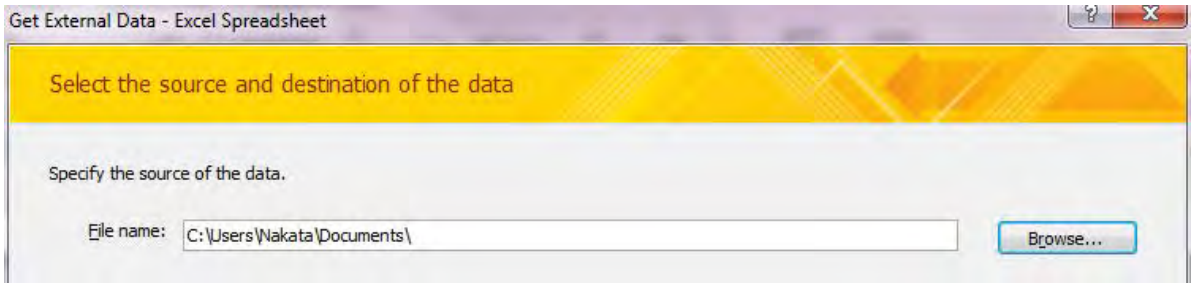
## 2.2 Import Inventory File into Access

Data on stationary source inventory is generated in “StationarySources.mdb”. This explains the method to import the inventory developing in 2.1.3 to “StationarySources.mdb”.

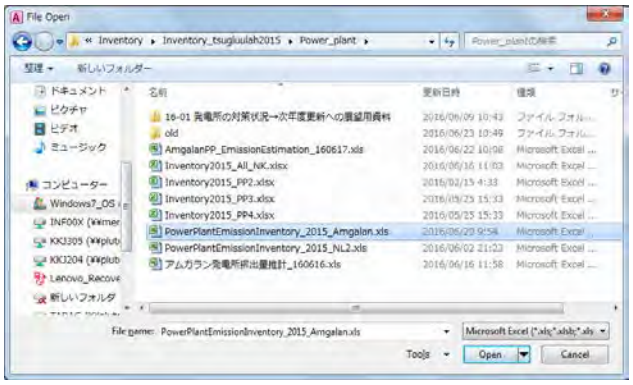
Select [Excel] button of [Import & Link] in [External Data] tab.



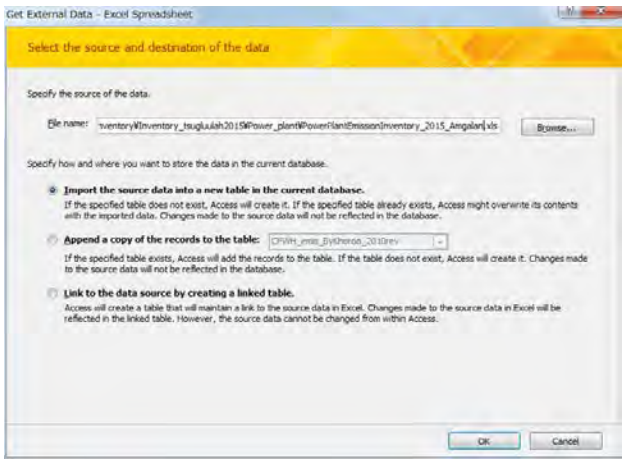

Click [Browse].



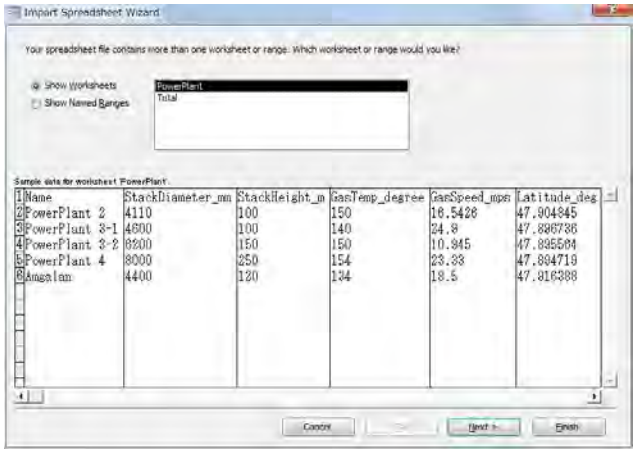

Select the file you want to import (Here it is “PowerPlantEmissionInventory_2015_Amgalan.xlsx”).



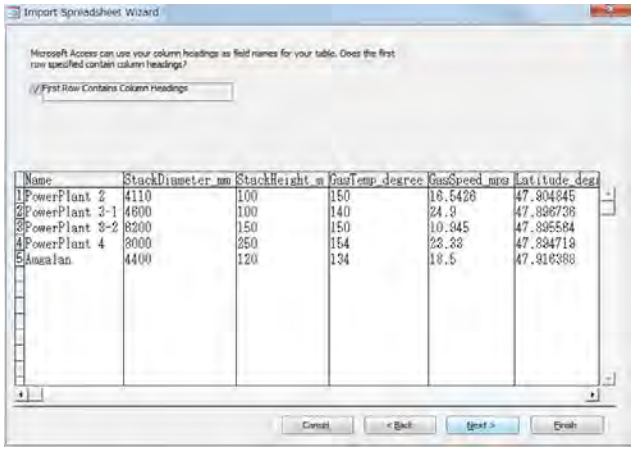

Select [Import the source data into a new table in the current database.] and click [OK].



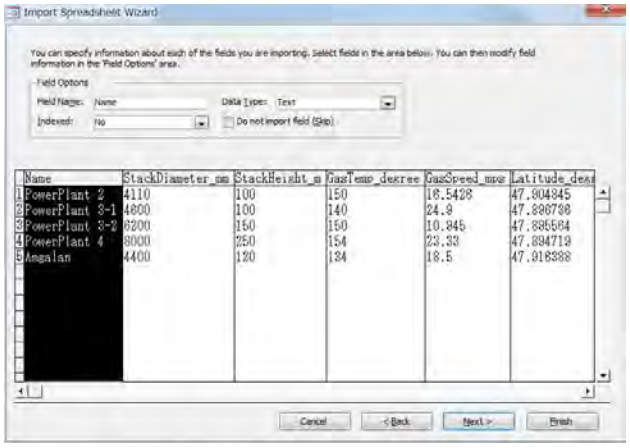

Check [Show Worksheets] is selected, select [PowerPlant] sheet, and click [Next].



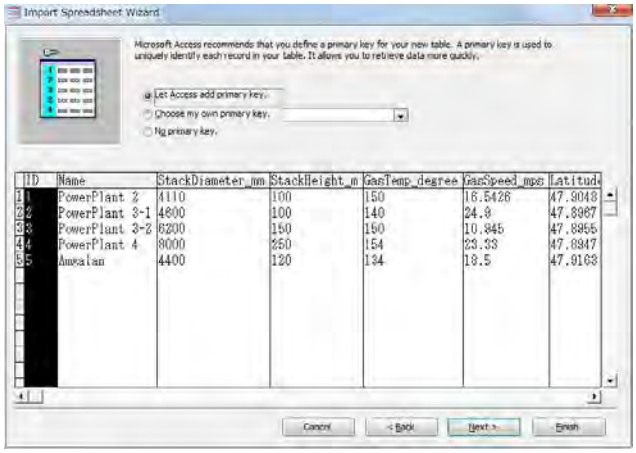

Check [First Row Contains Column Headings] is checked and click [Next].




Set the unnecessary column for inventory and simulation checked [Do not import field (Skip)] and click [Next].

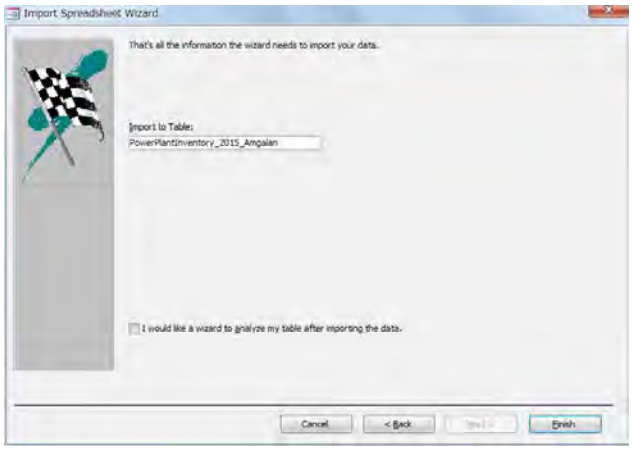



Select [Let Access add primary key.] and Click [Next].

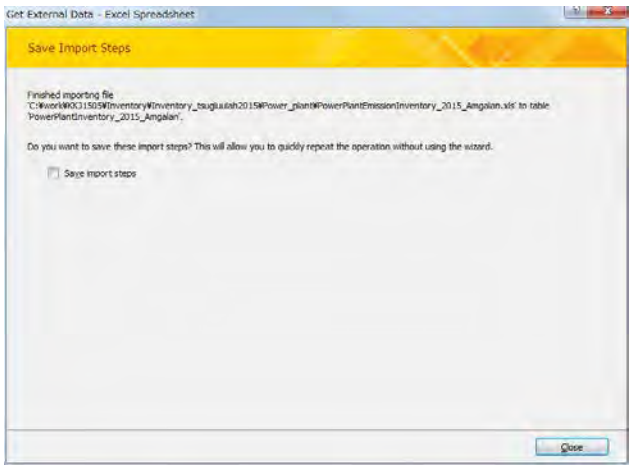



Input the table name in the [Import to Table:] textbox and click [Finish].

(Here it is “PowerPlantInventory_2015_Amgalan”.)



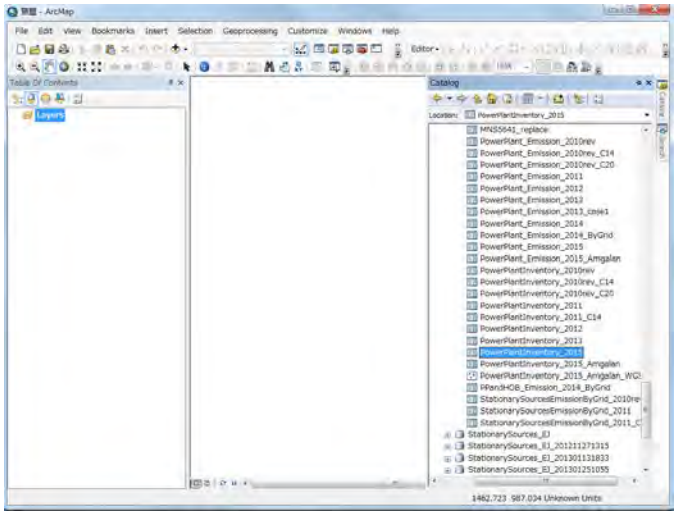

Click [Close].



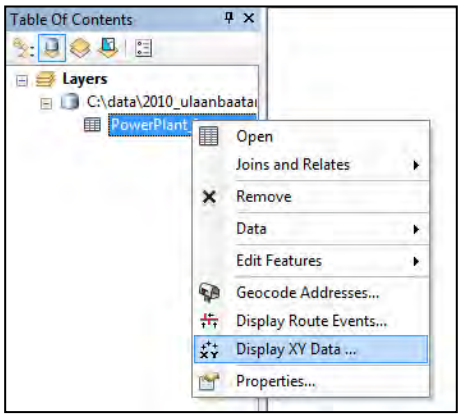
## 2.3 Addition and Conversion Method of Coordinate System to Point Source Data

Open empty ArcMap and [Catalog] at the right side. Select the imported table in “StationarySorces.mdb” file and drag and drop in ArcMap.

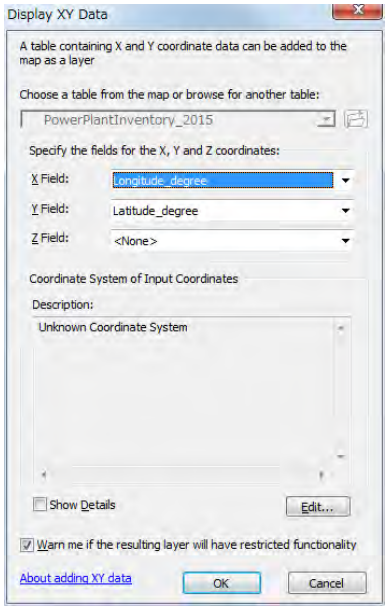
(Here it is “PowerPlant_Inventory_2015” table.)



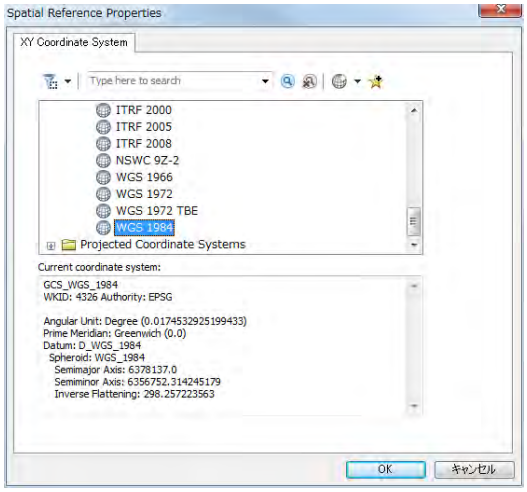
Right-click the imported table in [Table Of Contents] and click [Display XY Data].



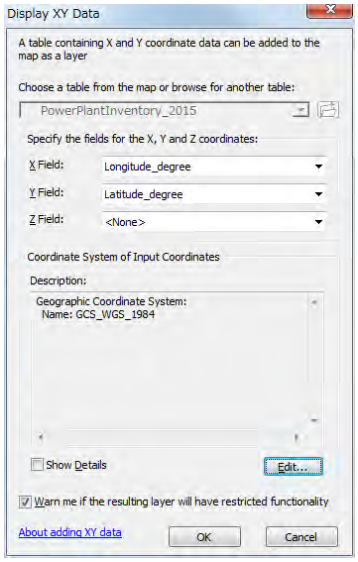

After you select [Longitude_degree] in [X Field], [Latitude_degree] in [Y Field], and [<None>] in [Z Field], click [Edit]




Select [Geographic Coordinate Systems]-[world]-[WGS 1984] and click [OK].

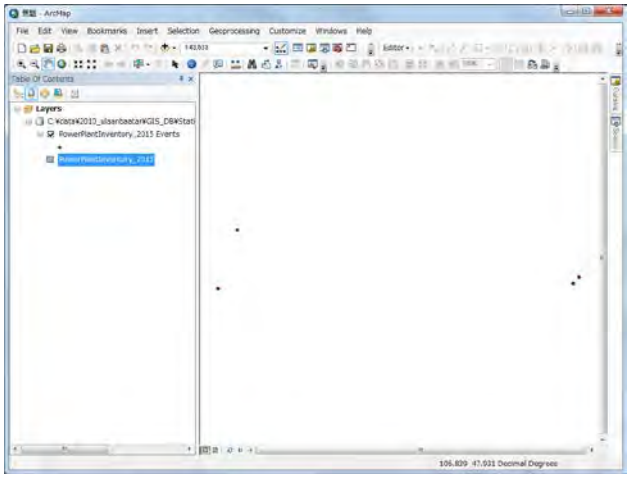



Check [GCS_WGS_1984] shown in [Description] and click [OK].

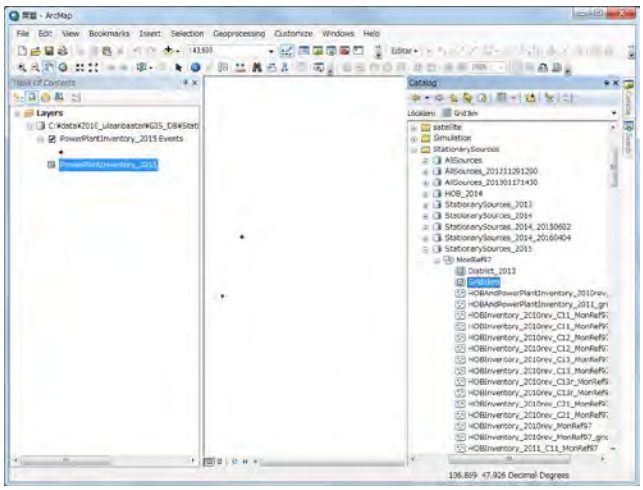



Coordinated layer is shown in ArcMap. Check if positional relation is correct.

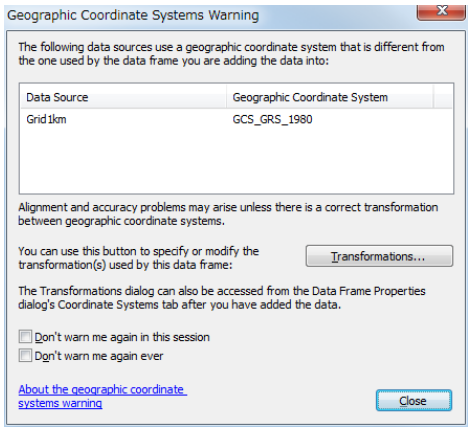
(Here this layer is “PowerPlant_Inventory_2015 Events” layer.)



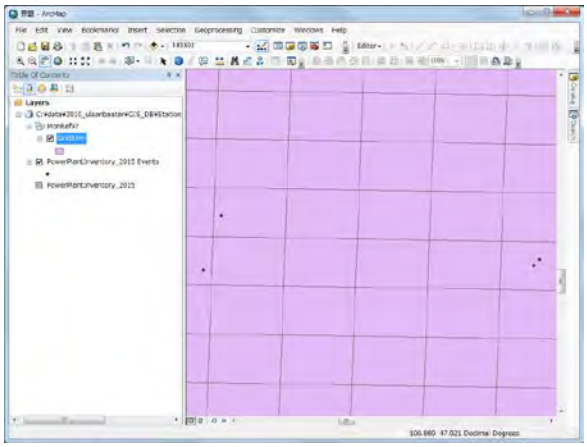
Select the [Grid1km] featureclass in [StationarySources.mdb]-[MonRef97] dataset and drag-drop it in ArcMap.



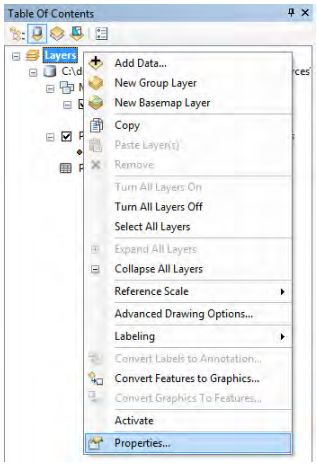
If the following dialog shows, click [Close].



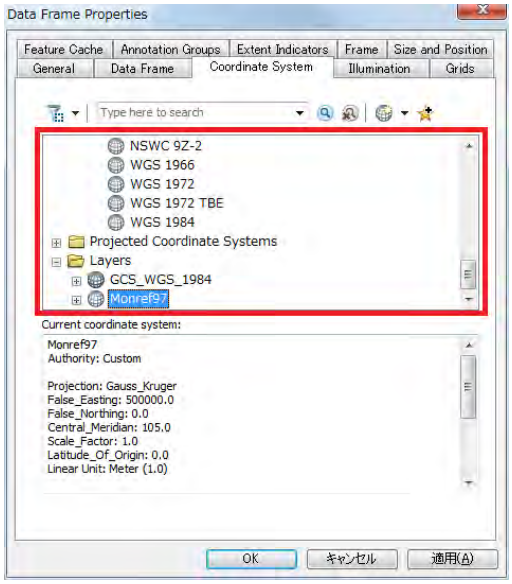

Originally, [Grid1km] is shown as square, however, it is shown as distorted rectangle on ArcMap, because geodetic datum of this featureclass is different from on ArcMap.



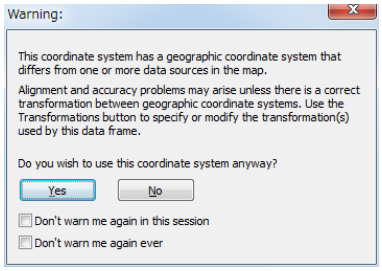
Right-click [Layers] in [Table Of Contents] and click [Properties].



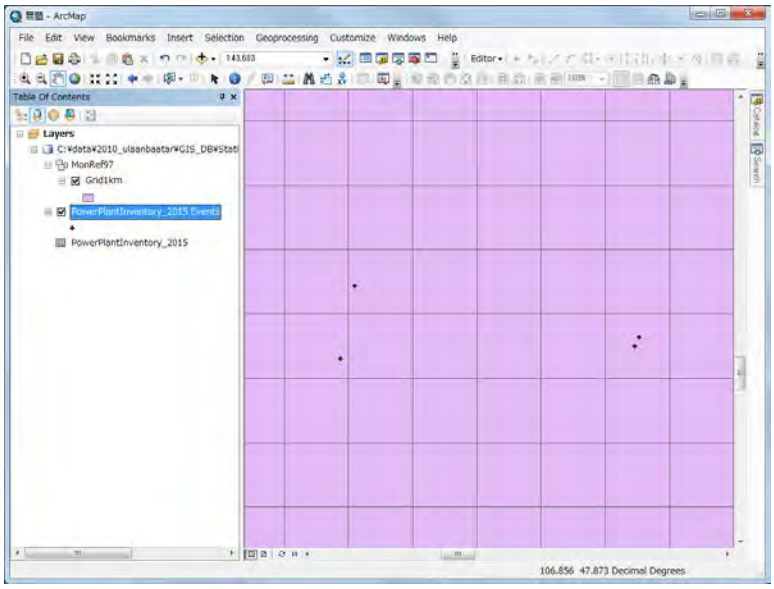

Select [Coordinate System] tab and [Layers]-[Monref97] in the red rectangle, and click [OK].




If this warning message shows, click [Yes].

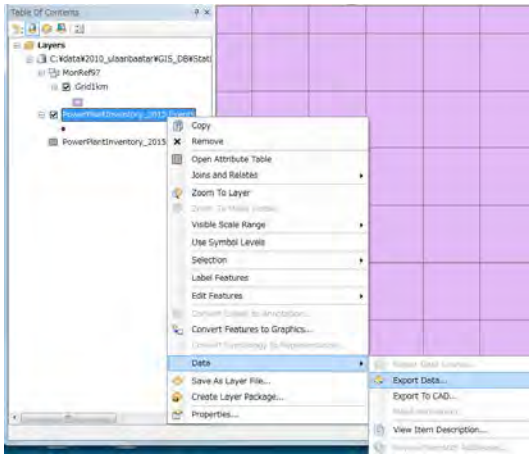



Geodetic datum in ArcMap is changed to [Monref97]. [Grid1km] is shown as the true square in ArcMap.

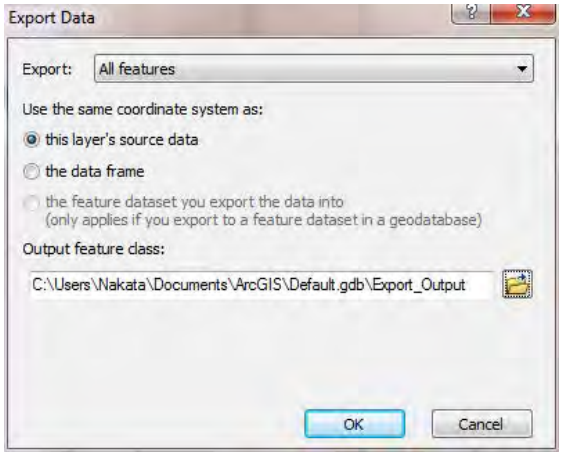



Right-click the coordinated layer and click [Data]-[Export Data].

(Here this layer is “PowerPlant_Inventory_2015 Events” layer.)

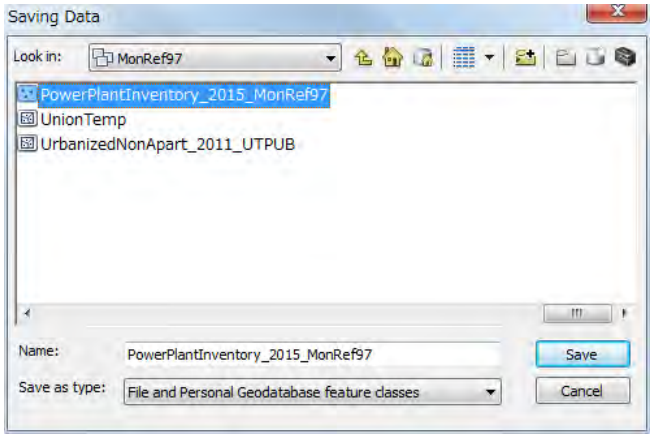



Select [Browse].

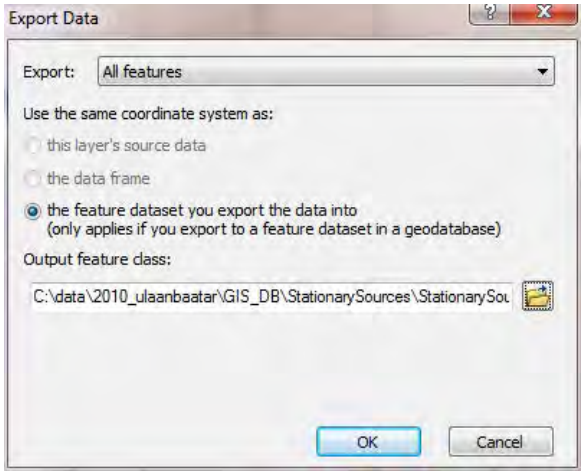



Select [StationarySources.mdb]-[MonRef97] dataset and input the featureclass name to export to.

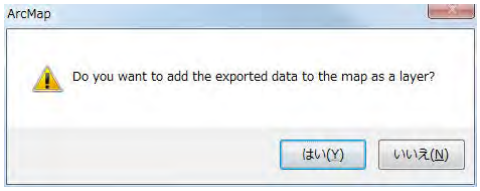
(Here featureclass name is “PowerPlant_Inventory_2015_MonRef97”)



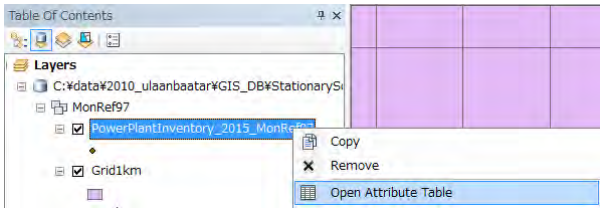

Select [the feature dataset you export the data into] and click [OK]. The feasureclass of power plant is made setting [Monref97] coordinate system



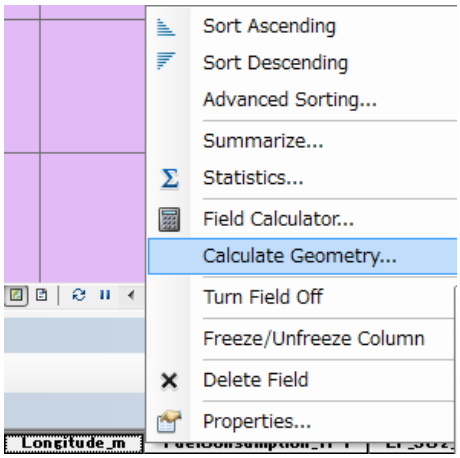

Since this message box requests if the created featureclass is shown in the map or not, click [Yes].



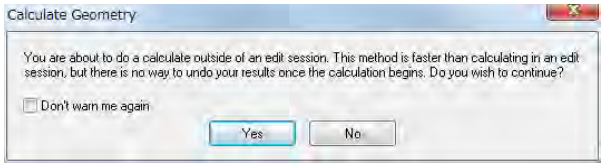

Right-click the created feasureclass and click [Open Attribute Table].



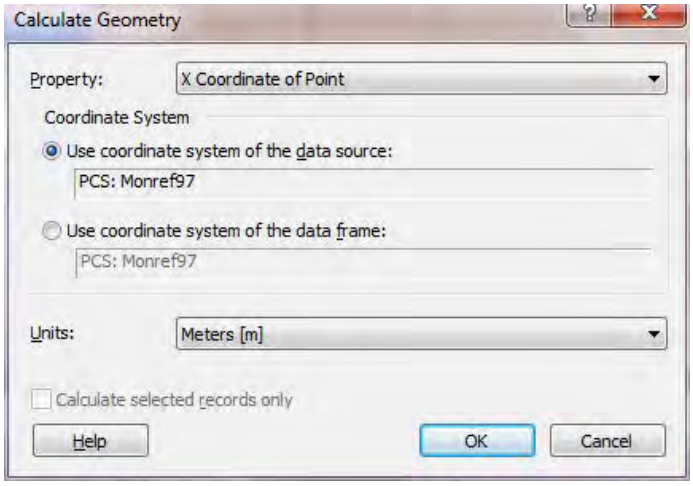

Right-click on the title of [Longitude_m] column in [Attribute Table] and select [Calculate Geometry].



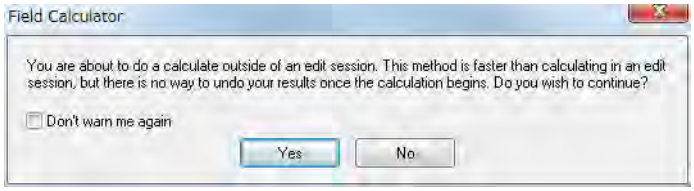

This message means that there is no way to undo your results once the automatic calculation begins. Click [Yes].



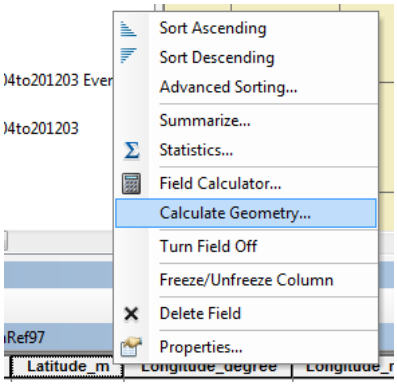

After selecting [X Coordinate of Point] at [Property], [Use coordinate system of the data source] at [Coordinate System], and [Meters [m]] at [Units], click [OK]. X Coordinate of Point in Monref97 coordinate system is calculated to [Longitude_m] column of each row.



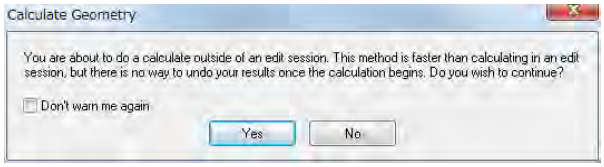

This message means that there is no way to undo your results once the automatic calculation begins. Click [Yes].



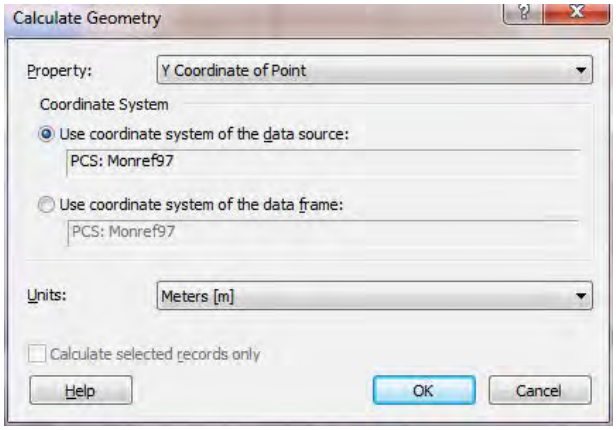

Right-click on the title of [Latitude_m] column in [Attribute Table] and select [Calculate Geometry].



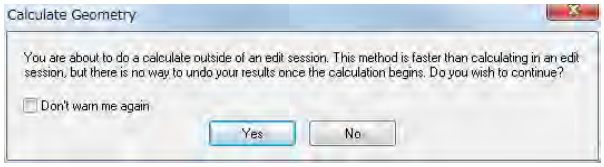

This message means that there is no way to undo your results once the automatic calculation begins. Click [Yes].



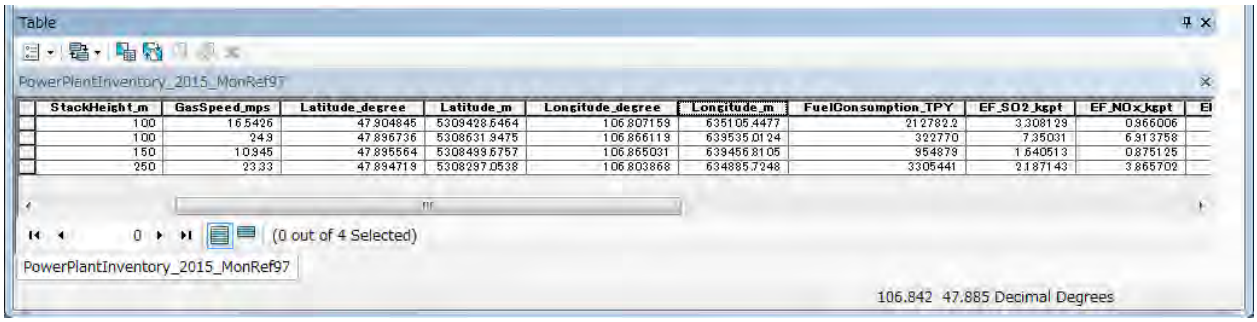

After selecting [Y Coordinate of Point] at [Property], [Use coordinate system of the data source] at [Coordinate System], and [Meters [m]] at [Units], click [OK]. Y Coordinate of Point in Monref97 coordinate system is calculated to [Longitude_m] column of each row.




This message means that there is no way to undo your results once the automatic calculation begins. Click [Yes].

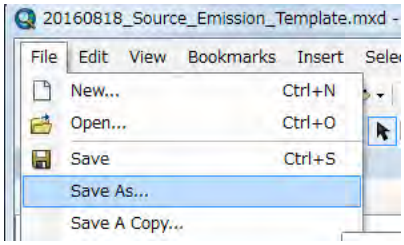



The value of X and Y coordinate in in Monref97 coordinate system is inputted in emission inventory of power plant.

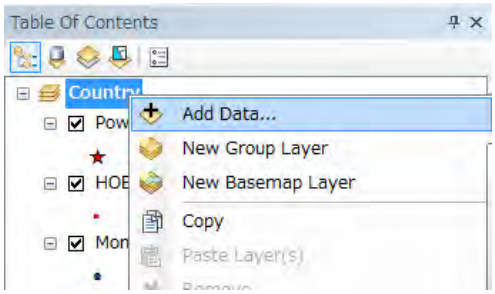



## 2.4 Drawing Emission Distribution Map

Open template file, click [File]-[Save As], and saved as other name.

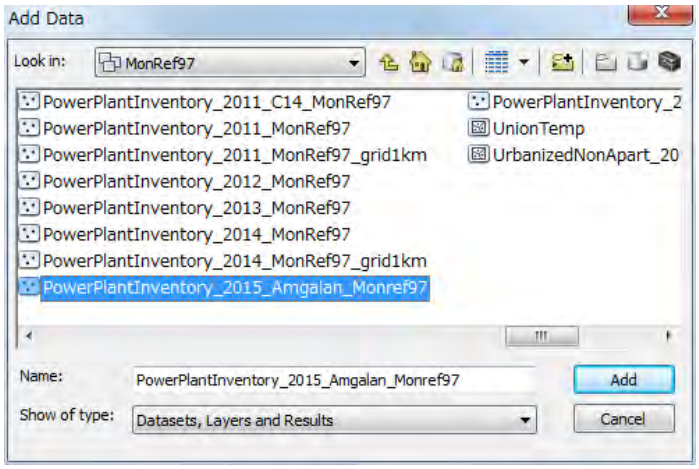



Right-click [Country] and click [Add Data].

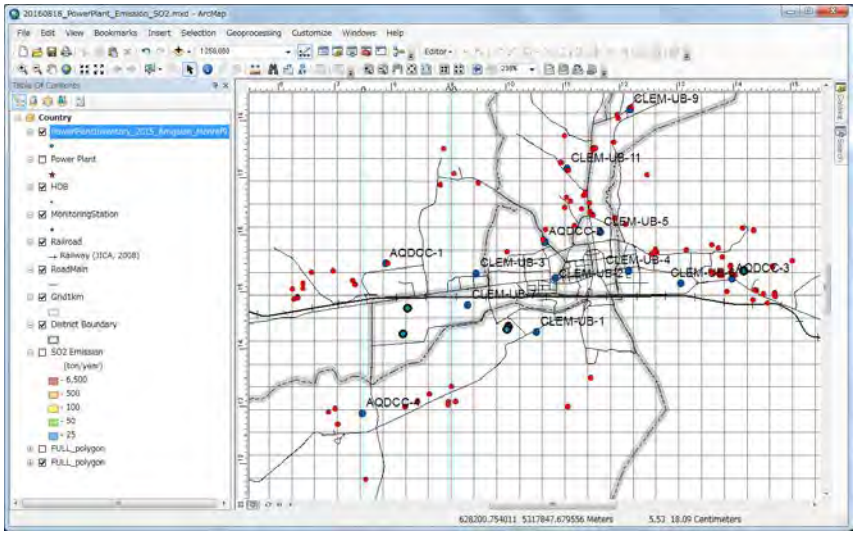



Select the point featureclass of power plant to add the map.

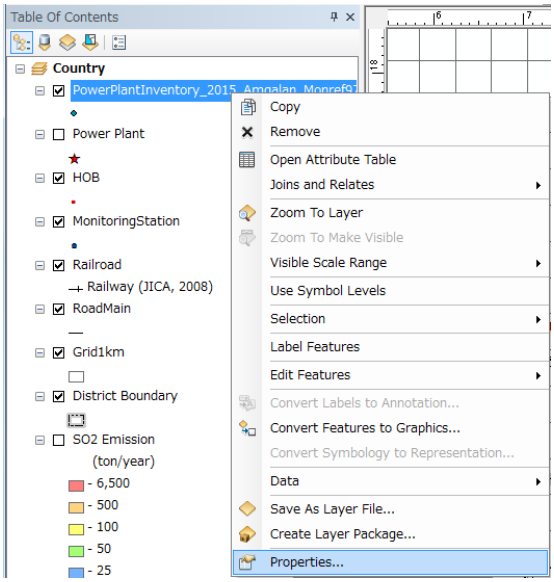
(Here it is “PowerPlantInventory_2015_Amgalan_MonRef97”.)



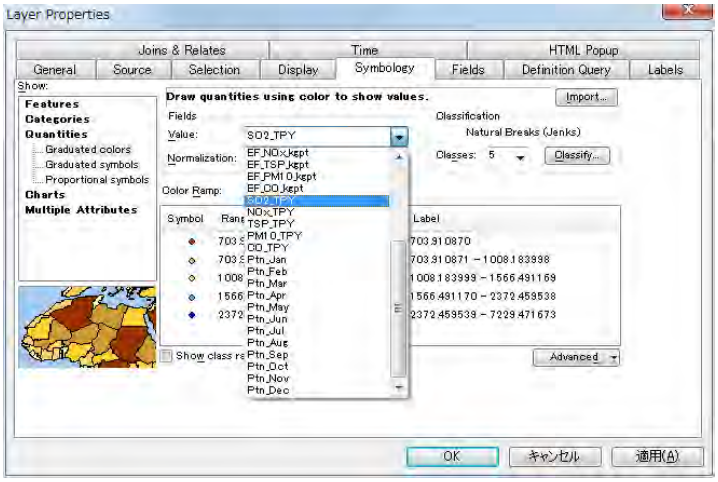

The location of power plant is shown in ArcMap.



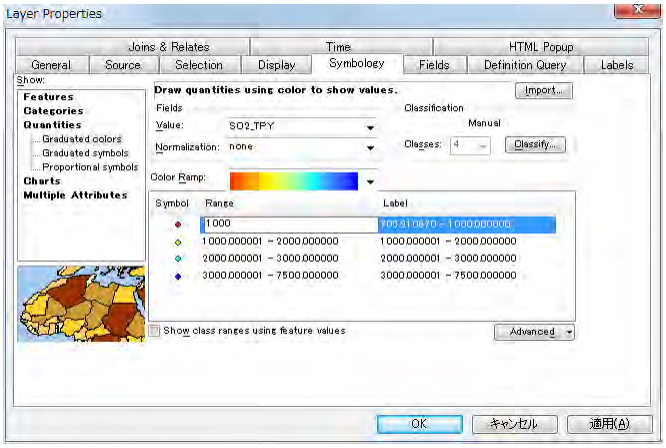

Paint the color of symbol according to emission. Right-click the created point feature class and click [Properties].



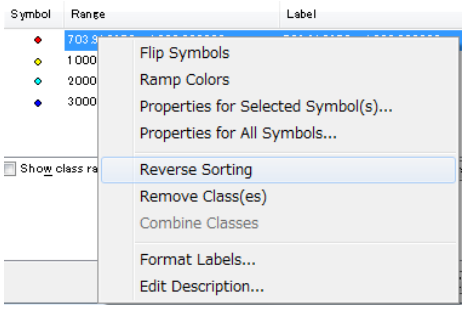

Click [Symbology] tab and select [Quantities]-[Graduated colors]. Click and select the target column name at the drop down button of [Value] (Here it is [SO2_TPY].).



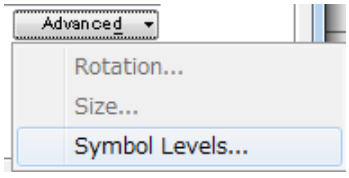

After selecting a rank, click the [Range] of the selected rank and input the maximum of the rank.



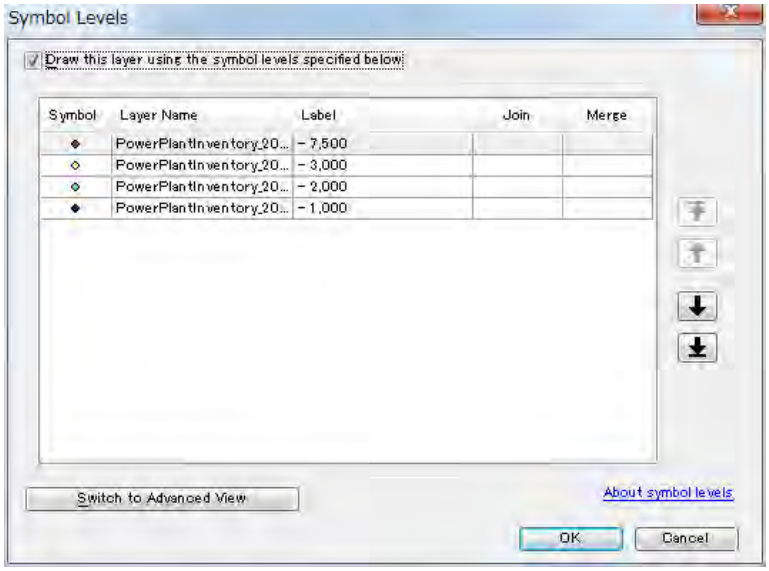

When click [Reverse Sorting] after you right-click on the [Range] column, the display order of rank changes. According to the order of symbol color, decide the display order of rank.



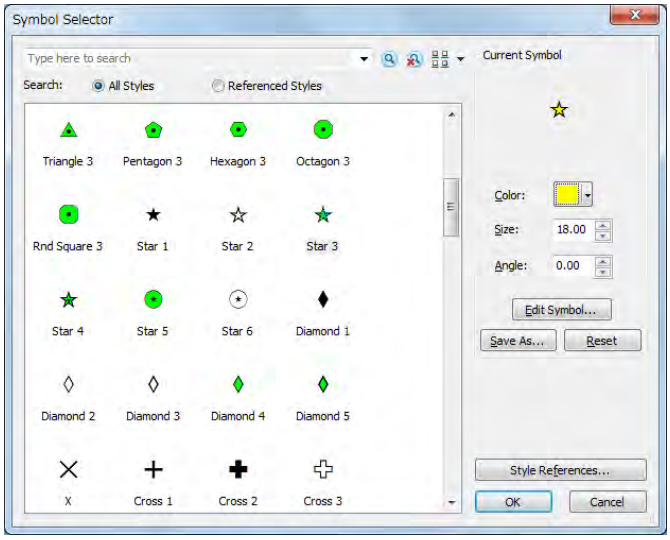

To set the order to show point in the map, click [Advanced]-[Symbol Levels].



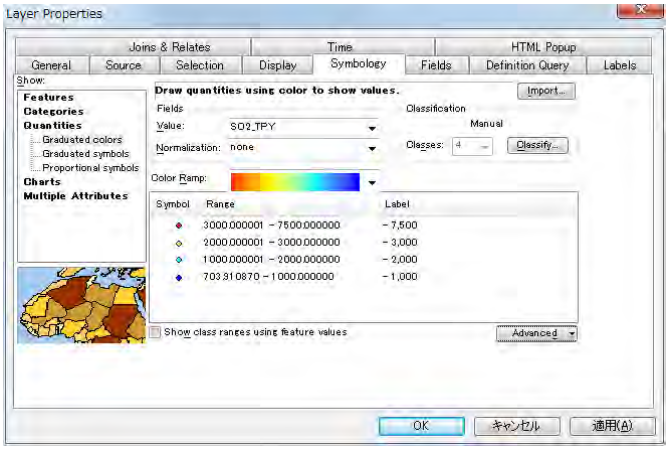
Select [Draw this layer using the symbol levels specified below] checkbox, arrange the order of point featureclass, and click [OK]. The more upper symbol shows forward in this map.



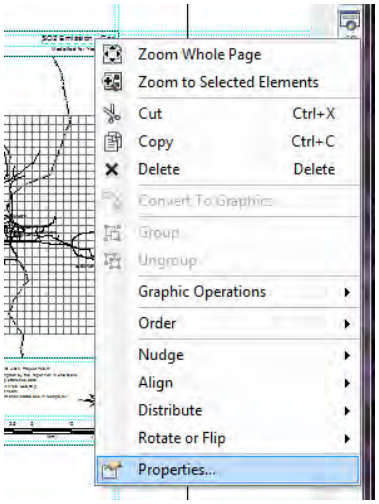

Double-clicking a symbol, you can set the form and color of symbol.



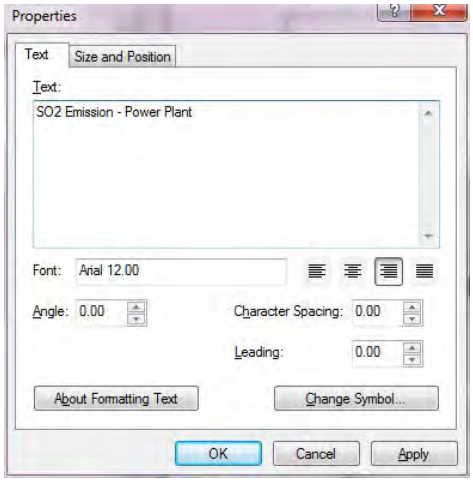

When all setting completed, click [OK].



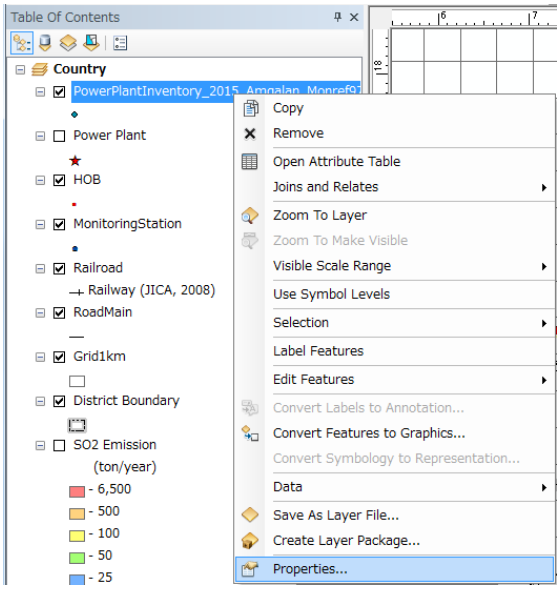

Change the title of this map. Move the cursor to the textbox of title, right-click it, and click [Properties].



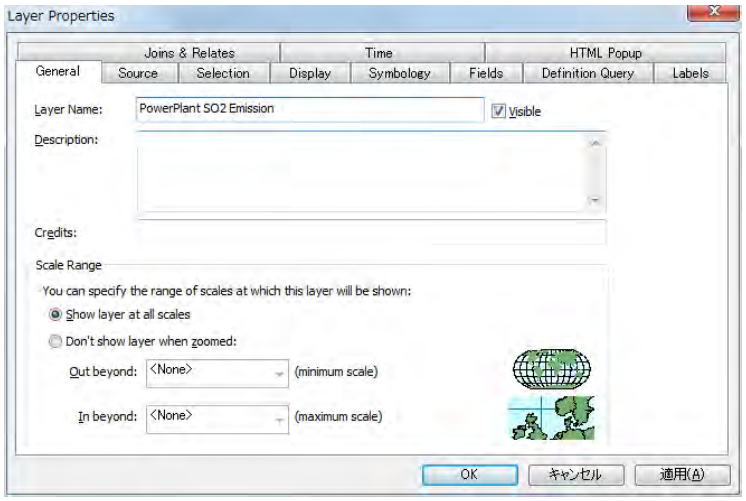

Input a title in [Text] (Here it is “SO2 Emission – Power Plant”.).



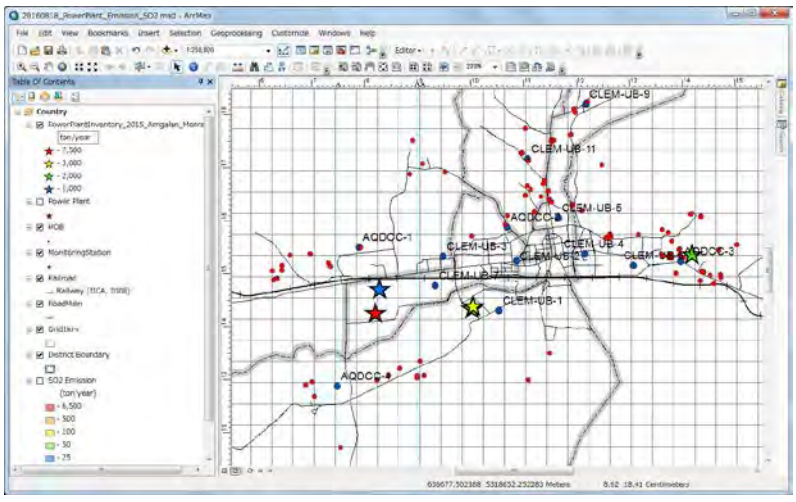

Right-click the added layer and click [Properties].



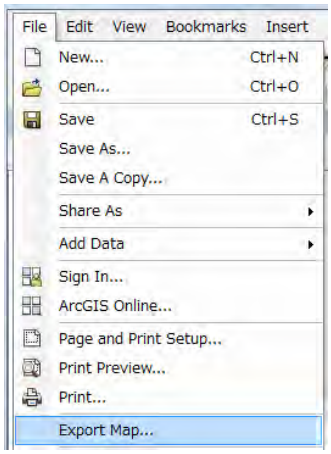

Input a meaningful name to [Layer Name] (Here it is “PowerPlant SO2 Emission”).



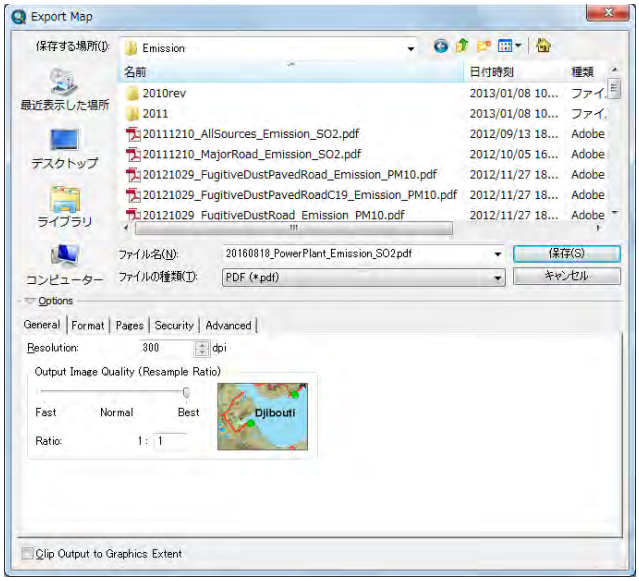

The location of power plant colored by emission rank is shown in the map.



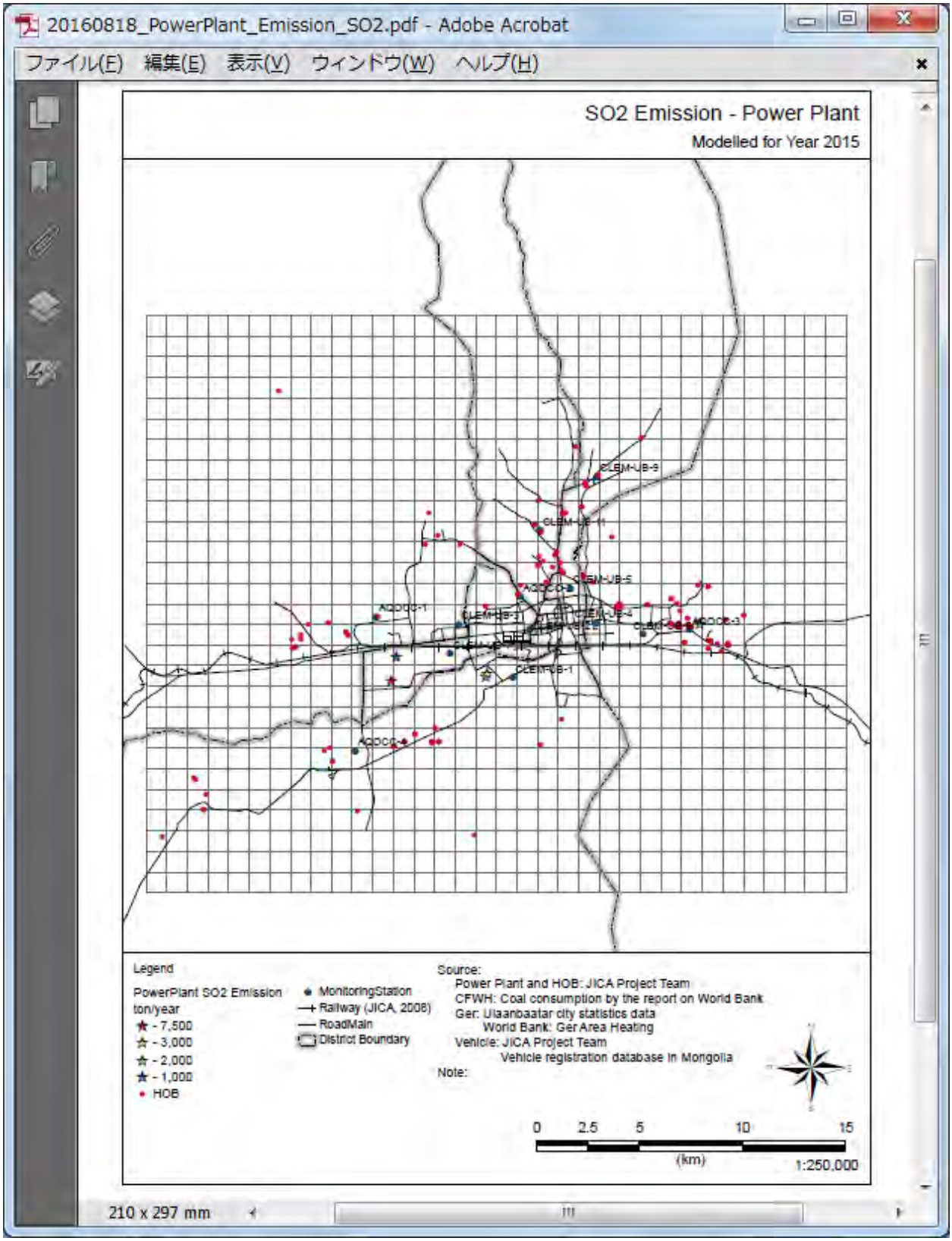
To export the distribution map to PDF file, click [File]-[Export Map].




Setting the destination and file name and click [Save].




Create the PDF file of distribution map.


20160818_PowerPlant_Emission_SO2.pdf - Adobe Acrobat
ファイル(F) 編集(E) 表示(V) ウィンドウ(W) ヘルプ(H)
SO2 Emission - Power Plant
Modelled for Year 2015
CLEM-UB-9
CLEM-UB-11
CLEM-UB-5
CLEM-UB-4
CLEM-UB-1
ADODC-1
ADODC-3
ADODC-4
Legend
PowerPlant SO2 Emission ton/year
- 7,500
- 3,000
- 2,000
- 1,000
HOB
MonitoringStation
Railway (JICA, 2008)
RoadMain
District Boundary
Source:
Power Plant and HOB: JICA Project Team
CFWH: Coal consumption by the report on World Bank
Ger: Ulaanbaatar city statistics data
World Bank: Ger Area Heating
Vehicle: JICA Project Team
Vehicle registration database in Mongolia
Note:
0 2.5 5 10 15
(km)
1:250,000
210 x 297 mm

# 3 HOB

## 3.1 Developing and Updating Method for Emission inventory

The emissions by stacks are estimated. In the case of collected stack, the emission of each boiler is calculated and this summation is the emission from the collected stack. Calculation flow diagram of the emission from HOB is shown in Figure 3-1. Emission is calculated by using the following formula. Regarding temporal change, the survey result on the operating pattern of boiler written in questionnaire of boiler inspection is used.

$$E_i = AD_i \times EF_i$$

Ei: Emission from stack i (ton/year)

ADi: Annual coal consumption of boiler connected to stack i (ton/year)

EFi: Emission factor of boiler connected to stack i (kg/ton fuel)

Emission factor of boiler is applied based on the following situation.

1) The same boiler as the boiler that flow gas measurement was conducted: Apply the emission factor by the flow gas measurement result of the same boiler
2) The other boilers: Apply the average of emission factors of all boilers that flow gas measurement was conducted

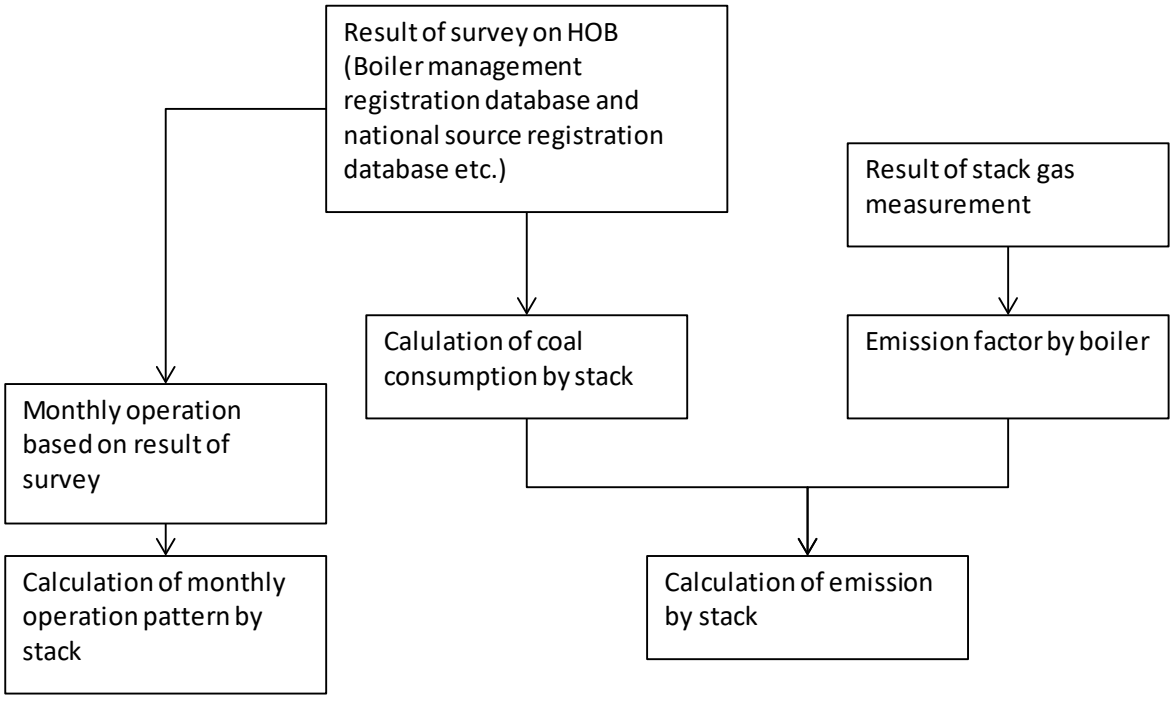


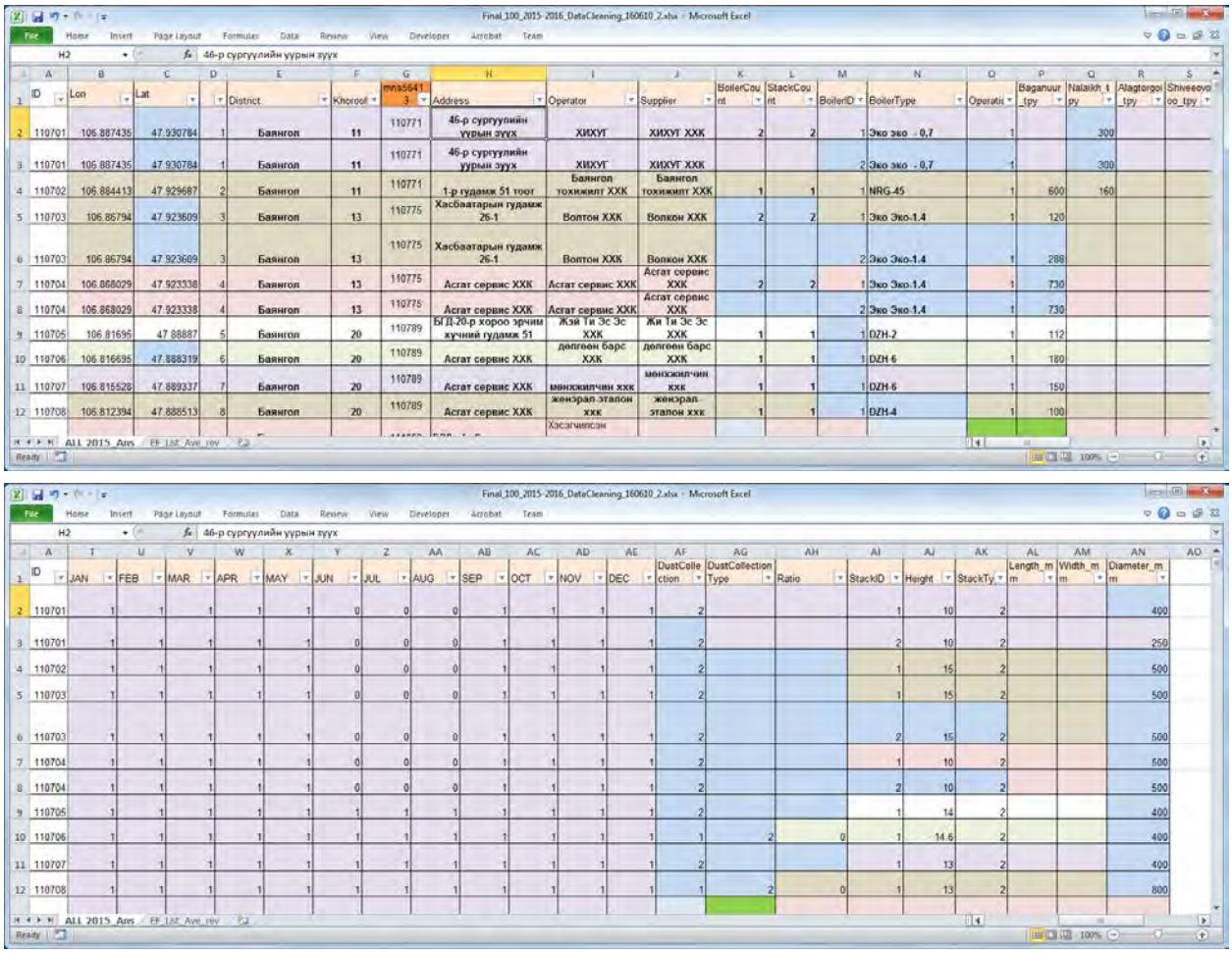

**Figure 3-1 Calculation Flow Diagram of the Emission from HOB**

### 3.1.1 Collecting and Organizing Boiler Information

APRD and Inspection Agency of UB city implement boiler inspection survey for HOB facilities every year from 2014.Since this survey results include boiler type, coal consumption, and stack information, you can use them to develop HOB inventory. Obtain the survey result picking up the only necessary information to develop

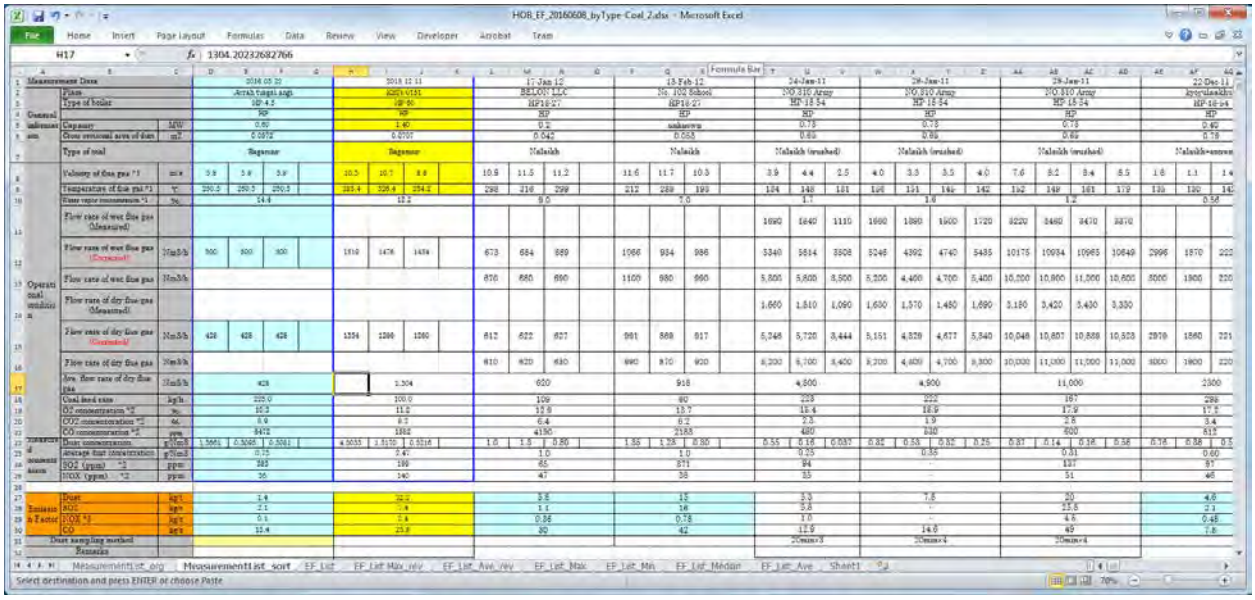
inventory from the person in charge of this survey in APRD. The necessary information for inventory is the following.

1) Location information of HOB facility (Longitude and Latitude), address (district, Khoroo, and lot number), operator, and supplier
2) Count of boiler and stack
3) Boiler type and operation condition
4) Coal consumption by coal production area
5) Operating term of boiler
6) Information on the flow gas treatment facility (with or without introduction, treatment method, and reduction efficiency)
7) Stack height, form length and width (rectangle), and diameter (circle)
8) Connection relation among boiler, treatment facility, and stack



### 3.1.2 Collecting Information for Developing Emission Factor

For the boiler inspection, APRD conducts the flow gas measurement of HOB every winter and calculate the emission factor of each measurement. By obtaining this information from the person in charge of analysis and organizing, calculate the emission factor by boiler type.



Since sulfur content and ash content differ depending on coal production area, if the location of the coal production at the time of measurement is known, the accuracy of emission will be improved by subdividing the emission factor by coal production area.

Assuming the case where the emission of HOB becomes the maximum, the target emission factor is the one based on the measurement result at the winter season (November to February) when hot water supply is always necessary.

The organizing results of emission factors based on the flow gas measurement results up to 2015 are shown. The emission factor of “Others” is applied to boilers not listed in the table below. In addition, flow gas measurement results of boilers that were measured in the past but are not currently used in UB city are excluded from totaling of emission factors.

| No | Boiler Type | Coal Type | Velocity of flue gas | Temperature of flue gas | Dust | PM10 | SO2 | NOx | CO |
|---|---|---|---|---|---|---|---|---|---|
| | | | m/s | $^0$C | kg/t | kg/t | kg/t | kg/t | kg/t |
| 1 | HP | Baganuur | 7.87 | 266.15 | 16.79 | 15.95 | 4.75 | 1.27 | 20.59 |
| 2 | HP | Nalaikh | 6.04 | 173.97 | 8.64 | 8.21 | 8.83 | 1.21 | 25.27 |
| 3 | HP | Others | 6.42 | 193.04 | 10.45 | 9.93 | 7.81 | 1.22 | 24.23 |
| 4 | MDZ | Baganuur | 6.24 | 90.00 | 13.23 | 12.57 | 6.82 | 4.25 | 34.86 |
| 5 | MDZ | Nalaikh | 5.23 | 195.88 | 6.57 | 6.24 | 9.72 | 1.04 | 11.11 |
| 6 | MDZ | Others | 5.41 | 177.19 | 7.90 | 7.51 | 9.14 | 1.68 | 15.86 |
| 7 | MUHT | Baganuur | 13.41 | 138.30 | 11.06 | 10.51 | 11.80 | 3.67 | 19.90 |
| 8 | MUHT | Nalaikh | 14.08 | 181.90 | 15.08 | 14.33 | 3.94 | 0.72 | 26.32 |
| 9 | MUHT | Others | 13.86 | 167.37 | 13.74 | 13.05 | 6.56 | 1.70 | 24.18 |
| 10 | KCR | Baganuur | 4.95 | 201.78 | 4.86 | 4.62 | 0.94 | 0.23 | 14.08 |
| 11 | KCR | Nalaikh | 11.02 | 218.00 | 1.49 | 1.42 | 1.84 | 0.44 | 138.44 |
| 12 | KCR | Others | 5.78 | 203.99 | 4.38 | 4.16 | 1.07 | 0.26 | 31.84 |
| 13 | DZL | All | 15.55 | 104.59 | 5.58 | 5.30 | 12.01 | 3.35 | 20.52 |
| 14 | Carborobot | All | 19.83 | 137.26 | 8.87 | 8.43 | 10.54 | 1.19 | 54.78 |
| 15 | Eco Eco | Baganuur | 6.10 | 79.55 | 1.16 | 1.10 | 4.28 | 0.77 | 32.88 |
| 16 | Eco Eco | Tavantolgoi | 12.50 | 135.70 | 1.88 | 1.79 | 28.96 | 3.22 | 26.75 |
| 17 | Eco Eco | Others | 8.23 | 98.27 | 1.40 | 1.33 | 12.51 | 1.59 | 30.83 |
| 18 | CLSG | All | 10.45 | 332.53 | 13.28 | 12.62 | 7.77 | 0.50 | 45.43 |
| 19 | Viaduras | All | 8.21 | 189.75 | 2.64 | 2.51 | 4.70 | 0.69 | 109.82 |
| 20 | MWB | All | 6.34 | 165.27 | 20.67 | 19.64 | 5.04 | 0.47 | 56.46 |
| 21 | DZH | Baganuur | 18.68 | 76.03 | 7.60 | 7.22 | 0.74 | 0.10 | 11.96 |
| 22 | DZH | Nalaikh | 12.60 | 100.98 | 5.17 | 4.91 | 9.39 | 0.79 | 27.77 |
| 23 | DZH | Alagtolgoi | 30.55 | 171.22 | 2.70 | 2.57 | 13.23 | 2.34 | 4.01 |
| 24 | DZH | All | 21.00 | 124.09 | 4.67 | 4.44 | 9.20 | 1.27 | 15.11 |
| 25 | EcoEffect | All | 13.96 | 111.63 | 2.59 | 2.46 | 14.78 | 1.10 | 51.42 |
| 26 | SL | All | 7.80 | 353.70 | 0.28 | 0.27 | 0.41 | 0.18 | 4.77 |
| 27 | LSG | All | 5.18 | 322.67 | 7.60 | 7.22 | 28.57 | 4.91 | 65.10 |
| 28 | CLHG | All | 3.16 | 208.70 | 8.04 | 7.64 | 16.15 | 4.80 | 274.68 |
| 29 | BZUI | All | 14.32 | 228.27 | 10.64 | 10.11 | 3.77 | 1.07 | 32.08 |
| 30 | Euro Zigi Star-kom | All | 4.59 | 164.87 | 63.76 | 60.57 | 6.74 | 2.26 | 48.18 |
| 31 | Odcon | All | 4.60 | 228.03 | 1.29 | 1.23 | 0.61 | 0.06 | 4.10 |
| 32 | E-1.4 | All | 4.40 | 101.80 | 1.91 | 1.81 | 6.65 | 0.31 | 6.58 |
| 33 | Others | Baganuur | 7.52 | 181.33 | 9.85 | 9.36 | 3.97 | 1.17 | 30.59 |
| 34 | Others | Nalaikh | 11.65 | 165.41 | 8.33 | 7.91 | 9.73 | 1.58 | 41.55 |
| 35 | Others | Alagtolgoi | 30.55 | 171.22 | 2.70 | 2.57 | 13.23 | 2.34 | 4.01 |
| 36 | Others | Shiveeovoo | 9.36 | 165.03 | 6.28 | 5.97 | 5.21 | 0.69 | 19.33 |
| 37 | Others | Tavantolgoi | 12.50 | 135.70 | 1.88 | 1.79 | 28.96 | 3.22 | 26.75 |
| 38 | Others | Others | 11.15 | 168.06 | 8.51 | 8.08 | 8.57 | 1.51 | 37.12 |

### 3.1.3 Developing and Updating Emission Inventory

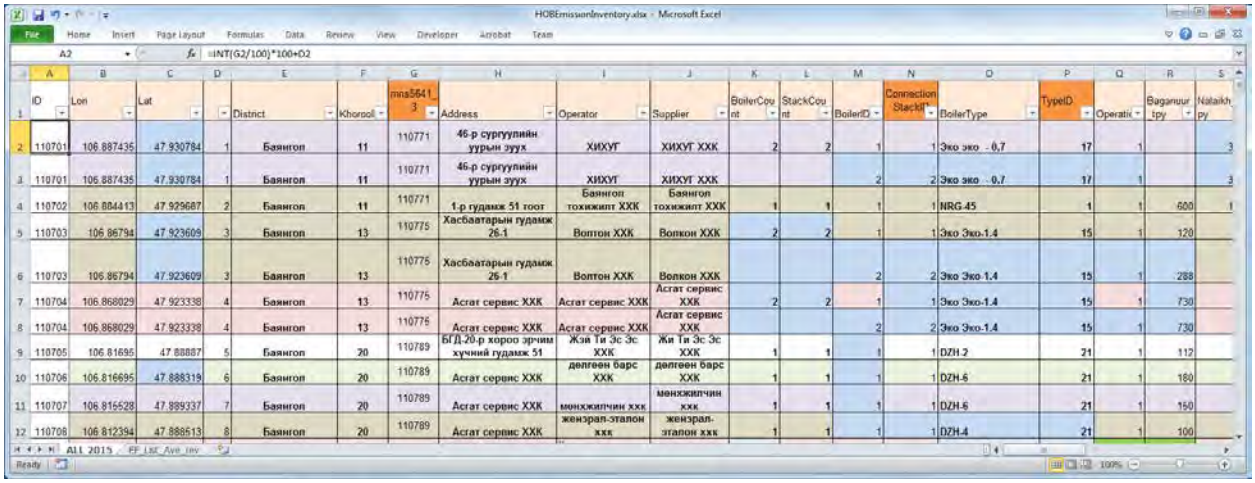
Use “HOBEmissionInventory.xlsx” for developing and updating emission inventory of HOB.

Assign [TypeID] that matches the list of emission factors ([EF_List_Ave_rev] sheet) from the boiler type name ([Boiler Type] column) and the coal producing area being used, and the emission factor, the flow gas velocity, and the flow gas temperature corresponding to [Type ID] are applied.

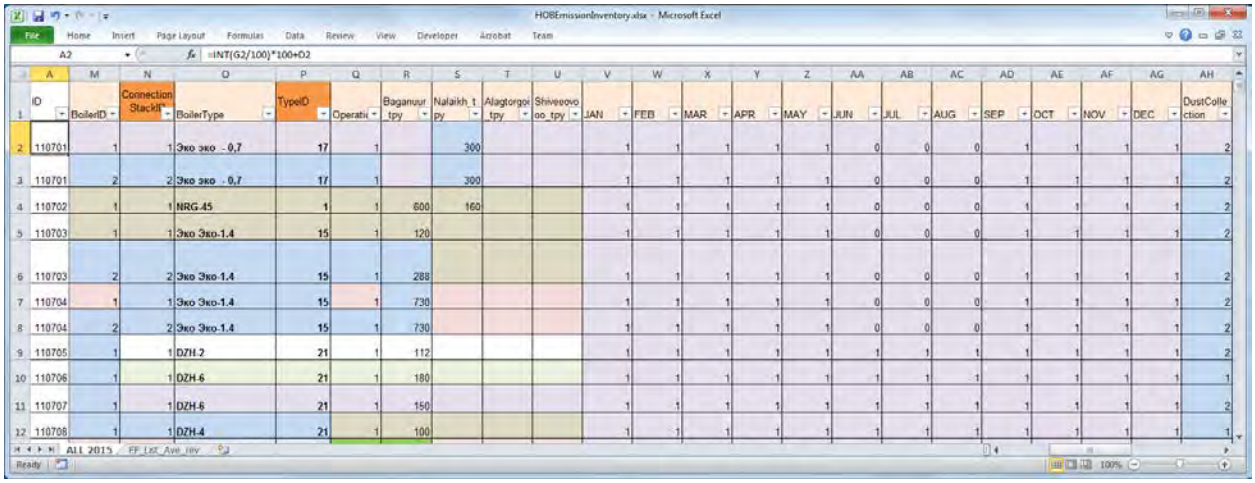
If the connection relation among the boiler, the flow gas treatment device and the stack is unclear, confirm the survey result of the boiler inspection. If it still does not understand, assume a connection state which can actually be referenced with reference to other HOB.

Emission is automatically calculated by using fuel consumption and emission factor.

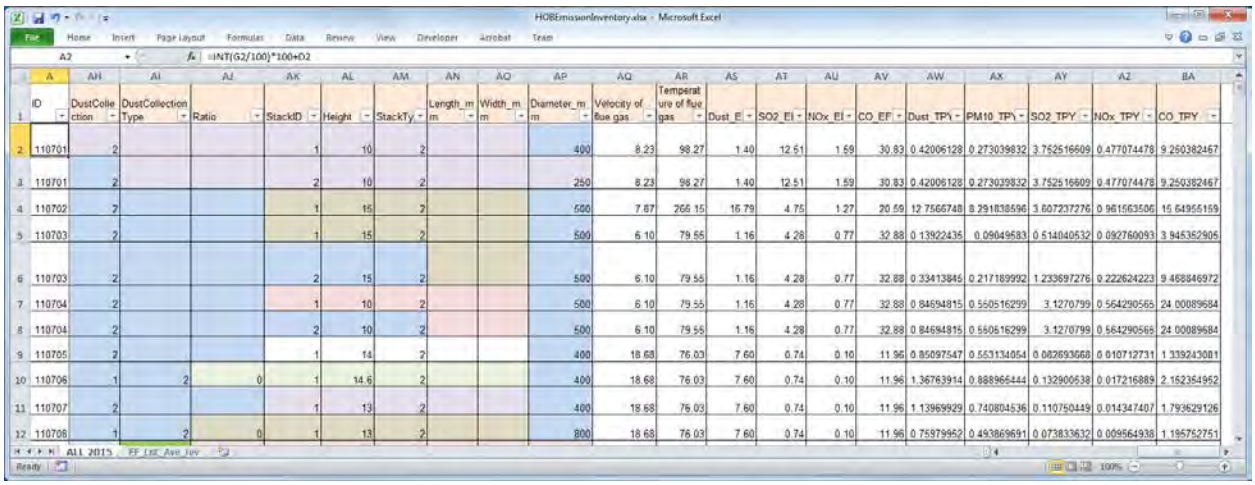
Coordinate of stack, stack height, diameter, flue gas temperature, flue gas speed and monthly operating pattern are used in dispersion simulation.



| ID | Lon | Lat | | District | Khoroo | mns5641_3 | Address | Operator | Supplier | BoilerCount | StackCount | BoilerID | ConnectionStackID | BoilerType | TypeID | Operation | Baganuur_tpy | Nalaikh_tpy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 110701 | 106.887435 | 47.930784 | 1 | Баянгол | 11 | 110771 | 46-р сургуулийн уурын зуух | ХИХУГ | ХИХУГ ХХК | 2 | 2 | 1 | 1 | Эко эко - 0,7 | 17 | 1 | | 3 |
| 110701 | 106.887435 | 47.930784 | 1 | Баянгол | 11 | 110771 | 46-р сургуулийн уурын зуух | ХИХУГ | ХИХУГ ХХК | | | 2 | 2 | Эко эко - 0,7 | 17 | 1 | | 3 |
| 110702 | 106.884413 | 47.929687 | 2 | Баянгол | 11 | 110771 | 1-р гудамж 51 тоот | Баянгол тохижилт ХХК | Баянгол тохижилт ХХК | 1 | 1 | 1 | 1 | NRG-45 | 1 | 1 | 600 | 1 |
| 110703 | 106.86794 | 47.923609 | 3 | Баянгол | 13 | 110775 | Хасбаатарын гудамж 26-1 | Волтон ХХК | Волкон ХХК | 2 | 2 | 1 | 1 | Эко Эко-1.4 | 15 | 1 | 120 | |
| 110703 | 106.86794 | 47.923609 | 3 | Баянгол | 13 | 110775 | Хасбаатарын гудамж 26-1 | Волтон ХХК | Волкон ХХК | | | 2 | 2 | Эко Эко-1.4 | 15 | 1 | 288 | |
| 110704 | 106.868029 | 47.923338 | 4 | Баянгол | 13 | 110775 | Асгат сервис ХХК | Асгат сервис ХХК | Асгат сервис ХХК | 2 | 2 | 1 | 1 | Эко Эко-1.4 | 15 | 1 | 730 | |
| 110704 | 106.868029 | 47.923338 | 4 | Баянгол | 13 | 110776 | Асгат сервис ХХК | Асгат сервис ХХК | Асгат сервис ХХК | | | 2 | 2 | Эко Эко-1.4 | 15 | 1 | 730 | |
| 110705 | 106.81695 | 47.88887 | 5 | Баянгол | 20 | 110789 | БГД-20-р хороо эрчим хүчний гудамж 51 | Жэи Ти Эс Эс ХХК | Жи Ти Эс Эс ХХК | 1 | 1 | 1 | 1 | DZH.2 | 21 | 1 | 112 | |
| 110706 | 106.816695 | 47.888319 | 6 | Баянгол | 20 | 110789 | Асгат сервис ХХК | долгөөн барс ХХК | долгөөн барс ХХК | 1 | 1 | 1 | 1 | DZH.6 | 21 | 1 | 180 | |
| 110707 | 106.816528 | 47.889337 | 7 | Баянгол | 20 | 110789 | Асгат сервис ХХК | монхжилчин ххк | монхжилчин ххк | 1 | 1 | 1 | 1 | DZH.6 | 21 | 1 | 150 | |
| 110708 | 106.812394 | 47.888513 | 8 | Баянгол | 20 | 110789 | Асгат сервис ХХК | женэрал-эталон ххк | женэрал-эталон ххк | 1 | 1 | 1 | 1 | DZH.4 | 21 | 1 | 100 | |



| ID | BoilerID | ConnectionStackID | BoilerType | TypeID | Operation | Baganuur_tpy | Nalaikh_tpy | Alagtorgoi_tpy | Shiveegovoo_tpy | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | DustCollection |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 110701 | 1 | 1 | Эко эко - 0,7 | 17 | 1 | | 300 | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| 110701 | 2 | 2 | Эко эко - 0,7 | 17 | 1 | | 300 | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| 110702 | 1 | 1 | NRG-45 | 1 | 1 | 600 | 160 | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| 110703 | 1 | 1 | Эко Эко-1.4 | 15 | 1 | 120 | | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| 110703 | 2 | 2 | Эко Эко-1.4 | 15 | 1 | 288 | | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| 110704 | 1 | 1 | Эко Эко-1.4 | 15 | 1 | 730 | | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| 110704 | 2 | 2 | Эко Эко-1.4 | 15 | 1 | 730 | | | | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 |
| 110705 | 1 | 1 | DZH.2 | 21 | 1 | 112 | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 110706 | 1 | 1 | DZH.6 | 21 | 1 | 180 | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 110707 | 1 | 1 | DZH.6 | 21 | 1 | 150 | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 |
| 110708 | 1 | 1 | DZH.4 | 21 | 1 | 100 | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

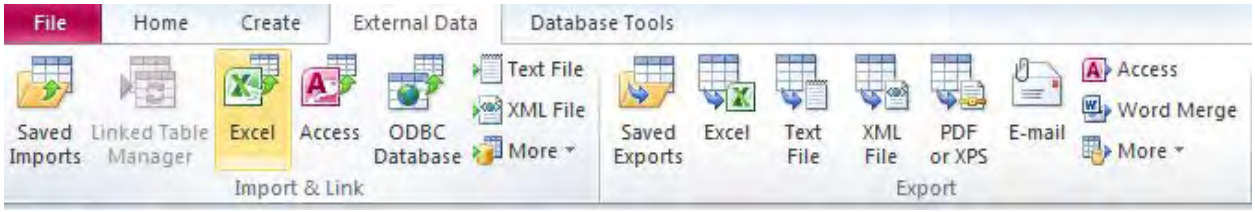


| ID | DustCollection | DustCollectionType | Ratio | StackID | Height | StackType | Length_m | Width_m | Diameter_m | Velocity of flue gas | Temperature of flue gas | Dust_EF | SO2_EF | NOx_EF | CO_EF | Dust_TPY | PM10_TPY | SO2_TPY | NOx_TPY | CO_TPY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 110701 | 2 | | | 1 | 10 | 2 | | | 400 | 8.23 | 98.27 | 1.40 | 12.51 | 1.59 | 30.83 | 0.42006128 | 0.273039832 | 3.752516609 | 0.477074478 | 9.250382467 |
| 110701 | 2 | | | 2 | 10 | 2 | | | 250 | 8.23 | 98.27 | 1.40 | 12.51 | 1.59 | 30.83 | 0.42006128 | 0.273039832 | 3.752516609 | 0.477074478 | 9.250382467 |
| 110702 | 7 | | | 1 | 15 | 2 | | | 500 | 7.87 | 266.15 | 16.79 | 4.75 | 1.27 | 20.59 | 12.7566748 | 8.291838596 | 3.607237276 | 0.961563506 | 15.64955159 |
| 110703 | 2 | | | 1 | 15 | 2 | | | 500 | 6.10 | 79.55 | 1.16 | 4.28 | 0.77 | 32.88 | 0.13922436 | 0.09049583 | 0.514040532 | 0.092760093 | 3.945362905 |
| 110703 | 2 | | | 2 | 15 | 2 | | | 500 | 6.10 | 79.55 | 1.16 | 4.28 | 0.77 | 32.88 | 0.33413846 | 0.217189992 | 1.233697276 | 0.222624223 | 9.468846972 |
| 110704 | 2 | | | 1 | 10 | 2 | | | 500 | 6.10 | 79.55 | 1.16 | 4.28 | 0.77 | 32.88 | 0.84694815 | 0.550516299 | 3.1270799 | 0.564290565 | 24.00089684 |
| 110704 | 2 | | | 2 | 10 | 2 | | | 500 | 6.10 | 79.55 | 1.16 | 4.28 | 0.77 | 32.88 | 0.84694815 | 0.550516299 | 3.1270799 | 0.564290565 | 24.00089684 |
| 110705 | 2 | | | 1 | 14 | 2 | | | 400 | 18.68 | 76.03 | 7.60 | 0.74 | 0.10 | 11.96 | 0.85097547 | 0.553134054 | 0.082693668 | 0.010712731 | 1.339243081 |
| 110706 | 1 | 2 | 0 | 1 | 14.6 | 2 | | | 400 | 18.68 | 76.03 | 7.60 | 0.74 | 0.10 | 11.96 | 1.36763914 | 0.888966444 | 0.132900538 | 0.017216889 | 2.152354952 |
| 110707 | 2 | | | 1 | 13 | 2 | | | 400 | 18.68 | 76.03 | 7.60 | 0.74 | 0.10 | 11.96 | 1.13969929 | 0.740804536 | 0.110750449 | 0.014347407 | 1.793629126 |
| 110708 | 1 | 2 | 0 | 1 | 13 | 2 | | | 800 | 18.68 | 76.03 | 7.60 | 0.74 | 0.10 | 11.96 | 0.75979952 | 0.493869691 | 0.073833632 | 0.009564938 | 1.195752751 |

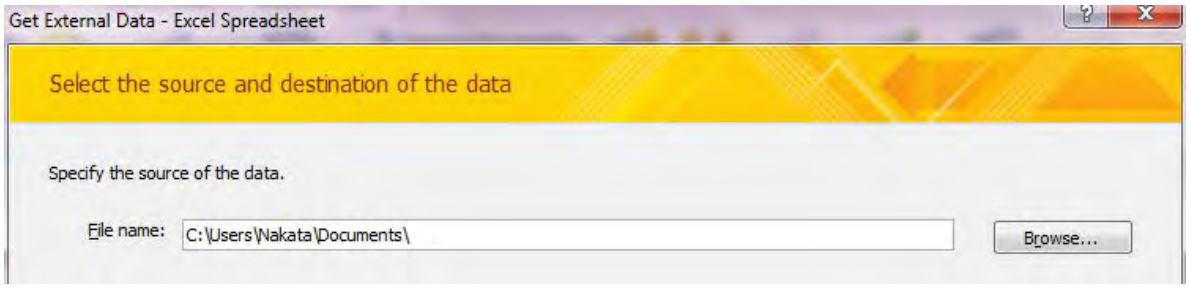
## 3.2 Import Inventory File into Access

Data on stationary source inventory is generated in “StationarySources.mdb”. This explains the method to import the inventory developing in 3.1.3 to “StationarySources.mdb”.

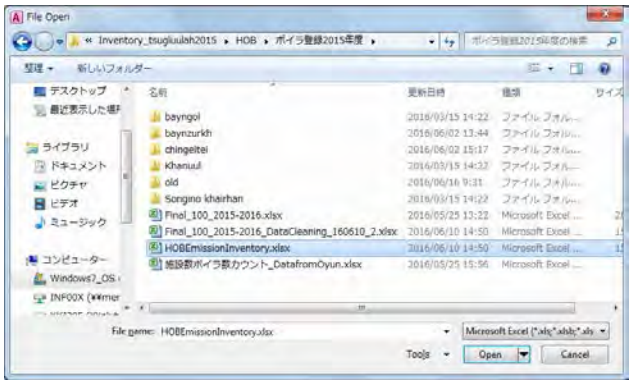
Select [Excel] button of [Import & Link] in [External Data] tab.



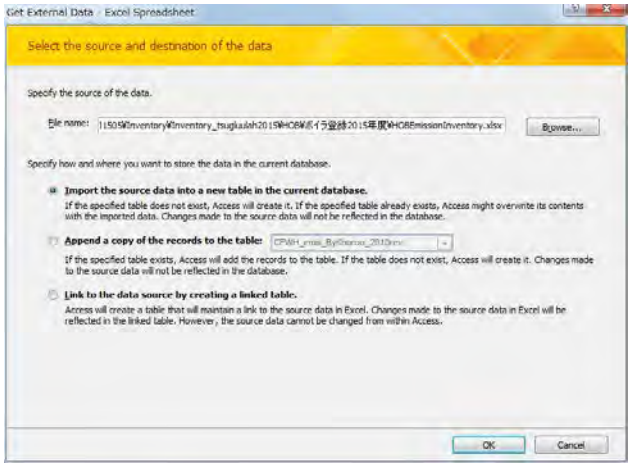

Click [Browse].



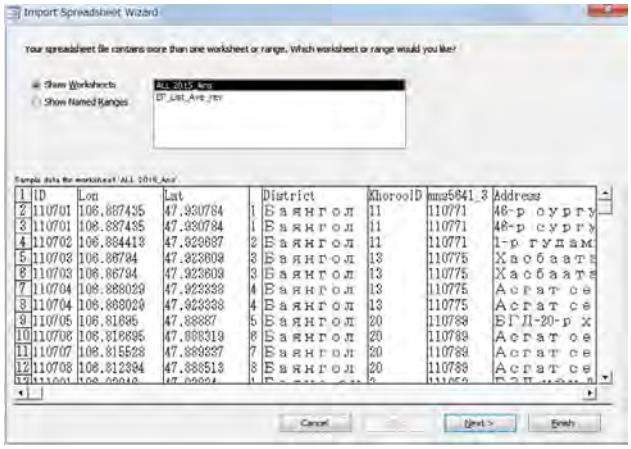

Select the file you want to import (Here it is “HOBEmissionInventory.xlsx”).



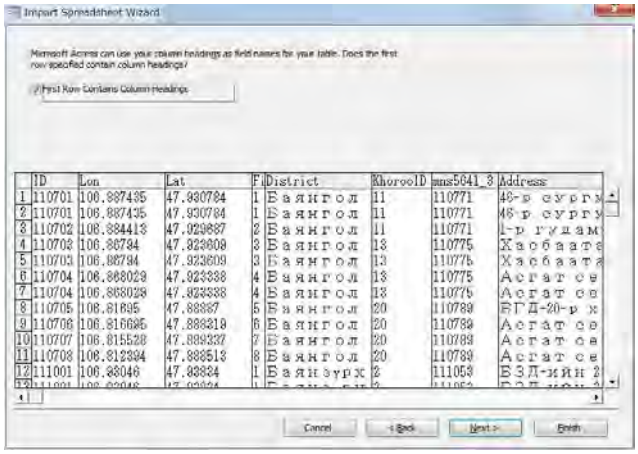

Select [Import the source data into a new table in the current database.] and click [OK].



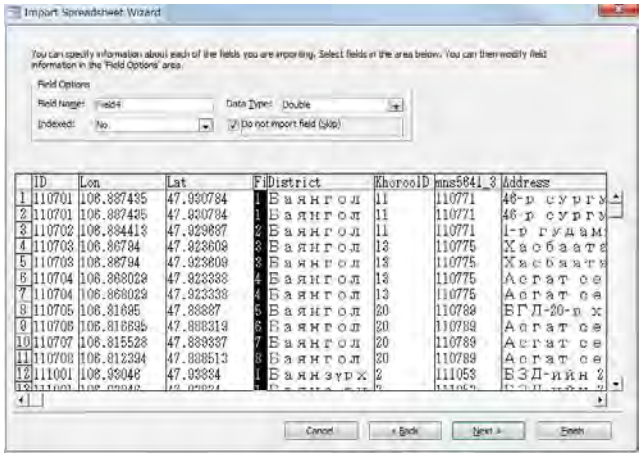

Check [Show Worksheets] is selected, select [ALL_2015_Ans] sheet, and click [Next].



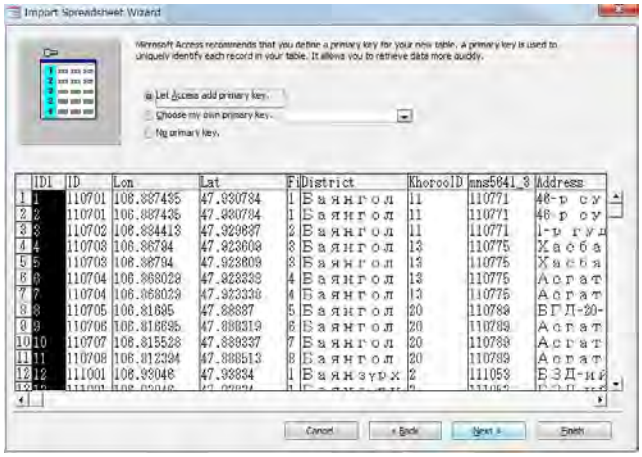

Check [First Row Contains Column Headings] is checked and click [Next].




Set the unnecessary column for inventory and simulation checked [Do not import field (Skip)] and click [Next].

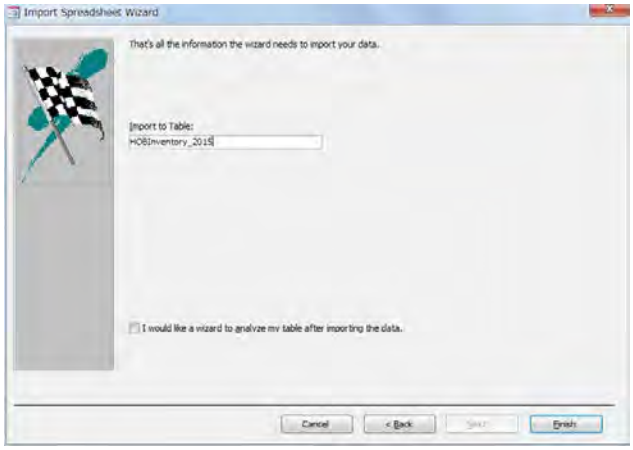



Select [Let Access add primary key.] and Click [Next].

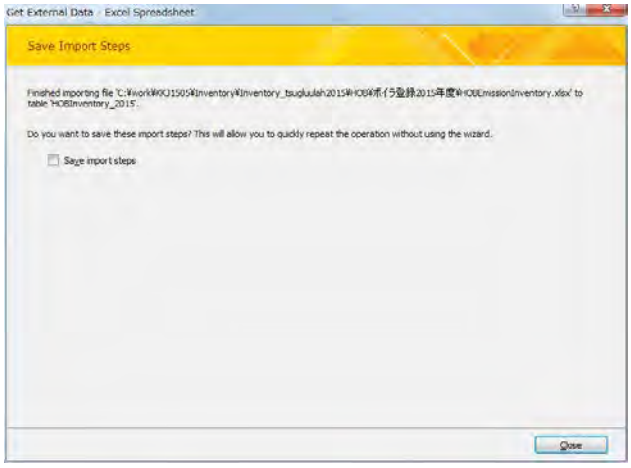



Input the table name in the [Import to Table:] textbox and click [Finish].

(Here it is “HOBInventory_2015”.)

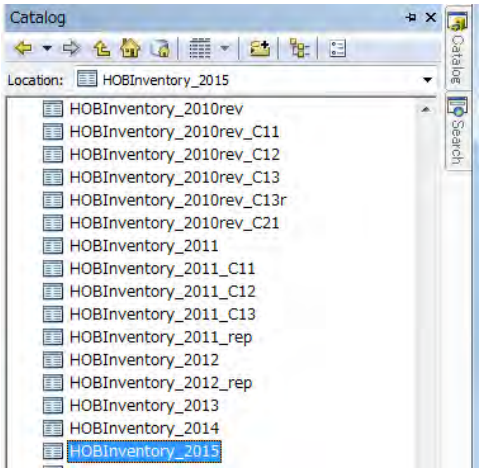



Click [Close].

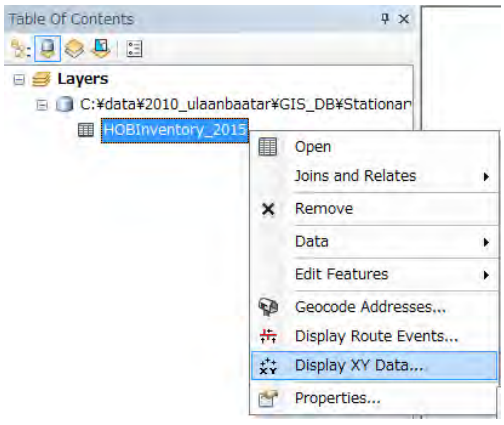



## 3.3 Addition and Conversion Method of Coordinate System to Point Source Data

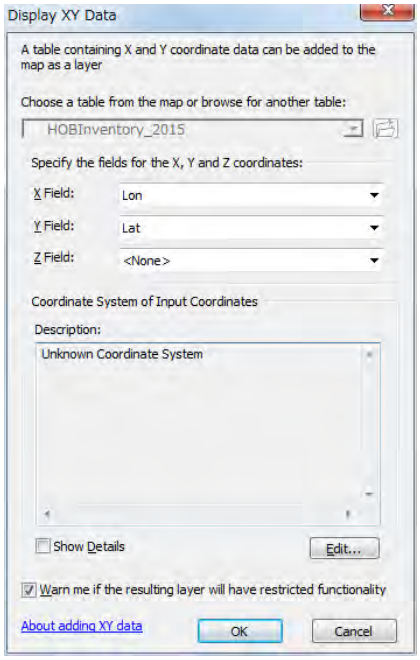
Open empty ArcMap and [Catalog] at the right side. Select the imported table in “StationarySorces.mdb” file and drag and drop in ArcMap.(Here it is “HOB_Inventory_2015” table.)



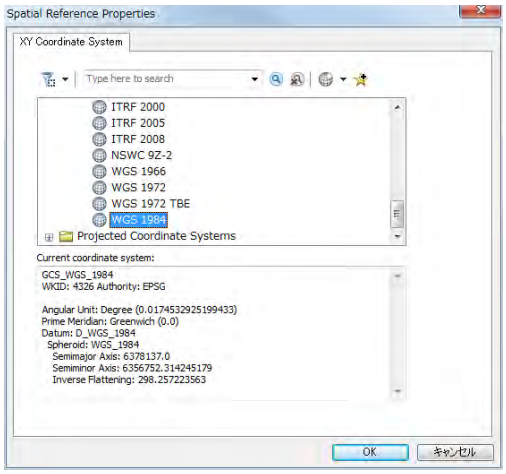

Right-click the imported table in [Table Of Contents] and click [Display XY Data].



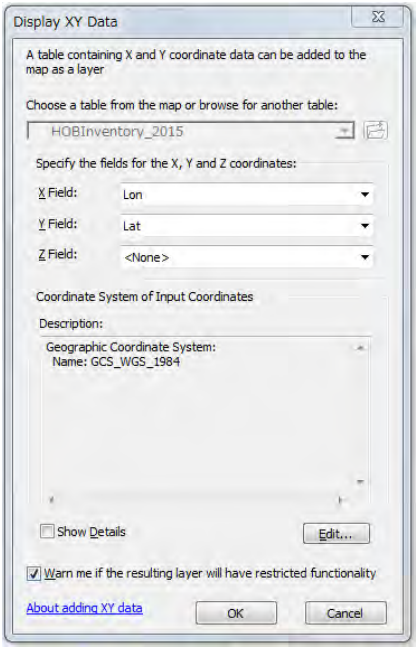

After you select [Lon] in [X Field], [Lat] in [Y Field], and [<None>] in [Z Field], click [Edit]




Select [Geographic Coordinate Systems]-[world]-[WGS 1984] and click [OK].

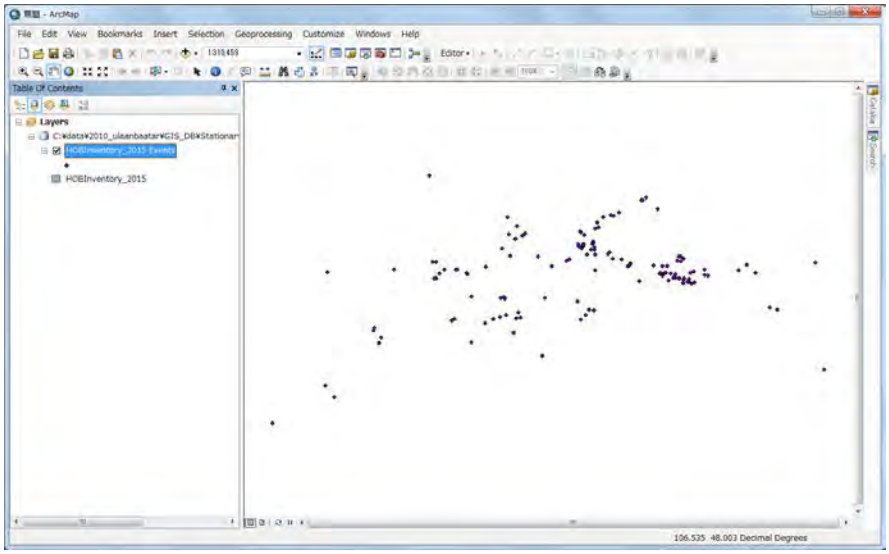



Check [GCS_WGS_1984] shown in [Description] and click [OK].

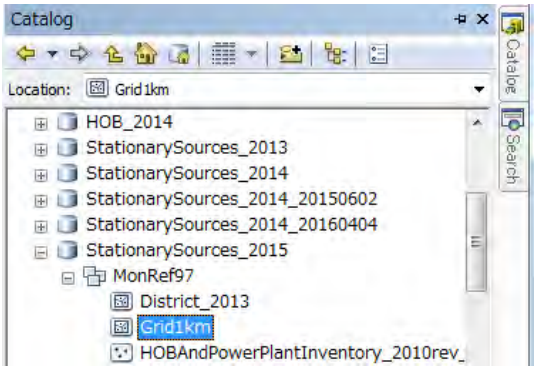



Coordinated layer is shown in ArcMap. Check if positional relation is correct.

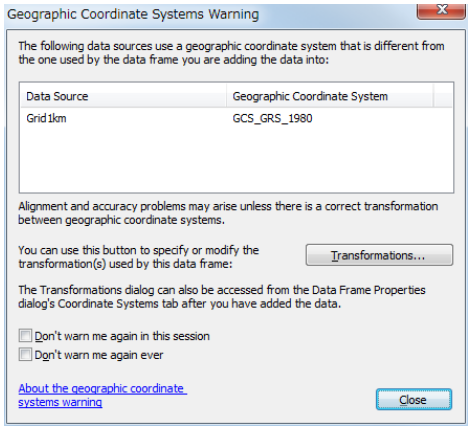
(Here this layer is “HOB_Inventory_2015 Events” layer.)



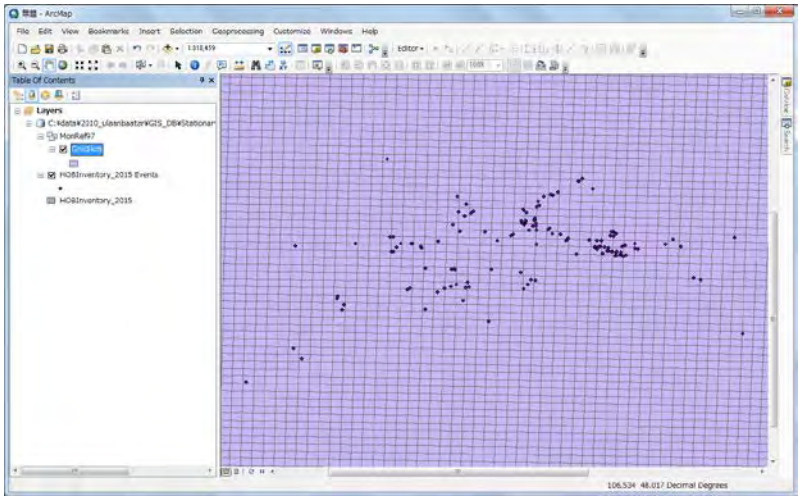
Select the [Grid1km] featureclass in [StationarySources.mdb]-[MonRef97] dataset and drag-drop it in ArcMap.



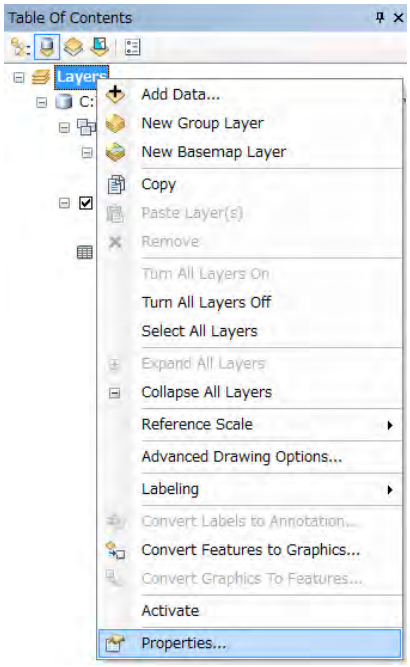

If the following dialog shows, click [Close].



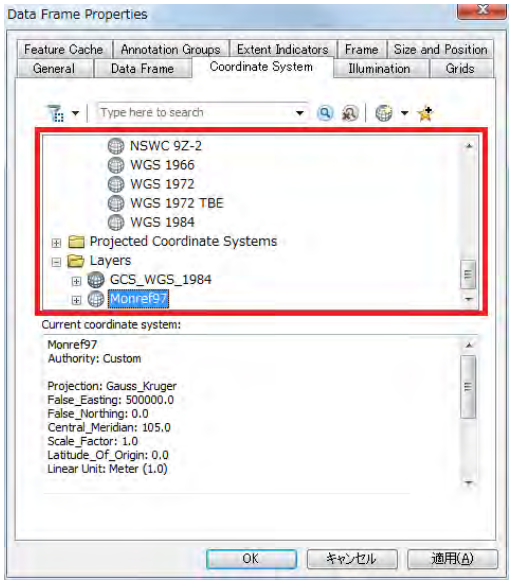

Originally, [Grid1km] is shown as square, however, it is shown as distorted rectangle on ArcMap, because geodetic datum of this featureclass is different from on ArcMap.



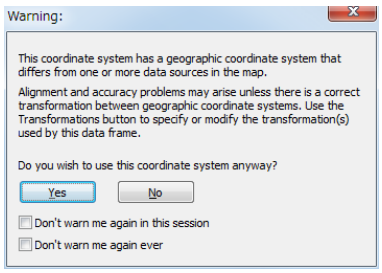
Right-click [Layers] in [Table Of Contents] and click [Properties].



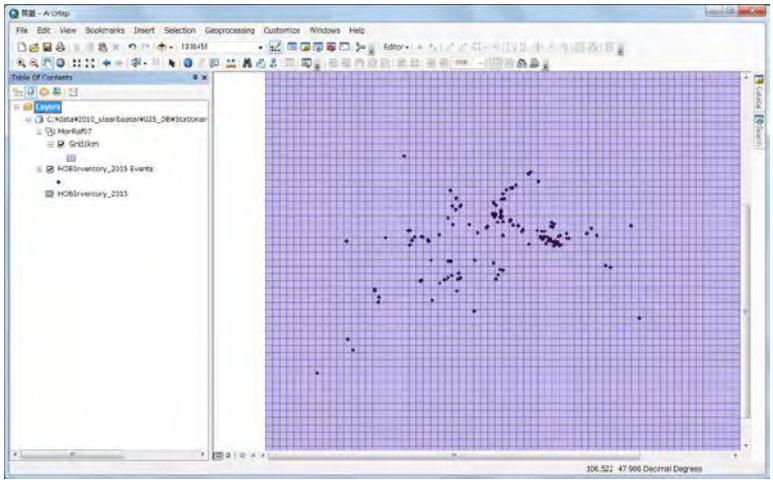

Select [Coordinate System] tab and [Layers]-[Monref97] in the red rectangle, and click [OK].




If this warning message shows, click [Yes].

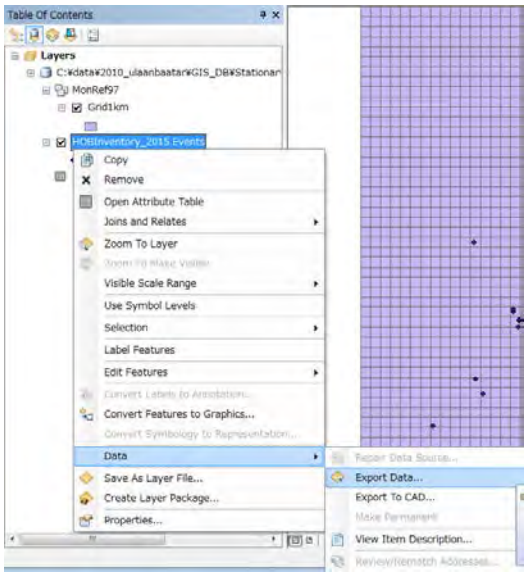


Geodetic datum in ArcMap is changed to [Monref97]. [Grid1km] is shown as the true square in ArcMap.

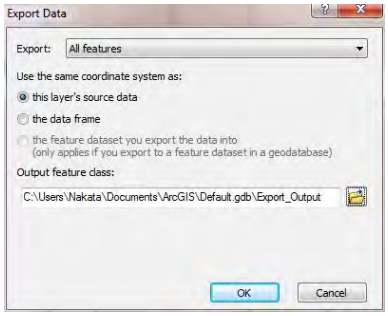


Right-click the coordinated layer and click [Data]-[Export Data].

(Here this layer is “HOB_Inventory_2015 Events” layer.)

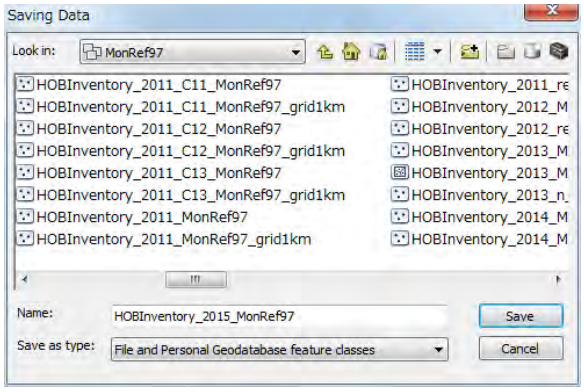



Select [Browse].

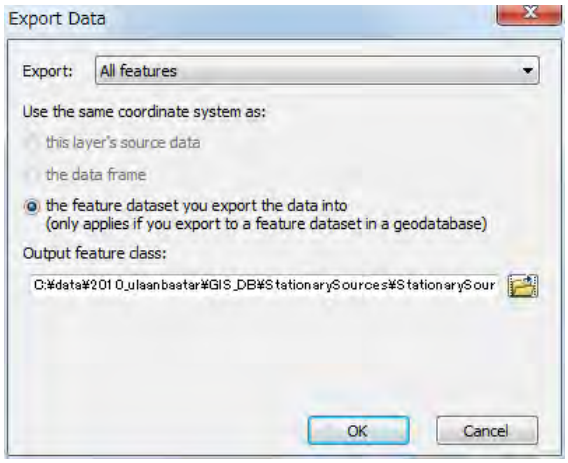



Select [StationarySources.mdb]-[MonRef97] dataset and input the featureclass name to export.

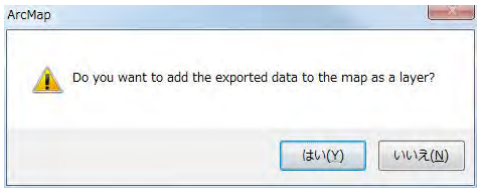
(Here featureclass name is “HOB_Inventory_2015_MonRef97”)



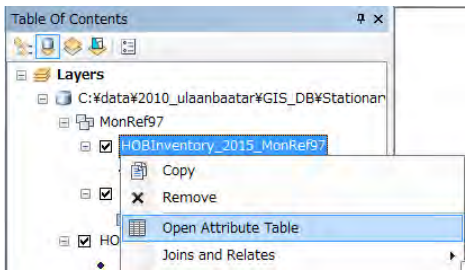

Select [the feature dataset you export the data into] and click [OK]. The feasureclass of power plant is made setting [Monref97] coordinate system



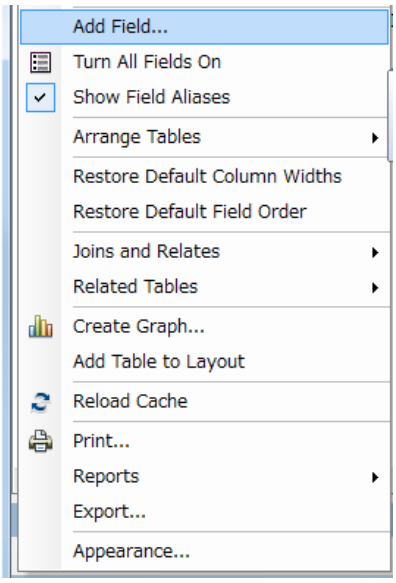

Since this message box requests if the created featureclass is shown in the map or not, click [Yes].



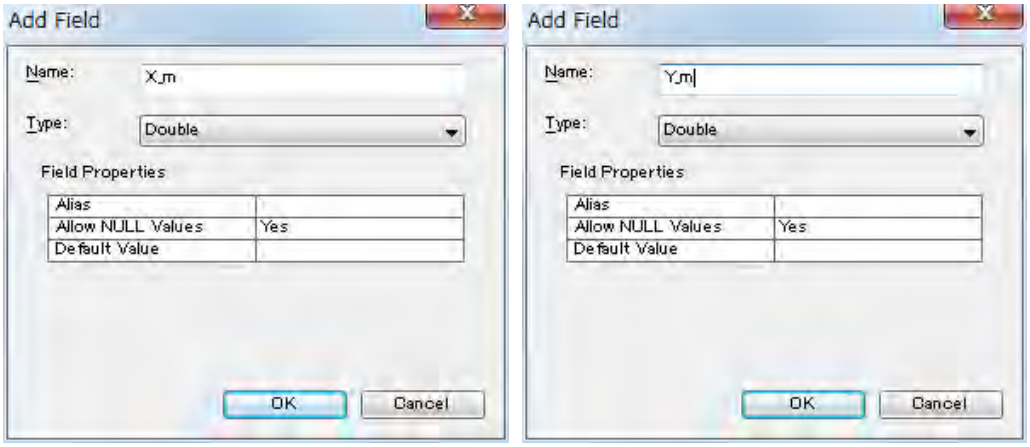

Right-click the created feasureclass and click [Open Attribute Table].



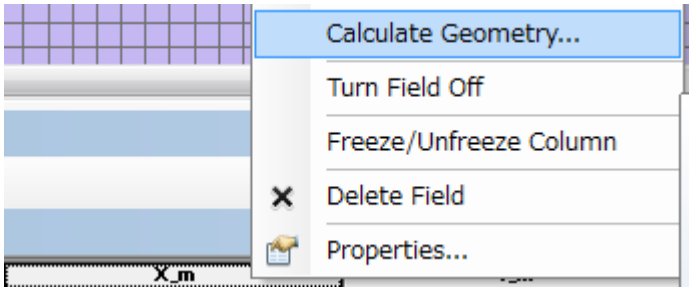
Click  and select [Add Field...].



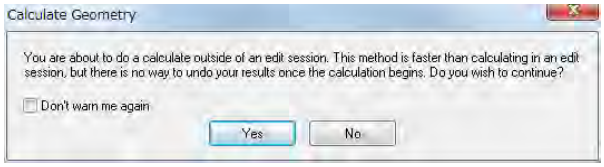

Input “X_m” in [Name] and select [Double] in [Type]. The Y coordinate (Y_m) is also set similarly.



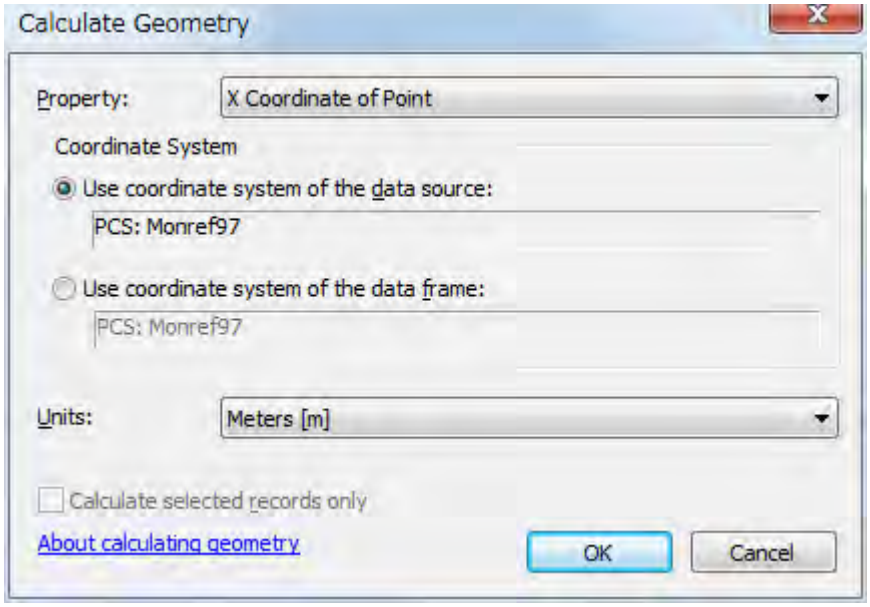

Right-click on the title of [X_m] column in [Attribute Table] and select [Calculate Geometry].



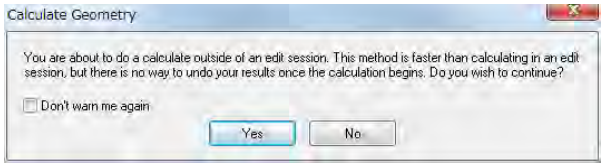

This message means that there is no way to undo your results once the automatic calculation begins. Click [Yes].



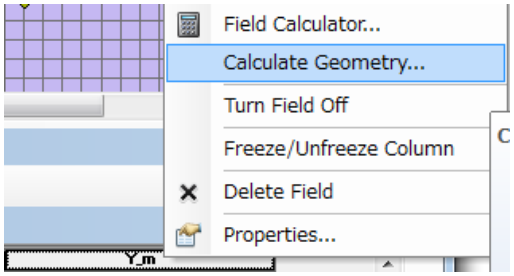

After selecting [X Coordinate of Point] at [Property], [Use coordinate system of the data source] at [Coordinate System], and [Meters [m]] at [Units], click [OK]. X Coordinate of Point in Monref97 coordinate system is calculated to [X_m] column of each row.



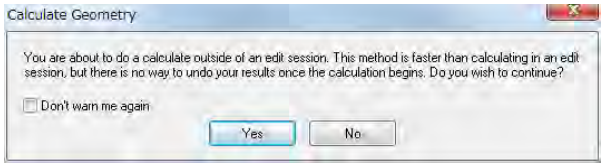

This message means that there is no way to undo your results once the automatic calculation begins. Click [Yes].



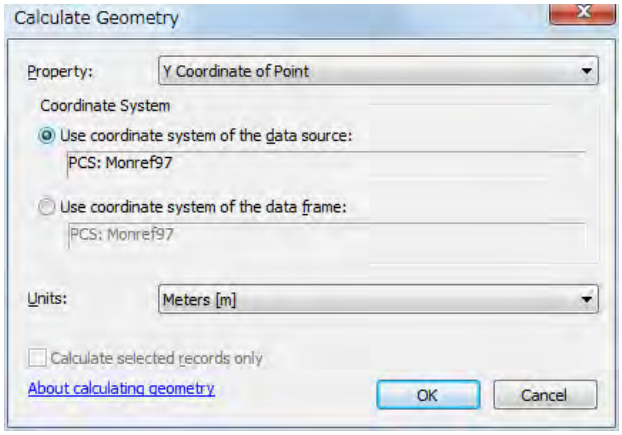

Right-click on the title of [Y_m] column in [Attribute Table] and select [Calculate Geometry].



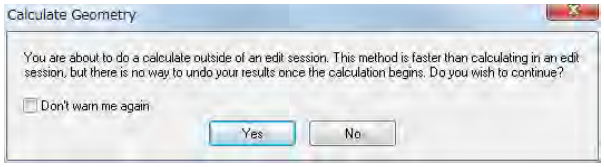

This message means that there is no way to undo your results once the automatic calculation begins. Click [Yes].



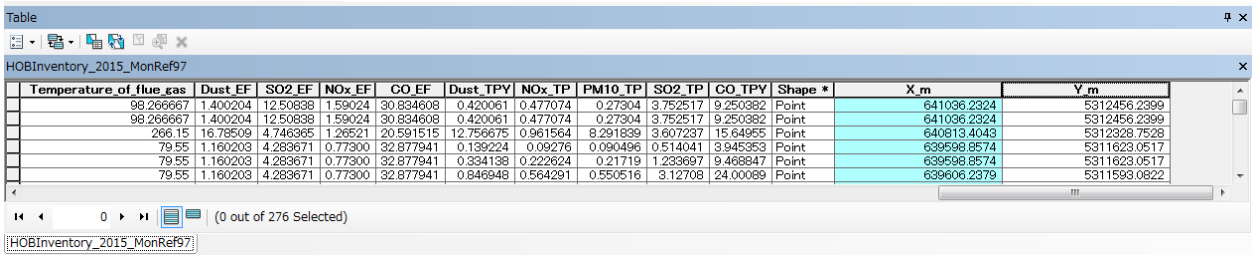

After selecting [Y Coordinate of Point] at [Property], [Use coordinate system of the data source] at [Coordinate System], and [Meters [m]] at [Units], click [OK]. Y Coordinate of Point in Monref97 coordinate system is calculated to [Y_m] column of each row.




This message means that there is no way to undo your results once the automatic calculation begins. Click [Yes].

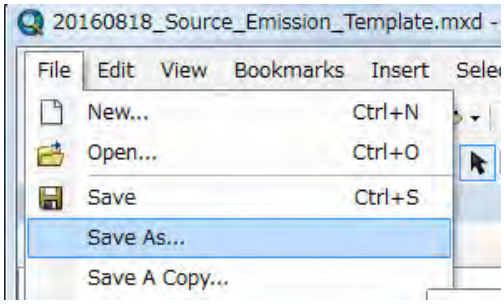



The value of X and Y coordinate in in Monref97 coordinate system is inputted in emission inventory of HOB.

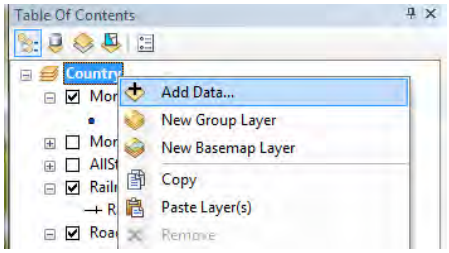



## 3.4 Drawing Emission Distribution Map

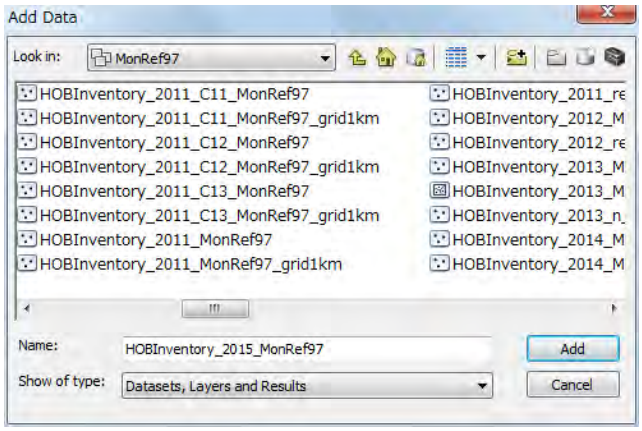
Open template file, click [File]-[Save As], and saved as other name.



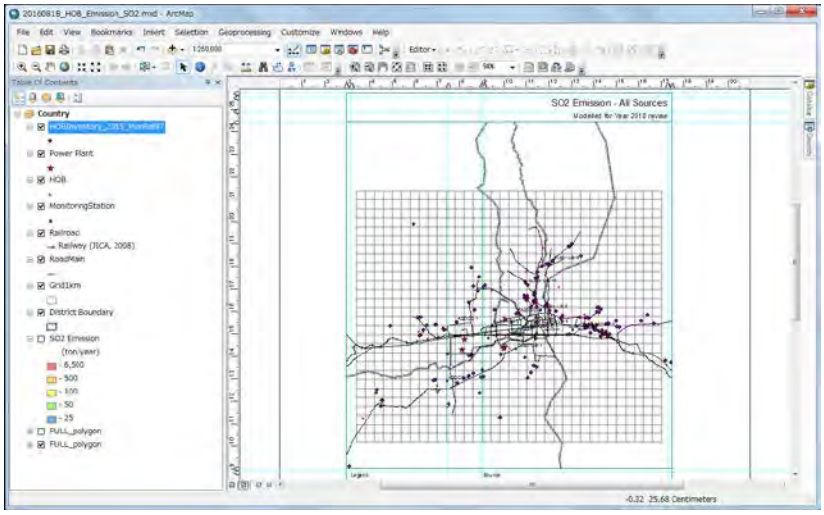

Right-click [Country] and click [Add Data].



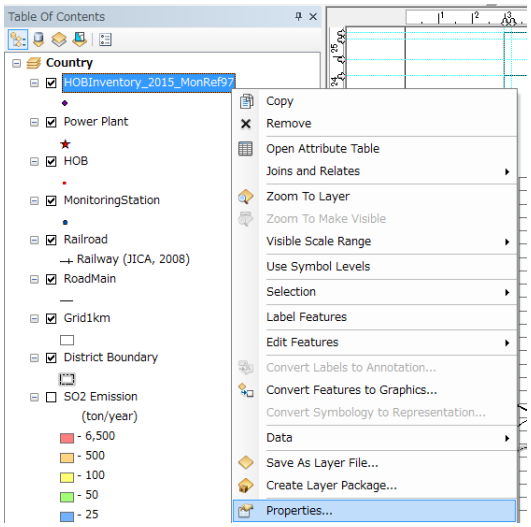

Select the point featureclass of power plant to add the map.(Here it is “HOBInventory_2015_MonRef97”.)



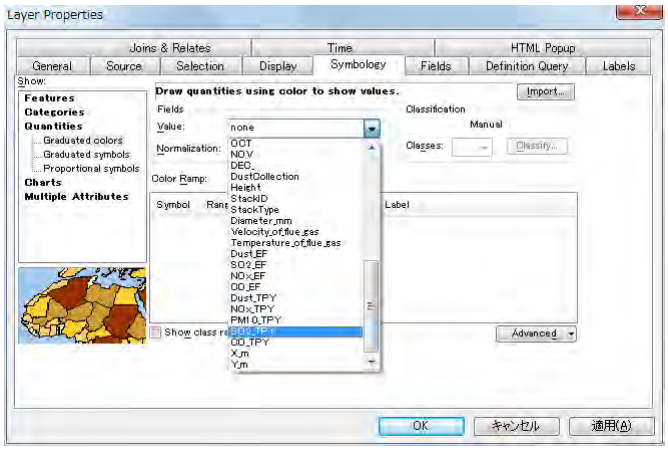

The location of HOB is shown in ArcMap.



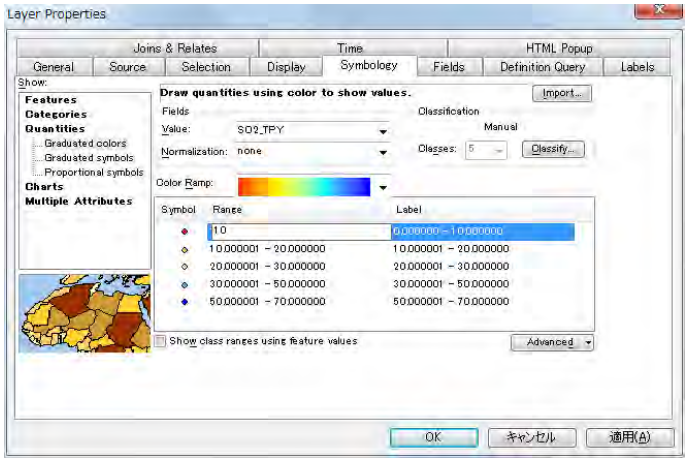
Paint the color of symbol according to emission. Right-click the created point feature class and click [Properties].



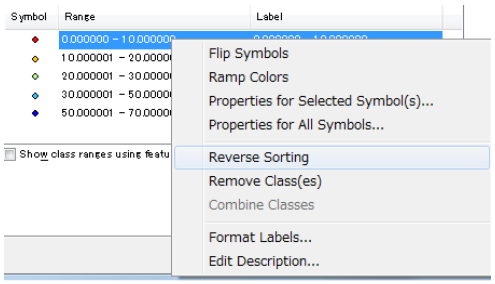

Click [Symbology] tab and select [Quantities]-[Graduated colors]. Click and select the target column name at the drop down button of [Value] (Here it is [SO2_TPY].).



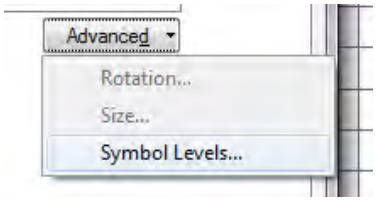

After selecting a rank, click the [Range] of the selected rank and input the maximum of the rank.



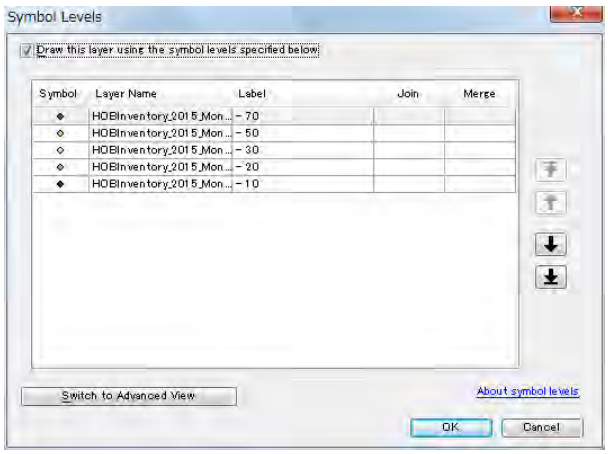

When click [Reverse Sorting] after you right-click on the [Range] column, the display order of rank changes. According to the order of symbol color, decide the display order of rank.



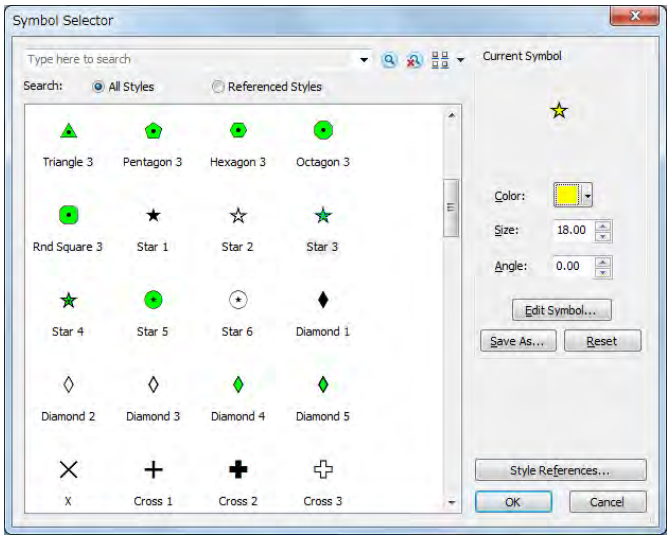

To set the order to show point in the map, click [Advanced]-[Symbol Levels].



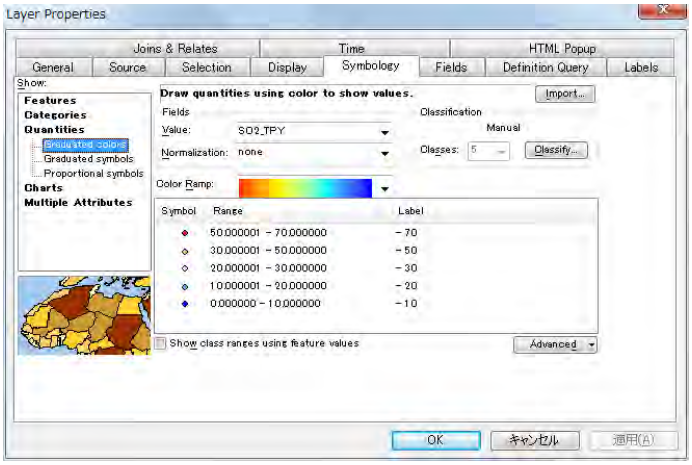

Select [Draw this layer using the symbol levels specified below] checkbox, arrange the order of point featureclass, and click [OK]. The more upper symbol shows forward in this map.



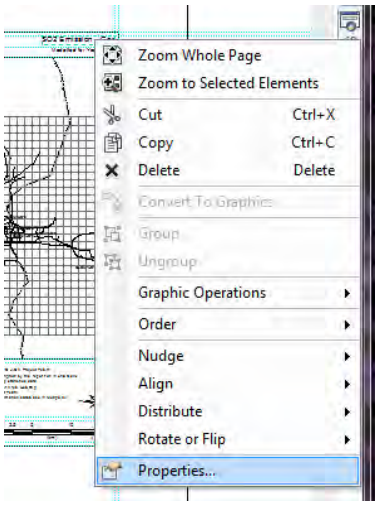
Double-clicking a symbol, you can set the form and color of symbol.



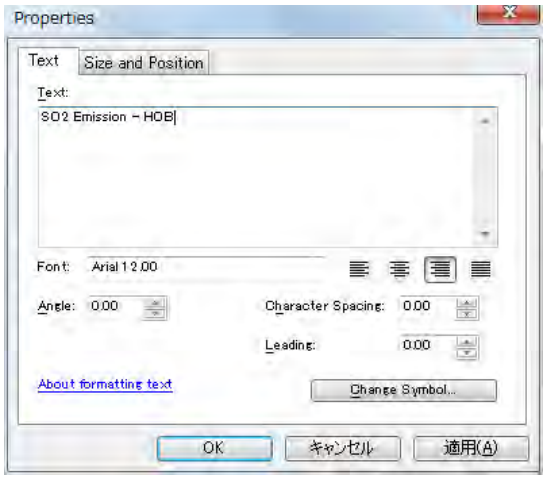

When all setting completed, click [OK].



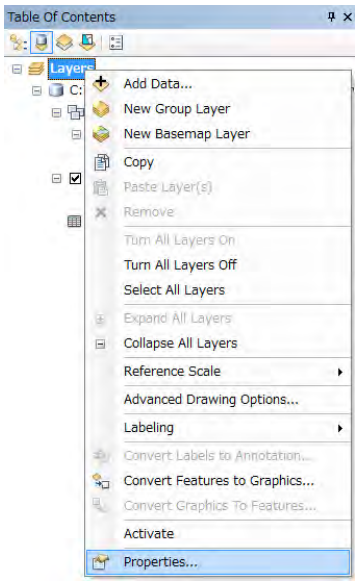

Change the title of this map. Move the cursor to the textbox of title, right-click it, and click [Properties].



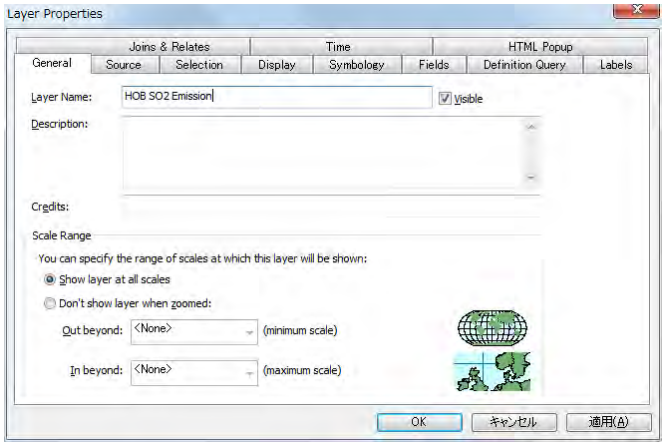
Input a title in [Text] (Here it is “SO2 Emission – HOB”.).



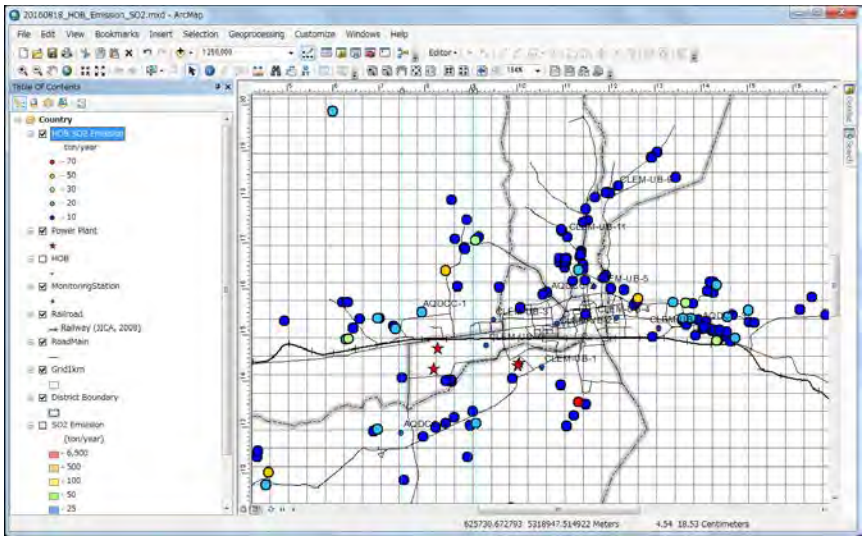

Right-click the added layer and click [Properties].



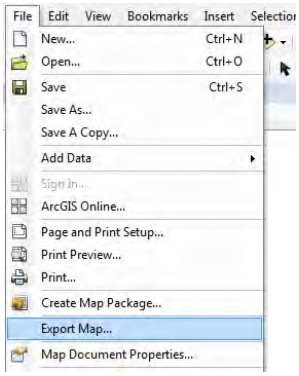

Input a meaningful name to [Layer Name] (Here it is “HOB SO2 Emission”).



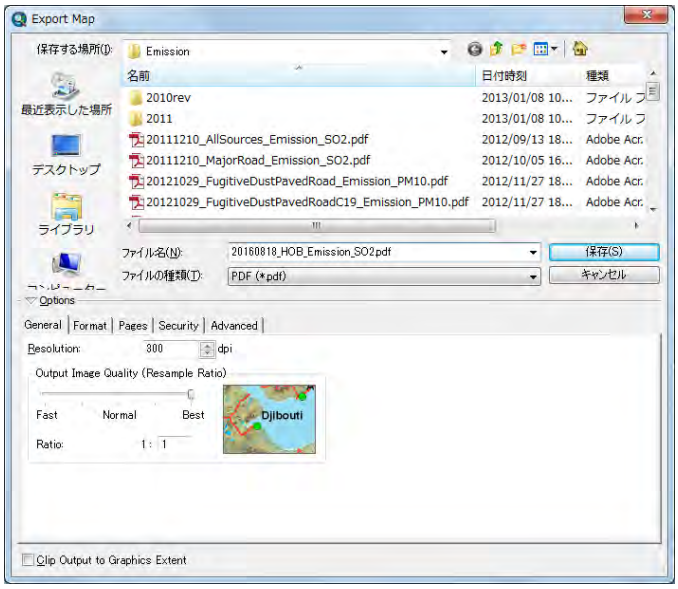
The location of HOB colored by emission rank is shown in the map.



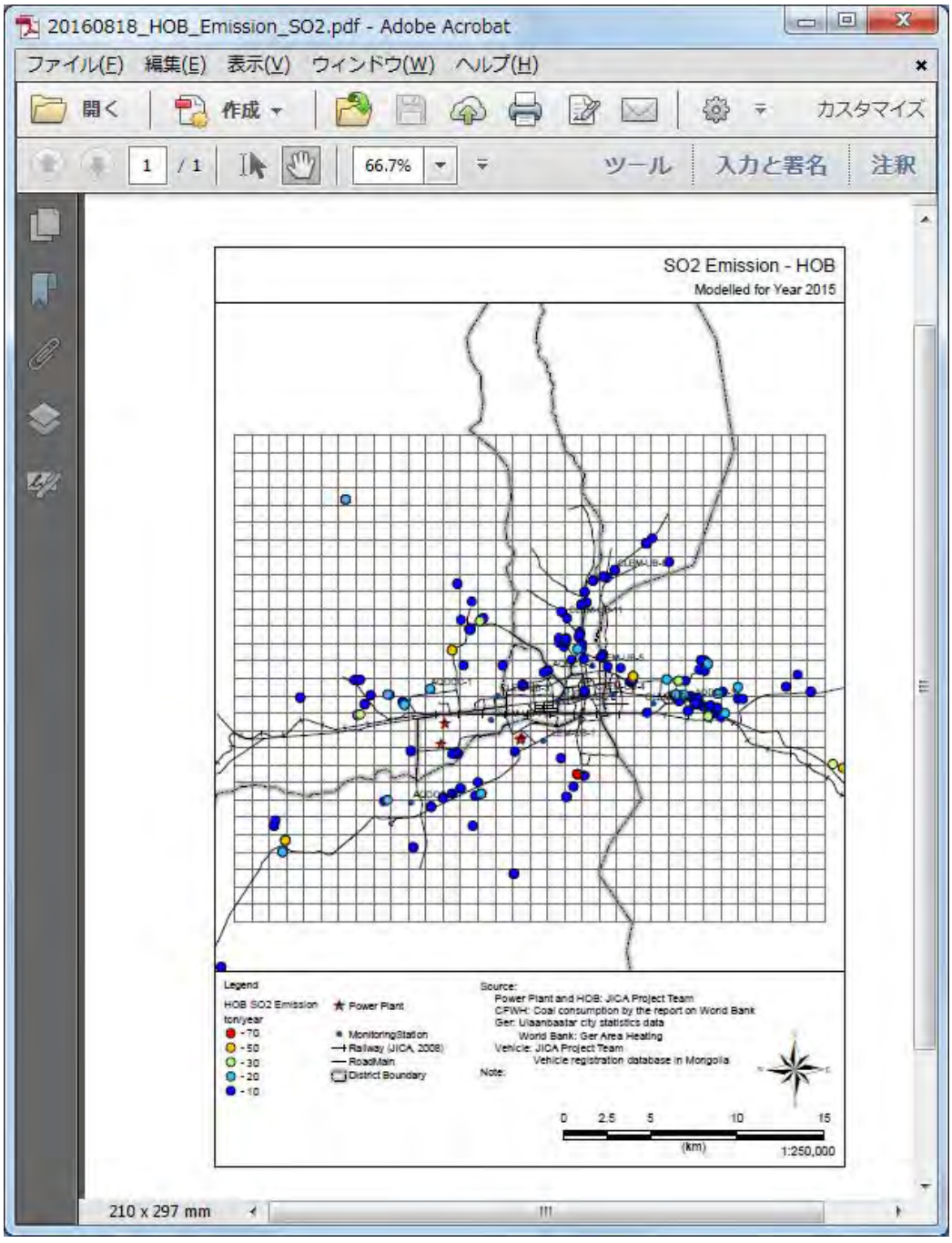
To export the distribution map to PDF file, click [File]-[Export Map].




Setting the destination and file name and click [Save].



Create the PDF file of distribution map.



# 4 CFWH

## 4.1 Developing and Updating Method for Emission inventory

CFWH (Coal Fired Water Heater) means the hot-water boiler whose rating capacity is less than 100kW and is used for kiosk and small-sized hotel etc. Calculation flow diagram of the emission from CFWH is shown in Figure 4-1. Emission is calculated by using the following formula. Regarding temporal change, hourly operating pattern by season is calculated by using the seasonal input number of fuel by time zone in "Mongolia Heating in Poor, Peri-urban Ger Areas of Ulaanbaatar"(2009) written by the World bank. When you want to grasp the more detailed operating condition, the measurement survey on the fuel consumption needs to be conducted for CFWH.

$$E_i = AD_i \times EF$$

Ei: Emission from CFWH in khoroo i (ton/year)

ADi: Annual fuel consumption of CFWH in khoroo i (ton/year)

EF: Emission factor (kg/ton fuel)

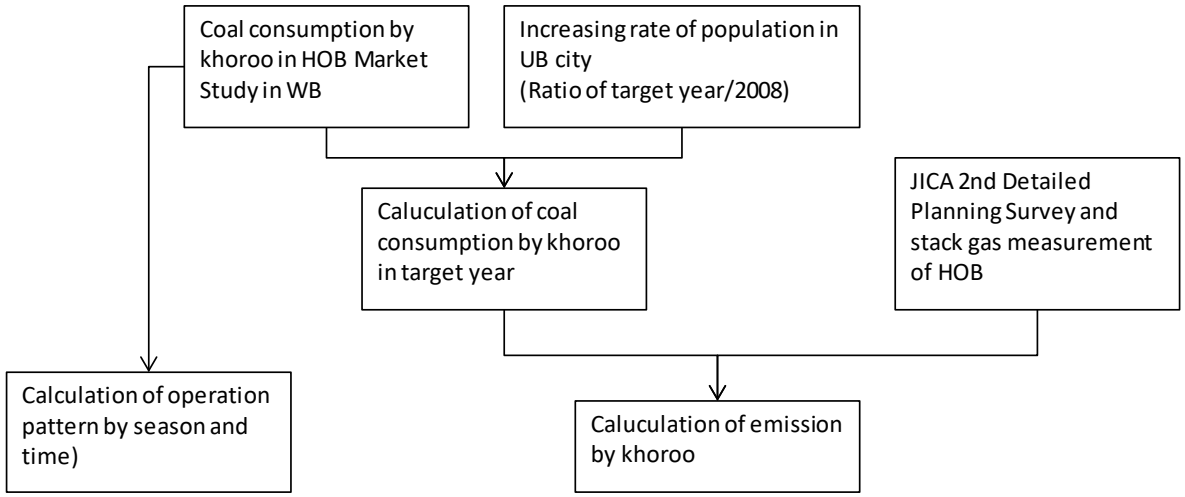



**Figure 4-1 Calculation Flow Diagram of the Emission from CFWH**

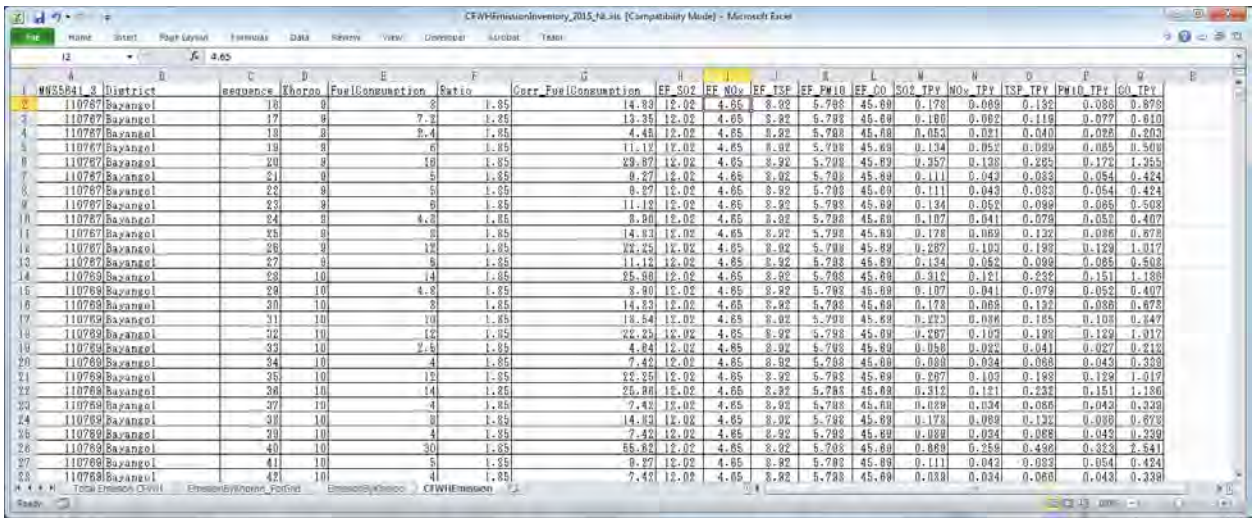
### 4.1.1 Collecting and Organizing of Boiler Registration Information of 100 kW or Less

#### 4.1.1.1 Method of Using the Survey Result by World Bank in 2009

The information on the coal consumption of CFWH in UB city is based on "Market Study of Heat-only Boilers and Coal-fired Water Heaters" (CBDICFP, 2009).

First, coal consumption for 2009 is calculated by summing the coal consumption of this survey by khoroo. Regarding the coal consumption for after 2010, coal consumption by khoroo was estimated by multiplying coal consumption for 2009 by the population increase ratio in 6 districts of UB from 2009 based on the assumption that the economic activity will change in proportion to the population increase and the number of

hot water boilers with rated capacity less than 100 kW will also change. Data of Statistics Department of Ulaanbaatar[6] is used as population statistics.



| WNSSR41_3 | District | sequence | Khoroo | FuelConsumption | Ratio | Corr_FuelConsumption | EF_SO2 | EF_NOx | EF_TSP | EF_PM10 | EF_CO | SO2_TPY | NOx_TPY | TSP_TPY | PM10_TPY | CO_TPY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 110767 | Bayangol | 16 | 8 | 8 | 1.85 | 14.80 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.178 | 0.069 | 0.132 | 0.086 | 0.678 |
| 110767 | Bayangol | 17 | 8 | 7.2 | 1.85 | 13.32 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.160 | 0.062 | 0.119 | 0.077 | 0.610 |
| 110767 | Bayangol | 18 | 8 | 2.4 | 1.85 | 4.44 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.053 | 0.021 | 0.040 | 0.026 | 0.203 |
| 110767 | Bayangol | 19 | 8 | 6 | 1.85 | 11.10 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.134 | 0.052 | 0.099 | 0.065 | 0.508 |
| 110767 | Bayangol | 20 | 9 | 16 | 1.85 | 29.60 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.357 | 0.138 | 0.265 | 0.172 | 1.355 |
| 110767 | Bayangol | 21 | 9 | 5 | 1.85 | 9.25 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.111 | 0.043 | 0.083 | 0.054 | 0.424 |
| 110767 | Bayangol | 22 | 9 | 5 | 1.85 | 9.25 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.111 | 0.043 | 0.083 | 0.054 | 0.424 |
| 110767 | Bayangol | 23 | 9 | 6 | 1.85 | 11.10 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.134 | 0.052 | 0.099 | 0.065 | 0.508 |
| 110767 | Bayangol | 24 | 9 | 4.2 | 1.85 | 8.90 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.107 | 0.041 | 0.079 | 0.052 | 0.407 |
| 110767 | Bayangol | 25 | 9 | 8 | 1.85 | 14.80 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.178 | 0.069 | 0.132 | 0.086 | 0.678 |
| 110767 | Bayangol | 26 | 9 | 12 | 1.85 | 22.20 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.267 | 0.103 | 0.198 | 0.129 | 1.017 |
| 110767 | Bayangol | 27 | 9 | 6 | 1.85 | 11.10 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.134 | 0.052 | 0.099 | 0.065 | 0.508 |
| 110769 | Bayangol | 28 | 10 | 14 | 1.85 | 25.90 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.312 | 0.121 | 0.232 | 0.151 | 1.186 |
| 110769 | Bayangol | 29 | 10 | 4.8 | 1.85 | 8.90 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.107 | 0.041 | 0.079 | 0.052 | 0.407 |
| 110769 | Bayangol | 30 | 10 | 8 | 1.85 | 14.80 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.178 | 0.069 | 0.132 | 0.086 | 0.678 |
| 110769 | Bayangol | 31 | 10 | 10 | 1.85 | 18.50 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.223 | 0.086 | 0.165 | 0.108 | 0.847 |
| 110769 | Bayangol | 32 | 10 | 12 | 1.85 | 22.20 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.267 | 0.103 | 0.198 | 0.129 | 1.017 |
| 110769 | Bayangol | 33 | 10 | 2.6 | 1.85 | 4.84 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.058 | 0.022 | 0.043 | 0.028 | 0.220 |
| 110769 | Bayangol | 34 | 10 | 4 | 1.85 | 7.40 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.089 | 0.034 | 0.066 | 0.043 | 0.339 |
| 110768 | Bayangol | 35 | 10 | 12 | 1.85 | 22.20 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.267 | 0.103 | 0.198 | 0.129 | 1.017 |
| 110768 | Bayangol | 36 | 10 | 14 | 1.85 | 25.90 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.312 | 0.121 | 0.232 | 0.151 | 1.186 |
| 110768 | Bayangol | 37 | 10 | 4 | 1.85 | 7.40 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.089 | 0.034 | 0.066 | 0.043 | 0.339 |
| 110769 | Bayangol | 38 | 10 | 8 | 1.85 | 14.80 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.178 | 0.069 | 0.132 | 0.086 | 0.678 |
| 110769 | Bayangol | 39 | 10 | 4 | 1.85 | 7.40 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.089 | 0.034 | 0.066 | 0.043 | 0.339 |
| 110768 | Bayangol | 40 | 10 | 30 | 1.85 | 55.50 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.668 | 0.259 | 0.496 | 0.323 | 2.541 |
| 110760 | Bayangol | 41 | 10 | 5 | 1.85 | 9.25 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.111 | 0.043 | 0.083 | 0.054 | 0.424 |
| 110768 | Bayangol | 42 | 10 | 4 | 1.85 | 7.40 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.089 | 0.034 | 0.066 | 0.043 | 0.339 |

### 4.1.1.2 Method of Using Surbey Result Based on the National Source Registration in 2014

The information on coal consumption of CFWH in UB city before 2013 was only the above. Extract data of all hot-water boilers with rated capacity less than 100 kW among databases the Air Pollution Reduction Committee developed using the air quality smart management system in 2014 and calculate coal consumption by khoroo.

The person in charge of NAMEM possesses this data and fuel type, unit and consumption are registered for each boiler.

Regarding the coal consumption after 2015, it is necessary to propose implementing a continuing survey to grasp coal consumption, or discuss whether to consider increasing the coal consumption proportional to the population increase or to maintain the current situation.

### 4.1.2 Collecting Information for Developing Emission Factor

Emission factor is the following table based on the result of flow gas measurement in this project.

| SO2 | NOx | TSP | PM10 | CO |
|---|---|---|---|---|
| 12.02 | 4.65 | 8.92 | 7.689 | 45.69 |

Unit: kg/ton

Note: Based on the measurements in the survey of the JICA second detailed plan formulation in 2009 and the measurement in 2012 and 2014. The coal type used for measurement in 2009 is unknown. Coal used for measurements in 2012 and 2014 are Nalaikh and Baganuur respectively.

These flow gas measurements were carried out in 2012 and 2014, and since the number of measurements is not large, variation is observed for each measurement. For this reason, the emission factor is calculated by adding the standard deviation to the average value, but the accuracy of the emission factor expect to be increased by increasing the measurement results in the future.

[6] http://www.ubstat.mn/

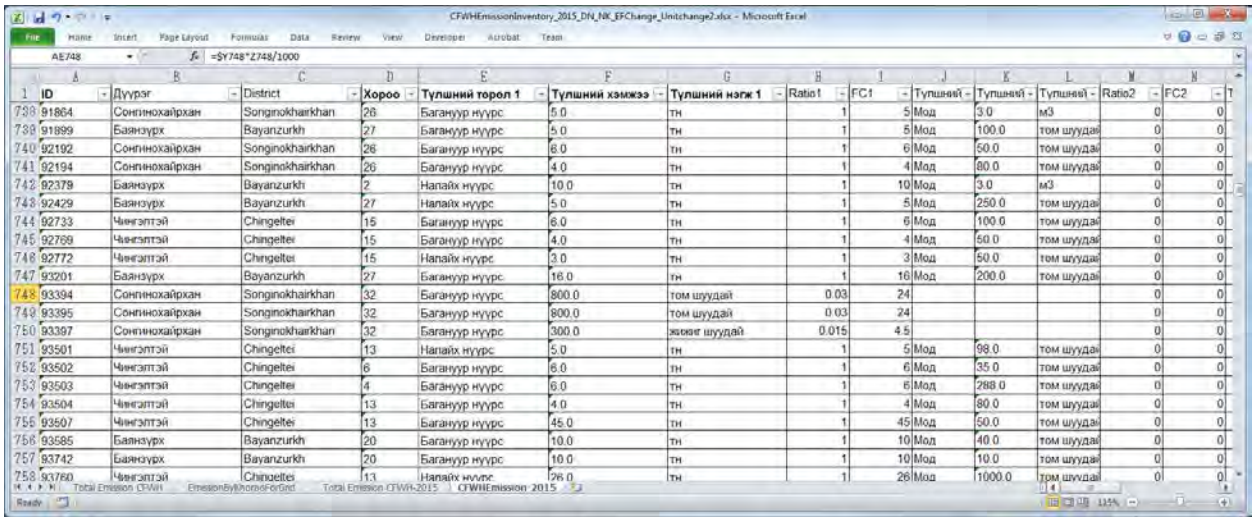
### 4.1.3 Developing and Updating Emission Inventory

Use “CFWHEmissionInventory.xls” for developing and updating emission inventory of CFWH.

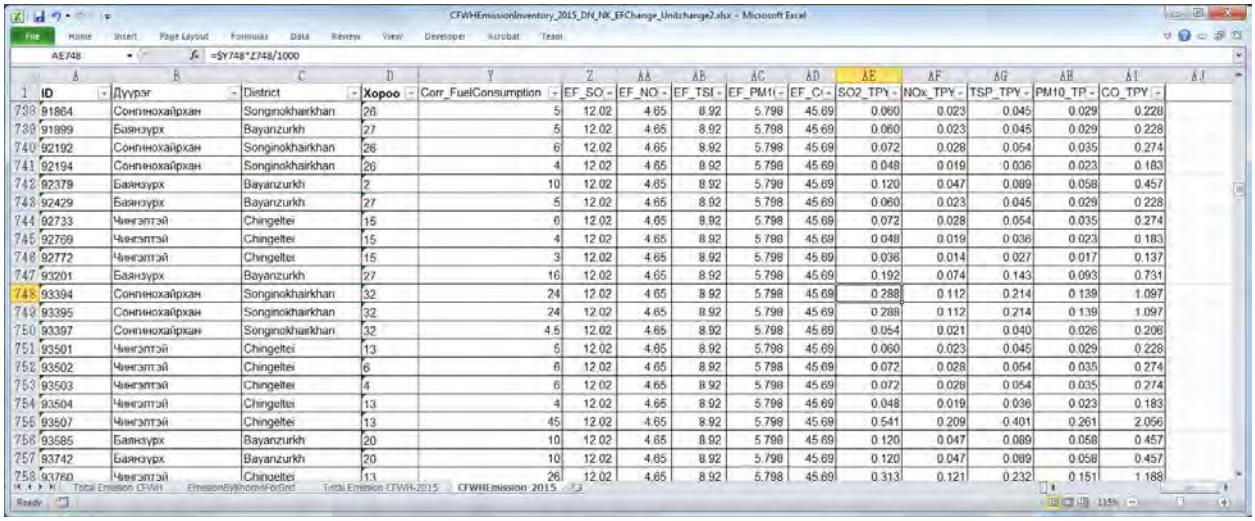
The emission of each CFWH is calculated on the "CFWHEmission" sheet. “Ratio” is set when correcting fuel consumption according to its unit or correcting fuel consumption according to the target year of inventory.

When obtaining the latest emission factor, update [EF_SO2] column etc.

Emission is automatically calculated by using fuel consumption after correction and emission factor.

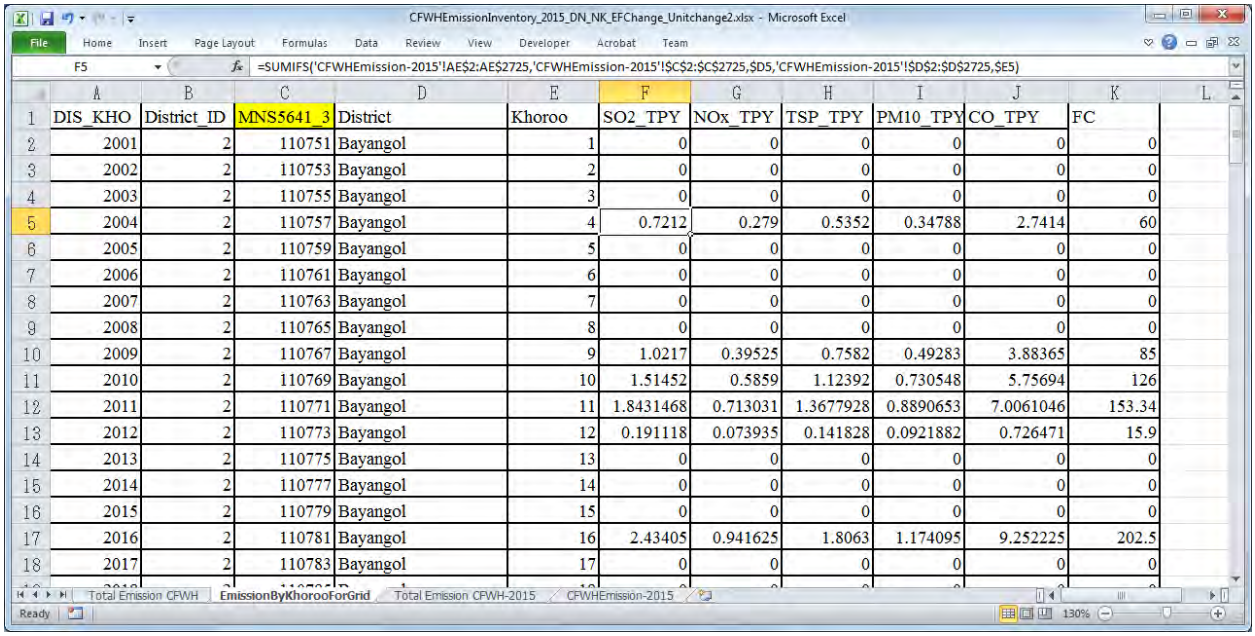


| | ID | Дүүрэг | District | Хороо | Түлшний төрөл 1 | Түлшний хэмжээ | Түлшний нэгж 1 | Ratio1 | FC1 | Түлшний | Түлшний | Түлшний | Ratio2 | FC2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 738 | 91864 | Сонгинохайрхан | Songinokhairkhan | 26 | Багануур нүүрс | 5.0 | тн | 1 | 5 | Мод | 3.0 | м3 | 0 | 0 |
| 739 | 91899 | Баянзүрх | Bayanzurkh | 27 | Багануур нүүрс | 5.0 | тн | 1 | 5 | Мод | 100.0 | том шуудай | 0 | 0 |
| 740 | 92192 | Сонгинохайрхан | Songinokhairkhan | 26 | Багануур нүүрс | 6.0 | тн | 1 | 6 | Мод | 50.0 | том шуудай | 0 | 0 |
| 741 | 92194 | Сонгинохайрхан | Songinokhairkhan | 26 | Багануур нүүрс | 4.0 | тн | 1 | 4 | Мод | 80.0 | том шуудай | 0 | 0 |
| 742 | 92378 | Баянзүрх | Bayanzurkh | 2 | Напайх нүүрс | 10.0 | тн | 1 | 10 | Мод | 3.0 | м3 | 0 | 0 |
| 743 | 92429 | Баянзүрх | Bayanzurkh | 27 | Напайх нүүрс | 5.0 | тн | 1 | 5 | Мод | 250.0 | том шуудай | 0 | 0 |
| 744 | 92733 | Чингэлтэй | Chingeltei | 15 | Багануур нүүрс | 6.0 | тн | 1 | 6 | Мод | 100.0 | том шуудай | 0 | 0 |
| 745 | 92769 | Чингэлтэй | Chingeltei | 15 | Багануур нүүрс | 4.0 | тн | 1 | 4 | Мод | 50.0 | том шуудай | 0 | 0 |
| 746 | 92772 | Чингэлтэй | Chingeltei | 15 | Напайх нүүрс | 3.0 | тн | 1 | 3 | Мод | 50.0 | том шуудай | 0 | 0 |
| 747 | 93201 | Баянзүрх | Bayanzurkh | 27 | Багануур нүүрс | 16.0 | тн | 1 | 16 | Мод | 200.0 | том шуудай | 0 | 0 |
| 748 | 93394 | Сонгинохайрхан | Songinokhairkhan | 32 | Багануур нүүрс | 800.0 | том шуудай | 0.03 | 24 | | | | 0 | 0 |
| 749 | 93395 | Сонгинохайрхан | Songinokhairkhan | 32 | Багануур нүүрс | 800.0 | том шуудай | 0.03 | 24 | | | | 0 | 0 |
| 750 | 93397 | Сонгинохайрхан | Songinokhairkhan | 32 | Багануур нүүрс | 300.0 | жижиг шуудай | 0.015 | 4.5 | | | | 0 | 0 |
| 751 | 93501 | Чингэлтэй | Chingeltei | 13 | Напайх нүүрс | 5.0 | тн | 1 | 5 | Мод | 98.0 | том шуудай | 0 | 0 |
| 752 | 93502 | Чингэлтэй | Chingeltei | 6 | Багануур нүүрс | 6.0 | тн | 1 | 6 | Мод | 35.0 | том шуудай | 0 | 0 |
| 753 | 93503 | Чингэлтэй | Chingeltei | 4 | Багануур нүүрс | 6.0 | тн | 1 | 6 | Мод | 288.0 | том шуудай | 0 | 0 |
| 754 | 93504 | Чингэлтэй | Chingeltei | 13 | Багануур нүүрс | 4.0 | тн | 1 | 4 | Мод | 80.0 | том шуудай | 0 | 0 |
| 755 | 93507 | Чингэлтэй | Chingeltei | 13 | Багануур нүүрс | 45.0 | тн | 1 | 45 | Мод | 50.0 | том шуудай | 0 | 0 |
| 756 | 93585 | Баянзүрх | Bayanzurkh | 20 | Багануур нүүрс | 10.0 | тн | 1 | 10 | Мод | 40.0 | том шуудай | 0 | 0 |
| 757 | 93742 | Баянзүрх | Bayanzurkh | 20 | Багануур нүүрс | 10.0 | тн | 1 | 10 | Мод | 10.0 | том шуудай | 0 | 0 |
| 758 | 93760 | Чингэлтэй | Chingeltei | 13 | Напайх нүүрс | 26.0 | тн | 1 | 26 | Мод | 1000.0 | том шуудай | 0 | 0 |



| | ID | Дүүрэг | District | Хороо | Corr_FuelConsumption | EF_SO | EF_NO | EF_TSI | EF_PM1( | EF_C( | SO2_TPY | NOx_TPY | TSP_TPY | PM10_TP | CO_TPY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 738 | 91864 | Сонгинохайрхан | Songinokhairkhan | 26 | 5 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.060 | 0.023 | 0.045 | 0.029 | 0.228 |
| 739 | 91899 | Баянзүрх | Bayanzurkh | 27 | 5 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.060 | 0.023 | 0.045 | 0.029 | 0.228 |
| 740 | 92192 | Сонгинохайрхан | Songinokhairkhan | 26 | 6 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.072 | 0.028 | 0.054 | 0.035 | 0.274 |
| 741 | 92194 | Сонгинохайрхан | Songinokhairkhan | 26 | 4 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.048 | 0.019 | 0.036 | 0.023 | 0.183 |
| 742 | 92378 | Баянзүрх | Bayanzurkh | 2 | 10 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.120 | 0.047 | 0.089 | 0.058 | 0.457 |
| 743 | 92429 | Баянзүрх | Bayanzurkh | 27 | 5 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.060 | 0.023 | 0.045 | 0.029 | 0.228 |
| 744 | 92733 | Чингэлтэй | Chingeltei | 15 | 6 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.072 | 0.028 | 0.054 | 0.035 | 0.274 |
| 745 | 92769 | Чингэлтэй | Chingeltei | 15 | 4 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.048 | 0.019 | 0.036 | 0.023 | 0.183 |
| 746 | 92772 | Чингэлтэй | Chingeltei | 15 | 3 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.036 | 0.014 | 0.027 | 0.017 | 0.137 |
| 747 | 93201 | Баянзүрх | Bayanzurkh | 27 | 16 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.192 | 0.074 | 0.143 | 0.093 | 0.731 |
| 748 | 93394 | Сонгинохайрхан | Songinokhairkhan | 32 | 24 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.288 | 0.112 | 0.214 | 0.139 | 1.097 |
| 749 | 93395 | Сонгинохайрхан | Songinokhairkhan | 32 | 24 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.288 | 0.112 | 0.214 | 0.139 | 1.097 |
| 750 | 93397 | Сонгинохайрхан | Songinokhairkhan | 32 | 4.5 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.054 | 0.021 | 0.040 | 0.026 | 0.206 |
| 751 | 93501 | Чингэлтэй | Chingeltei | 13 | 5 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.060 | 0.023 | 0.045 | 0.029 | 0.228 |
| 752 | 93502 | Чингэлтэй | Chingeltei | 6 | 6 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.072 | 0.028 | 0.054 | 0.035 | 0.274 |
| 753 | 93503 | Чингэлтэй | Chingeltei | 4 | 6 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.072 | 0.028 | 0.054 | 0.035 | 0.274 |
| 754 | 93504 | Чингэлтэй | Chingeltei | 13 | 4 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.048 | 0.019 | 0.036 | 0.023 | 0.183 |
| 755 | 93507 | Чингэлтэй | Chingeltei | 13 | 45 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.541 | 0.209 | 0.401 | 0.261 | 2.056 |
| 756 | 93585 | Баянзүрх | Bayanzurkh | 20 | 10 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.120 | 0.047 | 0.089 | 0.058 | 0.457 |
| 757 | 93742 | Баянзүрх | Bayanzurkh | 20 | 10 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.120 | 0.047 | 0.089 | 0.058 | 0.457 |
| 758 | 93760 | Чингэлтэй | Chingeltei | 13 | 26 | 12.02 | 4.65 | 8.92 | 5.798 | 45.69 | 0.313 | 0.121 | 0.232 | 0.151 | 1.188 |

Calculate the emission and fuel consumption by khoroo in the [CFWHEmission] sheet on the [EmissionByKhoroo_ForGrid] sheet.



CFWHEmissionInventory_2015_DN_NK_EFChange_Unitchange2.xlsx - Microsoft Excel

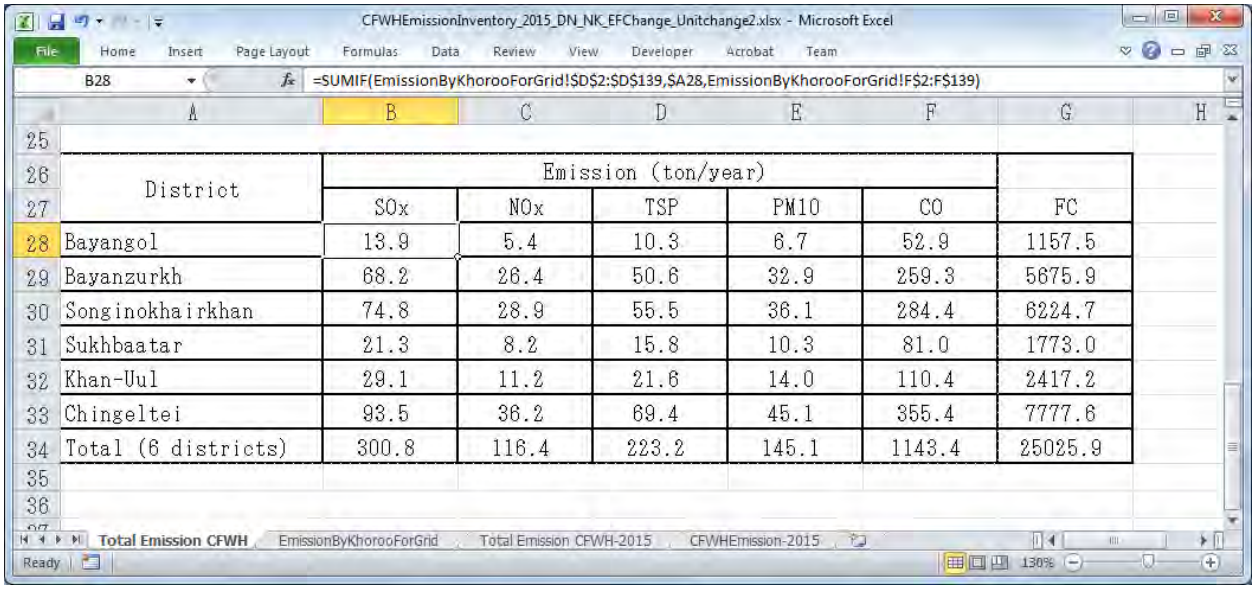
=SUMIFS('CFWHEmission-2015'!AE$2:AE$2725,'CFWHEmission-2015'!$C$2:$C$2725,$D5,'CFWHEmission-2015'!$D$2:$D$2725,$E5)

| | A | B | C | D | E | F | G | H | I | J | K |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DIS_KHO | District_ID | MNS5641_3 | District | Khoroo | SO2_TPY | NOx_TPY | TSP_TPY | PM10_TPY | CO_TPY | FC |
| 2 | 2001 | 2 | 110751 | Bayangol | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 2002 | 2 | 110753 | Bayangol | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 2003 | 2 | 110755 | Bayangol | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 2004 | 2 | 110757 | Bayangol | 4 | 0.7212 | 0.279 | 0.5352 | 0.34788 | 2.7414 | 60 |
| 6 | 2005 | 2 | 110759 | Bayangol | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 2006 | 2 | 110761 | Bayangol | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 2007 | 2 | 110763 | Bayangol | 7 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 2008 | 2 | 110765 | Bayangol | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 2009 | 2 | 110767 | Bayangol | 9 | 1.0217 | 0.39525 | 0.7582 | 0.49283 | 3.88365 | 85 |
| 11 | 2010 | 2 | 110769 | Bayangol | 10 | 1.51452 | 0.5859 | 1.12392 | 0.730548 | 5.75694 | 126 |
| 12 | 2011 | 2 | 110771 | Bayangol | 11 | 1.8431468 | 0.713031 | 1.3677928 | 0.8890653 | 7.0061046 | 153.34 |
| 13 | 2012 | 2 | 110773 | Bayangol | 12 | 0.191118 | 0.073935 | 0.141828 | 0.0921882 | 0.726471 | 15.9 |
| 14 | 2013 | 2 | 110775 | Bayangol | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 2014 | 2 | 110777 | Bayangol | 14 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 2015 | 2 | 110779 | Bayangol | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17 | 2016 | 2 | 110781 | Bayangol | 16 | 2.43405 | 0.941625 | 1.8063 | 1.174095 | 9.252225 | 202.5 |
| 18 | 2017 | 2 | 110783 | Bayangol | 17 | 0 | 0 | 0 | 0 | 0 | 0 |

Total Emission CFWH | EmissionByKhorooForGrid | Total Emission CFWH-2015 | CFWHEmission-2015

Ready

Calculate the emission and fuel consumption in 6 districts of UB city on [Total_Emission_CFWH] sheet.



CFWHEmissionInventory_2015_DN_NK_EFChange_Unitchange2.xlsx - Microsoft Excel

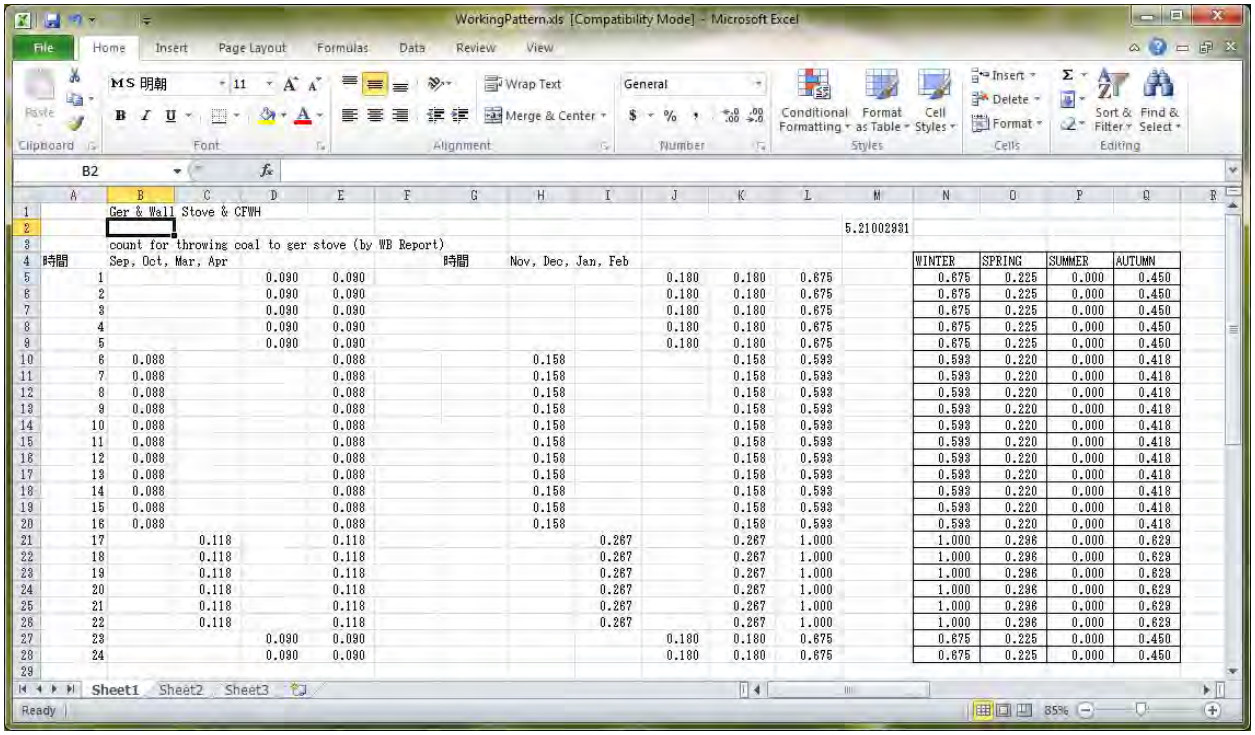
=SUMIF(EmissionByKhorooForGrid!$D$2:$D$139,$A28,EmissionByKhorooForGrid!F$2:F$139)

| | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| 25 | | | | | | | |
| 26 | District | Emission (ton/year) | | | | | |
| 27 | | SOx | NOx | TSP | PM10 | CO | FC |
| 28 | Bayangol | 13.9 | 5.4 | 10.3 | 6.7 | 52.9 | 1157.5 |
| 29 | Bayanzurkh | 68.2 | 26.4 | 50.6 | 32.9 | 259.3 | 5675.9 |
| 30 | Songinokhairkhan | 74.8 | 28.9 | 55.5 | 36.1 | 284.4 | 6224.7 |
| 31 | Sukhbaatar | 21.3 | 8.2 | 15.8 | 10.3 | 81.0 | 1773.0 |
| 32 | Khan-Uul | 29.1 | 11.2 | 21.6 | 14.0 | 110.4 | 2417.2 |
| 33 | Chingeltei | 93.5 | 36.2 | 69.4 | 45.1 | 355.4 | 7777.6 |
| 34 | Total (6 districts) | 300.8 | 116.4 | 223.2 | 145.1 | 1143.4 | 25025.9 |
| 35 | | | | | | | |
| 36 | | | | | | | |

Total Emission CFWH | EmissionByKhorooForGrid | Total Emission CFWH-2015 | CFWHEmission-2015

Ready

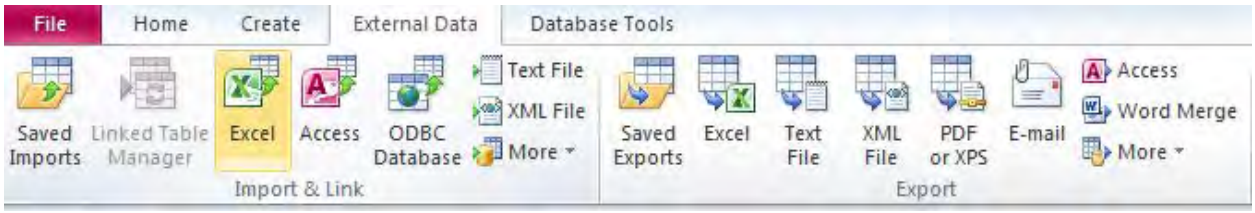
The hourly operating pattern by season of CFWH was calculated based on the number of hourly fuel inputs by season (Table 4.3) of the World Bank's "Mongolia Heating in Poor, Peri-urban Ger Areas of Ulaanbaatar" (2009).



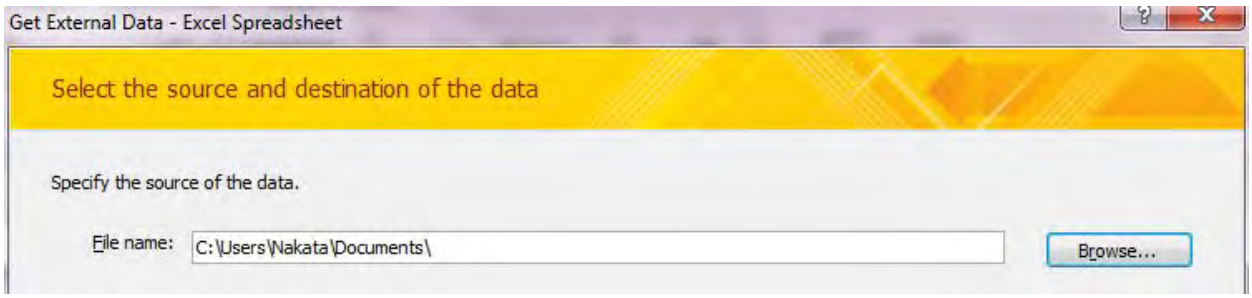

## 4.2 Import Inventory File into Access

Data on stationary source inventory is generated in “StationarySources.mdb”. This explains the method to import the inventory developing in 4.1.3 to “StationarySources.mdb”.

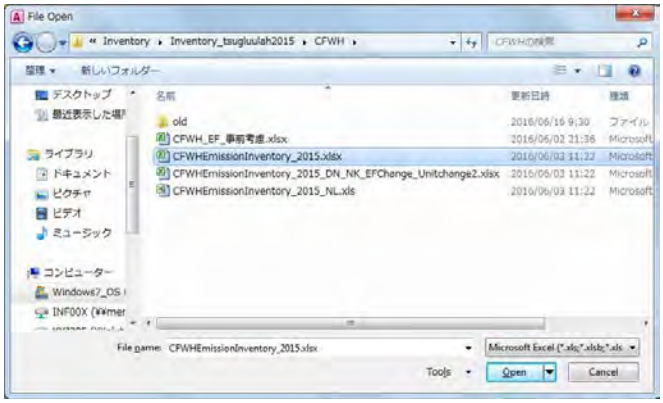
Select [Excel] button of [Import & Link] in [External Data] tab.



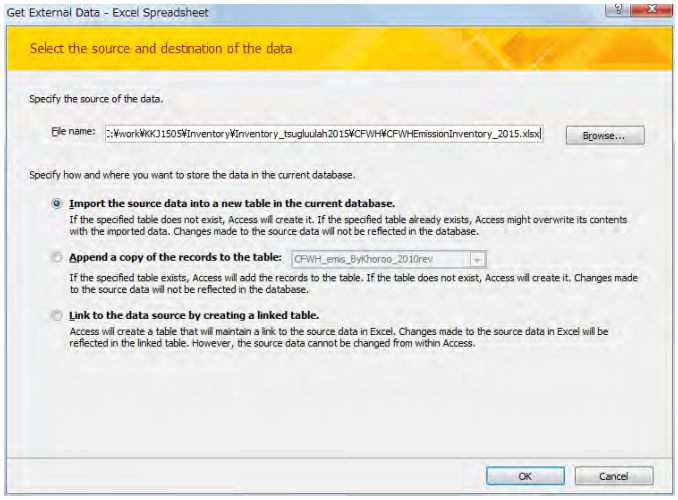

Click [Browse].



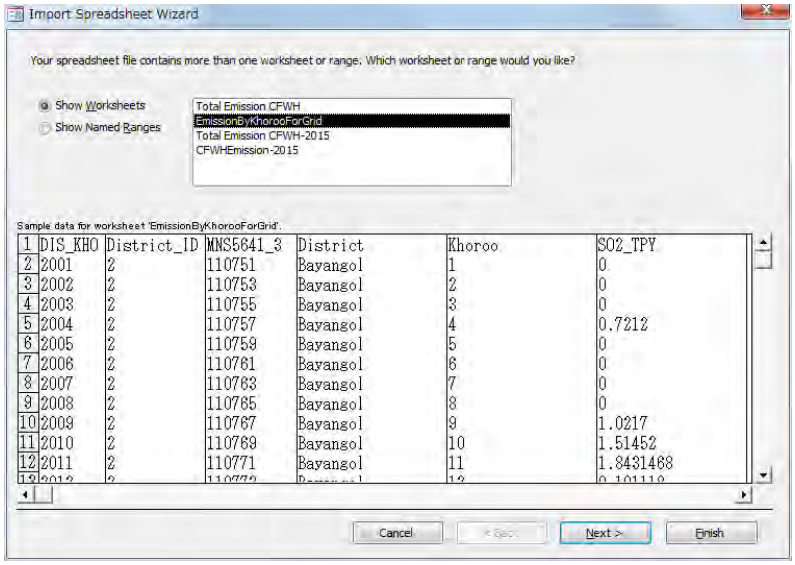

Select the file you want to import (Here it is “CFWHEmissionInventory_2015.xls”).



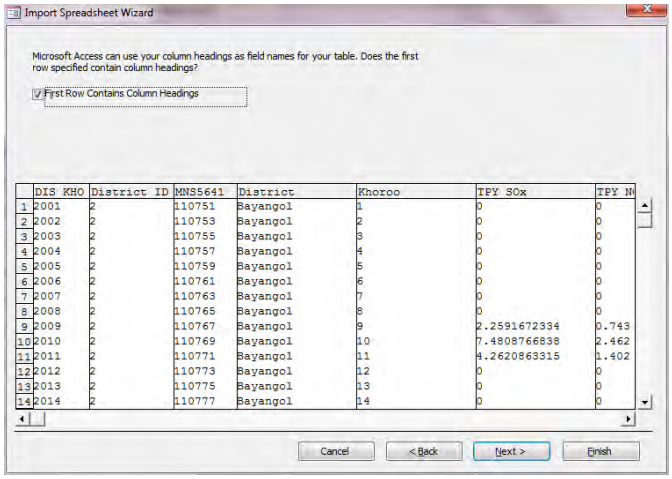

Select [Import the source data into a new table in the current database.] and click [OK].



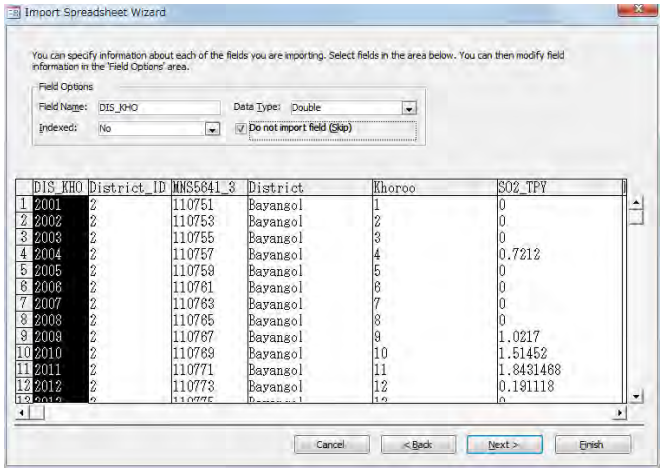

Check [Show Worksheets] is selected, select [EmissionByKhorooForGrid] sheet, and click [Next].



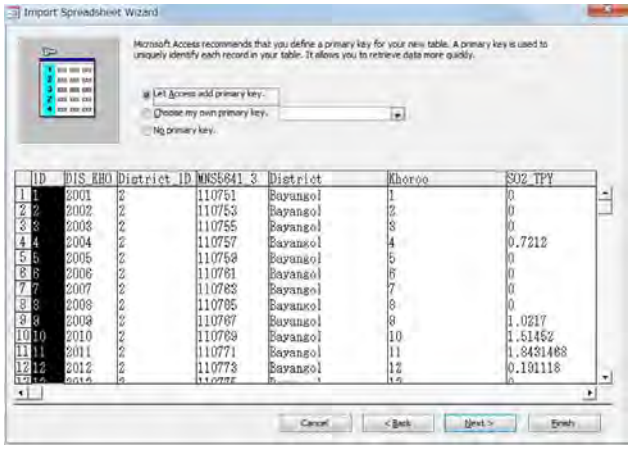

Check [First Row Contains Column Headings] is checked and click [Next].




Set [DIS_KHO] and [District_ID] column checked [Do not import field (Skip)] and click [Next].

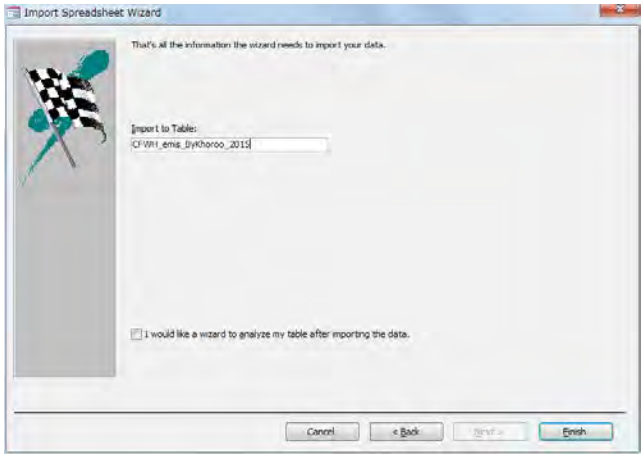



Select [Let Access add primary key.] and Click [Next].

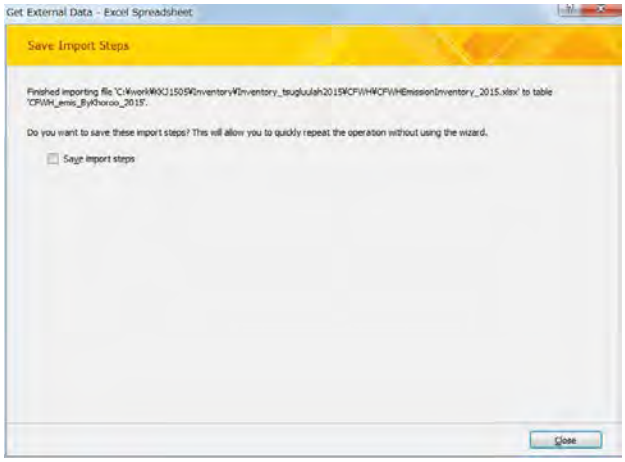



Input the table name in the [Import to Table:] textbox and click [Finish].

(Here it is “CFWH_emis_ByKhoroo_2015”.)




Click [Close].




## 4.3 Spatial Distribution to the Grid of Emission by Khoroo

Since the emission of CFWH was calculated for each khoroo, when using the emission for simulation, the emission was distributed for each grid.

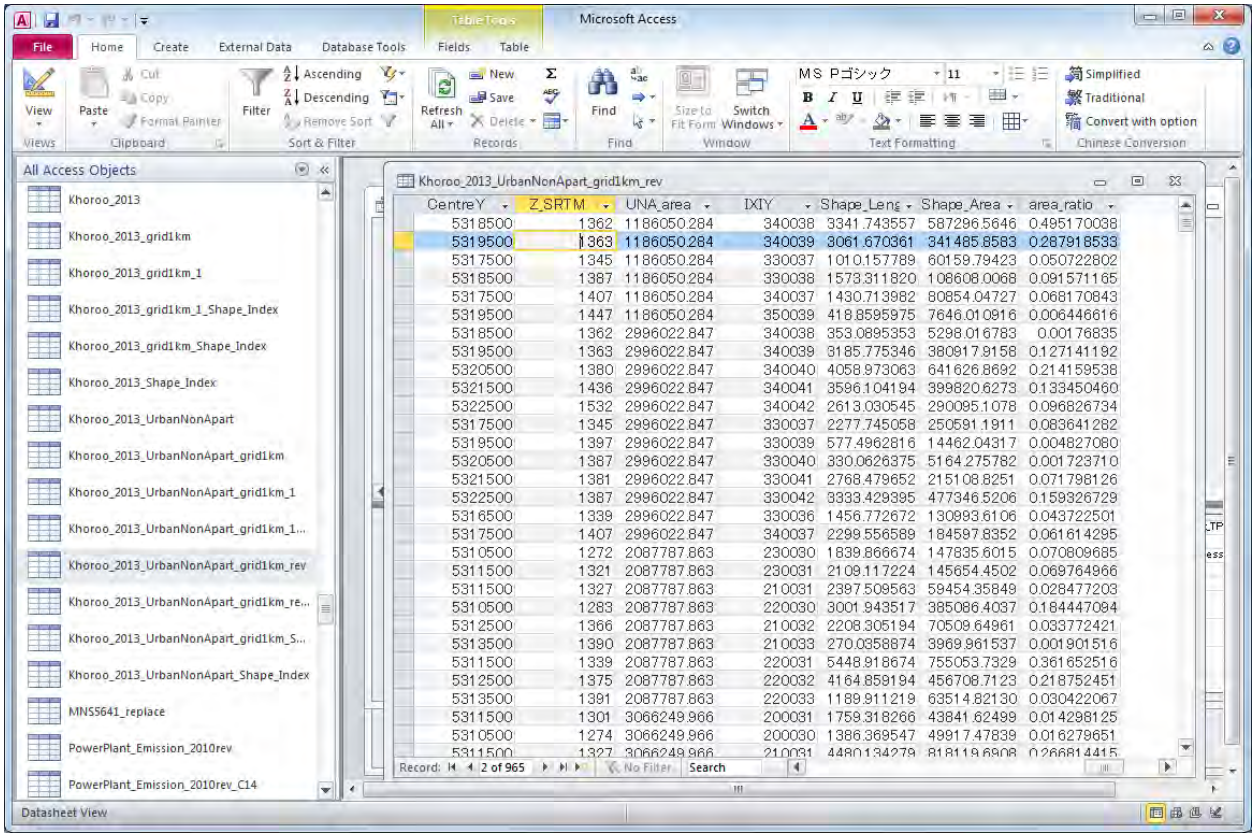
The emission by grid in a khoroo is calculated by the following formula.

Emission by grid in a khoroo

= emissing in a khoroo x the ratio of the non-apartment area of a khoroo in a grid to the total non-apartment area of a khoroo ([area_ratio])

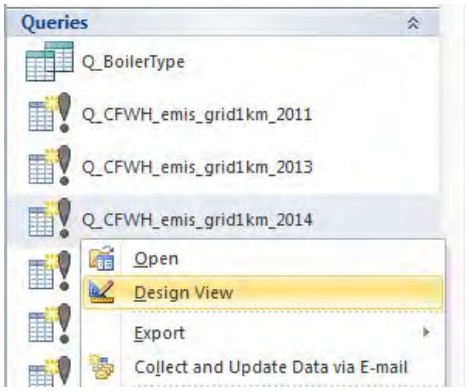
[area_ratio]=[SHAPE_Area] / [UNA_area]

the ratio of the non-apartment area of a khoroo in a grid / the total non-apartment area of a khoroo



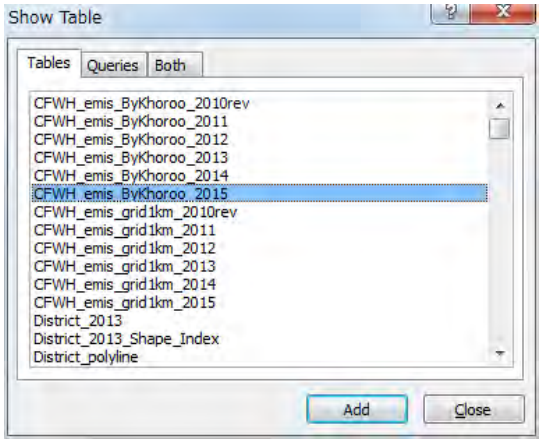

Right-click the query calculated emission by grid for previous year and click [Design View]. Change this query name to the one of target year and save as new file.

Here, open [Q_CFWH_emis_grid1km_2014] query and save the query as [Q_CFWH_emis_grid1km_2015].

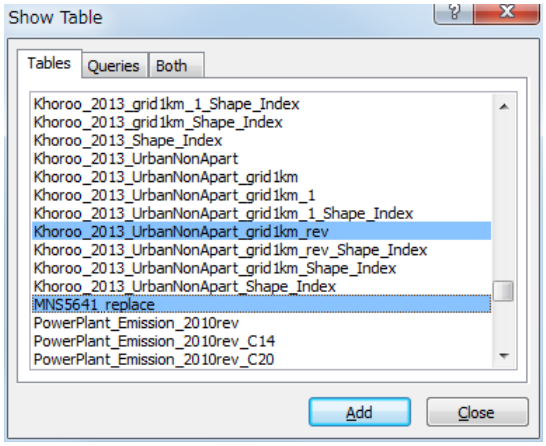



Click [Show Table] in [Design] tab.

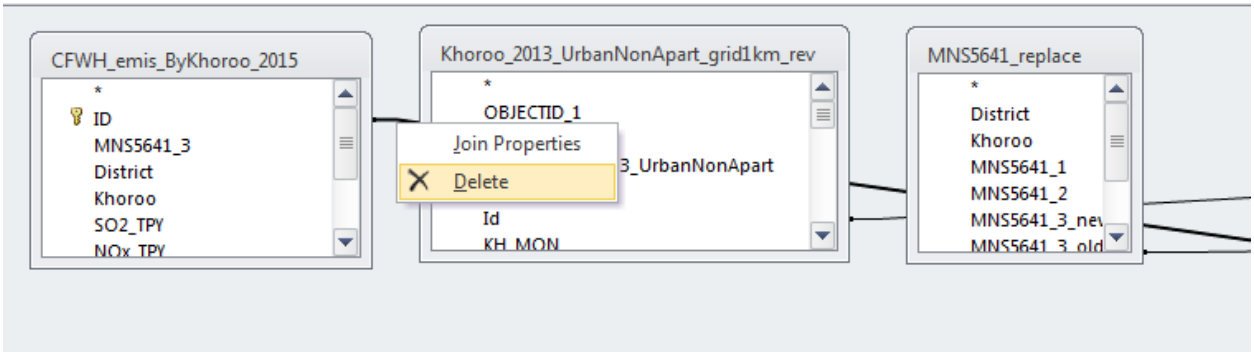
Select “CFWH_emis_ByKhoroo_2015” table and click [Add].



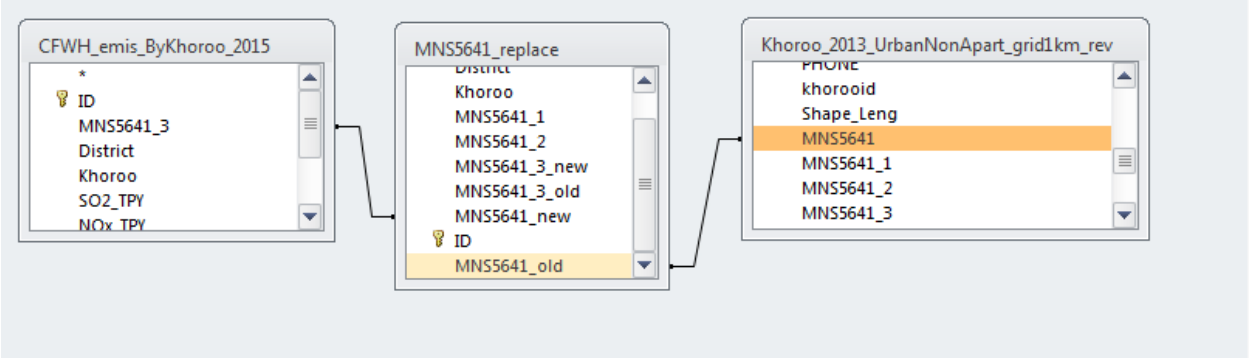

Select “Khoroo_2013_UrbanNonApart_grid1km_rev” table and “MNS5641_replace” table, and click [Add].



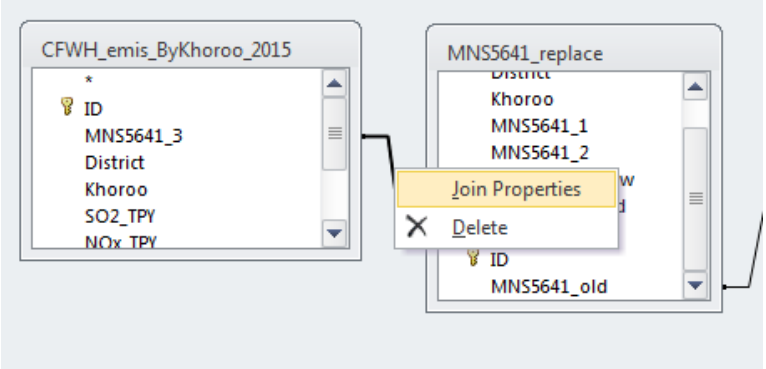

Right-click on the line connected to [ID] columns, and click [Delete].



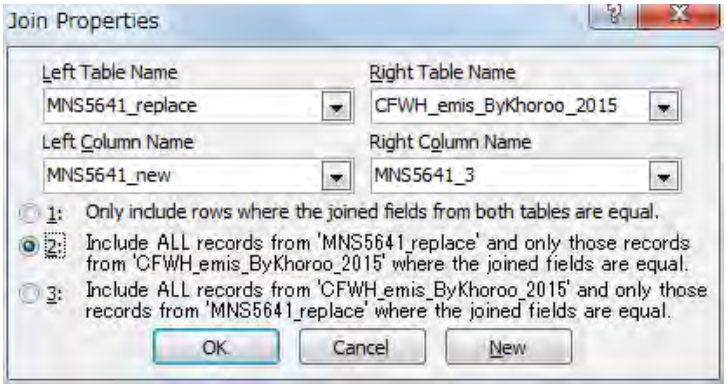

Select [MNS5641_new] column in “MNS5641_replace” table, drag and drop to [MNS5641_3] column in “CFWH_emis_ByKhoroo_2015” table. In addition, select [MNS5641] column in “Khoroo_2013_UrbanNonApart_grid1km_rev” table, drag and drop to [MNS5641_old] column in “MNS5641_replace” table.



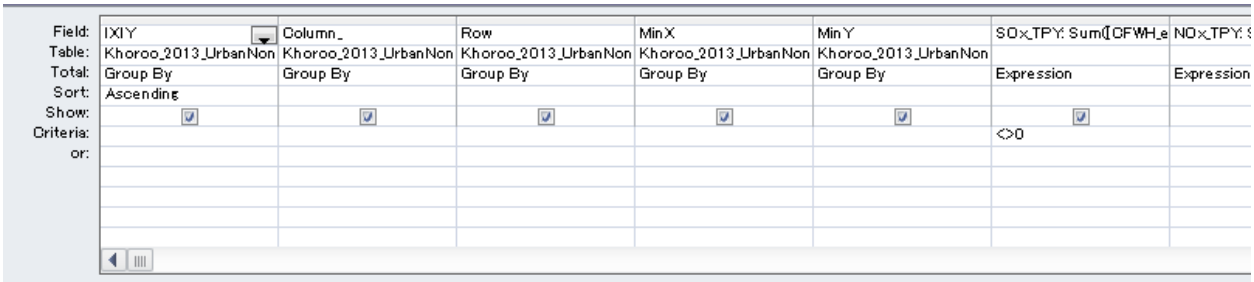

Right-click on the line connected between “MNS5641_replace” table and “CFWH_emis_ByKhoroo_2015” table, and click [Join Properties].




Select “2” and click [OK]. Check that the allow points to “CFWH_emis_ByKhoroo_2015”.

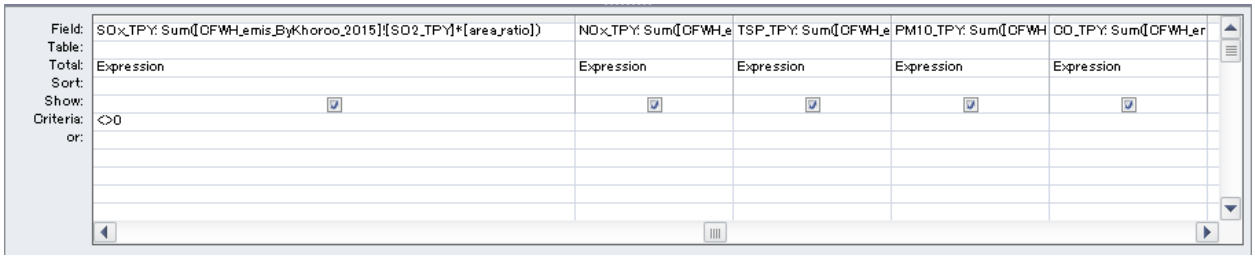



Set [table] of [IXIY], [Column_], [Row], [MinX], and [MinY] column as [Khoroo_2013_UrbanNonApart_grid1km_rev]. Select [Ascending] in [Sort] of [IXIY] column.

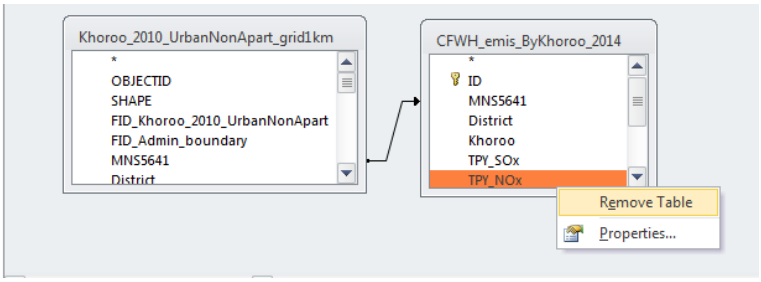


Calculate the emission for each pollutant by using this formula.

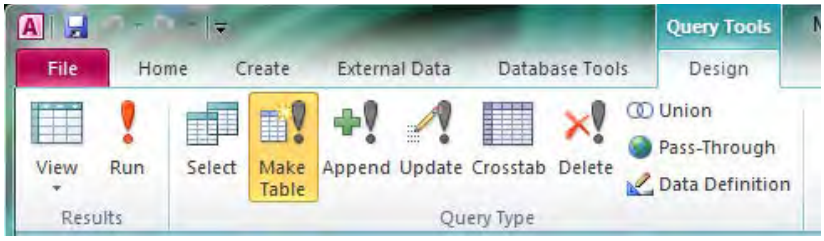
Example: SOx = Sum([CFWH_emis_ByKhoroo_2015]![SO2_TPY]*[area_ratio])



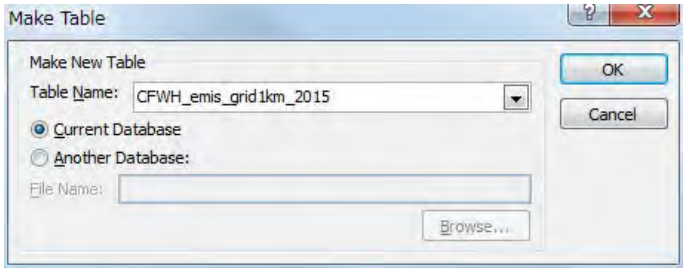

Right-click the old table and click [Remove Table] (Here it is “CFWH_emis_ByKhoroo_2014” table and “Khoroo_2010_UrbanNonApart_grid1km” table).



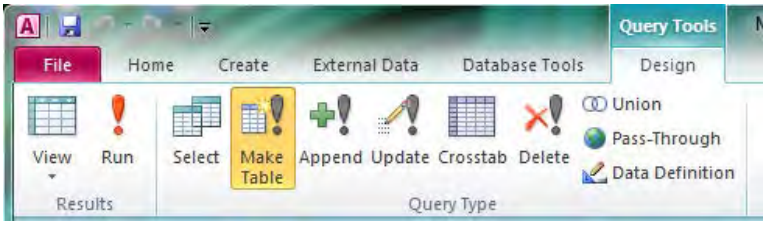

Click [Make Table] in [Design]



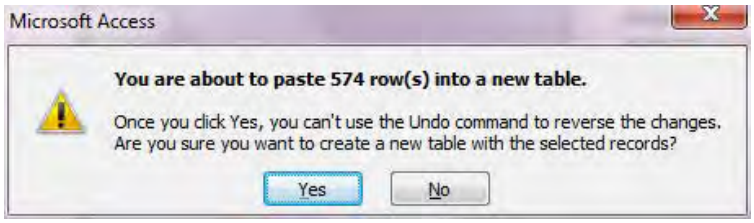

Set the table name (Here it is “CFWH_emis_grid1km_2015”).



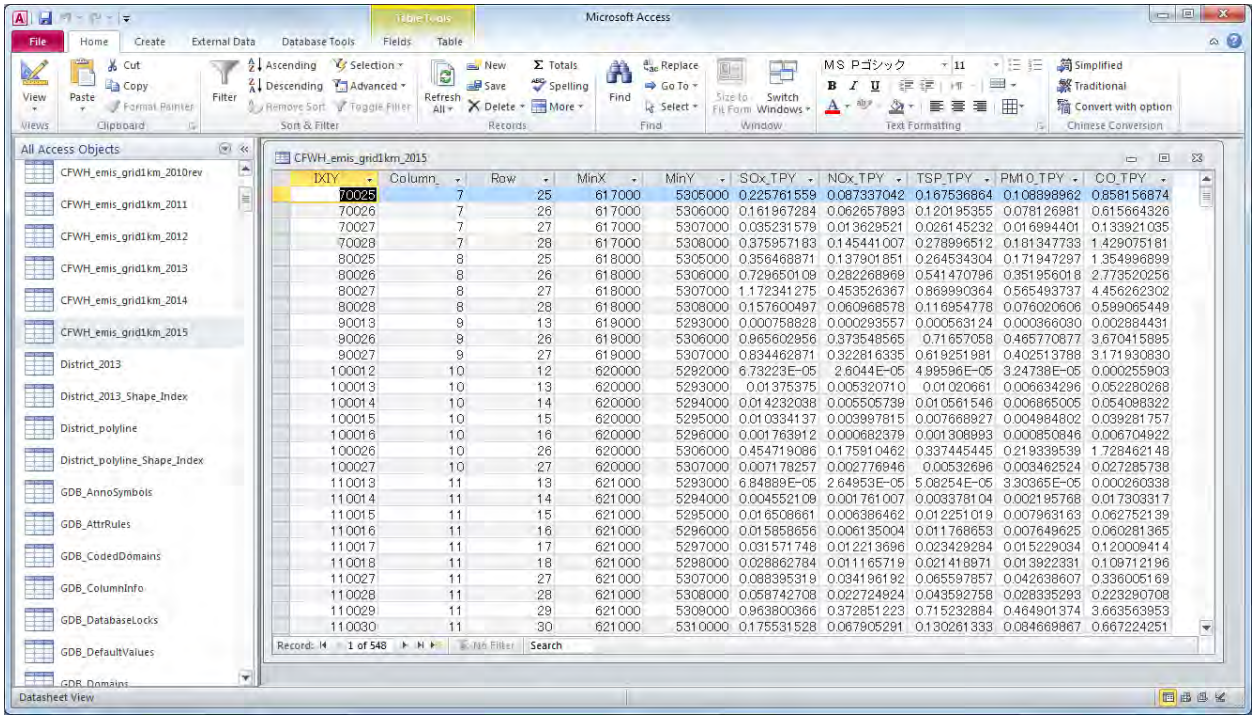

Click [Run] in [Design]




Click [Yes].

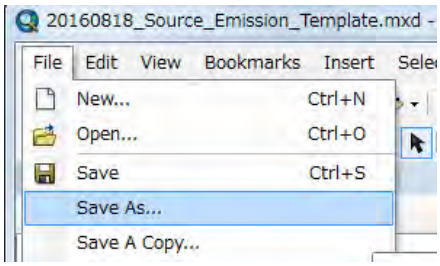



Create the emission table distributing emission by khoroo to grid.



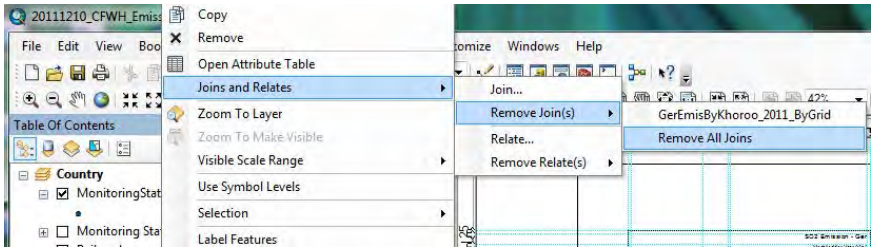

## 4.4 Drawing Emission Distribution Map

Open template file, click [File]-[Save As], and saved as other name.

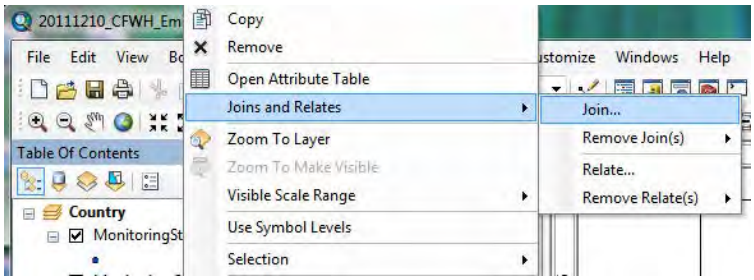


Join the table of emission by grid to “SO2 Emission” layer

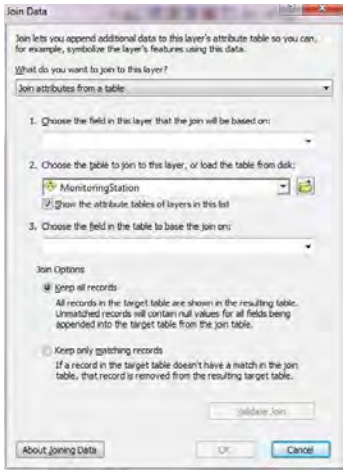
If the table is already a joined table, select [Joins and Relates]-[Remove Join(s)]-[Remove All].



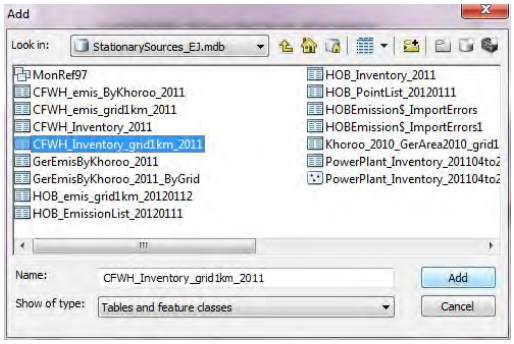

Right-click “SO2 Emission” layer and select [Joins and Relates]-[Join].



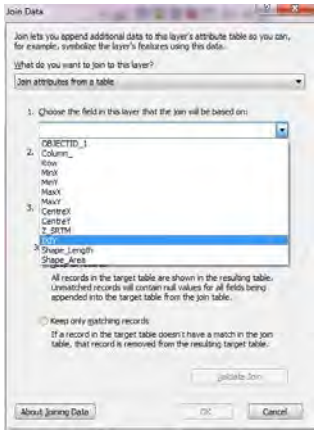

When showing the following dialog, click  button.



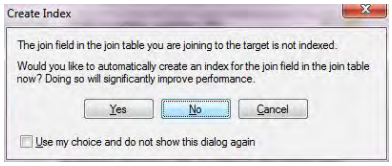

Select the table of emission by grid to join and click [Add] (Here it is “CFWH_Inventory_grid1km_2011” table).



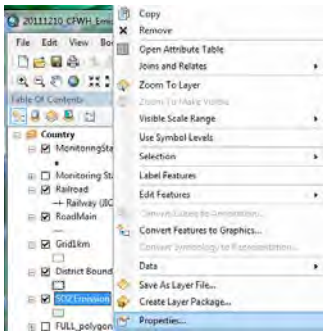

Show the selected table in the dropdown textbox of “2.”. When clicking the dropdown button of “1.” and selecting “IXIY”, show “IXIY” in “3.” automatically. After then, click [OK].

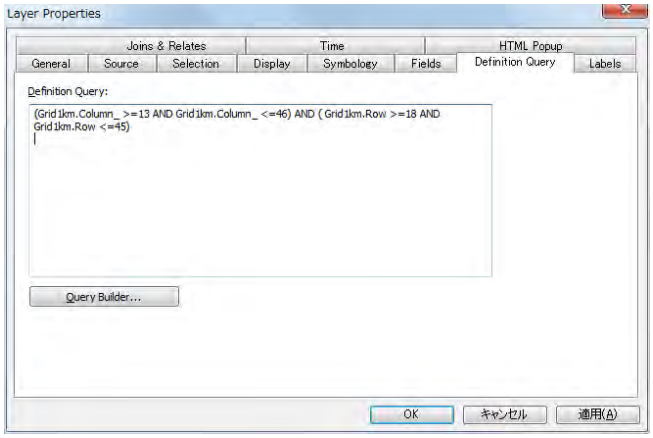



If the following dialog may be shown, click [No].

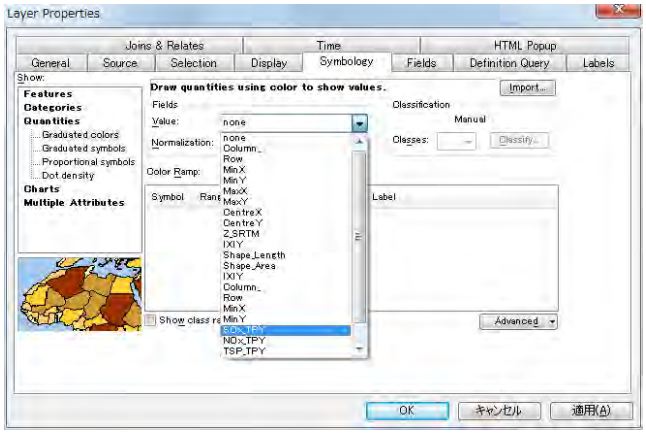



Right-click “SO2 Emission” layer and click [Properties].

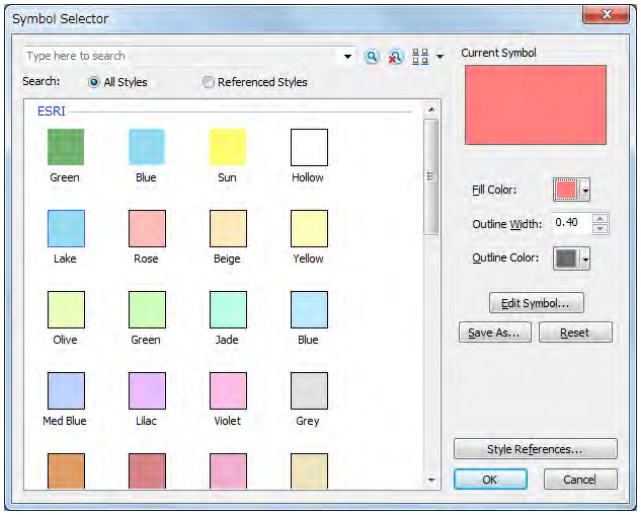




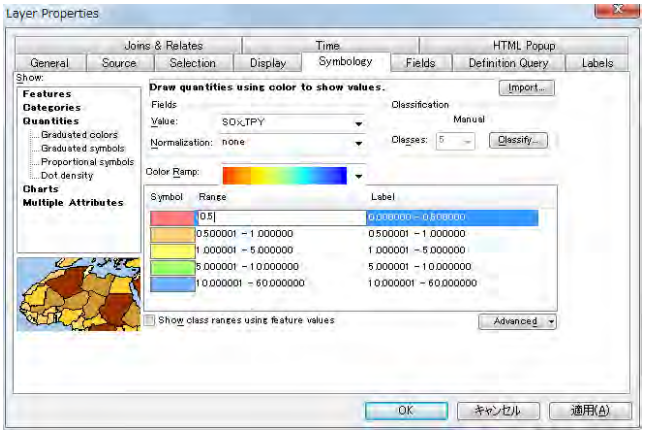

Click [Symbology] tab and select [Quantities]-[Graduated colors]. Click and select the target column name at the drop down button of [Value] (Here it is [SOx_TPY].).



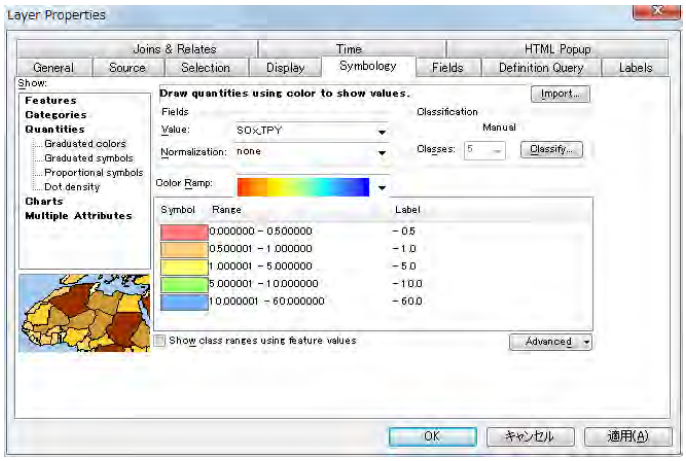

When double-clicking color in [Symbol] column, since the following dialog is shown, select color.



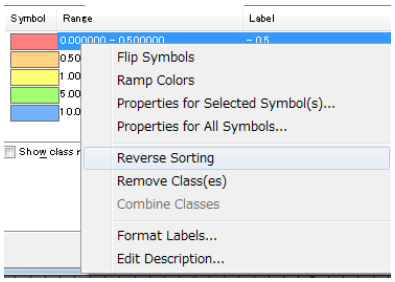

After selecting a rank, click the [Range] of the selected rank and input the maximum of the rank.



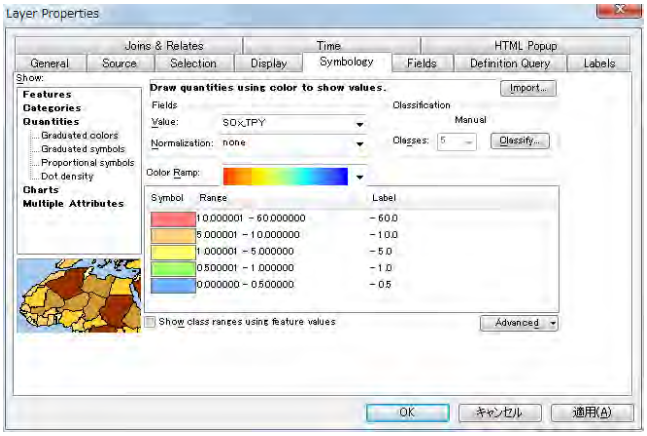

Input the label to display in legend in [Label] column.



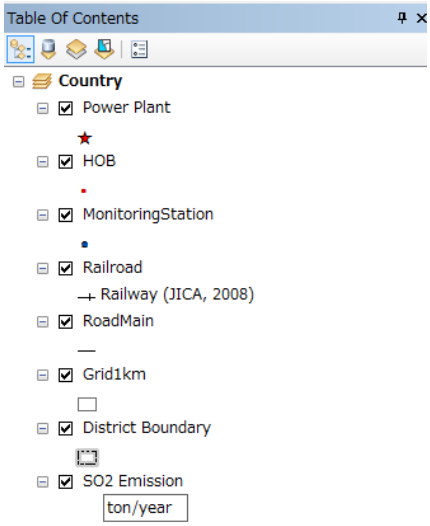

When click [Reverse Sorting] after you right-click on the [Range] column, the display order of rank changes. According to the order of symbol color, decide the display order of rank.



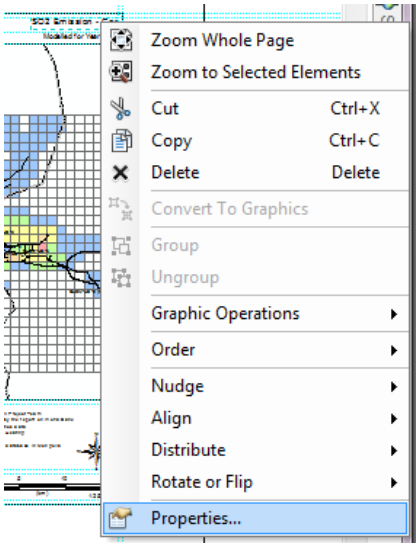

When all setting completed, click [OK].



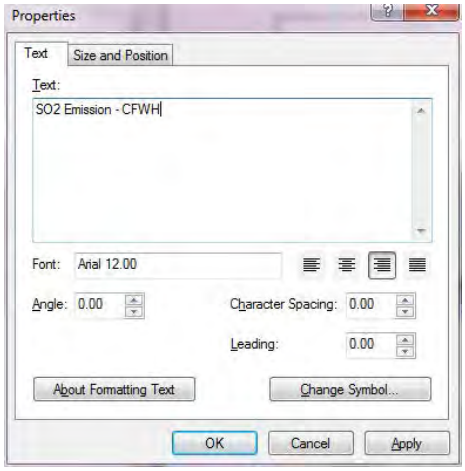

Click “SO2_tpy” of “SO2 Emission” layer and make it editable and change to “ton/year”.



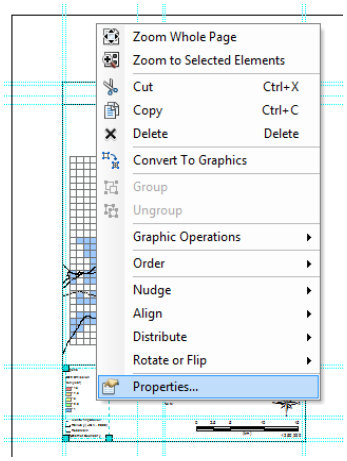

Change the title of this map. Move the cursor to the textbox of title, right-click it, and click [Properties].



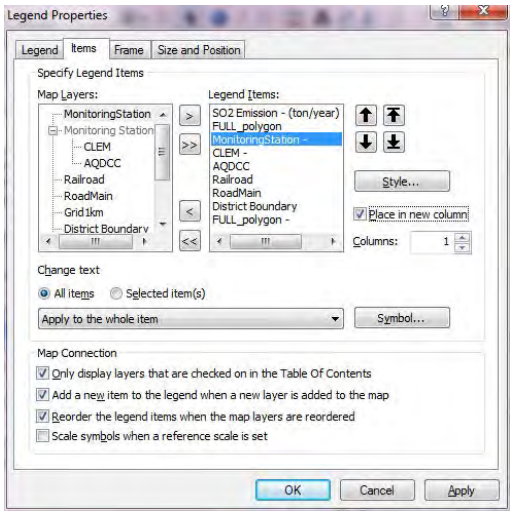
Input a title in [Text] (Here it is “SO2 Emission – CFWH”.).



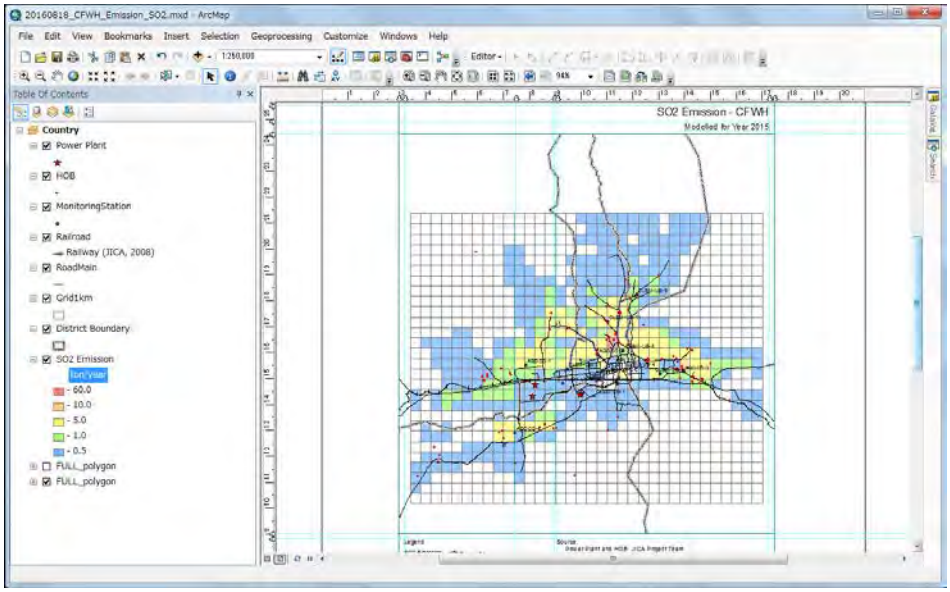

Select and right-click the legend and click [Properties].



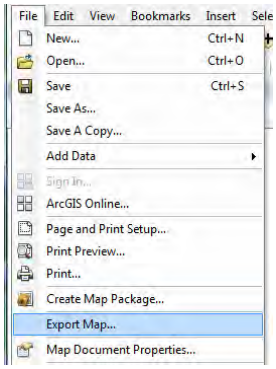

Select [MonitoringStation -] in [Legend Items] of [Items], put [Place in new column] checked, and click [OK]. After then, you can added the columns of legend.



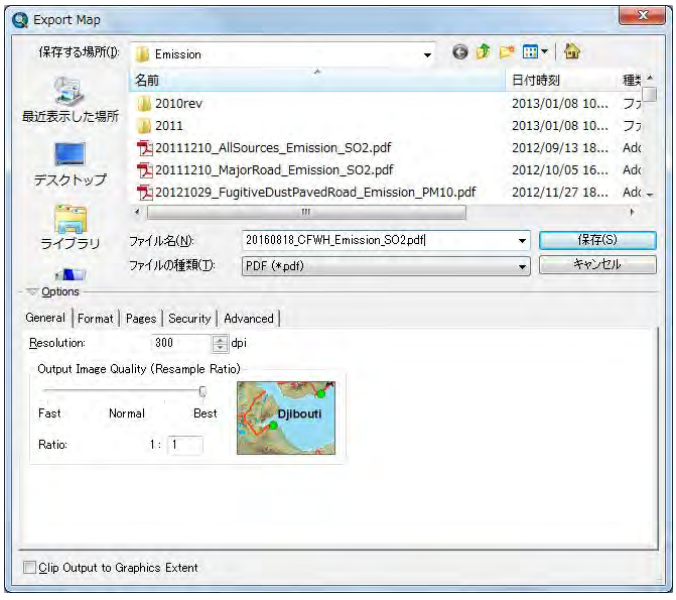
Complete drawing the map by ArcGIS.



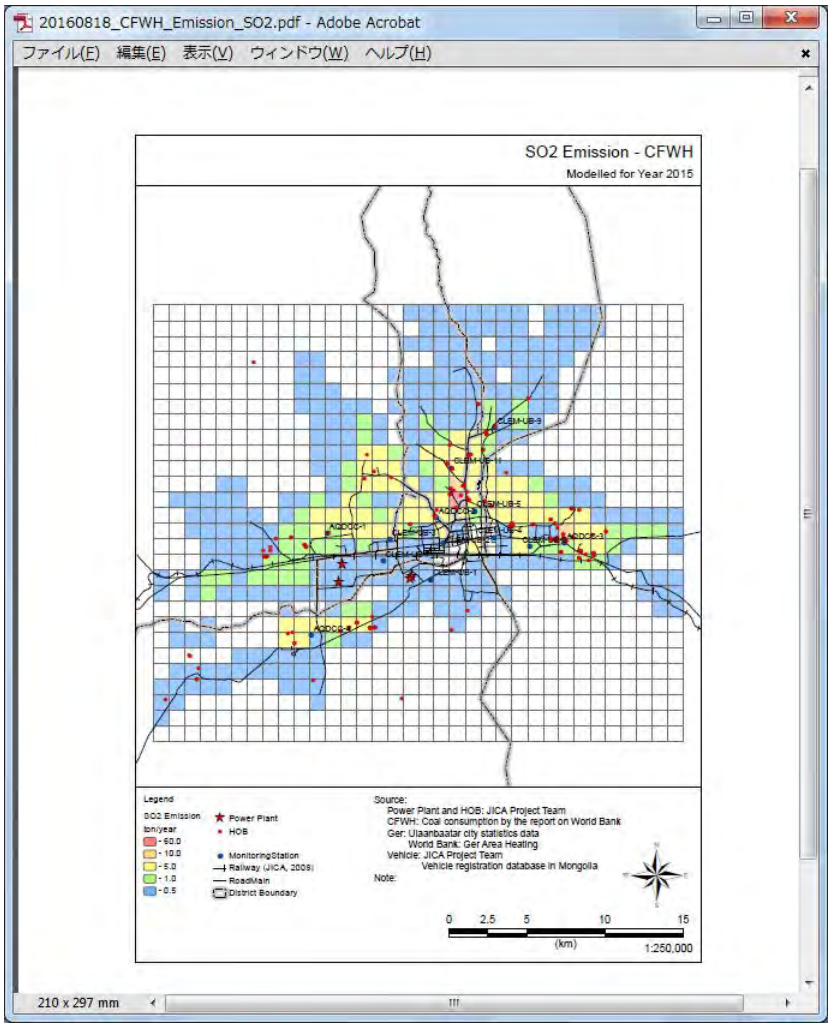

To export the distribution map to PDF file, click [File]-[Export Map].




Setting the destination and file name and click [Save].



Create the PDF file of distribution map.



# 5 Small Stove for Household

## 5.1 Developing and Updating Method for Emission inventory

### 5.1.1 Collecting and Organizing Information on the Activity Data of Small Stove for Household

Small stove for household in this manual means ger stove, wall stove and improved stove used in general house. Improved stove means a Turkish stove sold through APRD with a subsidy from 2011 to 2015. Calculation flow diagram of the emission from small stove for household is shown in Figure 5-1. Emission is calculated by using the following formula. Regarding temporal change, hourly operating pattern by season is calculated by using the difference of seasonal SO2 concentration by time between ger area and apartment area. When you want to grasp the more detailed operating condition, the measurement survey on the fuel consumption needs to be conducted for small stove.

$$\mathrm{E}_i = \sum_{k=1}^{3} \sum_{j=1}^{2} \mathrm{AD}_{i,j,k} \times \mathrm{EF}_{j,k}$$

Ei: Emission from small stove for household in khoroo i (ton/year)

ADi,j,k: Annual consumption of fuel j using stove k in khoroo i (ton/year)

EFj,k: Emission factor of stove k using fule j (kg/ton fuel)

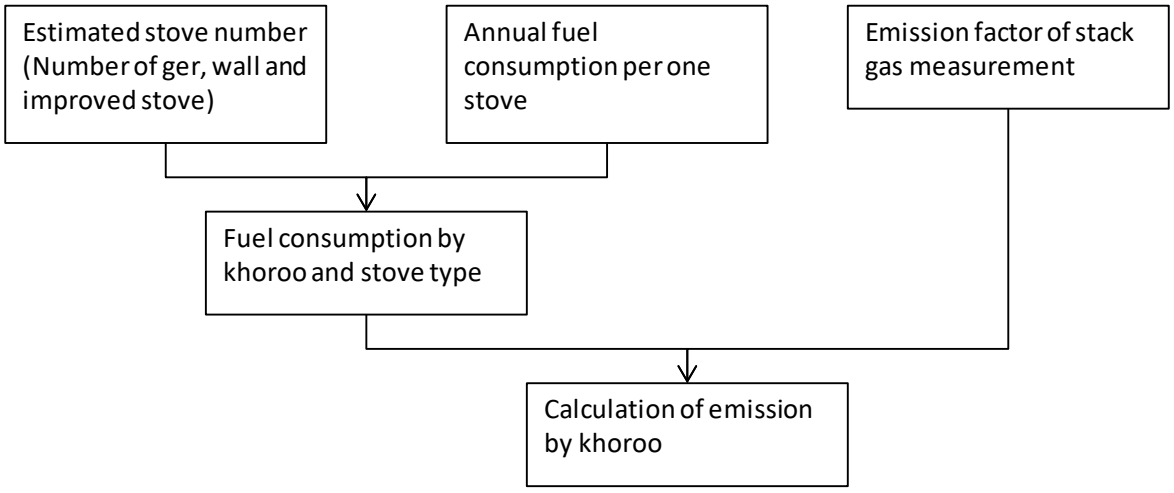



**Figure 5-1 Calculation Flow Diagram of the Emission from Small Stove for Household**

#### 5.1.1.1 Organizing the Activity Data by Using the Statistics in UB

The fuel consumption by khoroo is estimated by using the statistics of households by khoroo in UB city and the cumulative sales number result of improved stove by khoroo. The calculation method is described in "Air Pollutant Emission Inventory Guidelines in Mongolia (2nd Edition)".

$$\mathrm{AD}_{i,j,k} = \mathrm{SC}_{i,k} \times \mathrm{FC}_{j,k}$$

SCi,k：: Number of stove k in khoroo i (unit)

FCj,k：: Annual fuel consumption per stove of stove k of fuel j (ton/year/unit)

#### 5.1.1.2 Organizing the Activity Data by Using the National Source Registration Data in 2014

Extract data of small stove for household among databases the Air Pollution Reduction Committee developed using the air quality smart management system in 2014 and calculate coal consumption by khoroo.

The person in charge of NAMEM possesses this data and fuel type, unit and consumption are registered for each stove.

Regarding the coal consumption after 2015, it is necessary to propose implementing a continuing survey to grasp coal consumption, or discuss whether to consider increasing the coal consumption proportional to the population increase or to maintain the current situation.

### 5.1.2 Collecting Information for Developing Emission Factor

Emission factor is the following table based on the result of flow gas measurement in this project.

| | | | SO2 | NOx | TSP | PM10 | CO |
|---|---|---|---|---|---|---|---|
| Traditional stove | Coal | Ger | 3.32 | 1.15 | 6.23 | 5.61 | 62.71 |
| | | Wall | 6.06 | 0.61 | 9.77 | 8.79 | 60.37 |
| | Wood | | 1.22 | 1.50 | 5.42 | 5.15 | 27.71 |
| Improved stove | Coal | | 3.32 | 0.93 | 1.23 | 1.10 | 21.29 |
| | Wood | | 1.22 | 1.50 | 5.42 | 5.15 | 27.71 |

Unit: kg/ton
Note: Based on the flow gas measurement using Nalaikh and Baganuur coal

Although the combustion test results in the laboratory have been accumulated to verify the effect of the improved stove, the flow gas measurement subject to the calculation of the emission factor is not conducted much. Therefore, it is requested that many of flow gas measurements are conducted in the improved stove used in actual life, and reflect the result of measurement in the past emission factor.

There is doubt about the fact that the TSP and PM10 emission factor of the wall stove is much larger than the emission factor of the ger stove. Since the number of measurements is small and variation in each measurement is large, the emission factor may be excessive. In the future, it is requested that many flow gas measurements for the wall stove used in actual life be conducted, and the measurement result is reflected to the past emission factor.

### 5.1.3 Developing and Updating Emission Inventory

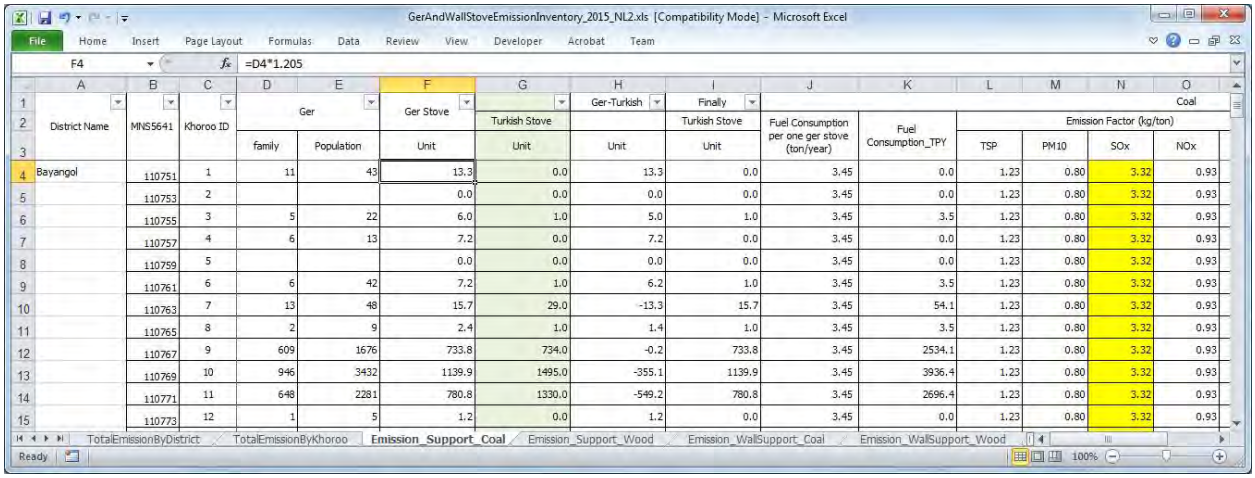
Use “GerAndWallStoveEmissionInventory.xls” for developing and updating emission inventory of small stove for household. Outline of each sheet is as follows.

| Sheet Name | Stove | Fuel |
|---|---|---|
| Emission_Support_Coal | Convert from ger stove to improved stove | Coal |
| Emission_Support_Wood | | Wood |
| Emission_WallSupport_Coal | Convert from wall stove to improved stove | Coal |
| Emission_WallSupport_Wood | | Wood |
| Emission_Ger_Coal | Ger stove | Coal |
| Emission_Ger_Wood | | Wood |
| Emission_Wall_Coal | Wall stove | Coal |
| Emission_Wall_Wood | | Wood |

In “TotalEmissionByKhoroo”, Total emission by khoroo was calculated from these sheets.

In “TotalEmissionByDistrict”, Total emission by district was calculated from “TotalEmissionByKhoroo” sheet.

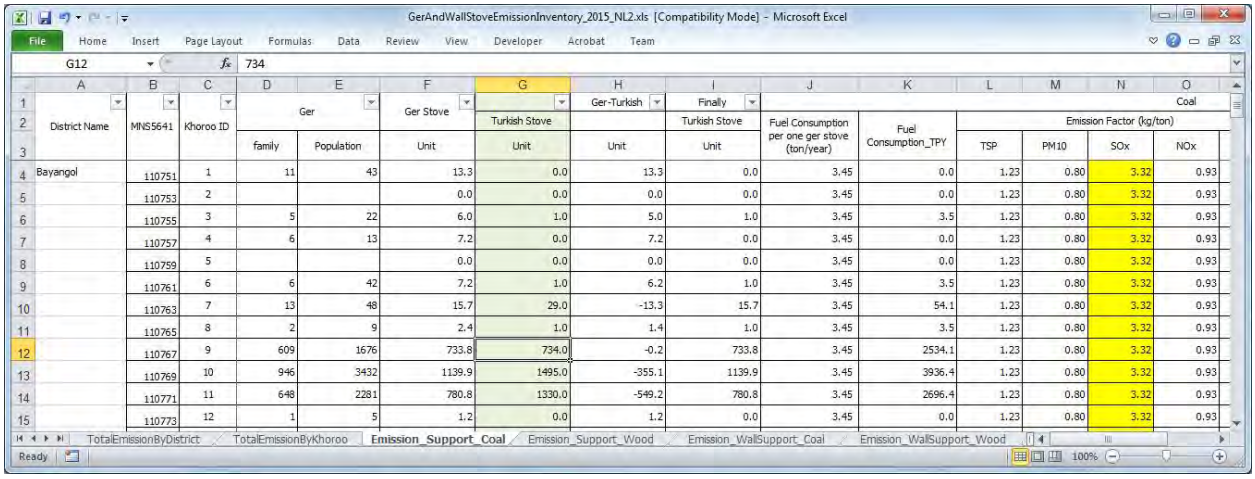
Update the population and household of ger or detached house of each khoroo in each sheet to the target year's data. At this time, the number of ger and wall stove is estimated in consideration of the number of households possessing more than one stove.

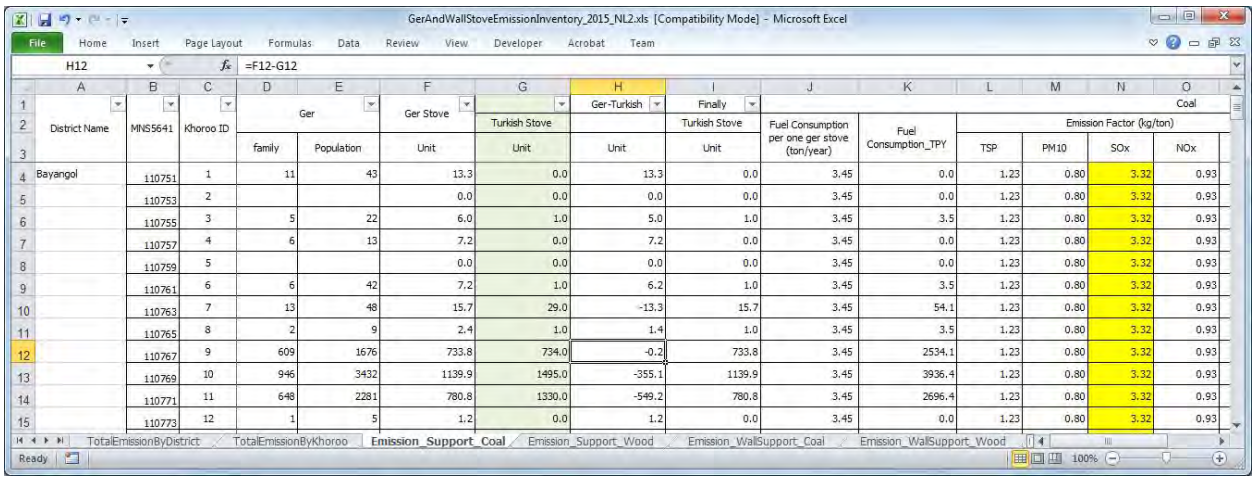


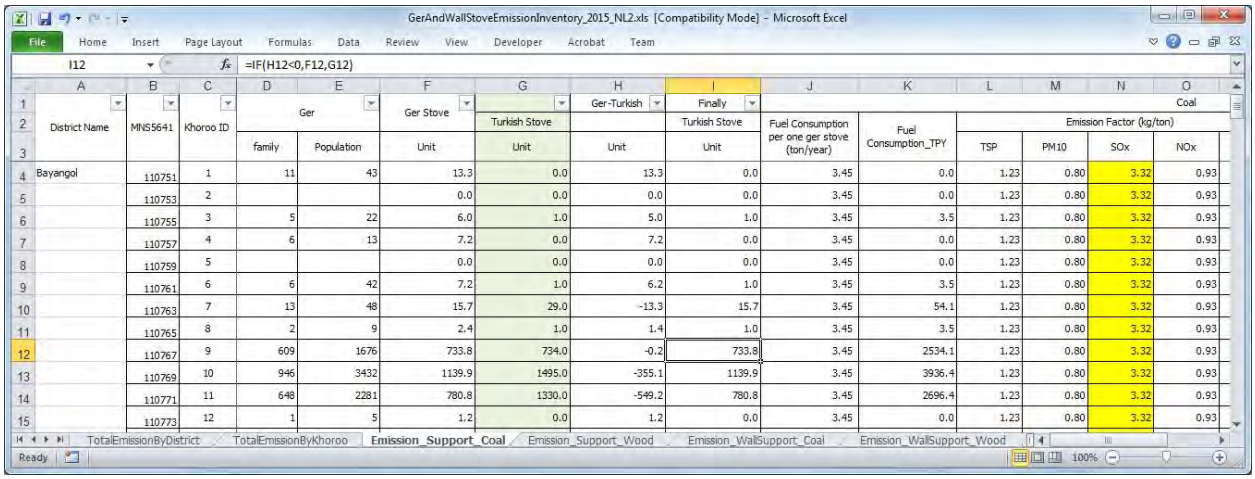

Update the cumulative sales number result of improved stove by khoroo to latest value. Estimate the number of remaining ger and wall stove by subtracting sales number from the estimated stove number. The following sheets are the target sheet of this calculation.

[Emission_Support_Coal], [Emission_Support_Wood]

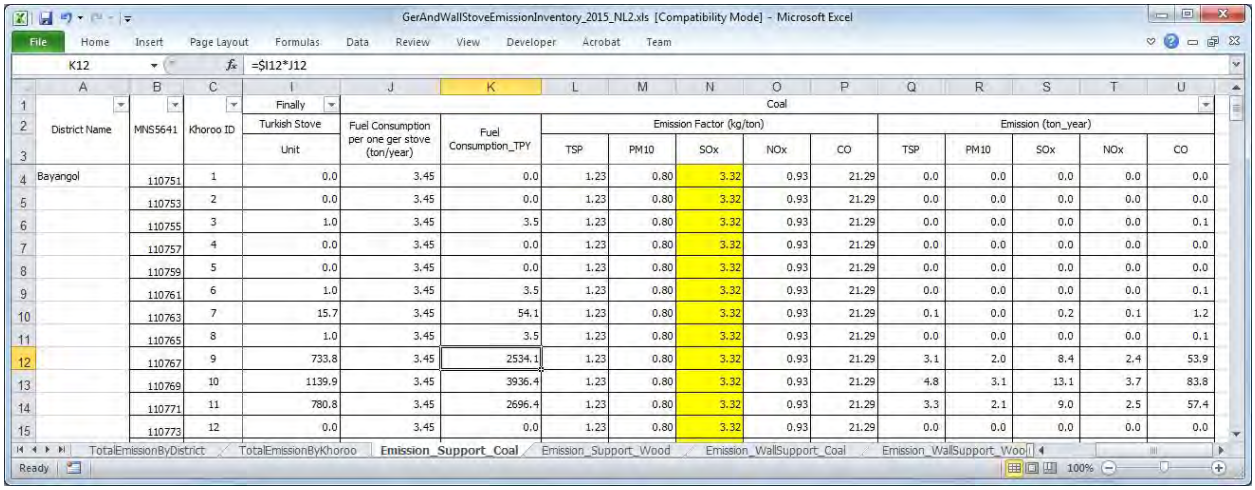
[Emission_WallSupport_Coal], [Emission_WallSupport_Wood]



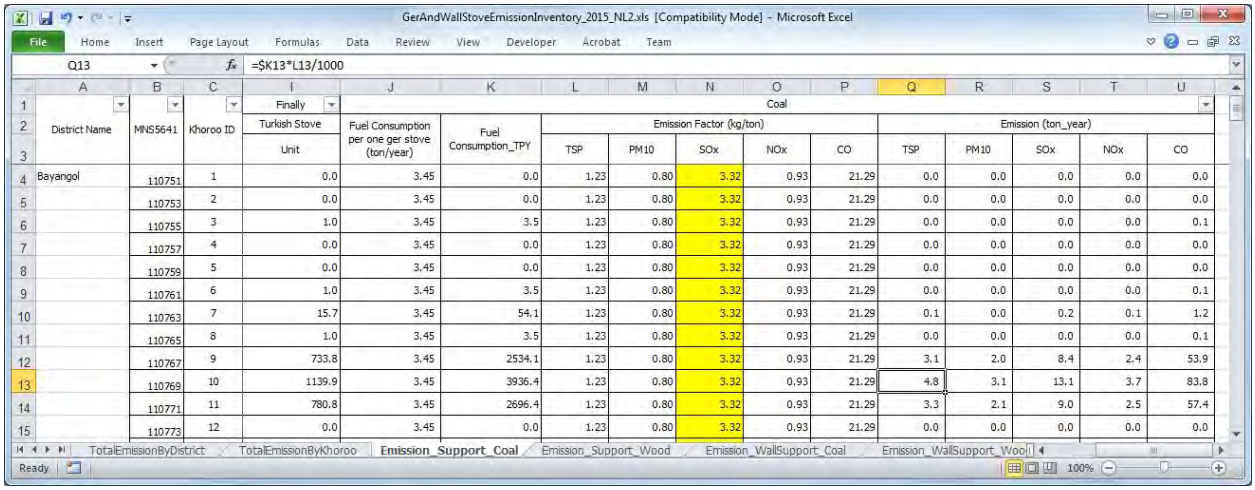




Input the annual fuel consumption per stove and update the fuel consumption by khoroo.



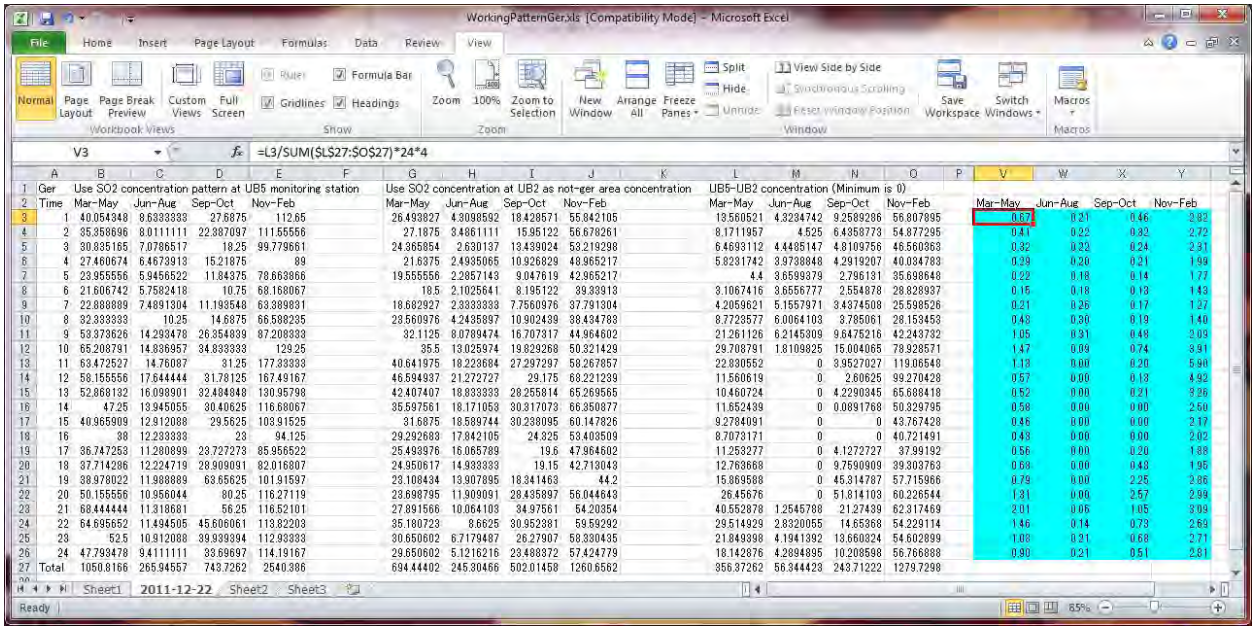

| | A | B | C | I | J | K | L | M | N | O | P | Q | R | S | T | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | Finally | | | Coal | | | | | | | | | |
| 2 | District Name | MNS5641 | Khoroo ID | Turkish Stove | Fuel Consumption per one ger stove (ton/year) | Fuel Consumption_TPY | Emission Factor (kg/ton) | | | | | Emission (ton_year) | | | | |
| 3 | | | | Unit | | | TSP | PM10 | SOx | NOx | CO | TSP | PM10 | SOx | NOx | CO |
| 4 | Bayangol | 110751 | 1 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | | 110753 | 2 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 | | 110755 | 3 | 1.0 | 3.45 | 3.5 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 7 | | 110757 | 4 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8 | | 110759 | 5 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 | | 110761 | 6 | 1.0 | 3.45 | 3.5 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 10 | | 110763 | 7 | 15.7 | 3.45 | 54.1 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.1 | 0.0 | 0.2 | 0.1 | 1.2 |
| 11 | | 110765 | 8 | 1.0 | 3.45 | 3.5 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 12 | | 110767 | 9 | 733.8 | 3.45 | 2534.1 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 3.1 | 2.0 | 8.4 | 2.4 | 53.9 |
| 13 | | 110769 | 10 | 1139.9 | 3.45 | 3936.4 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 4.8 | 3.1 | 13.1 | 3.7 | 83.8 |
| 14 | | 110771 | 11 | 780.8 | 3.45 | 2696.4 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 3.3 | 2.1 | 9.0 | 2.5 | 57.4 |
| 15 | | 110773 | 12 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

Update the emission factor by organizing the result of flow gas measurement in 5.1.2. Emission is automatically calculated from the number of stove, annual fuel consumption per stove, and emission factor.




| | A | B | C | I | J | K | L | M | N | O | P | Q | R | S | T | U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | Finally | | | Coal | | | | | | | | | |
| 2 | District Name | MNS5641 | Khoroo ID | Turkish Stove | Fuel Consumption per one ger stove (ton/year) | Fuel Consumption_TPY | Emission Factor (kg/ton) | | | | | Emission (ton_year) | | | | |
| 3 | | | | Unit | | | TSP | PM10 | SOx | NOx | CO | TSP | PM10 | SOx | NOx | CO |
| 4 | Bayangol | 110751 | 1 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5 | | 110753 | 2 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 6 | | 110755 | 3 | 1.0 | 3.45 | 3.5 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 7 | | 110757 | 4 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 8 | | 110759 | 5 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 9 | | 110761 | 6 | 1.0 | 3.45 | 3.5 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 10 | | 110763 | 7 | 15.7 | 3.45 | 54.1 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.1 | 0.0 | 0.2 | 0.1 | 1.2 |
| 11 | | 110765 | 8 | 1.0 | 3.45 | 3.5 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| 12 | | 110767 | 9 | 733.8 | 3.45 | 2534.1 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 3.1 | 2.0 | 8.4 | 2.4 | 53.9 |
| 13 | | 110769 | 10 | 1139.9 | 3.45 | 3936.4 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 4.8 | 3.1 | 13.1 | 3.7 | 83.8 |
| 14 | | 110771 | 11 | 780.8 | 3.45 | 2696.4 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 3.3 | 2.1 | 9.0 | 2.5 | 57.4 |
| 15 | | 110773 | 12 | 0.0 | 3.45 | 0.0 | 1.23 | 0.80 | 3.32 | 0.93 | 21.29 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

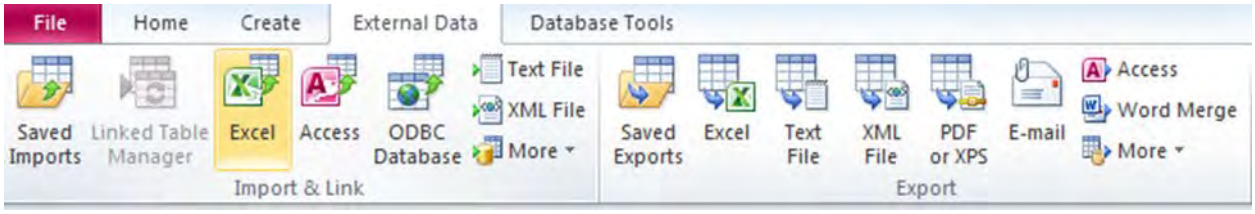
The hourly operating pattern by season of small stove for household was calculated by estimating the SO2 concentration from stove by taking the difference between the hourly SO2 concentration by season of ger area and apartment area.



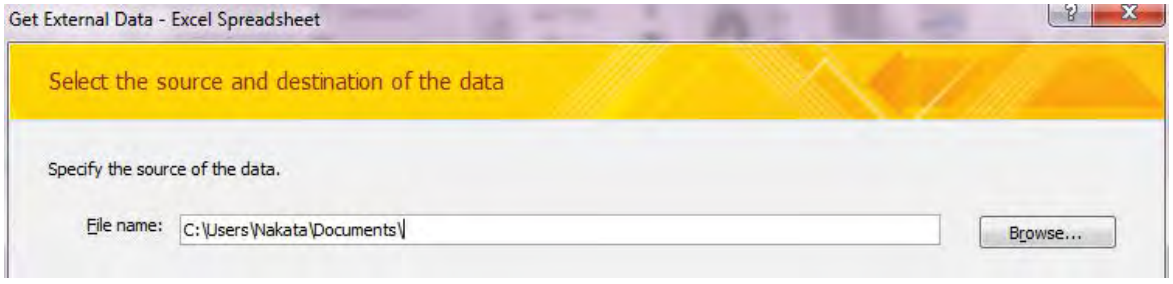

## 5.2 Import Inventory File into Access

Data on stationary source inventory is generated in “StationarySources.mdb”. This explains the method to import the inventory developing in 5.1.3 to “StationarySources.mdb”.

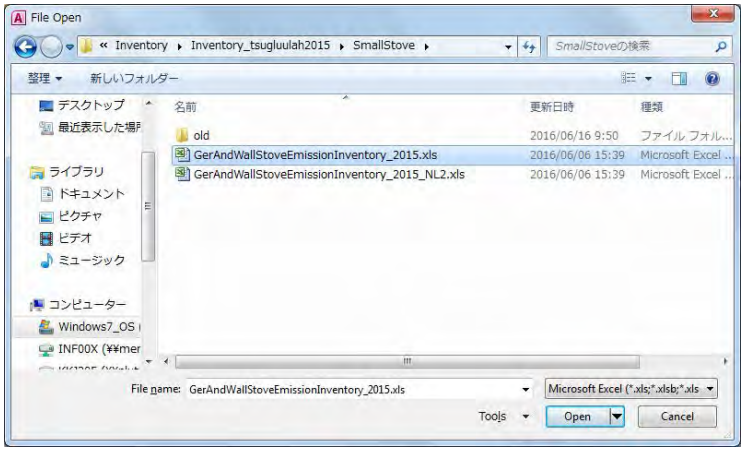
Select [Excel] button of [Import & Link] in [External Data] tab.



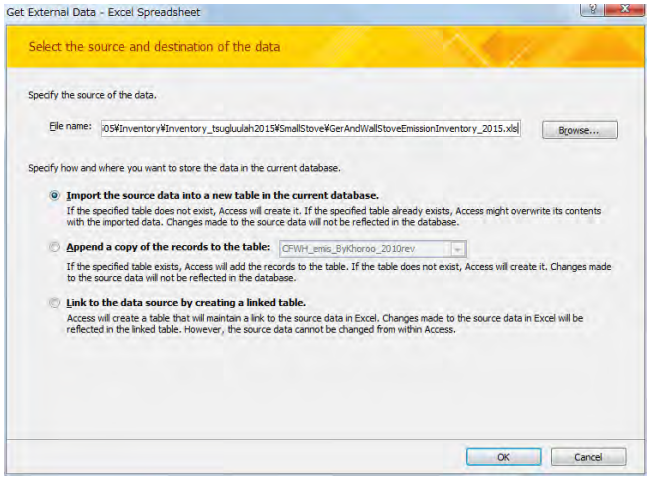

Click [Browse].



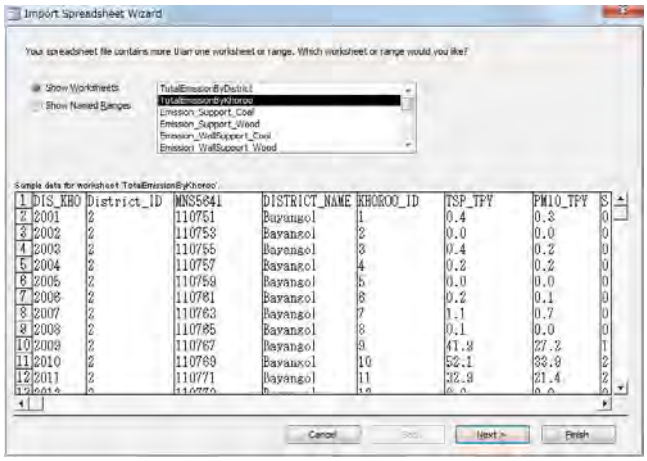

Select the file you want to import (Here it is “GerAndWallStoveEmissionInventory_2015.xls”).



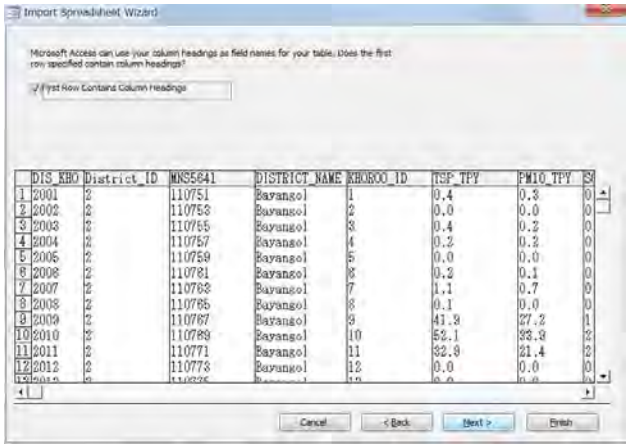

Select [Import the source data into a new table in the current database.] and click [OK].



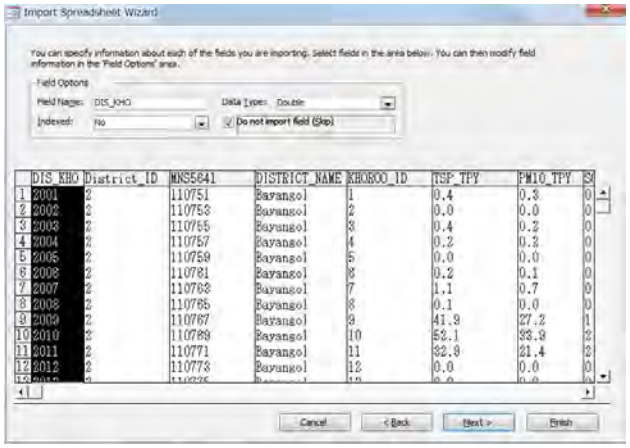

Check [Show Worksheets] is selected, select [TotalEmissionByKhoroo] sheet, and click [Next].



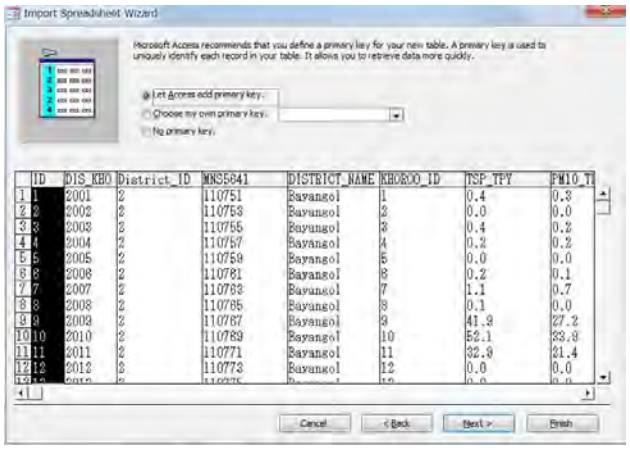

Check [First Row Contains Column Headings] is checked and click [Next].




Set [DIS_KHO] and [District_ID] column checked [Do not import field (Skip)] and click [Next].

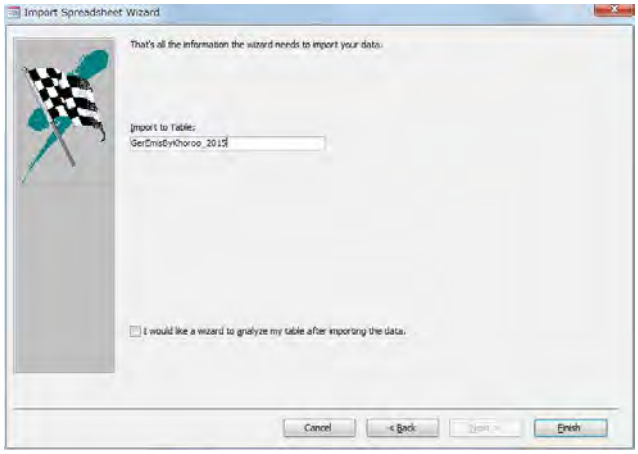



Select [Let Access add primary key.] and Click [Next].

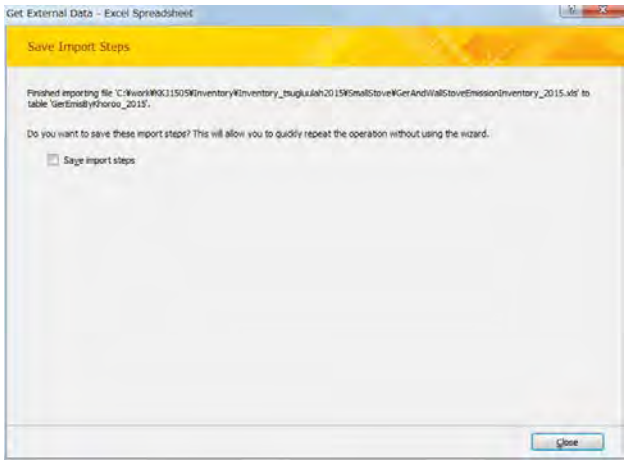



Input the table name in the [Import to Table:] textbox and click [Finish].

(Here it is “GerEmisByKhoroo _2015”.)




Click [Close].




## 5.3 Spatial Distribution to the Grid of Emission by Khoroo

Since the emission of small stove for household was calculated for each khoroo, when using the emission for simulation, the emission was distributed for each grid.

The emission by grid in a khoroo is calculated by the following formula.

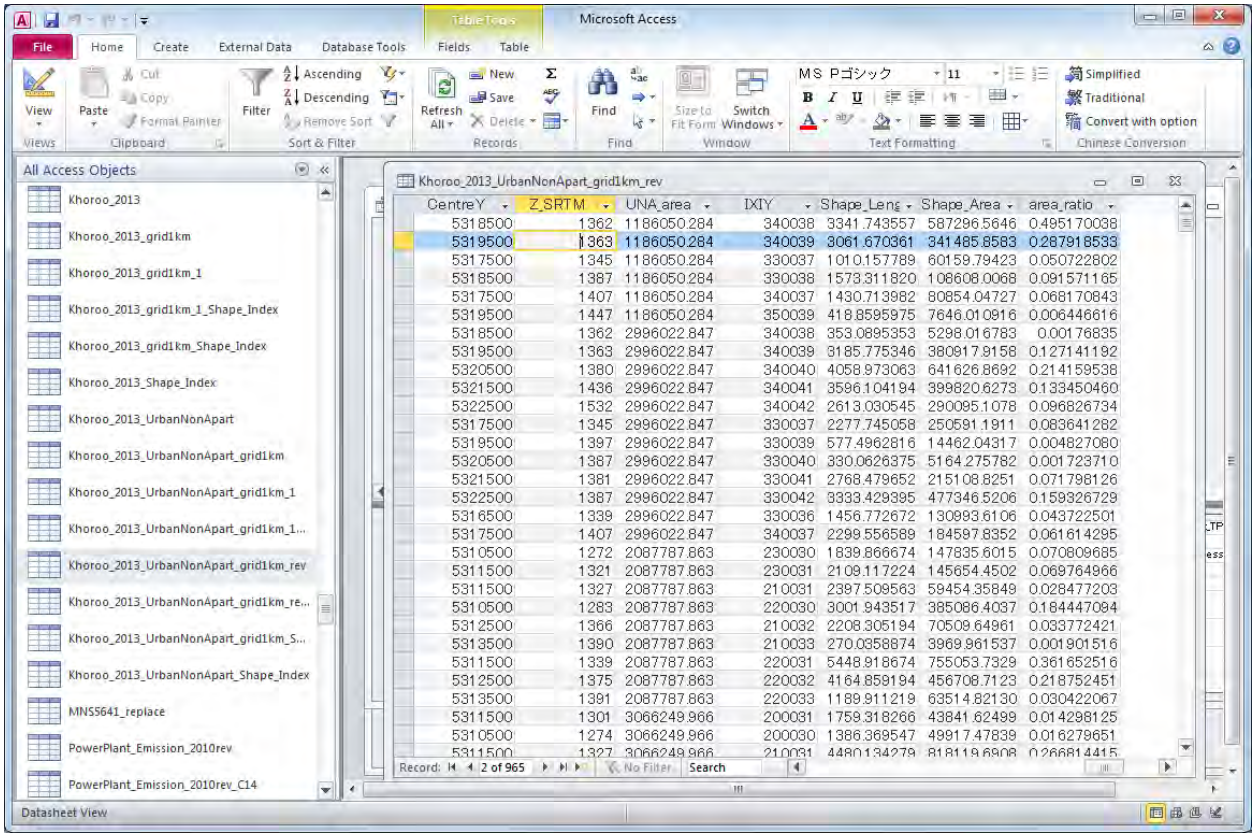
Emission by grid in a khoroo

= emissing in a khoroo x the ratio of the non-apartment area of a khoroo in a grid to the total non-apartment area of a khoroo ([area_ratio])

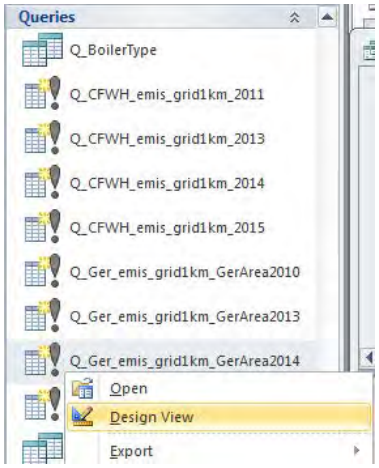
([area_ratio])

[area_ratio]=[SHAPE_Area] / [UNA_area]

the ratio of the non-apartment area of a khoroo in a grid / the total non-apartment area of a khoroo

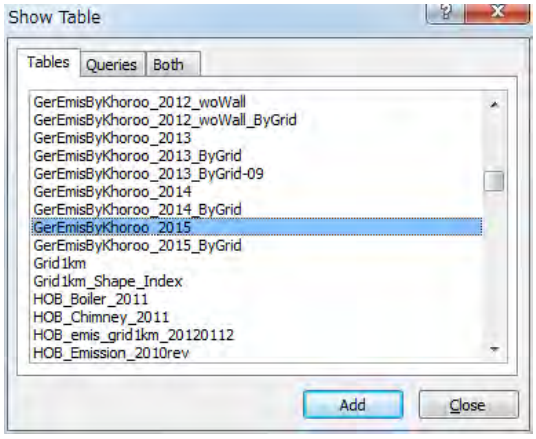



Here, open “Q_Ger_emis_grid1km_2014” query and save the query as “Q_Ger_emis_grid1km_2015”.

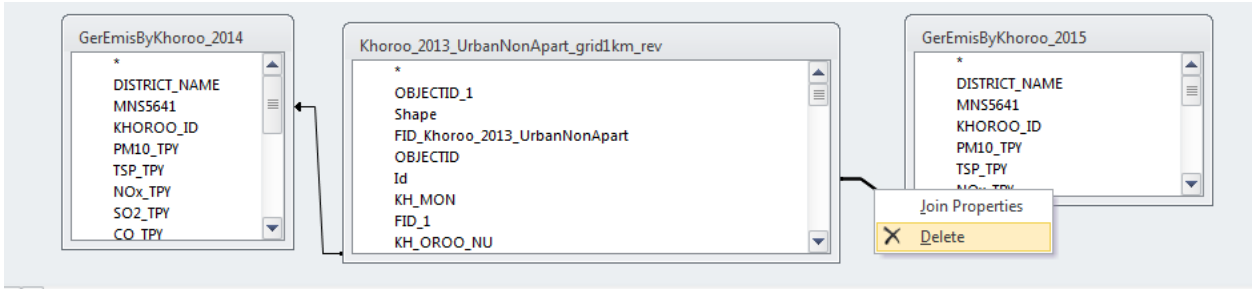



Click [Show Table] in [Design] tab.

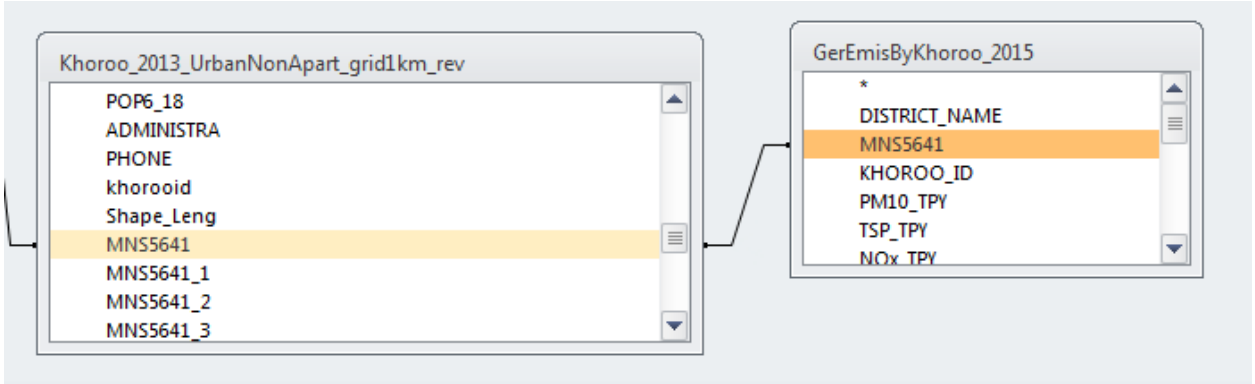
Select “GerEmisByKhoroo_2015” table and click [Add].



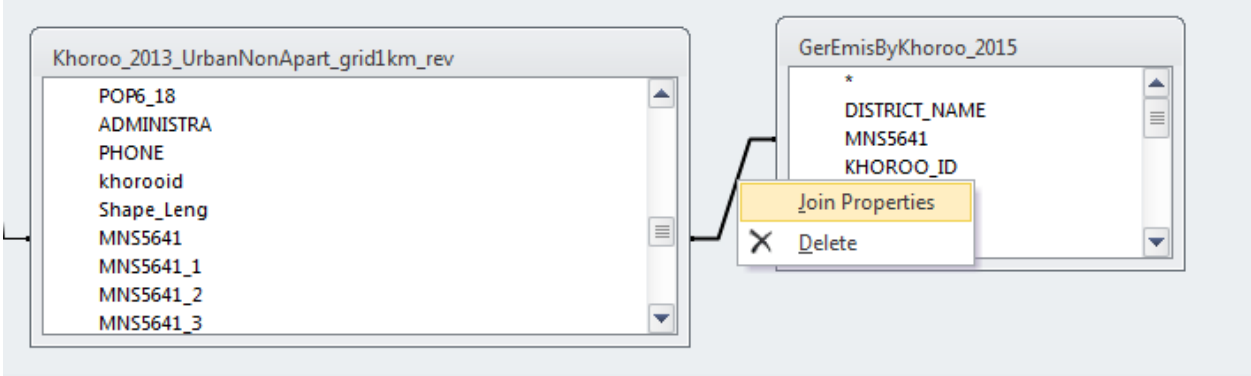

Right-click on the line connected to [ID] columns, and click [Delete].



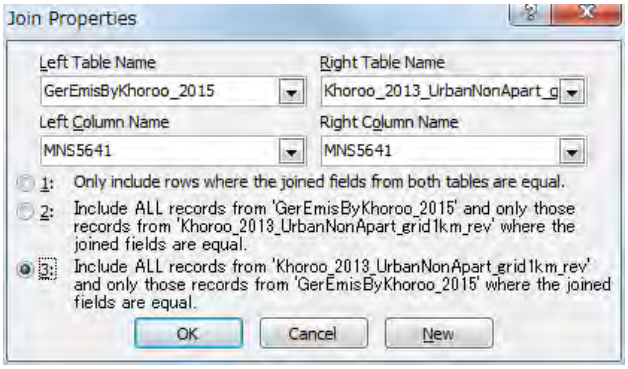

Select [MNS5641] column in “GerEmisByKhoroo_2015” table, drag and drop to [MNS5641] column in “Khoroo_2013_UrbanNonApart_grid1km_rev” table.




Right-click on the line connected between “Khoroo_2013_UrbanNonApart_grid1km_rev” table and “GerEmisByKhoroo_2015” table, and click [Join Properties].



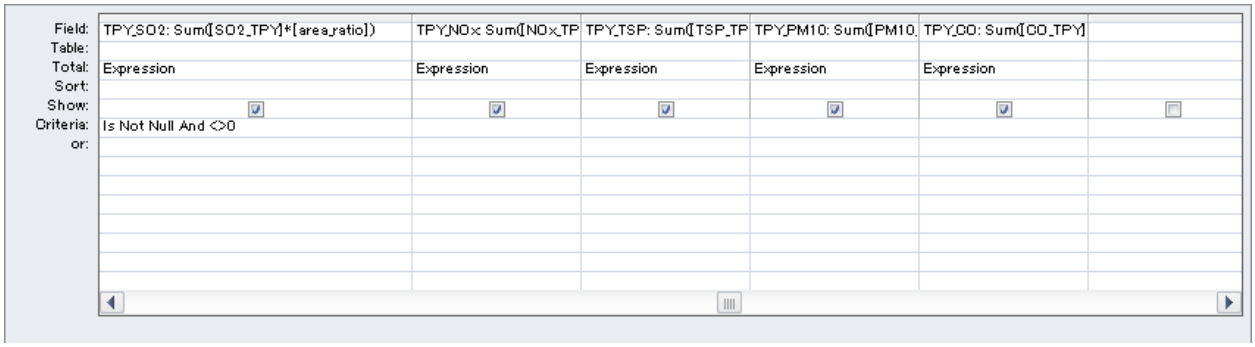

Select “3” and click [OK]. Check that the allow points to “GerEmisByKhoroo_2015”.



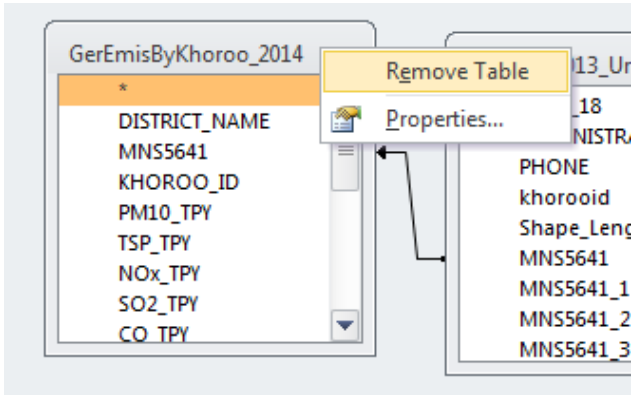

Set [table] of [IXIY], [Column_], [Row], [MinX], and [MinY] column as [Khoroo_2013_UrbanNonApart_grid1km_rev]. Select [Ascending] in [Sort] of [IXIY] column.


Calculate the emission for each pollutant by using this formula.

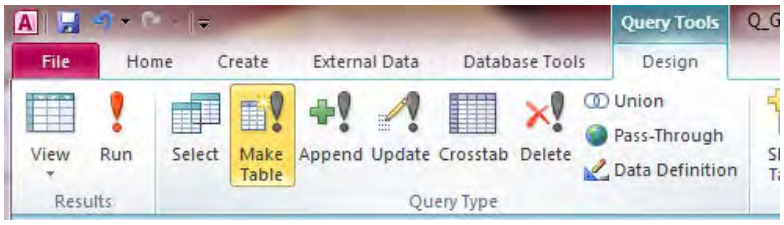
Example: SOx = Sum([SO2_TPY]*[area_ratio])



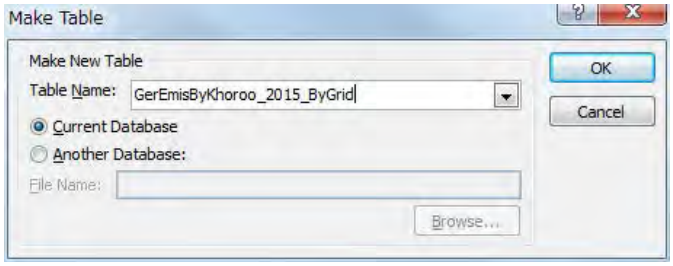

Right-click the old table and click [Remove Table] (Here it is “GerEmisByKhoroo_2014” table).



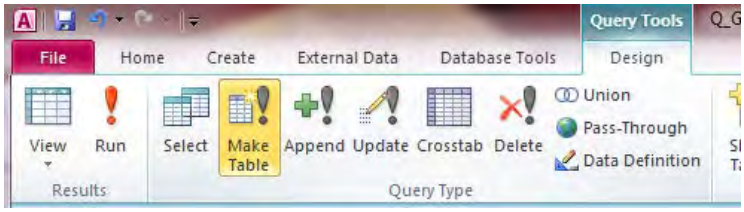

Click [Make Table] in [Design]



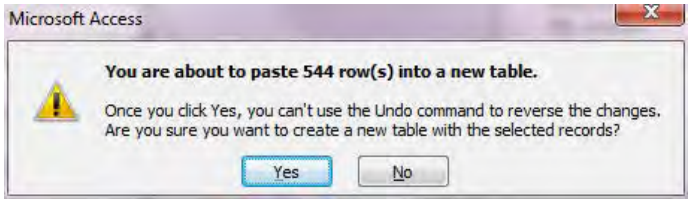

Set the table name (Here it is “GerEmisByKhoroo_2015_ByGrid”).



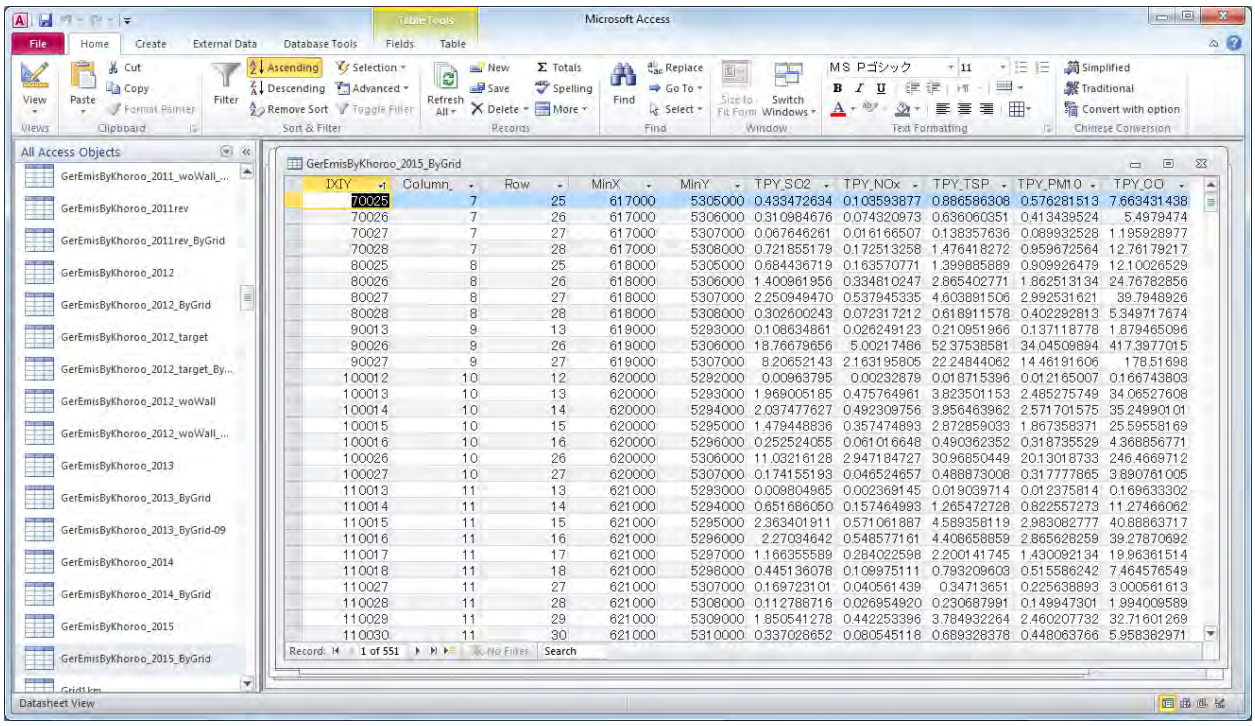

Click [Run] in [Design]




Click [Yes].

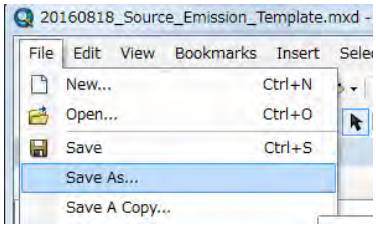



Create the emission table distributing emission by khoroo to grid.



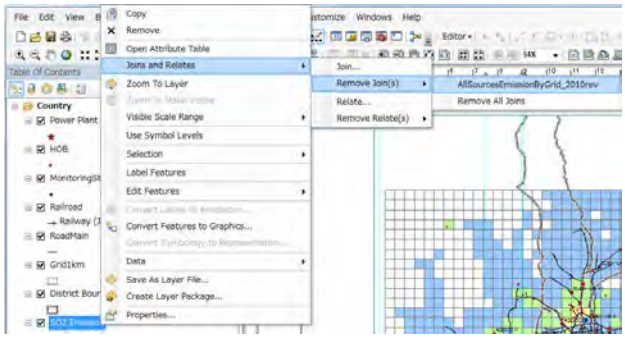

## 5.4 Drawing Emission Distribution Map

Open template file, click [File]-[Save As], and saved as other name.

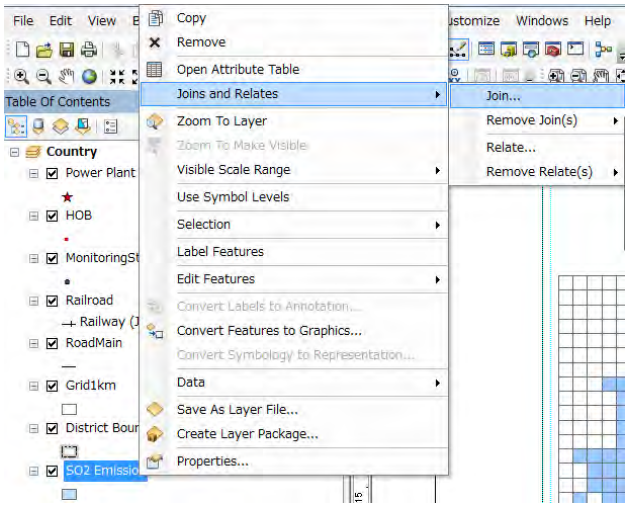


Join the table of emission by grid to “SO2 Emission” layer

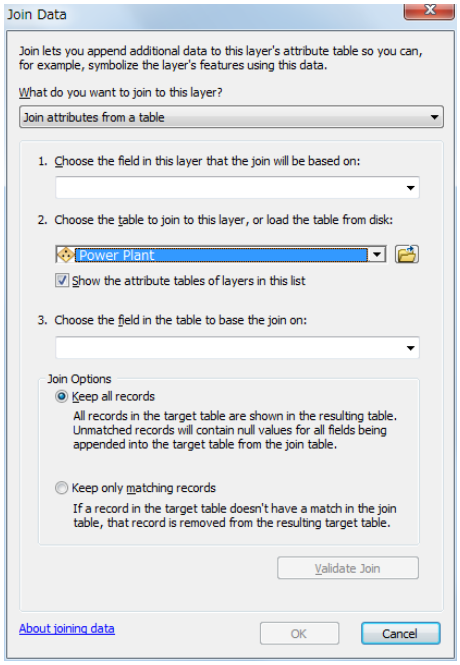
If the table is already a joined table, select [Joins and Relates]-[Remove Join(s)]-[Remove All].



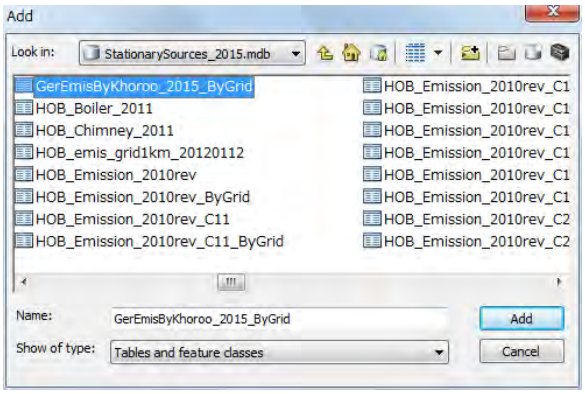
Right-click “SO2 Emission” layer and select [Joins and Relates]-[Join].



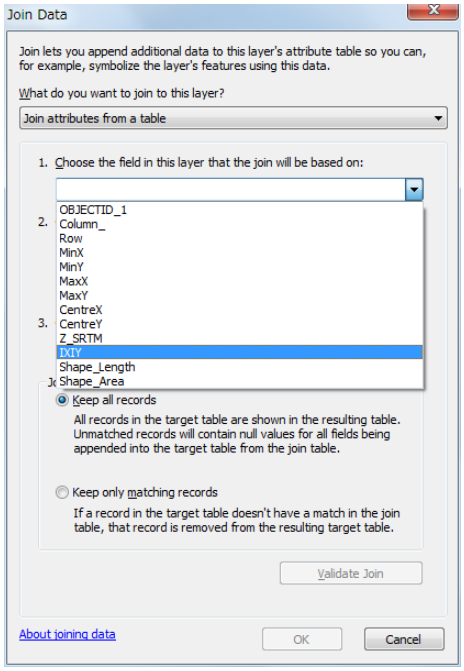

When showing the following dialog, click  button.




Select the table of emission by grid to join and click [Add] (Here it is “GerEmisByKhoroo_2015” table).

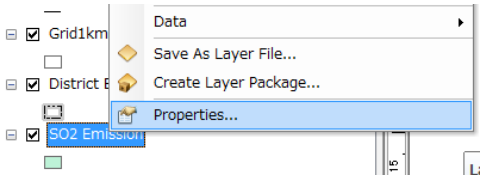



Show the selected table in the dropdown textbox of “2.”. When clicking the dropdown button of “1.” and selecting “IXIY”, show “IXIY” in “3.” automatically. After then, click [OK].

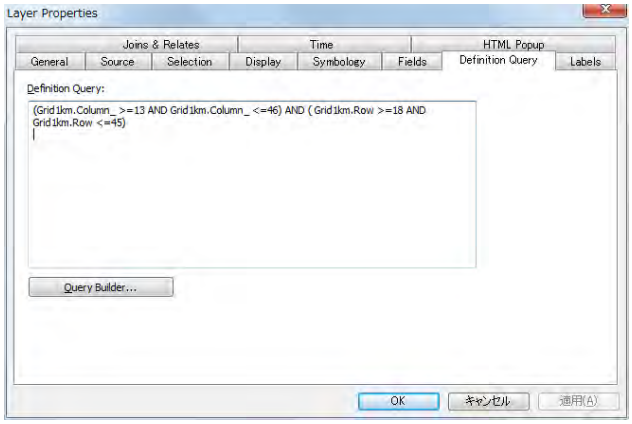



If the following dialog may be shown, click [No].

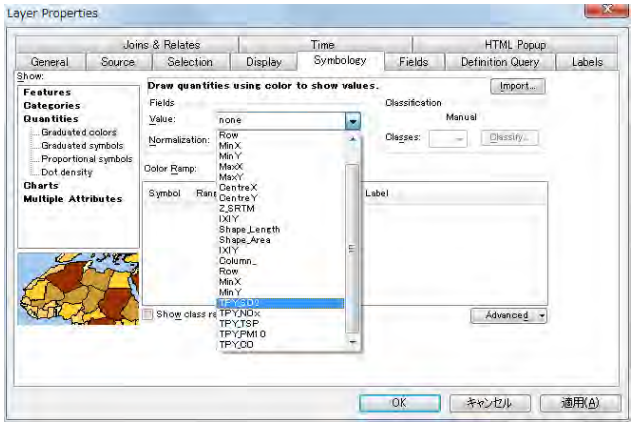

Right-click “SO2 Emission” layer and click [Properties].



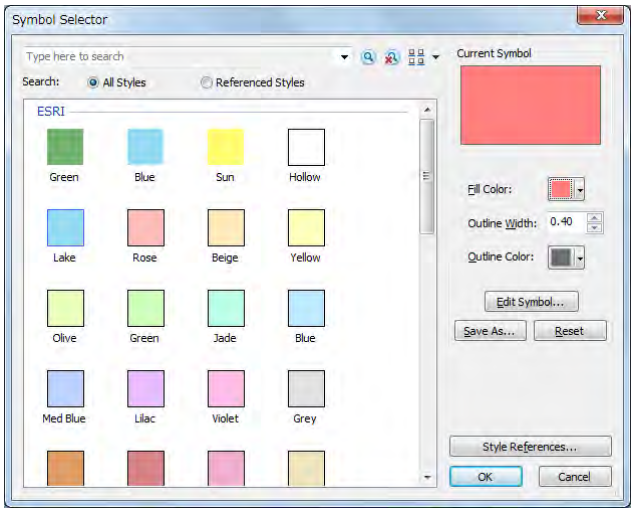

Set the range of viewing.



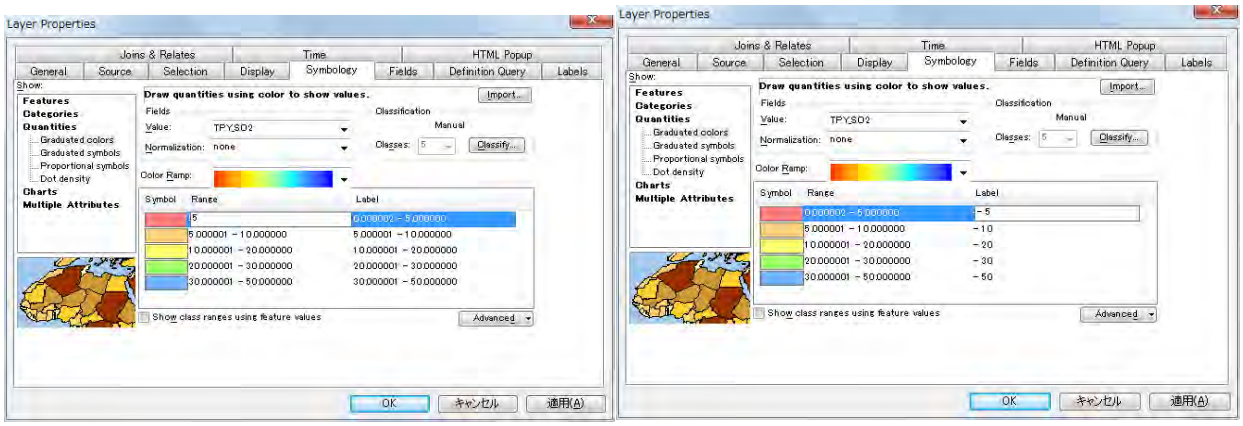
Click [Symbology] tab and select [Quantities]-[Graduated colors]. Click and select the target column name at the drop down button of [Value] (Here it is [TPY_SO2].).



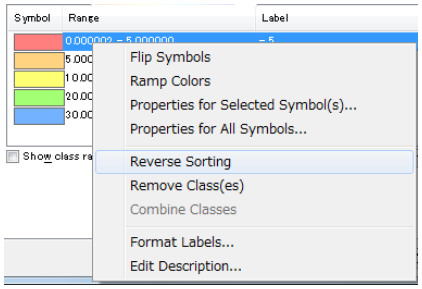

When double-clicking color in [Symbol] column, since the following dialog is shown, select color.



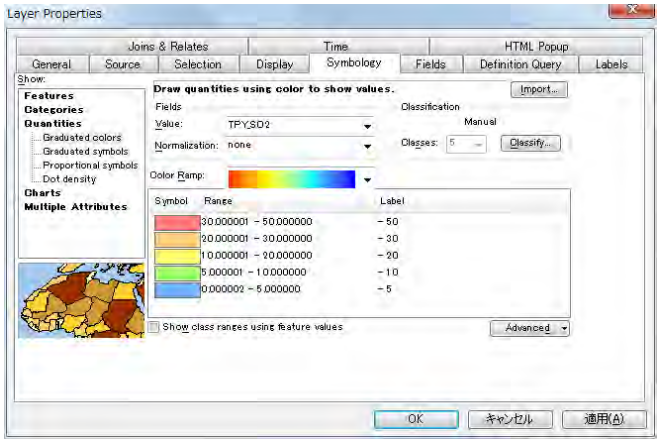

After selecting a rank, click the [Range] of the selected rank and input the maximum of the rank. Input the label to display in legend in [Label] column.



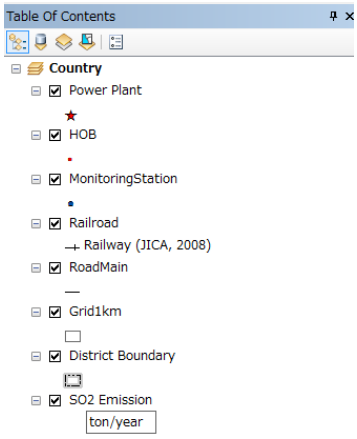
When click [Reverse Sorting] after you right-click on the [Range] column, the display order of rank changes. According to the order of symbol color, decide the display order of rank.



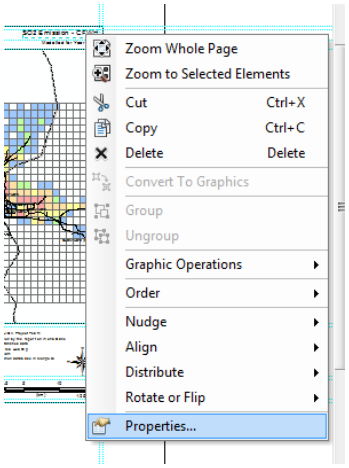

When all setting completed, click [OK].



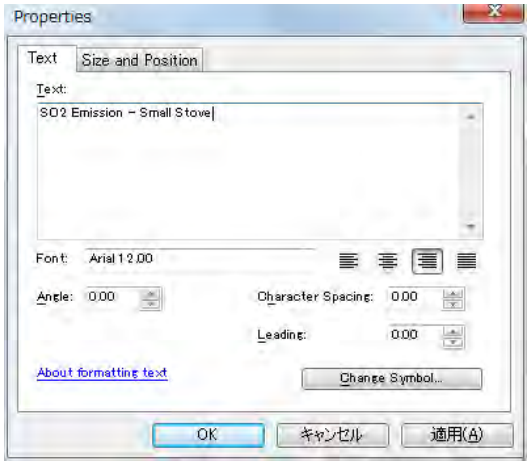

Click “SO2_tpy” of “SO2 Emission” layer and make it editable and change to “ton/year”.



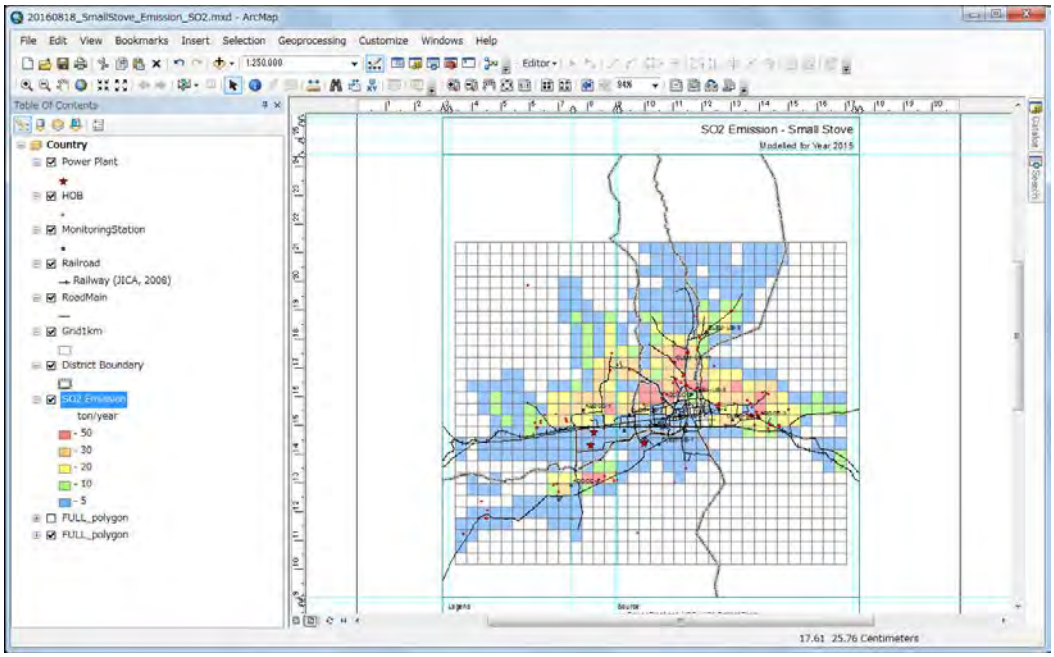

Change the title of this map. Move the cursor to the textbox of title, right-click it, and click [Properties].



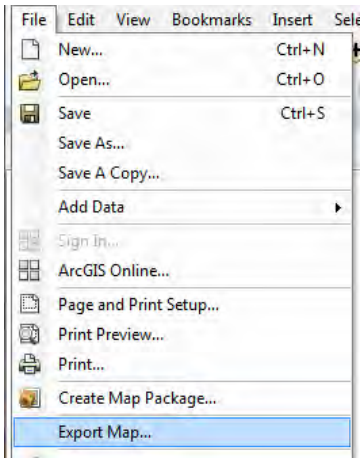

Input a title in [Text] (Here it is “SO2 Emission – Small Stove”.).



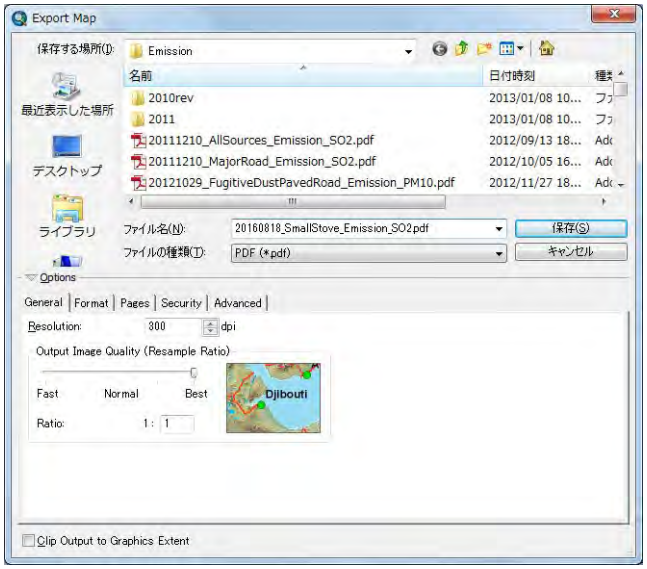

Complete drawing the map by ArcGIS.



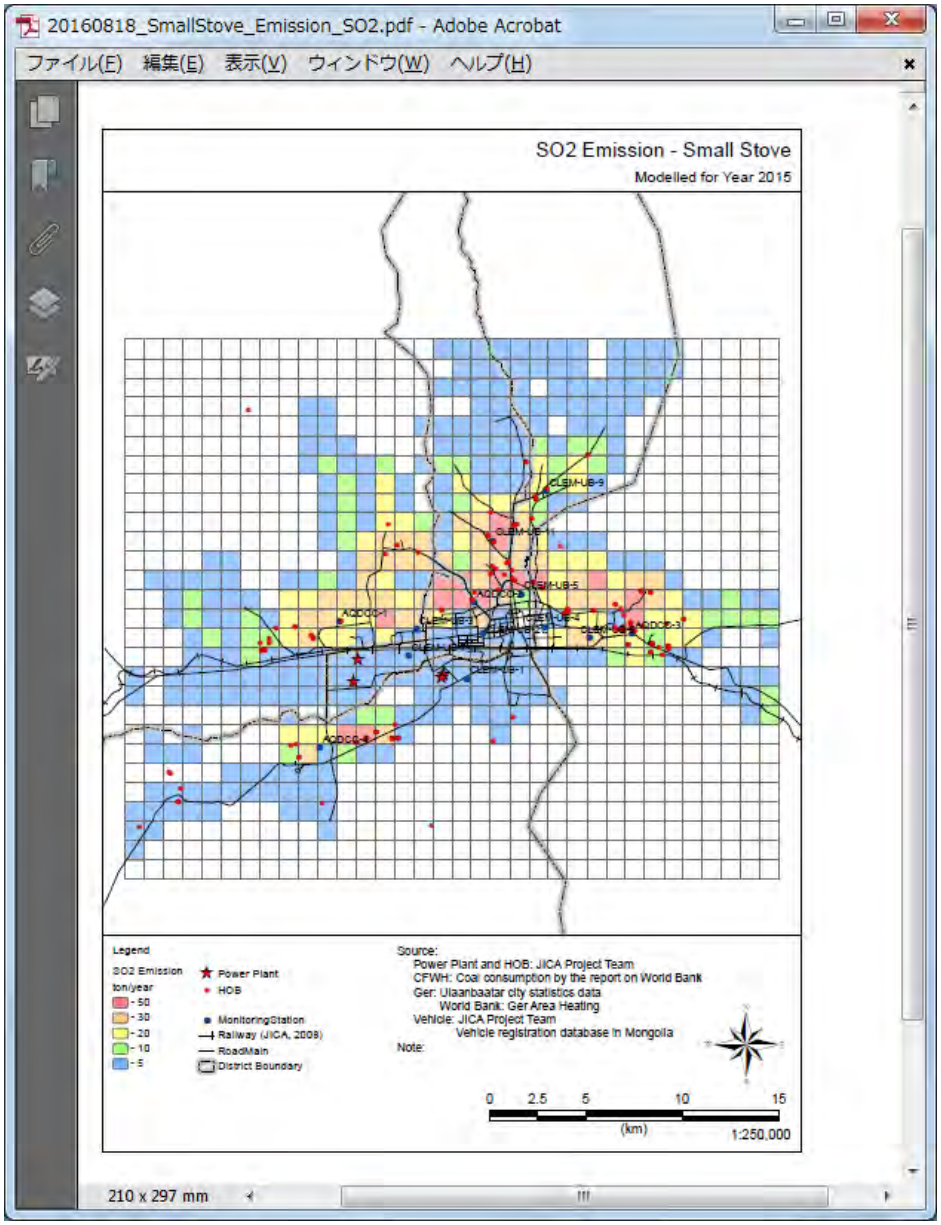
To export the distribution map to PDF file, click [File]-[Export Map].




Setting the destination and file name and click [Save].




Create the PDF file of distribution map.


20160818_SmallStove_Emission_SO2.pdf - Adobe Acrobat
ファイル(F) 編集(E) 表示(V) ウィンドウ(W) ヘルプ(H)
SO2 Emission - Small Stove
Modelled for Year 2015
Legend
SO2 Emission
ton/year
- 50
- 30
- 20
- 10
- 5
Power Plant
HOB
MonitoringStation
Railway (JICA, 2008)
RoadMain
District Boundary
Source:
Power Plant and HOB: JICA Project Team
CFWH: Coal consumption by the report on World Bank
Ger: Ulaanbaatar city statistics data
World Bank: Ger Area Heating
Vehicle: JICA Project Team
Vehicle registration database in Mongolia
Note:
0 2.5 5 10 15
(km)
1:250,000
210 x 297 mm