

## **TCE: A calculation tool optimized for the development and management of non-point emission inventories.**

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### **ABSTRACT**

The Tool for Calculating Emissions (TCE) is an extension to the Regional Pollutant Inventory Development System (RAPIDS) that has been optimized for the workflow and procedures used by non-point source inventory developers. This system includes a development environment that minimizes repetitive tasks, and enhancements for tracking progress.

### **BACKGROUND**

As a result of the Clean Air Amendments of 1990, the United States Environmental Protection Agency (USEPA) required that state agencies submit inventories of criteria pollutant emissions from both facilities and non-point sources. To comply with this requirement many area source inventory developers made the necessary calculations on spreadsheets using one worksheet for each source category and pollutant. Since that time, new initiatives have resulted in the number of pollutants to be inventoried expanding from three to well over a hundred. What started as a manageable, if somewhat tedious, method quickly became too cumbersome and time-consuming to be effective.

Because of our involvement with the Great Lake Commission's (GLC) Air Toxics Inventory Project we adopted the RAPIDS system for storage of our non-point inventories. While the RAPIDS client tool has the functionality to integrate the development and storage of inventory data, its design is not particularly efficient for non-point source use. The main problem is that point source developers approach inventories one source at a time, whereas area source developers tend to think about one source category at a time. Instead of a tool that expects developers to enter information for source-by-source, pollutant-by-pollutant, we wanted a tool that lets the developer focus on methodology for the source category and will handle most of the details of calculating county level data. In addition, we also wanted a tool that would help inventory developers to track their progress along with organizing and prioritizing their work.

## **THE TOOL FOR CALCULATING EMISSIONS**

### **Inventory Approach**

The TCE system supports a top-down approach to developing area source emission inventories. Typically in non-point inventories many counties will share the same calculation methodology for a source category with the only difference being the activity level applied. Many times the same activity level is reused with multiple emission factors, either for additional pollutants or for different sources.

The central idea behind TCE was to develop a database of factors and their associated activity levels. The developer would select the best factor for each pollutant/SCC-code combination and the system would either provide the necessary activity level or prompt the user to enter the required activity information. Because the inventory process is not always that simple, the system would also need to support emissions estimation by speciation and the direct entry of emissions. The calculations must also have the ability to account for growth, controls, rule effectiveness, rule penetration, and double counting.

In addition to managing the necessary calculations, we also needed a system that could store inventory data for a variety of different years and different inventory projects. For this reason it made sense for our calculation tool to be tightly integrated with a database system.

When Pennsylvania started the selection process for a developer we were very careful not to specify a particular technical solution. After reviewing a number of very different approaches, we selected the proposal from Windsor Technologies, which used RAPIDS as a foundation for the system with some internal extensions and a new graphical user interface (GUI) tailored to our specific needs.

### **Inventory Development**

A project in TCE begins with defining the scope of the effort. The project manager defines the sources and pollutants to be inventoried as well as the geographic area. Once the parameters are selected, the “Build Inventory” process assembles all the necessary data structures in the underlying database and establishes a target that the status tracking screens will use to determine what work remains to be completed. In addition to improved performance and tracking, this step allows developers to clearly label each inventory. See Figure 1, which shows the project set up screen; Figure 2, which is the geography project management screen; and Figure 3, which is the pollutants project management screen.

With the scope of the project established, the user can move on to the inventory development screens. This begins with selecting default calculation methods for each SCC/pollutant combination. The method can be emission factor calculation, speciation, or direct entry of emissions. An example showing the default calculation screen is given in Figure 4 and the county specific methods and factors example is given in Figure 5.

Although the RAPIDS system has the ability to attempt multiple methods of calculation, starting with emission factors and resorting to speciation if it is unable to make a factor calculation, TCE will only calculate using the methods and factors selected. The RAPIDS method can be useful, but taking the decision out of the hands of the inventory developer

may add confusion and, in this case, it can impact on the performance of the emissions estimation routines.

Whenever a factor-based calculation is selected, the users are presented with a list of emissions factors already in the database for that source and pollutant. This list will also identify the sort of activity data required for each factor along with the date it was established and a quality rating if available. Typically the user would want to select the most current factor with an acceptable quality rating and available activity level data. If no factors on the list meet the criteria, or the developer wishes to use a custom value, a new factor can be added to the list. This selection screen is shown in Figure 6. A similar screen will allow the user to select an appropriate speciation factor and, instead of an activity level, the pollutant which will be used as a basis for speciation.

### **The Status and Tracking Display**

An important consideration in developing TCE was the ability to be flexible in accommodating different workflows. Some tasks must be completed in a certain order out of necessity, but for most sources the developer should be able to prioritize the work as desired or as the data becomes available.

The Status and Tracking Display depicts basic information about each source category selected for the inventory and the status of the calculation, allowing the developer to see at a glance where additional information is needed. A sample inventory status tracking by SCC screen is shown in Figure 7 and by County/SCC is shown in Figure 8.

Currently the system does not perform any validation or reasonableness checks on the calculations, but it will attempt to determine the reason why a particular emission estimation attempt failed and provide a hyperlink to the screens where the developer can fix the problem. For example, the screen may list some SCC/pollutant codes that do not have default methodologies selected, some that have a methodology but no emissions factor, and some that have factors but no appropriate activity level data.

### **The Emissions Estimator**

The emissions estimation engine that was originally part of the RAPIDS client has been replaced with stored procedures, written in PL/SQL, that remain on the Oracle database server. Performing the calculations on the server side eliminates a significant amount of network traffic and improves the calculation performance. In addition, the centralized code can, in many cases, be altered without having to deploy new copies of the client.

### **Adjustment Factors**

For the most part adding adjustment factors to the inventory is a very straightforward process; the exception to this is the concept of double counting. If we assume that the emissions factor for degreasing, for example, is based on national solvent sales, it's obvious that a significant portion of those sales are to industries that report the emissions as a stationary source. Reporting the same emissions as an area source will double the amount claimed emissions. The Emission Inventory Improvement Program's (EIIP) Area Source Committee addressed this issue, but a clear solution was not presented.

Determining the best method to subtract the point source emissions from the area source inventory is complicated by the fact that point source SCC codes do not match very well with area source SCC codes. To associate similar emissions, TCE makes use of a table that maps one set of codes to the other, and utilizes a database link to query Pennsylvania's point source inventory system. The user will have the ability to review and edit the calculated adjustments on a case-by-case basis.

## **Reporting**

TCE supports some basic reporting for Q/A and data export purposes, but a decision was made early on not to provide any ad hoc reporting capabilities. Because the system is built on top of the RAPIDS database, we can easily run a RAPIDS client and gain all of its reporting functions. In addition, the choice to build the system against an Oracle database has allowed us to use many excellent reporting tools such as the Tool for Oracle Application Developers (TOAD), SAS, and even Excel.

## **Limitations**

The ability to implement the TCE system on top of the RAPIDS database is a testament to the flexibility of the original design. While we tried to preserve as much of that flexibility as possible in the TCE client tool, we felt it was important to keep the most common tasks as simple as possible. This resulted in some limitations of the system.

One such limitation is that the software has less flexibility in the way it handles multi-state data. The GUI assumes that the default calculation methodology entered for an SCC code applies to all states in the inventory. There are several possible workarounds for this issue and adjusting the GUI to better accommodate multi-state inventories has been identified as a possible enhancement, but will not be added to the first version of the software.

Similarly, the system is not designed to store information at the sub-county level. While there are occasions that this is useful, we typically develop county level emissions and apportion them to the sub-county level for modeling using other tools. We felt the limited use would not justify the additional complexity required to add this feature.

Although using an Oracle database it is optional in RAPIDS, the TCE system requires Oracle. RAPIDS is distributed with a basic database system that can run on the client machine, unfortunately marinating this support in TCE would prevent the system from taking full advantage of Oracle's power. In particular, the emissions estimation routines are much faster when implemented as stored procedures in Oracle.

## **System Requirements**

The TCE client tool has been tested with Windows NT 4.0. The database has been tested with Oracle 8.

## **CONCLUSIONS**

When this project was initially conceived, we were very careful to specify the goals we wanted to achieve and not the technology that should be used to meet those goals, giving information technology contractors the flexibility to suggest what they felt were the best

solutions. This approach paid off in a number of very interesting proposals, but required significant effort and technical knowledge on the part of the selection committee to evaluate the alternate methodologies.

By building TCE as a layer on top of the RAPIDS we have been able to make use of much of the work done for that system. We also feel we are contributing to the ongoing RAPIDS development effort by serving as a test platform for some features that have long been discussed as possible enhancements to RAPIDS.

## **REFERENCES**

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<http://www.epa.gov/ttn/chief/eiip/techreport/volume03/index.html>

“System Manual, RAPIDS Regional Air Pollutant Inventory Development System.”  
Windsor Technologies, Inc., 1997

## **KEYWORD**

Emission Inventories

Area Sources

RAPIDS

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Figure 1. Project management screen for the inventory project set up

The screenshot shows the 'Inventory Project Management' window with the following fields and values:

- ID: SCL\_DEMO
- Sheet Desc: SAMPLE Inventory
- Inventory Type: APPEAL AVERAGE
- Purpose: Demonstrational
- Creation Date: 04/05/00
- Creation Date/Time: 06:00:14 AM
- State Code: WV
- Project Manager Name: Steve Demco
- Inventory Period:
  - Start Date: 1/1/00
  - End Date: 12/31/00
  - Numerator Unit Code: TON
  - Denominator Unit Code: YR
- Comment: (empty)

Figure 2. Project management screen by geography

The screenshot shows the 'Inventory Project Management' window with the 'Geography' tab selected. A table displays the following data:

Select Counties	State Name	State Fips	County Name	County Fips
	PENNSYLVANIA	42	ALLEGHENY	003
	PENNSYLVANIA	42	ADAMS	009

Figure 3. Project management screen by pollutants

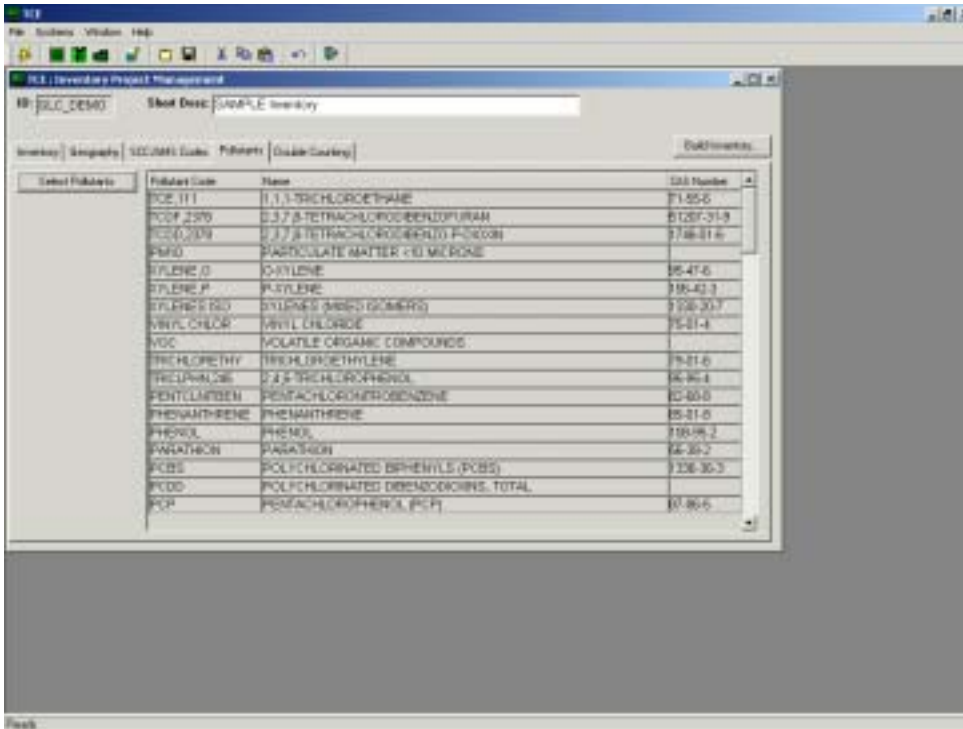


Figure 4. Calculation screen showing default methods and factors

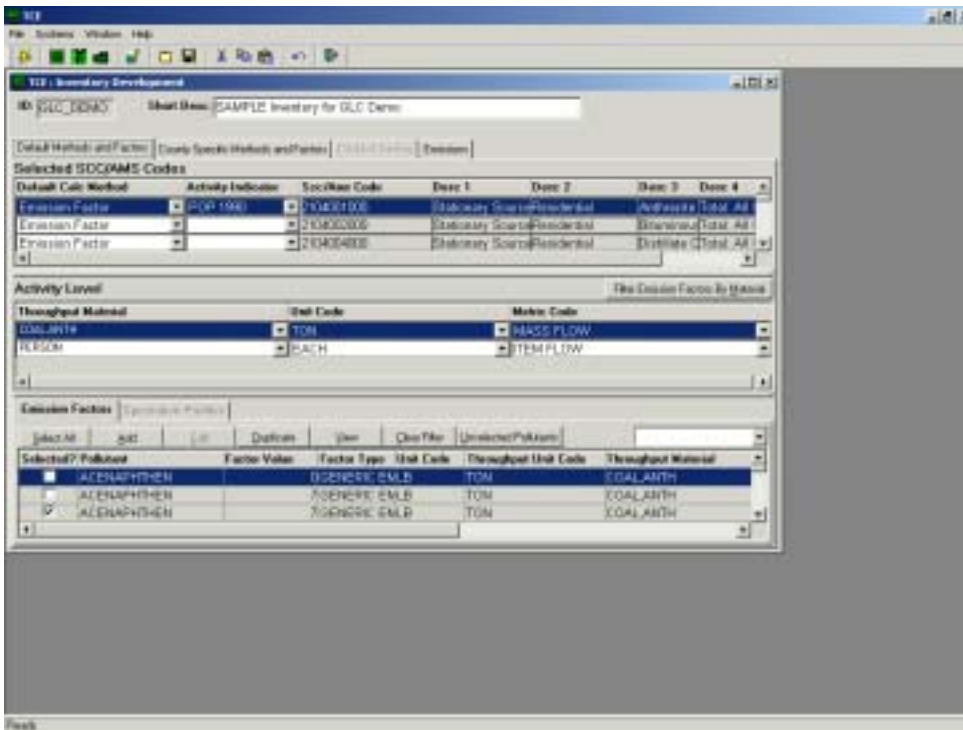


Figure 5. Calculation screen showing county specific methods and factors

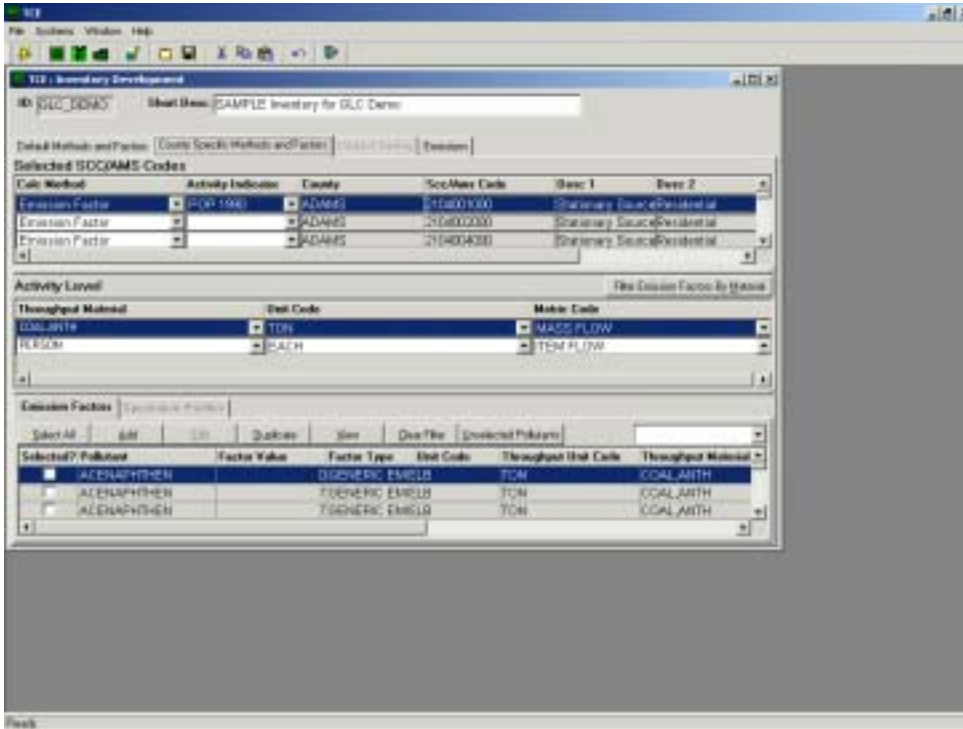


Figure 6. Emission selection screen

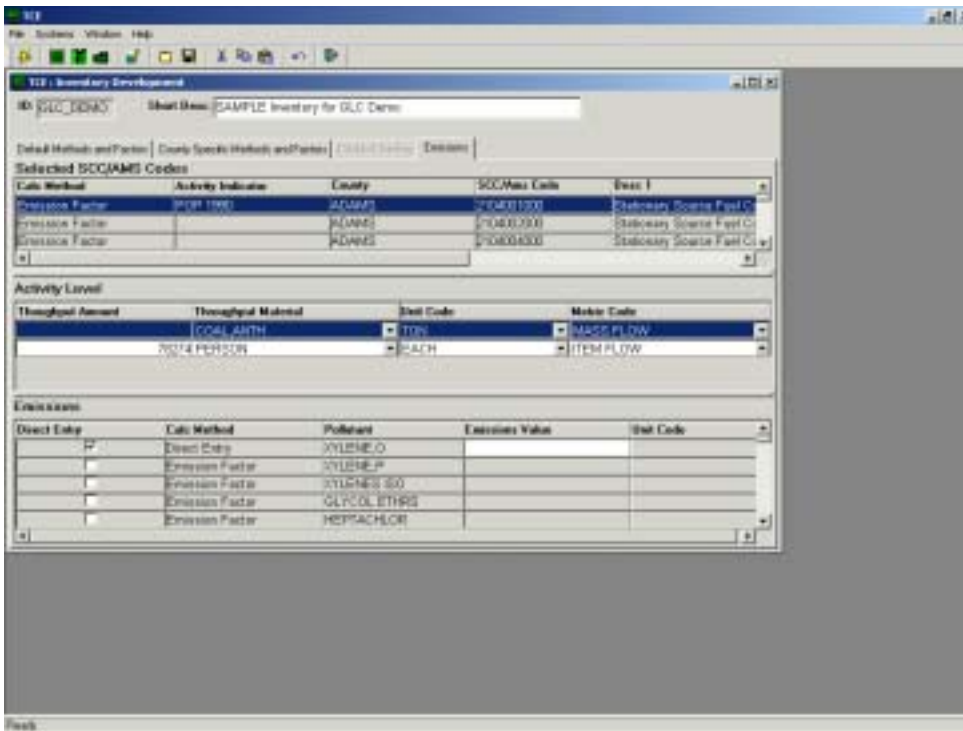




Figure 7. Inventory Status / Tracking by SCC

Inventory Status/Tracking

Sheet Name: SAMPLE Inventory for GLE Demo

Filter: SCC

SCC/MS Code	County Specific Data?	Method Chosen?	Factors/Profile Chosen?	Activity Data Available?	Calculation Complete?
270601808	Y	P	P	F	N
270602308	Y	P	P	F	N
270603308	Y	P	P	F	N
270604308	N	P	P	F	N
270605308	N	P	P	F	N
270606308	N	V	V	F	Y
270607308	Y	P	P	F	N
270608308	Y	P	P	F	N
270609308	Y	P	P	F	N
270609818	N	N	N	F	N
270609878	N	P	P	F	N
270609898	N	V	V	F	Y
270609901	Y	P	P	F	N
270609922	Y	P	P	F	N
270609993	Y	P	P	F	N
270609995	N	N	N	F	N
270609998	N	P	P	F	N

Figure 8. Inventory Status / Tracking by County/SCC

Inventory Status/Tracking

Sheet Name: SAMPLE Inventory for GLE Demo

Filter: County/SCC

County	SCC/MS Code	County Specific Data?	Method Chosen?	Factors/Profile Chosen?	Activity Data Available?	Calculation Complete?
ADAMS	2184001082	Y	P	P	F	N
ADAMS	2184002082	Y	P	P	F	N
ADAMS	2184003082	Y	P	P	F	N
ADAMS	2184004082	N	N	N	F	N
ADAMS	2184005082	N	P	P	F	N
ADAMS	2184006082	N	V	V	F	Y
ADAMS	2184007082	Y	P	P	F	N
ADAMS	2184008082	Y	P	P	F	N
ADAMS	2184009081	Y	P	P	F	N
ADAMS	2184009219	N	N	N	F	N
ADAMS	2184009379	N	P	P	F	N
ADAMS	2184009989	N	V	V	F	Y
ADAMS	2184009991	Y	P	P	F	N
ADAMS	2184009992	Y	P	P	F	N
ADAMS	2184009993	Y	P	P	F	N
ADAMS	2184009995	N	N	N	F	N
ADAMS	2184011082	N	P	P	F	Y
ALLEGHENY	2184001083	N	V	V	F	Y
ALLEGHENY	2184002083	Y	P	P	F	N
ALLEGHENY	2184003083	N	N	N	F	N
ALLEGHENY	2184004083	N	P	P	F	N
ALLEGHENY	2184004983	N	P	P	F	Y