Mapping and Analysis Tools for Emissions on the Internet: Community Health Air Pollution Information System (CHAPIS) for Toxics and Criteria Pollutants

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ABSTRACT

This paper will demonstrate the functionality and design of the Community Health Air Pollution Information System (CHAPIS). It is a tool designed to provide interactive, visual access to emission inventory information over the Internet, using both dynamic maps and tabular data. CHAPIS uses current Geographic Information System (GIS) tools for Internet applications. The goal is to make it easier to access, understand, and use the data in the California Air Resources Board (ARB) emission inventory database, and to tap the potential for using spatial relationships among sources to better understand cumulative air pollution impacts. Analysts and community stakeholders alike can zoom into their neighborhood using "live" maps, and view the spatial relationships and relative contributions of emission sources. The combined contributions of mobile, area-wide, and stationary (point) sources are addressed by using a gridded cell-based approach. Analysis tools are provided, including query tools that calculate summary statistics for an area of interest, and measuring tools to calculate distances between sources and/or receptors, using lines or circles. CHAPIS also links the user to existing web-based tools that directly query the emission inventory relational database. In addition, some of the longer-term visions for the tools will also be discussed briefly.

INTRODUCTION

The California Air Resources Board (ARB) has developed the community health program to ensure that all California communities have clean, healthful air, by placing new emphasis on community health issues in our existing programs. The goal is to ensure that all Californians, especially the children and elderly, can live, work, and play in a healthful environment – free from harmful exposure to air pollution – by addressing both regional smog as well as nearby toxic air pollution. The program includes identifying air pollution's health effects, assessing public health risk in communities, and reducing public health risks. As part of our programs, the ARB is developing tools to assess the cumulative impacts of air pollution at neighborhood scales and providing better access to the data.

The Community Health Air Pollution Information System (CHAPIS) is a tool designed to provide interactive, visual access to emission inventory information over the Internet, using both maps and tabular data. When fully populated, it is designed to help provide useful information to analysts, the community, and land use planners about the spatial relationships and relative emissions between sources of air pollution.

The paper will demonstrate the functionality of the CHAPIS system and will discuss design considerations and tips for delivering a powerful mapping tool over the Internet, yet taking into account older browsers and slow connections. The paper will touch on considerations that arise in populating the data, particularly for air toxics sources. The paper will also briefly discuss some of the longer-term visions for the tools. These include related tools for reviewing ambient air monitoring data, the concept of a centralized Internet "portal", and design efforts underway assessing cumulative impacts due to air emissions.

The ARB designed CHAPIS with programming support from VESTRA Resources.[1]

WHAT IS CHAPIS?

The Community Health Air Pollution Information System is a tool designed to provide access to emission inventory information over the Internet by allowing interactive mapping of emission sources including individual industrial and commercial facilities, as well as mobile and area-wide types of sources. CHAPIS builds upon current Geographic Information System (GIS) tools for Internet applications to generate dynamic, interactive maps as well as provide access to the underlying numeric data. The goal is to make it easier to access, understand, and use the data in the California emission inventory database, and to use the spatial relationships among sources to better understand cumulative air pollution impacts. Analysts and community stakeholders can zoom into a neighborhood using "live" maps and view the spatial relationships and relative contributions of emission sources.

The initial phase of CHAPIS includes emission sources and amounts of emissions. Later versions will include the results of air dispersion modeling to estimate health risk impacts. When most of the emission sources have been fully populated, this phase of CHAPIS is designed to help answer questions like "What are the sources of air pollution in my neighborhood?," "What are the relative amounts of various chemicals emitted?," and "Are there emission sources near my child's school?." The ability to visualize the spatial relationships among air pollution sources, and the proximity of industrial sources, roadways, and other sources relative to sensitive receptors, is also intended to assist those who need to evaluate land use and siting issues.

To address the combined contributions of mobile, area-wide, and stationary (point) sources, a colored "grid" cell approach (1 or 2 km squares) is used (as discussed later), in addition to showing individual industrial facilities as scaled triangles on the map. Analysis tools include measuring tools that calculate distances between map features using either lines or circles, and query tools that list and calculate summary totals for all sources within the user-defined map view. CHAPIS also links the user to existing web-based tools that directly query the ARB's emission inventory relational database. The first phase of CHAPIS is scheduled for public release in summer 2003. By then, the tools will be essentially complete. The underlying emissions database is being populated in stages to ensure the data are as current and accurate as possible.

Overarching Technical Design Strategies

As a government agency serving the public, we desire to support a wide variety of public and internal users. Therefore, CHAPIS has been designed to accommodate differences in web browsers, monitor screen display settings, and connection speeds, to a greater extent than most "out-of-the-box" GIS software permits. CHAPIS must be simple in what it delivers to the user's ("client") computer, to minimize long download times, which large plug-ins would entail, and to ensure compatibility with the widest range and vintage of browsers. This means delivering "thin" client applications, avoiding HTML "frames," avoiding plug-ins, and tailoring some display aspects depending on the user's browser and display settings. The opening page of CHAPIS senses what screen resolution and what type and vintage browser the user has, and makes adjustments accordingly. For example, a user with 800 by 600 pixel screen settings will be sent a slightly smaller map image than a user with larger screen settings. In both cases, the opening page starts with a map in the upper left corner to ensure that the map and most important tools are visible with minimal need to use the scrollbars. These types of adaptations and "thin" client constraints generally require customization beyond the standard GIS software for Internet applications.

In particular, CHAPIS is based on custom programming code using Active Server Pages (ASP), and uses the ActiveX Connector to the ArcIMS software available from Environmental Systems Research Institute (ESRI)[2]. The "state" of the user's window is maintained between refreshes using hidden Form variables. No Java or HTML frames are used in order to maximize compatibility with all browsers. Some Dynamic HyperText Markup Language (DHTML) and JavaScript have been used sparingly, with care taken to ensure compatibility with most browsers.

Basic Functionality of CHAPIS

Ultimately, the CHAPIS mapping application will be available through a hyperlink from ARB's Community Health Program web pages. To advise users of both the abilities and limitations of the data in CHAPIS, users will first be directed through one or more text pages, before launching the map. These pages communicate the context that mobile sources (especially cars and trucks, as well as some off-road diesel sources) generally dominate both the emissions and estimated health impacts, compared to individual stationary (point) sources, in most areas and for most of the key pollutants. It is important to establish this context, to avoid a tendency for users to focus in on the industrial facility symbols on the map to the exclusion of the often more significant mobile and area-wide sources of emissions. These pages also communicate that the initial phase of CHAPIS includes only emission estimates, and that more information is needed regarding the dispersion of those emissions, to estimate actual human exposures and the resultant relative health risks. (Static maps of modeled cancer risk estimates are available elsewhere on the ARB's web site, and improved versions will eventually be included as a later phase of the CHAPIS tool as well.) These opening web pages contain numerous hyperlinks to provide further definitions, background, or related information. These pages also describe which source types have been populated to date, as additional industrial facility data are phased in on a periodic basis. We have tried to design the text to be understandable by non-technical members of the public, with the hyperlinks providing access to more detailed technical information.

After these context pages, the user is presented the start page of the CHAPIS mapping application, to select an initial area of interest. Figure 1 illustrates the start page. This page includes dropdown boxes to choose a county, an air basin, an air district, or one of 20 pre-defined metropolitan regions, or enter a zip code. Clicking the "live" map also selects a county.

Please note that the data displayed in the sample maps in the prototype at this time do not reflect actual, current, or real data. Some data have been mocked up for test purposes.

After selecting an area, the main CHAPIS map window is then displayed for the selected area. Figure 2 shows the main CHAPIS map window, with a sample map based on selecting Los Angeles County. The main map window contains navigation tools (zoom and pan), tools to identify features, and dropdowns and buttons that select various parameters and perform functions. The user can then select a specific pollutant from a dropdown list including the traditional smog-forming (criteria) pollutants or approximately 50 air toxic pollutants. The user can select the "zoom in" tool, and use the mouse to draw a "rubber band" zoom box over an area, to zoom in further.

Figure 3 shows a sample map after selecting benzene as the pollutant and zooming in. The various GIS "layers" of features have scale-dependent visibility, so upon zooming in, more detail becomes visible, as it can be accommodated on the map. At this scale, for example, schools, hospitals, streets, parks and other landmarks, and air monitoring stations become visible. Conversely, the coarse hillshade relief showing the terrain at the statewide and county view is suppressed at this scale because it would become pixilated. A finer terrain layer could be added. However, such a data-intensive layer would degrade program performance. Therefore, we have opted to use only a coarse relief layer for aesthetics when zoomed further out. As another example of scale-dependent design, the airports are represented by two different layers, one showing simple points with an airplane symbol when zoomed out, then automatically switching to a second layer with a polygon outline for the airport (much like parks for example), when zoomed in. The individual industrial and commercial facilities that are included are displayed on the map as black triangles. The facility legend shows how the size of the triangle indicates the relative amount of emissions for the chosen pollutant (in tons per year for the criteria pollutants, and in pounds per year for the toxic pollutants). Different toxic compounds have vastly different ranges of emission levels, so the breakpoints for this legend are read from a lookup table, specific to each pollutant. The "Show Full Legend" button opens a pop-up window showing the meaning of the other symbols. The "Show Layer List" button shows the list of the different types of feature layers, which the user can turn off and on. An overview vicinity map can be toggled on and off from the toolbar. An extensive Help file is available, with definitions and navigation tips, by clicking the Help button.

Note there are two types of informational tips provided for the tools on the toolbar. By hovering the mouse over a tool, the user gets a short instruction on how to use the tool. In addition, when the tool is selected by clicking it, a short instructional tip is displayed in the message area above the map. These use light-weight processing that executes on the user's computer (the "client" machine), and is designed simply in order to be compatible with most browsers. Because they use client-side processing, these tool tips happen instantly, without the time involved for a round-trip back to the ARB's server and a complete refresh of all the graphics on the user's page. This is just one of many examples of design choices to address the need for a "thin" client application. These types of applications avoid the large plug-ins that require slow downloads over modem connections, yet provide instant response on key features that might irritate users if they had to wait for a round-trip back to the server and graphics refresh just to get a quick bit of information. Other examples of these design strategies are discussed in this and the next sections.

The tools on the upper toolbar have been grouped together because they all require a click on the map to execute the chosen function. Some of these tools, like the zoom and pan tools, require that the user merely select the tool then click on the map. Other tools, like the Identify feature tool, require that the user select the tool, have a specific feature layer chosen from a dropdown list in the lower part of the screen, and then click on a feature on the map. To help make the connection clearer between the tool and the associated layer, we repeat the icon for the Identify tool on both the tool bar and beside its corresponding layer dropdown (and likewise for the circle-drawing tool). As a further step to help users, when it is reasonably clear which layer the user intends for the Identify layer, we pre-load the dropdown to select that layer. For example, the facility emission layer is the default for Identify in this current view, but the gridded emission layer gets pre-selected when the user goes into the gridded mode, as shown later. That way, even if the user overlooks or forgets to choose a layer and goes directly to a map click, they will probably get what they intended, instead of waiting for the round-trip to the server and the page refresh, only to find they had the wrong layer chosen.

A challenging task on an Internet-based application (compared to a desktop application) is to provide an instantaneous way for a user to see the names of features on their map view, without an individual "Identify feature" click on each, with a slow round-trip to the server each time. Automatic labeling has poor ability to handle all the possible map scales of interactive maps, and is bound to obscure other features or labels. Desktop software users are accustomed to convenient "hover" (roll-over with a mouse) types of information pop-ups. These are not straightforward for an Internet application, where the changing information content must be retrieved from the server, requiring a round-trip and refresh. As discussed above, this hover-type of tip was reasonably easy to provide for static features like a fixed tool on the toolbar. However, hover tips are not normally possible for dynamically changing features, like particular industries (or schools) in any given map view to which the user has zoomed, because the server must provide new information, and it is not straightforward to render information over the server-generated map area. Yet it would be unacceptable to CHAPIS users to click one at a time on each facility, and wait for a server round-trip to see each name. So a solution was devised to nearly emulate the desktop ability to hover (roll-over) a facility on the map and see its name pop up instantly.

Figure 3 shows how the name of the industrial facility appears in the area atop the map as the user hovers their mouse over the triangular symbol. This solution entails a careful balance between functionality and performance speed. What is done within CHAPIS is a quick count of facilities as any new map view is being prepared on the server, in response to a user action. If 250 or fewer facilities are in the view, these features are queried and a short name attribute is passed to the client machine for these 250 visible features, at the same time as refreshing their overall map view. The names are then available as "hover" tips for the facilities, using client-side processing, thereby creating an instantaneous hover response. Limiting the number keeps the query fairly fast, and only a light-weight amount of data and script are passed to the client, so it does not degrade the overall performance of mapping. This hover capability can be applied to a different layer, for example the schools, by changing the dropdown to select the schools layer. (Changing the dropdown invokes a server trip while the features are loaded, but then they are available for instant roll-over.)

CHAPIS includes a Help file covering navigation and functionality, as well as definitions and further links to more information. In addition, CHAPIS creates a print-friendly version of the map, with an automatic legend, vicinity map, and date, as well as a user-entered title.

Additional Analysis Functions

While primarily a visualization tool, CHAPIS provides some basic analysis capabilities. Besides the map's width being shown, a measure tool can be used to calculate the distance between any two points in the map view using a straight line. Another common distance question is "What is within a half mile of this point?." Therefore, we designed a tool to draw circles of specified radius around any clicked point. Figure 4 shows the result of drawing a circle with a ½ mile radius around a school and a one-mile radius circle around each of two other points.

It is also desirable to have a way to zoom in on the map to some overall zone of interest and be able to get a summary list, totals, and other statistics on all the sources within the entire map view. The "Calculate Statistics" button is designed to do this. This provides users with the underlying numeric data in addition to the map's visual rendering of the data. Again, to ensure acceptable overall performance and a reasonable size pop-up box length, this tool is only activated when the number of facilities in the map view is 100 or fewer. To ensure that the user doesn't wait for a round-trip refresh only to learn there are too many sources for the button to function, a client-side message is generated immediately telling the user if they must zoom-in further before the button will be activated. Like the hover name capability, this works by doing a quick count of features when any new map view is generated, so the count is already known on the client side before they click the button.

When activated, the "Calculate Stats" button provides a pop-up box with numeric, tabular data listed for all the individual sources in the map view, sorted by the amount of reported emissions of the chosen pollutant. Figure 5 shows an example of the "Calculate Stats" result. Again, please note that the data in this prototype are NOT real data. On the figure, other statistics for the total, the maximum, and the average values for the entire map view are shown. Extra steps are taken within the code to display a fixed number of "significant digits" for each pollutant, rather than a fixed number of decimal places, in order to handle the wide ranges of emissions for different toxic pollutants.

Taking advantage of the web's ease of using hyperlinks, the individual sources are each hyperlinked to take the user to more detailed information about each. This link takes the user out of CHAPIS and to an existing web-based query tool called the "facility search engine" tool already on the

ARB's web site. The search engine queries data directly from the ARB's full relational database of emission inventory data. The search engine in turn has hyperlinks to health risk assessment results if the site conducted a risk assessment under California's Air Toxics "Hot Spots" program[3].

At this time, CHAPIS relies on pre-created GIS shapefiles, which are based on a recent snapshot of data for selected pollutants. However, by including the link to the "live" database search engine, the user can get to the full, current data in the emission inventory. For the future, we are developing a version of CHAPIS with the capability to generate spatial data layers "on the fly" using ArcSDE.

CHAPIS also allows the user to limit the display to a particular industry/business type using a dropdown menu. For example, if the user selects oil refineries, these facilities continue to be shown with black triangles, while all other types of industries or businesses are rendered as grayed out triangles. This provides a way to quickly scan an area for particular types of industries.

Toxic pollutants have widely different potencies in terms of health effects like cancer potency, and the pounds of emissions alone is a limited indicator of significance. Therefore, CHAPIS includes an option for "potency-weighted pounds" of emissions in the pollutant picklist. This weights the reported pounds of emissions of each pollutant by its relative cancer potency factor where a California-approved potency is available. The weighted amounts are summed for all pollutants at a facility. This relative parameter allows a more common comparison among pollutants than the pounds alone. A similar potency-weighted approach is used in the Air Toxics "Hot Spots" program as a first step in prioritizing industrial facilities for further evaluation for health risk assessment, and can be done for chronic and acute non-cancer effects, as well as cancer effects.

Combining Mobile, Area-wide, and Stationary Point Sources on a Map: Gridded Emissions

Displaying points on the map for stationary industrial sources is only one part of the overall emission source picture. However, data are not available on a statewide basis to map all the other types of sources with exact locations. This includes all the exact locations and amounts by roadway link of on-road mobile (vehicular) emissions, the off-road mobile sources like construction equipment, or highly dispersed (area-wide) sources like consumer products, architectural painting, and residential heating. These source types are traditionally inventoried only at county-level resolution. In order to find a common basis for mapping these sources along with individual industrial point sources, we use a "gridded emissions" approach. This approach divides the state into coarse "grid cells" (squares) that are one or two kilometers on a side. County-total emission estimates in our statewide emission inventory for on-road mobile sources, off-road mobile sources, and area-wide sources are spatially allocated to these grid cells using spatial surrogates. These spatial surrogates may rely on many complex sources of geographic distributions. For example, a census-based distribution of population may be used for allocating consumer product usage spatially. We also use the estimated traffic volumes on the roadway links of various travel demand model networks to allocate vehicular traffic to each grid cell.

Figure 6 shows a sample map of the gridded emissions functionality. The user can choose one or more combinations of gridded emission layers for on-road mobile, off-road mobile, area-wide, and stationary sources. Any emission source that falls within the grid cell region adds to the total emissions for the grid cell. The grid cells are then rendered by color to show the relative amounts of emissions. When the user clicks a grid cell using the Identify tool, the numeric totals of each source type are displayed in tabular form, in addition to the visual color rendering. Mobile source emissions typically dominate the emissions of the most important pollutants. Therefore, CHAPIS refers users to the gridded option to see combined mobile and other sources, in order to ensure that the overall context of air pollution emission sources will be communicated.

There are limitations to the spatial surrogates that are used, especially for key categories such as the on-road vehicular sources and key diesel off-road categories such as construction equipment, distribution centers, and ports. And the 1 or 2 kilometer resolution of the gridded approach may not be sufficient to capture important near-source differences in emissions and health impacts. To improve the allocation of on-road vehicular sources in the future, we are pursuing the development of a more detailed link-specific emission inventory for roadways, but the nature and resolution of travel demand model networks limits their application for this purpose, which is more exacting than the original purposes for which the networks were developed. In the future, it may be desirable to bifurcate the networks into major, high-volume links that correspond reasonably well to actual, on-the-ground highways and traffic volumes, while continuing to treat the smaller, pseudo-connector links through a coarser grid cell type of approach.

Location-Only Commercial Facilities

Recognizing the challenges in obtaining and maintaining up-to-date, site-specific information for small, widespread businesses such as gasoline stations and dry cleaners, CHAPIS includes functionality to display "location-only" data for these small commercial facilities that number in the thousands in California. The addresses of such businesses are more likely to be available through "electronic yellow page" listings or other agencies (for example, fuel taxation information), than are site-specific throughputs and emission rates. Having the location indicated on the map is useful spatial information relative to receptors and other sources, even without having exact data for each. Generic indications can be provided of the typical kinds of pollutants emitted and the range of risks involved. These location-only facilities are displayed with a different symbol, and when clicked, the Identify box provides generic information and a hyperlink to web pages with more information about these sources and what is being done to control them.

Future Plans

A parallel effort is underway to provide interactive mapping functionality for the ambient air monitoring data measured at monitoring stations around the state. The Air Quality and Meteorology Information System (AQMIS) provides maps of near real-time monitoring data for ozone, particulate matter, and ultimately other pollutants. Likewise, web-based query tools are available for tabular monitoring data and are being expanded. Currently, a CHAPIS user can click on the symbol for an air monitoring station on the CHAPIS map, and it will link them to data about the ambient air measurements from that site. In the long term, we plan to provide enhanced linkages between the CHAPIS and AQMIS applications for a more seamless approach.

The longer-term vision is a "web portal" type of approach, where the user can access many types of data from a common map-based central web location. This might ultimately include not only emissions and air monitoring data, but also eventually include forecasted trends in emissions, the modeled health risks due to the emissions, and perhaps other types of data such as census data.

For CHAPIS itself, the data for individual stationary sources will continue to be populated on an on-going basis. While the initial CHAPIS release includes only a limited number of the individual industrial facilities, additional sources will be added over time. Efforts are also underway to improve the spatial allocation parameters for important mobile and area-wide sources, as mentioned in the gridded emissions section. Data quality is a key consideration for a publicly accessible web-mapping site such as CHAPIS. Even though the underlying numeric emission inventory data have been public all along (for example through data requests and the web-based tabular query engine), there was considerable renewed focus on data quality issues and sensitivity regarding the data as the CHAPIS map prototype was being developed. Presenting the data in a more accessible and easy-to-use manner on GIS-based maps over the Internet makes it more imperative than ever to ensure accuracy of the data.

Particularly for emissions of air toxics from individual industrial and commercial facilities, there was a renewed focus on how accurate and current the reported data under California's Air Toxics "Hot Spots" program were. In addition, the reported location coordinates, which had very little quality control checking in the past, needed to be re-evaluated. A combination of geocoding using address-matching GIS techniques, in comparison to reported latitude/longitude or UTM coordinates and in some cases imagery data, was needed to better represent the location of sources. For these reasons, it was decided to phase in groups of the individual industrial facilities, allowing time to focus on the data quality for each group.

In addition to the emission maps, the long-term goal is for CHAPIS to also display maps that reflect the estimated potential health risks modeled from exposure to the emissions. Figure 7 outlines the future vision for tools to help with the overall assessment of air pollution impacts. In the long-term, the risk maps are being developed to help address questions such as "What is the relative risk in my neighborhood?" or "What are the cumulative impacts of air pollution?."

As part of our community health and environmental justice programs, the ARB has two detailed Neighborhood Assessment Program (NAP) studies underway in California. The NAP studies combine very detailed source characterization, monitoring, and air dispersion modeling in an effort to better understand cumulative impacts due to air pollution. The lessons learned from these studies will be important in California's efforts to address cumulative impacts.

Modeling the concentrations, exposures, and potential health risks resulting from the emissions is a complex process involving multiple components. Conducting microscale dispersion modeling is important to address the near-source impacts of key sources, such as busy roadways and other types of sources such as ground-level releases of diesel particulate matter or hexavalent chromium. However, it is also important to assess both the regional contributions of emissions and the atmospheric formation of pollutants such as formaldehyde and 1,3-butadiene. To address these issues of long-range transport and secondary formation, regional grid modeling is needed, in addition to microscale modeling, to capture the complete range of cumulative impacts.

The ARB is pursuing a combined approach, using regional airshed models and microscale modeling, to address statewide cumulative impacts. It is a major endeavor to use traditional regional grid models—which are generally designed for a few episode days—to estimate the long-term annual average concentrations needed to assess cancer and chronic non-cancer health risks. The long computation times and detailed chemistry mechanisms are key considerations. Sensitivity analysis and other computational techniques are being pursued to appropriately integrate and overlay the relatively coarse regional grid modeling results with the results from microscale modeling of key near-source impacts. Tools are also being developed to estimate the potential health risks from the modeled concentrations, based on health values and risk assessment methods approved for use in California. The ARB is sponsoring the development of the HotSpots Analysis and Reporting Program (HARP) software to support site-specific risk assessment. The long-term goal is to develop a methodology and tools for addressing cumulative impacts of air pollution. This includes providing basic statewide information to help support decision-making, as well as providing tools like HARP to support detailed, site-specific evaluations that may require additional local data collection efforts.

CONCLUSIONS

In summary, the CHAPIS web-mapping tool is designed to help users to visualize and analyze emission data spatially. Many aspects of the GIS design have been customized to provide powerful mapping capabilities, while maximizing compatibility with the wide variety of browsers, connection speeds, and computer capacity among members of the public. The long-term goal for ARB's web-mapping approach is to provide a unified approach for communicating information regarding emissions, air monitoring data, modeling and toxic risk information, and other data with spatial attributes. Ensuring good data quality is key to a publicly accessible web-mapping application such as CHAPIS. Putting the various types of data and sources of emissions into context is a key goal in appropriately communicating information through the CHAPIS tool. When fully populated, the tool is designed to help provide useful information to analysts, the community, and land use planners about the spatial relationships and relative emissions among sources of air pollution. Better communicating the wealth of data available, in ways that can be accessed and understood by all interested parties, is a key goal of the ARB's community health and environmental justice programs. By promoting greater involvement and making data more available, our goal is to improve the decision-making process and thereby improve the quality of life for Californians.

REFERENCES

1. VESTRA Resources, Inc., 962 Maraglia Street, Redding, California 96002. Programming support for CHAPIS and ArcIMS Active X Connector applications.

2. Air Toxics "Hot Spots" Information and Assessment Act of 1987, California Health and Safety Code, Sections 44300 – 44394.

3. Environmental Systems Research Institute, Inc. (ESRI), 380 New York Street, Redlands, California 92373. Software products including ArcIMS (for GIS mapping over the Internet), ArcSDE (for spatial database applications), and ArcGIS and ArcINFO (for mapping and analysis).

DISCLAIMER

The views reflect those of the staff, and do not necessarily reflect the views, policies, or opinions of the Air Resources Board. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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FIGURES

Figure 1. CHAPIS Start Page.

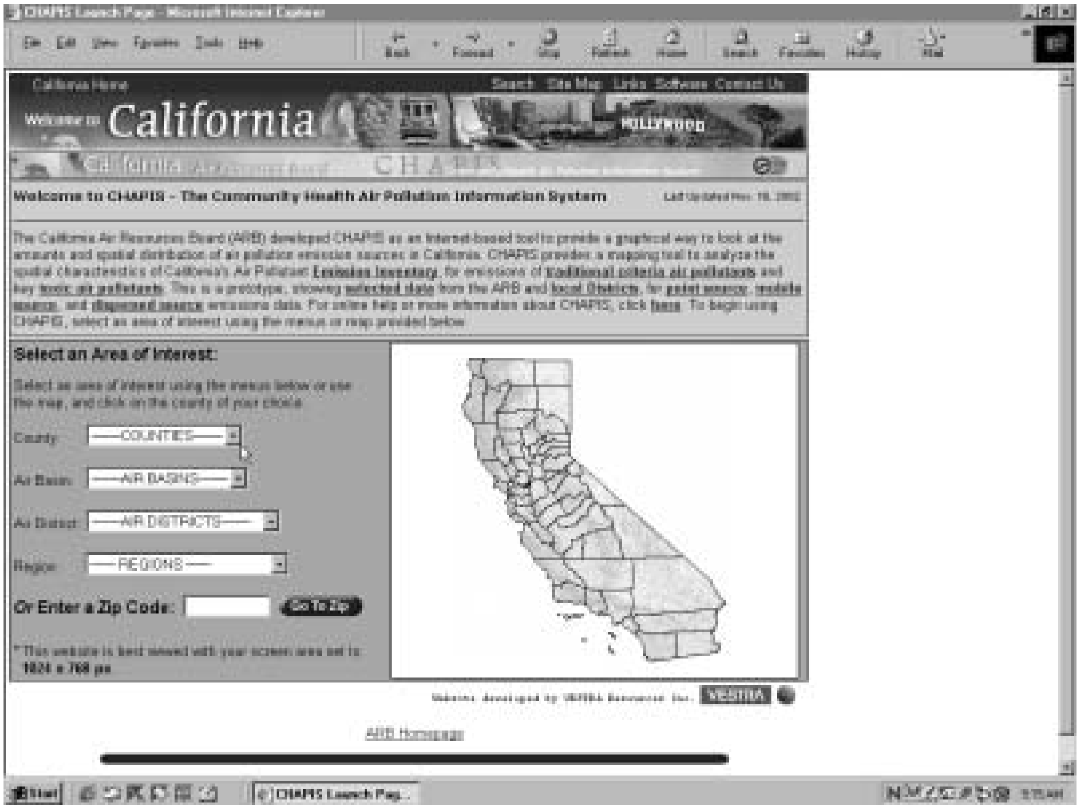


Figure 2. CHAPIS Main Window. Choose a pollutant and zoom in.

Figure 3. Sample CHAPIS Map with Point Sources, Roads, Schools (scale-dependent).

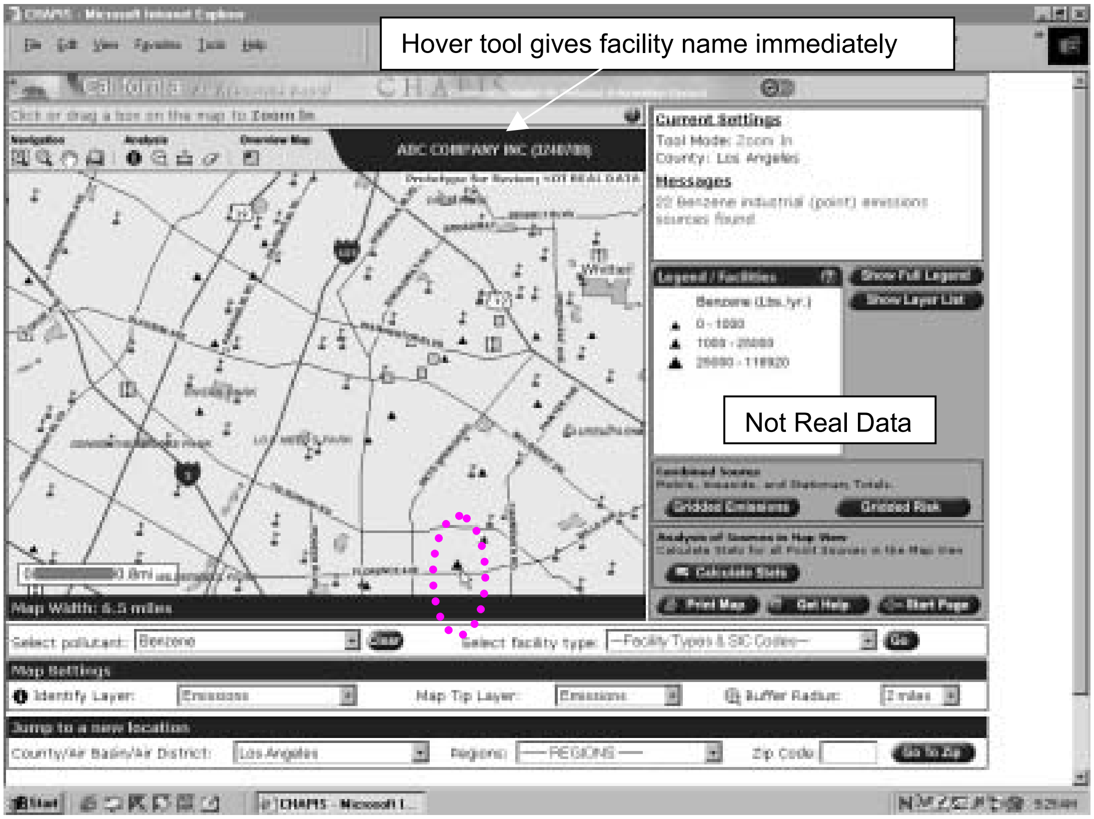


Figure 4. Measure Distances with Circles (or Lines).

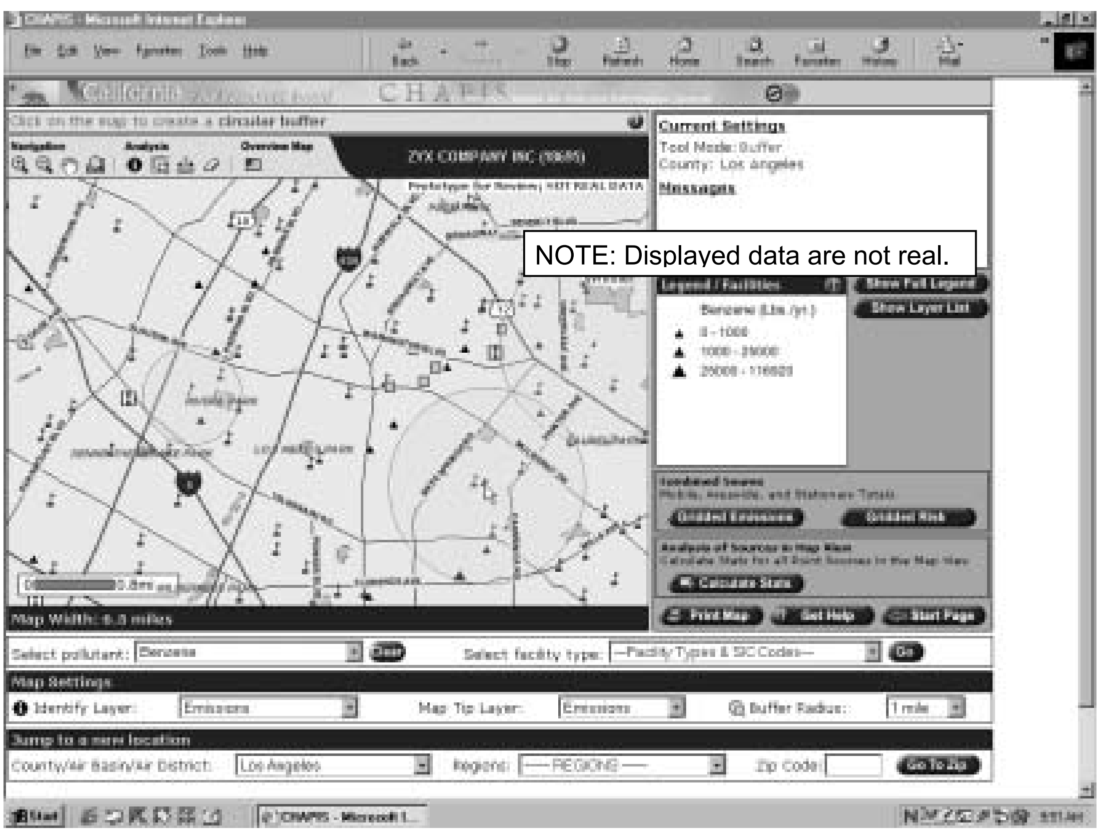


Figure 5. Calculate Summary Statistics for Facilities in the Map View.

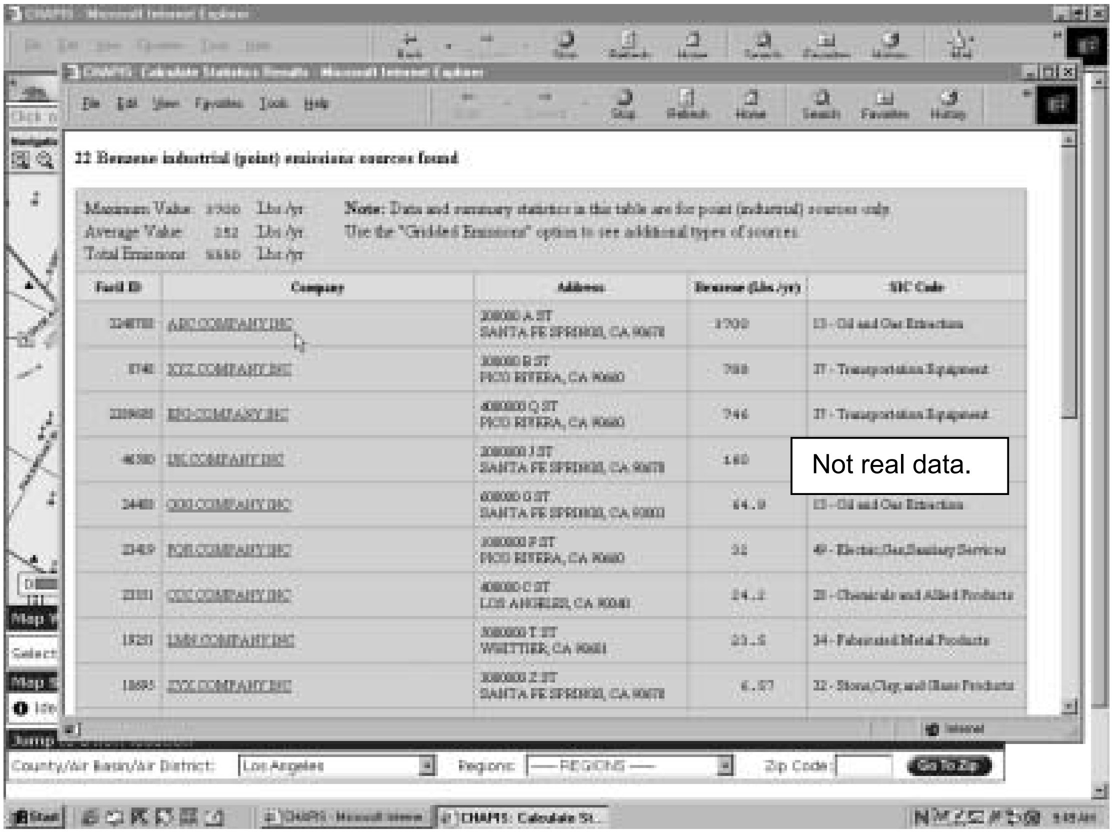


Figure 6. Gridded Emissions: Combines Mobile, Areawide, and Point Emissions.

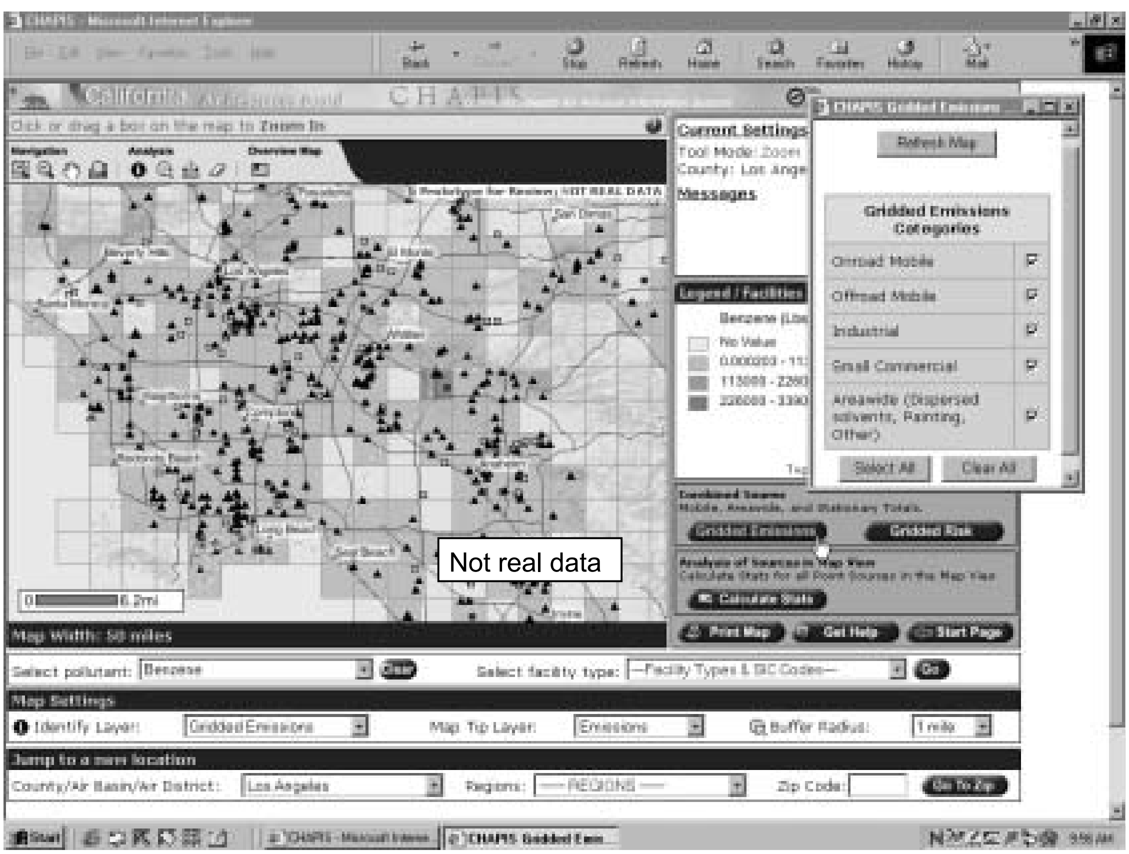
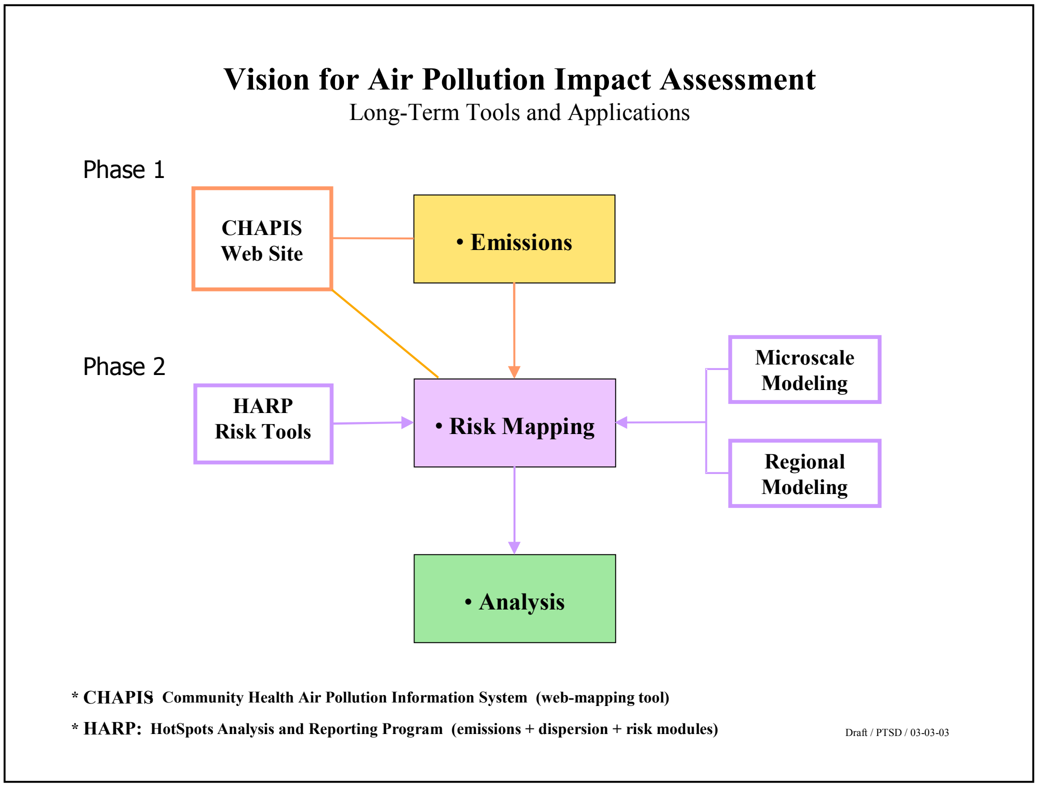


Figure 7. Vision for Air Pollution Impact Assessment.



KEYWORDS

Air Toxics
Community Health
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Emission Inventory
Environmental Justice
GIS