

1. Report No. FHWA/TX-05/0-4249-2		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle INFORMATION SYSTEM FOR FACILITATING THE USE OF NONHAZARDOUS RECYCLED MATERIALS IN CONSTRUCTION				5. Report Date September 2003 Resubmitted: December 2004	
				6. Performing Organization Code	
7. Author(s) Harlow C. Landphair, Christopher D. Ellis, Cindy K. Estakhri, and John H. Overman				8. Performing Organization Report No. Report 0-4249-2	
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No. Project 0-4249	
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P. O. Box 5080 Austin, Texas 78763-5080				13. Type of Report and Period Covered Technical Report: September 2001- August 2003	
				14. Sponsoring Agency Code	
15. Supplementary Notes Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration. Project Title: Natural Resource Utilization in the Construction of Transportation Facilities and Role of Recycled Materials					
16. Abstract The need to conserve finite natural resources and extend the life of existing waste disposal facilities has prompted a national mandate, Resource Conservation and Recovery Act (RCRA), Pub. L. 94-580, to utilize nonhazardous recyclable materials in manufacturing, agriculture, construction, and maintenance operations. However, gaining acceptance for the use of nonhazardous recyclable materials (NRMs) continues to be difficult. The reasons for this vary widely. Some of the delay is resistance related to concerns about the quality of finished products made with recycled materials compared to those made with natural raw materials. On the other hand, the lack of reuse can be related to a simple lack of information about the waste stream and the infrastructure for generating and incorporating quality recycled materials into finished construction products. The focus of this effort was on the latter issue of information collection and dissemination. This project identified nonhazardous recyclable materials that could replace a significant volume of virgin material used in highway construction and developed a web-based application for the collection and dissemination of information about these materials. The database application satisfies two primary objectives. First, it provides the Texas Department of Transportation (TxDOT) and other potential users, processors, or distributors of NRMs information about the source of quality NRMs. Second, it provides generators, processors, and marketers of NRM products with information about the potential market represented by TxDOT's construction projects. The system as designed may also have some application in gathering information required for compliance reporting to regulatory agencies.					
17. Key Words Recycled Materials, Waste Products, Coal Combustion By-products, Industrial Sands, Recycled Concrete, Bituminous Roofing Waste, Tires and Rubber, Glass, Compost			18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service Springfield, Virginia 22161 http://www.ntis.gov		
19. Security Classif.(of this report) Unclassified		20. Security Classif.(of this page) Unclassified		21. No. of Pages 86	22. Price

INFORMATION SYSTEM FOR FACILITATING THE USE OF NONHAZARDOUS RECYCLED MATERIALS IN CONSTRUCTION

by

Harlow C. Landphair, PhD
Research Scientist
Texas Transportation Institute

Christopher D. Ellis, PhD
Assistant Professor
Department of Landscape Architecture
Texas A&M University

Cindy K. Estakhri, P.E.
Associate Research Engineer
Texas Transportation Institute

and

John H. Overman, AICP
Associate Research Scientist
Texas Transportation Institute

Report 0-4249-2

Project Number 0-4249

Project Title: Natural Resource Utilization in the Construction
of Transportation Facilities and Role of Recycled Materials

Performed in cooperation with the
Texas Department of Transportation
and the
U.S. Department of Transportation
Federal Highway Administration

September 2003

Resubmitted: December 2004

TEXAS TRANSPORTATION INSTITUTE
The Texas A&M University System
College Station, Texas 77843-3135

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the Federal Highway Administration (FHWA) or the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. The researcher in charge was Harlow C. Landphair, Registered Landscape Architect, State of Texas, license number 651.

ACKNOWLEDGMENTS

The authors would like to thank the project director, Jeff Seiders and the entire Project Monitoring Committee: Tony Tijerina, Charles Gaskin, David Boswell, Tomas Saenz, and Rebecca Davio, who provided outstanding support and advice throughout the project. Special thanks also go to Tom De La Portilla for his assistance with the TxDOT data tracking systems. We also appreciate the contributions of many other TxDOT personnel in the Construction Division and General Services Division, who took time to provide insights and information that contributed to the project's success. In addition to the TxDOT personnel who have contributed to the project, we would also like to recognize the many cities and materials organizations that took time to review and comment on the merits of the project. We sincerely appreciate their help.

Chun-Man Cho, Jeong-Hun Mok, and Serena Gibson also contributed research time and content to this report. Finally, we wish to express our appreciation to TxDOT and the Federal Highway Administration for their financial sponsorship of the project.

TABLE OF CONTENTS

	Page
List of Figures.....	ix
Purpose.....	1
Construction Material Cycle.....	3
TxDOT Construction Projects	3
Candidate Recycling Materials for TxDOT Construction Projects	4
Waste Stream Reliability, Infrastructure, and Economics of Recycling	7
The Waste Stream	7
NRMs in General Use.....	7
Industrial Sands, Roofing Shingle Waste, and Ceramic Waste	8
Plastics	8
Glass.....	8
Rubber.....	9
Toner	9
Blast Furnace Slag	10
Compost	10
Need for Better Information Tracking	11
Tracking Information about Recyclable and Recycled Materials	13
Information Gathering	13
Information Dissemination	13
Availability of Material Data and Material Suppliers.....	13
The Potential Market.....	15
NRM Use Information	16
Frequently Asked Questions	16
Specifications Links.....	16
Other Issues of System Design	17
NRM Tracking System	19
Header, Navigation Bar, Main Screens, and Footer	21
Materials Module	21
Suppliers Module	30
TxDOT Module	31
Conclusions.....	33
System Feasibility.....	33
Useful Data and System Parts.....	33
Cost Effectiveness.....	34
Recommendations	35
Seek Joint Participation.....	35
Potential Market Information.....	35
Further Research	35
Bibliography	37
Appendix A Nonhazardous Recyclable Materials Tracking System	
Prototype Application	43

Appendix B Texas NRMs Tracking System CD-ROM Contents..... 53
Appendix C ASP, HTML, and Javascript Function Quick Reference 57

LIST OF FIGURES

	Page
Figure 1. Construction Materials Cycle.....	3
Figure 2. Structure of the TxDOT Nonhazardous Recyclable Materials Information System.....	18
Figure 3. Nonhazardous Recyclable Materials Information System Home Page.....	20
Figure 4. Material Availability Query Page.....	21
Figure 5. Material Availability Query Return.....	22
Figure 6. Material Availability Update Login Page.....	23
Figure 7. Material Availability Update Page	24
Figure 8. TxDOT Material Use Query Page.....	25
Figure 9. Material Market Use Table.....	26
Figure 10. Specifications and Material Quality Page	27
Figure 11. Materials Specifications Page with Bid Items.....	27
Figure 12. TxDOT Online Materials Specifications.....	28
Figure 13. Frequently Asked Questions Page.....	29
Figure 14. Example Question and Answer to a Frequently Asked Question	29
Figure 15. New User Registration Form.....	30
Figure 16. Map of Active and Inactive Quarries in the State of Texas	31
Figure A-1. Proposed System Architecture	46
Figure A-2. Server Folder Structure	48
Figure B-1. NRMs Information System CD-ROM Folder Structure	55

PURPOSE

TxDOT developed this system to:

- track the availability of recyclable and reusable materials for transportation construction projects;
- educate designers, contractors, waste generators, material processors, and potential suppliers of reclaimed materials about the availability of materials, reliability of the waste stream, quality specifications, potential uses, and environmental characteristics of recyclable and reclaimed materials;
- conserve and extend the life of the existing sources of virgin materials;
- conserve and extend the life of waste disposal sites; and
- assist in gathering information required to meet regulatory mandates related to use.

CONSTRUCTION MATERIAL CYCLE

TXDOT CONSTRUCTION PROJECTS

Figure 1 is a schematic of the materials cycle beginning with the extraction or harvest of raw materials and then transformation to a commodity. The commodity is then incorporated into a finished material or product and used for some purpose such as road building or other consumer product. When the useful life of that structure or product is over, it then becomes a part of the waste stream. That waste stream can either terminate in a landfill, or the material may be recycled for further use. It is believed that having better information about the availability, market, and potential application of recyclable materials will help increase their use.

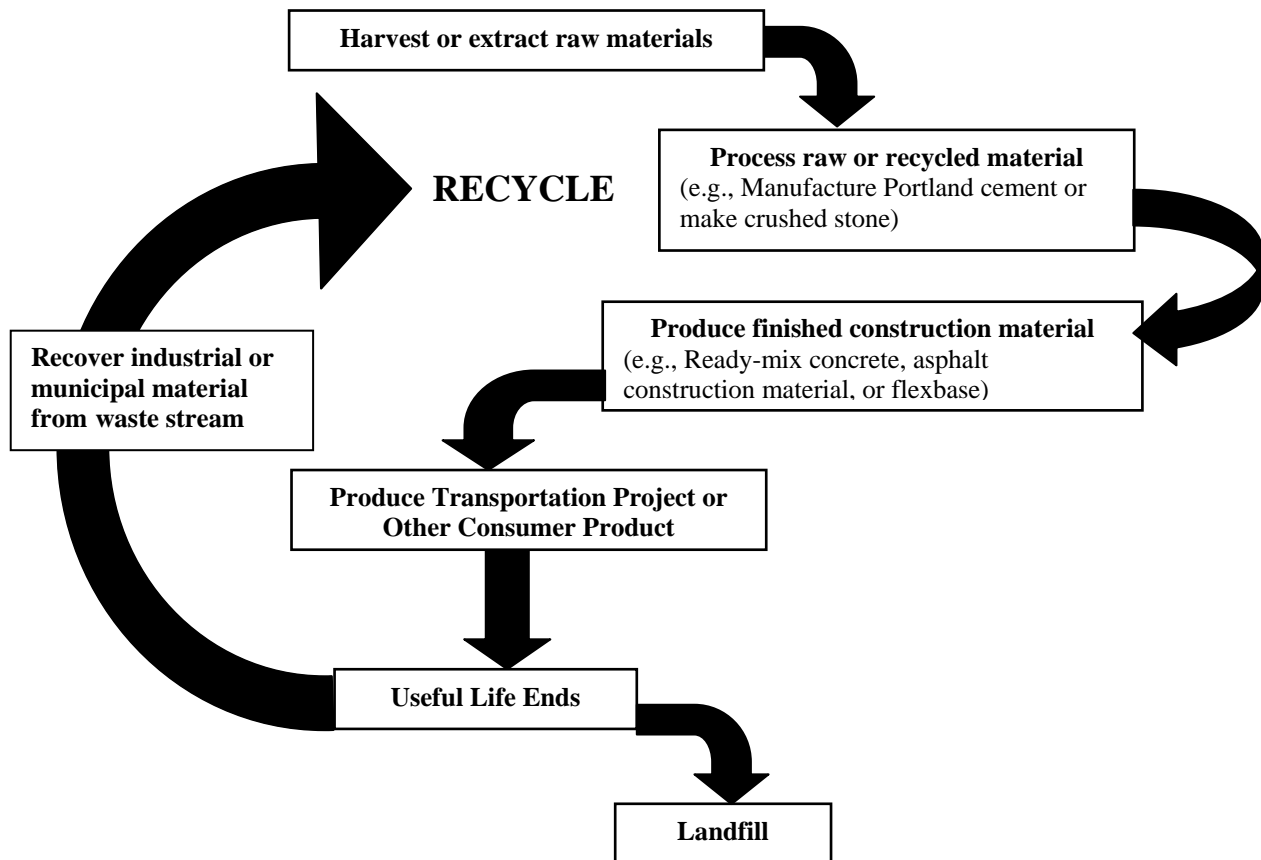


Figure 1. Construction Materials Cycle.

CANDIDATE RECYCLING MATERIALS FOR TXDOT CONSTRUCTION PROJECTS

Several materials have been considered as candidates for recycling into TxDOT projects and tested in one or more demonstration projects. The broad list includes:

- plastics,
- glass,
- rubber,
- roofing waste,
- ceramic waste,
- industrial sands,
- toner,
- composts,
- recycled asphalt,
- recycled concrete,
- fly ash, and
- slag.

All of these materials have been tested for use in a variety of transportation projects. Most materials can be incorporated successfully without any adverse environmental impact and, in some cases, actually improve the performance of materials made entirely of virgin raw materials.

Over the past two decades, the pressure to recycle materials has increased in response to environmental concerns associated with the operation of waste disposal sites and the desire to conserve finite resources. However, in order for materials of all types to be reused there must be a waste stream of sufficient volume, quality, and reliability to support an evolving reuse market. Next, there must be sufficient infrastructure to transport, process, and distribute the reprocessed materials to the point of use. Finally, recycling of materials must make economic sense. This does not imply that the recycled material itself must be less expensive; however, it must make economic sense in the context of the regional marketplace.

For example, many large urban centers have exhausted native reserves of sand and gravel and must now import aggregates from considerable distances. As the distances increase, the transport costs begin to outpace the costs associated with reprocessing and reusing concrete, glass, and asphalt materials for pavements and roadbeds.

The original concept of developing a nonhazardous recyclable materials (NRMs) information system assumed that market forces and the pressure to remove many of these materials from the waste stream being directed to landfill sites would create the infrastructure and demand to make the use of recycled materials in transportation construction practical.

If one considers the information posted on many of the public web sites concerned with recycling in Texas, it would appear that this is a good assumption. However, upon closer examination, researchers found this was not the case. In fact, less than half of the materials listed for consideration demonstrate strong potential for reaching broad general use within the foreseeable future unless there are changes in current practice in the materials marketplace.

Critical concerns identified in this study that discourage greater use of NRMs in transportation facility construction include:

- lack of information about the suitability of NRMs in construction,
- lack of knowledge about appropriate specifications for using NRMs,
- lack of knowledge about sources of NRM-based materials suitable for construction,
- lack of knowledge about the potential market for products currently in the waste stream, and
- skepticism about the reliability of NRMs in construction.

Clearly, the common thread in all of these concerns is a lack of information and knowledge about NRMs in general. For this reason, this project focused on the creation of a “Web-Based Information System” that provides a wide range of information to fill these identified critical information gaps. Critical concerns in creating the system included:

- The system should reach a wide audience including waste generators, NRM processors, brokers, general contractors, consultants and TxDOT personnel.
- The system should require a minimum of effort to keep up-to-date.
- The interface of the system should be simple and easy to use.
- Information should be spatially referenced.
- The system should be open so that it can be readily ported to other software environments.

These goals were generally met in the system developed and described in this report.

WASTE STREAM RELIABILITY, INFRASTRUCTURE, AND ECONOMICS OF RECYCLING

This section provides a brief overview and summary of the NRMs found to have the greatest application in transportation construction, setting the stage for the description of the TxDOT Nonhazardous Recyclable Materials Information System (NRMIS).

Four primary forces ultimately determine the ability of a particular material being recycled on a regular basis:

- the reliability and quality of the waste stream,
- the infrastructure needed to transport and process the recyclable material,
- the positive economics needed for a particular market region, and
- the consumer population must be knowledgeable.

THE WASTE STREAM

For some recycled materials, regulations require special collection efforts, and the waste quality must be considered. There must be a collection system in place that provides separation of recyclable material streams. For materials like glass and plastic, sorting and purity are major considerations. These requirements for purity complicate the sorting and preprocessing process. Highly specialized materials such as industrial sands, ceramic waste, roofing shingle waste, and the like are closely tied to where the waste is generated. In addition, there may not be a continuous waste stream of sufficient quantity to meet the demands of transportation construction projects, which may require long-term storage of materials in order to accumulate quantities sufficient to meet quantity demands.

NRMs in General Use

Several NRMs have reached a level that would be considered general use. These include: recycled asphalt pavement (RAP), recycled concrete material (RCM), and fly ash. While all of these materials are not in general use in all areas of the state, they do have a high level of acceptance and have demonstrated good results where in use.

Industrial Sands, Roofing Shingle Waste, and Ceramic Waste

The generation of usable industrial sands, roofing waste, and ceramic waste are what might be called point source materials. These materials are associated with manufacturing operations that produce limited quantities of waste material. This waste material must be accumulated and stockpiled over an extended period of time in order to provide a large enough quantity to be used in a major construction project. The limited availability of these materials and space required for storage limits widespread use. However, local jurisdictions and TxDOT districts that have sources that produce a viable waste stream may benefit by working with generators on a one-on-one basis.

Plastics

Recycled plastics have been used in demonstration projects as blocks for guard rail sections, sign post replacements, and parts of signs and other roadside furniture. However, because recycled plastic is generally not used in transportation construction without first being manufactured into complete products, this waste material was not included in the final information data set.

Glass

Recycled glass is processed into a variety of different products based on color and purity. Clean, color-sorted glass can be processed into fine glass beads. This material is used to make glass products as well as reflective sign and marking materials used on highways, which is the highest form of the recycled material.

Other recycled glass products include sorted color glass cullet and mixed glass cullet. The highest use of the color-sorted cullet is for recycling into new glass containers. However, this material must be completely free of any contamination from metals or paper. Slightly contaminated material and mixed cullet have been used successfully in hot mix, flex base, and as pipe bedding.

The cities in the Dallas and Ft. Worth region produce a potentially significant amount of recyclable glass. At the same time, a majority of the aggregates and materials, such as road base, is hauled from quarries 60 to 70 miles from the center of development. The trucks that move these materials between Dallas-Ft. Worth and the quarries in Bridgeport travel outbound empty. If a percentage of these trips ran full in both directions, that is, outbound carrying glass and

inbound with a mixed product that contains a prescribed percentage of glass, the economics could become significantly more attractive. However, it will require situations like this for glass to become a significant part of the material stream. Information about the availability of glass may indeed elevate its use to a level that would approach RAP or RCM.

Rubber

Recycled tires are processed in several different ways: bales, sliced tires, tire shreds, tire chips, and crumb rubber. Sliced and baled tires represent the lowest level of processing, followed by shreds and chips; crumb rubber is the most highly refined product of tire recycling. Crumb rubber has application as a modifier in asphalt binders and sealers and is a superior product for many sealing applications.

Rubber bales, shreds, and chips have been used in embankments and as lightweight fills, with mixed success. One problem associated with use is a possibility of combustion. Ignition is usually attributed to heat gain from the oxidization of metal reinforcing belts in the tire treads. This problem can apparently be mitigated by mixing tire chips with native soil in about a 50:50 ratio. While there is a significant waste stream in Texas, there is a very limited infrastructure producing chips, shreds, bales, and slices. There are numerous permits in force that would suggest a significant existing infrastructure. However, this number is very misleading since only a few of those with permits actually produce a usable product. It appears that the producers, potential producers, and the contractors who could use the chips in large construction projects do not communicate. Better information about suppliers of recycled rubber products complemented with information about the potential market for recycled rubber products could significantly increase the use of these products in the state of Texas.

Toner

Printer and copier toner by-product has been tested as a binder modifier in hot-mix asphalt pavements. It appears that using toner in pavement may be a beneficial use of this material. At this time, the use will likely be limited to projects that are close to the source of waste toner so this material's use would not likely increase significantly if included in an information database.

Blast Furnace Slag

Ground granulated blast furnace (GGBF) slag is a material that has been shown useful as an aggregate substitute in Portland cement concrete. In the case of Texas, there is no operating blast furnace operation that produces a slag suitable for general use in construction. Material used in TxDOT projects is currently imported from sources outside the state. Therefore, GGBF slag was not included in the information system at this time. However, if suppliers do become available it would be possible to add GGBF slag to the materials list.

Compost

Compost consists of decomposed organic materials. For the most part, composts are generated from recovered organic materials such as yard trimmings, food waste, animal manure or biosolids. The characteristics and the quality of the finished compost material depend on the raw organic material and the quality of the processing. The decomposition of organic material generates heat. This natural heat generation process helps break down the waste material into a loose friable mass and kills the pathogens that may be carried in the raw material. Maintaining the decomposition process and being sure the compost reaches the required temperature for a sufficient length of time to kill the pathogens is essential to producing quality compost.

The transportation construction and maintenance applications and benefits that can be derived from compost use are still not well understood by potential users. Research on the best applications, quality, and environmental compatibility are still being researched. At this time, compost has been proved effective in vegetation establishment, soil building, and in landscape establishment. Other uses, such as erosion control, have been tried but must be used with some sense of the longevity and cost related to alternative methods. In relatively flat terrain and where poor soils need help to establish surface cover, compost will likely be a material of choice.

There are numerous cities and independent processors providing compost materials. For these reasons, composts are considered an important candidate material for the NRM information system.

NEED FOR BETTER INFORMATION TRACKING

It is clear from the foregoing discussion that a major deterrent to increasing the use of nonhazardous recycled materials in transportation construction is the lack of information in three key areas:

- information about businesses that can supply a finished recycled product or material;
- what application the NRM has in transportation construction, that is, what are the requirements of the TxDOT materials specifications governing the application and quality of the NRM; and
- the market potential for specific NRMs.

TRACKING INFORMATION ABOUT RECYCLABLE AND RECYCLED MATERIALS

The concept of the NRMIS is to provide information to a wide audience of designers, specifiers, suppliers, waste generators, and waste processors that make or furnish products to TxDOT contractors. It will also serve as an information gathering and dissemination system to help TxDOT meet its regulatory reporting obligations.

INFORMATION GATHERING

To be of maximum benefit, the information in the system must be up-to-date and reliable. At the same time, the system needs to be structured in such a way that data management can be accomplished with minimum effort. To accomplish this part of the task, an automated Internet e-mail application is used to query contacts on a periodic basis, requesting that they check their profile and update their material data.

INFORMATION DISSEMINATION

The dissemination of information utilizes an Internet-based search engine that allows users to query the database for a variety of information including:

- names, addresses, and contact information of generators, processors, and suppliers of all types of construction materials and NRMs;
- material production and availability;
- searchable location maps based on material, company name by county, and TxDOT district;
- potential market represented by TxDOT contracts by district and county;
- material specifications; and
- information regarding the quality and requirements for providing NRMs to TxDOT and TxDOT contractors.

AVAILABILITY OF MATERIAL DATA AND MATERIAL SUPPLIERS

The implementation of data collection using the Internet is relatively straightforward. However, effectiveness depends on participation from the individual waste generators,

processors, and material suppliers. This part of the project has proved most problematic and may not be worth implementing in the initial system. Because the building materials industry is very competitive there is practically no source of accurate, timely data. For the most part, the available quantities and amounts of material processed for either virgin materials or NRMs are closely held and considered proprietary. Potential sources of material quantity data that have been explored over the course of the project include the following government and trade organizations:

- the Bureau of Economic Geology,
- U.S. Geological Survey,
- Texas Railroad Commission,
- Texas General Land Office,
- Texas Comptroller's Office,
- Texas Aggregates and Concrete Association (TACA),
- Western Region Ash Group (WRAG), and
- U.S. Composting Council (USCC).

Depending on the material, some information is available on a periodic basis of quarterly to annually. However, the data tend to be in lump sum amounts and are not geographically referenced or tied to a specific generator, processor, or supplier. Because distance from the point of availability to the point of use is a critical cost consideration in most cases, coarse data of this type are of little use.

Therefore, to be successful, data to populate the system will have to come from the individual generator, processor, or supplier of a particular virgin material or NRM. With some materials, there is a requirement to report gross volumes annually for tax or permit reasons, but overall, this does not represent a sufficiently detailed data pool. For example, there are over 41 registered scrap tire processors; however, only three of those contacted indicated that they could actually provide a processed material like chips or shreds that could be employed for light-weight backfill. Only one producer in Texas makes crumb rubber, and none of the processors

contacted regularly produces bales or sliced tires. Similar conditions are true for glass, roofing waste, and usable industrial sands.

RAP and RCM are somewhat different than other products that are generated from the waste stream. These two materials are already in place on state rights-of-way. In this case, it is only possible to deal with RAP and RCM as an in-place resource. To do this, it is possible to use the Pavement Management System inventory to estimate the recyclable quantities in place. These quantities can be used to estimate recyclable quantities on a project-by-project basis. Since this will also be done as part of the project development process, it is questionable whether implementation of this capability would be cost effective. The other avenue of obtaining the data would be to have TxDOT area offices report the quantities milled and stockpiled each month in their construction materials reports. This option did not seem viable when discussed with project advisors.

Taken together, the system will have to depend on participation of individual generators, processors, and suppliers as the primary source of data. For this to occur, these sources need motivation to provide the data to TxDOT.

From further discussions with TxDOT project advisors, it appears that having a list of up-to-date contact information and locations for the active generators, processors, and suppliers of NRMs would be just as valuable as having material quantities. This would allow design engineers and TxDOT contractors to explore the actual availability in their area as needed. Likewise, the vendors would be more likely to give them more precise volume and cost estimates than they would be inclined to publish in a public forum.

THE POTENTIAL MARKET

In searching for data to document the waste stream and material availability, it became clear that many of the generators, processors, and suppliers of NRM-based materials were not aware of the potential market represented by TxDOT construction projects. Furthermore, because it is TxDOT contractors and their suppliers who would actually purchase the NRM-based products, there needs to be a means to publicize the potential market to help sellers market their products more effectively.

A potential market feature was implemented by extracting quantities by item number from the monthly lettings and converting it into potential quantities of NRM-based material. For

example, flex base material could be 10 percent mixed glass cullet by volume; each cubic yard of flex base represents a potential market of 0.10 cubic yards of mixed glass cullet. This does not mean that much glass will be used; it only represents a potential market. This potential market feature coupled with other needed information about the quality requirements of each NRM-based material will help stimulate the marketing efforts of those vendors of NRM-based materials. This part of the system is easily implemented from data produced in a monthly report prepared by the TxDOT Construction Division.

NRM USE INFORMATION

There is also a widespread lack of knowledge about what and how NRMs can be incorporated into or substituted for virgin materials in TxDOT projects. To address this shortcoming, two features were needed in the overall structure of the information system. One feature was a Frequently Asked Question (FAQ) section and the other a section with links to specific parts of the Standard Specifications for the Construction of Highways, Streets, and Bridges or to other TxDOT specifications.

Frequently Asked Questions

The FAQ section was developed to address the most common questions about using NRMs. The answers to these questions generally focused on the novice user with limited knowledge about TxDOT's Materials Specifications; the Standard Specifications for the Construction of Highways, Streets, and Bridges; and Special Specifications. The FAQ section also provided information about the general requirements for supplying NRM-based products to TxDOT and its contractors.

Specifications Links

Specifications links were provided to Department Materials Specifications (DMS), Special Specifications, and the Standard Specifications for the Construction of Highways, Streets, and Bridges. These links are referenced by NRM and take the user to specific parts of various specifications that govern the use, quality and amount of various NRMs. These links take advantage of existing web-based materials currently maintained by TxDOT that individuals not familiar with the TxDOT construction and specification process might not find on their own.

Other Issues of System Design

With any computer-based information system, maintenance and security are major considerations. The conceptual framework of this system places the primary burden for updating information on the individual users. That is, suppliers, generators, and processors that wish to be included in the system are responsible for keeping their contact information up to date. To achieve this task, an automated e-mail system queries individuals in the system and confirm that their contact information is correct.

For security reasons initial sign-up would have to be filtered by a TxDOT administrator. Then once approved, users would be assigned a password that would allow them to update their contact information. This would prevent unauthorized access to the information. Other issues of security and housing of the database will have to be decided by TxDOT along with their decision on implementation. [Figure 2](#) shows the NRMIS structure, which consists of three major parts: the user interface, data acquisition section, and the primary database. The system users targeted for the system are the waste generators, material processors and suppliers, the general public, contractors, and TxDOT personnel involved in design and construction.

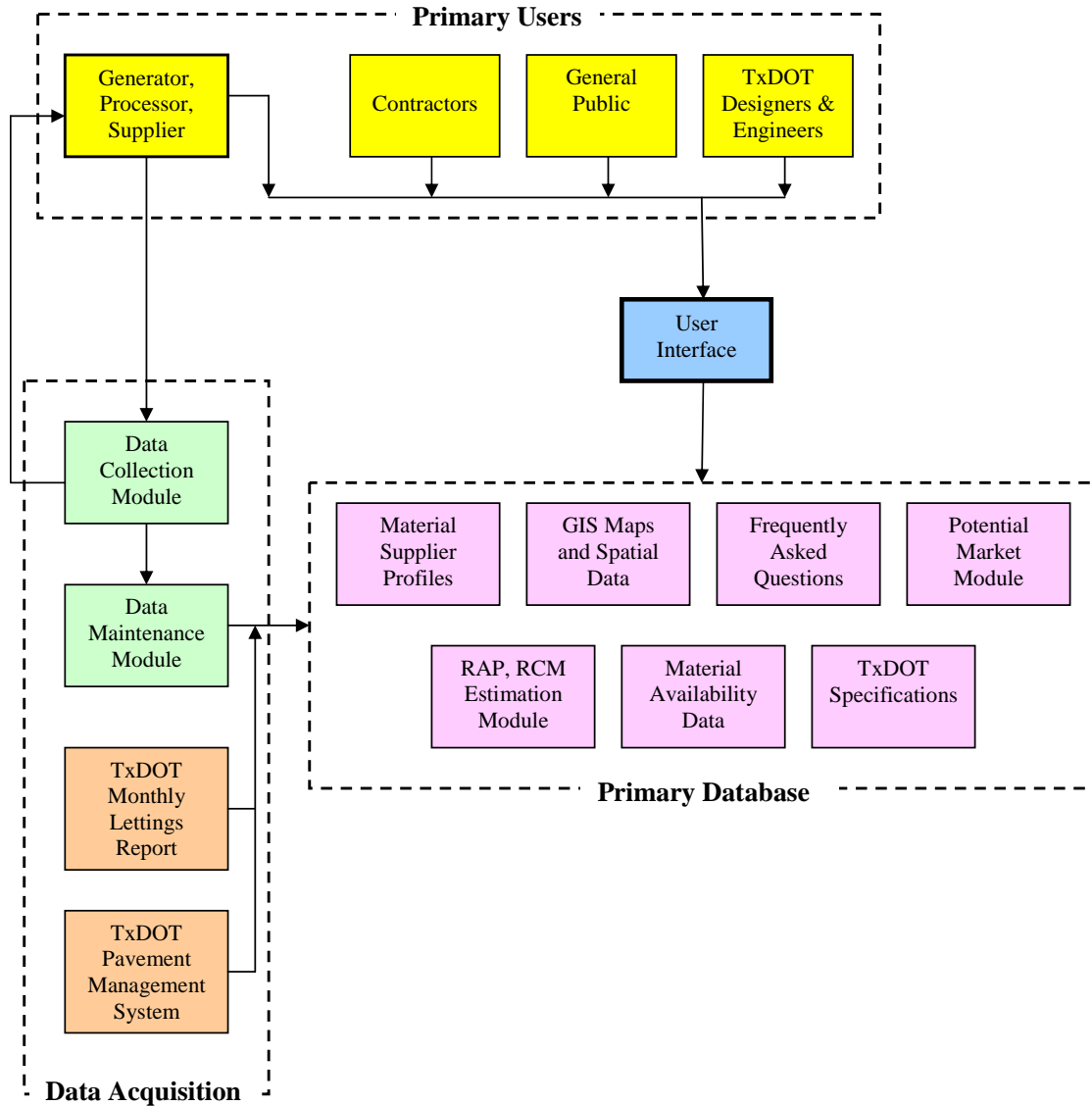


Figure 2. Structure of the TxDOT Nonhazardous Recyclable Materials Information System.

Researchers developed the system described in this report with guidance from the project monitoring committee (PMC). The TxDOT Information Services Division did not participate in the PMC, which raised concern in developing the final product. For this reason, all parts of the system have been carefully documented to facilitate any future efforts at system implementation.

As noted earlier, maintenance of the database is critical; therefore, emphasis was placed on minimizing the effort required to collect current information. Therefore, all the data

collection functions are automated using the Internet and e-mail as the means of collecting and checking data. To ensure that data are collected from an approved source and that they are complete, the data collection area is password protected and changes or updates must be reviewed by the system manager before they will be entered into the system. Given that nature and simplicity of the data and the time period between updates, development of an automated data checking module would not have been cost effective.

The user interface is a simple fill-in-the-blank page with drop-down lists. This structure lets the user simply click and select search categories. The data within the system are linked so that users can concurrently display spatial and tabular information in the data set.

The data acquisition module utilizes e-mail as the primary means of collecting data from generators, processors, and suppliers of NRMs and virgin materials. This information is collected in a maintenance module for review and approval before being sent to the primary database. The data set is divided into several relational data sets. This allows mixing and matching of information based on the needs and desires of the individual user.

NRM TRACKING SYSTEM

The database interface helps TxDOT and suppliers of nonhazardous recyclable materials communicate the current and historic volume of materials that could be used in road construction, as well as the location and availability of the material supplies.

Given the asynchronous and distributed nature of this communication need, the interface was designed to be accessed through the Internet using a series of web pages that follow the existing format of the TxDOT home pages (Figure 3). This prototype web site is no longer active.



Figure 3. Nonhazardous Recyclable Materials Information System Home Page (no longer active).

The User Interface of the Nonhazardous Recyclable Materials Information System is made up of three separate modules: (1) a materials module that provides information about availability, market opportunities, specifications, and frequently asked questions, (2) a suppliers module that enables NRM producers and processors to register their contact and operational information with the system, and allows TxDOT and TxDOT contractors to search for suppliers based on material and location, and (3) a mapping module that allows TxDOT to query and view the geographic distribution of NRM suppliers within Texas.

In addition to the three modules listed above, there is a working demonstration tutorial available to assist new users in navigating the system. The system has been optimized for intuitive navigation using standard usability principles and testing procedures.

Header, Navigation Bar, Main Screens, and Footer

The headers and footers used on each of these pages are standard on TxDOT home pages. The familiar model of using a navigation bar located along the left side of the computer screen is used to organize the hyperlinks that connect to the various modules and functions. As a user moves to various areas within the interface, the navigation bar with its links remains in place, while the particular link that is being viewed is highlighted to provide feedback to the user on where they are within the system. Each of the main screens within the different modules uses a common format with a title, column headers with white text on a dark blue background, and footers with decision links or buttons. Query parameters, input fields, and information output are sandwiched between the main screen headers and footers.

Materials Module

The Materials Module consists of functions to query for availability, market opportunities, specifications, and frequently asked questions. The availability function (Figure 4) enables the user to query for material availability by type, district, and time period. A set of pull-down lists allows the user to choose the type of material, the district of interest (including a choice for all districts), and the time period of interest by month and year (including all months and all years).

NRMs Tracking System - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address http://ttienv-util.tamu.edu/nrm/availability.asp

powered USB hub Search Web Search Site Search Images News Page Info Highlight

Texas Department of Transportation For Demonstration Only

Friday, June 27

MATERIALS
Availability
Market
Specifications
FAQs

SUPPLIERS
Register
Update
Search
List-all
Home

Material Availability - Query

Items	Conditions
Material	Fly Ash And
TxDOT District	Abilene And
Data Period	all months all years

<< Return Home MONTHLY UPDATE SUBMIT QUERY

Copyright statement and legal notices
This site is developed and maintained by Texas Transportation Institute, Texas A&M University System
01bb Oilohist Building, 2020 Research Parkway, TAMU Research Park, College Station, TX 77843-3135

Figure 4. Material Availability Query Page.

It also allows materials providers to update the volume of material they have available for construction use on a monthly basis. The user then has the option of returning to the main home page, updating their material availability (described below), or submitting a query based on the parameters chosen. After setting the parameters and submitting the query, a table is returned showing a list of companies and their location along with the volume of material available by month and year (Figure 5). A link to the contact information of each company is made available by clicking on subtotal volume located in the Available Amount column. The total volume is summed up on the bottom of the screen directly above the blue footer. The user then has the option of returning to the query screen or using the navigation buttons to access one of the other modules or functions.

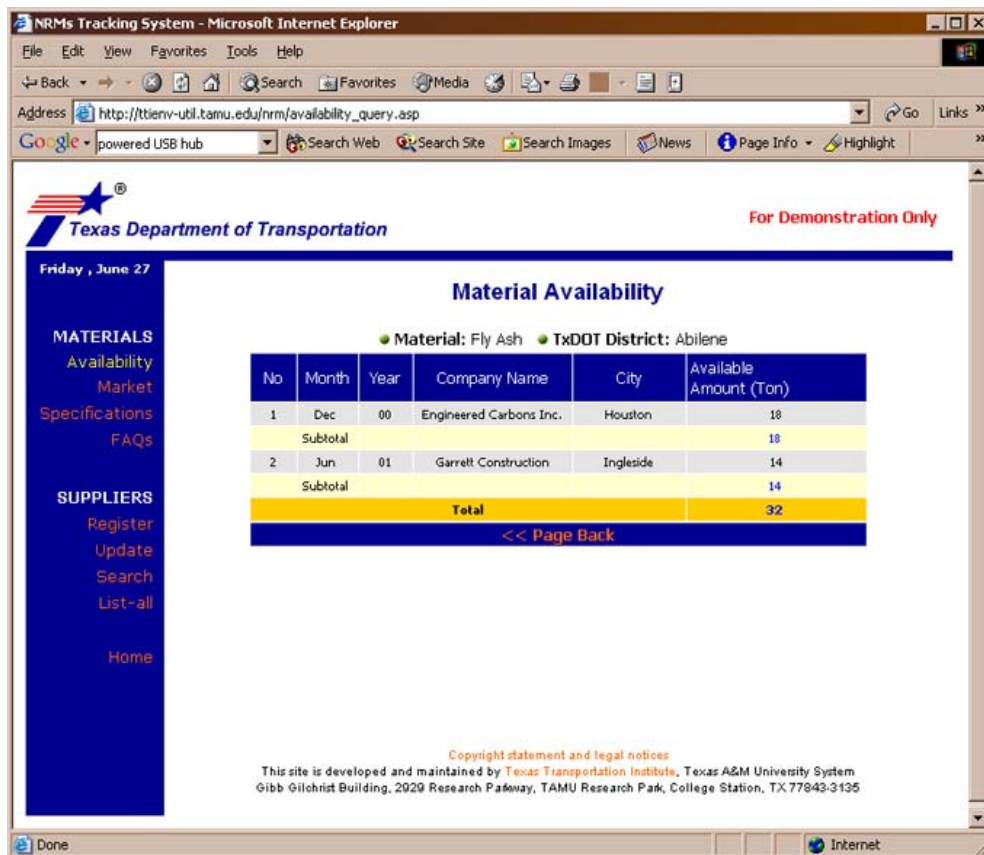


Figure 5. Material Availability Query Return.

Monthly updates of material availability can be accessed through the availability query screen. NRM suppliers that are registered with the system use this function to keep their availability data current. Their data are protected by a password and a login ID that are set by the supplier when registering with the system (Figure 6). A registered supplier receives an automated e-mail reminder each month to update their material availability that contains a link directly to this login screen. If a new user reaches this screen prior to registering with the system, a link has been provided next to the login button that will open the initial registration page. Registering with the system is covered in the Suppliers Module below.

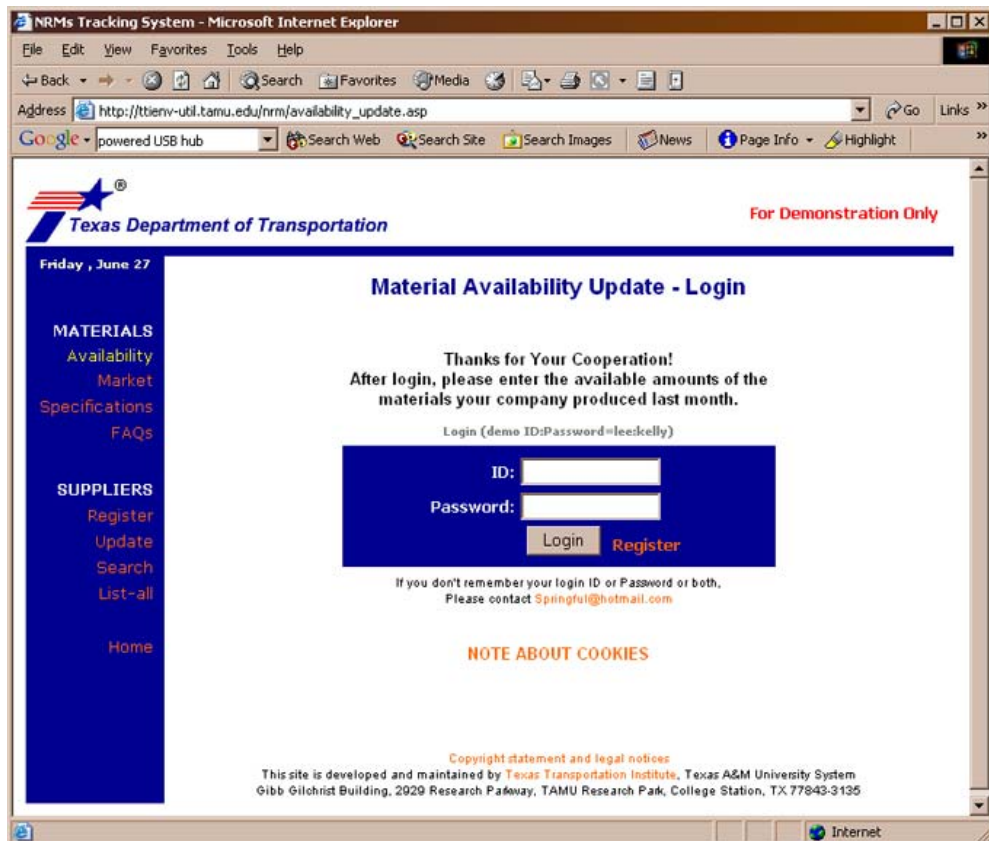


Figure 6. Material Availability Update Login Page.

Depending on the information provided in the supplier's registration form, a list of materials with open text fields beside them is provided to enable the supplier to update the volume of materials that is available (Figure 7). If the value entered into the system is not a numeric value, the system returns an error message box with instructions to enter only numbers into the forms. When the form is complete the supplier presses the enter button and is returned to the Materials Availability - Query page.

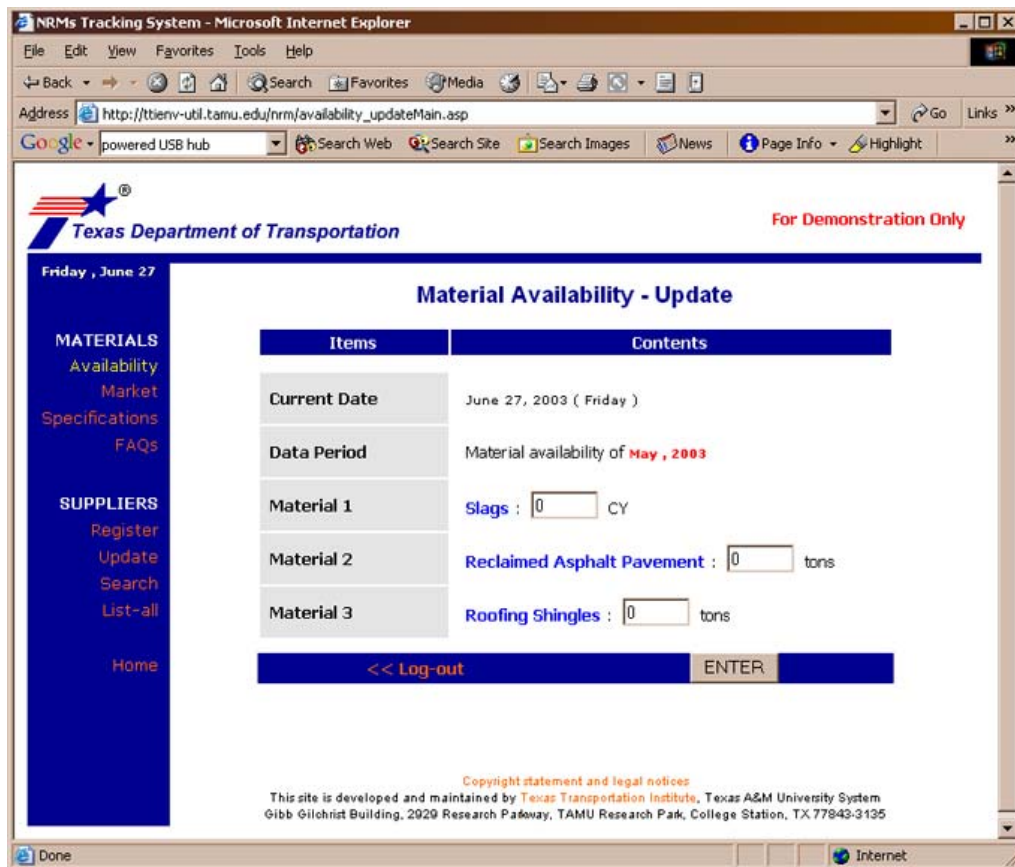


Figure 7. Material Availability Update Page.

The *market function* (Figure 8) enables the user to query the amount of NRMs that could have substituted for virgin materials on TxDOT construction projects by district (including all districts) and time period (including all months and years).

The volumes are calculated by multiplying the bid item volumes listed on monthly letting reports by a multiplier that translates the volume into an amount of an NRM that could be substituted for other virgin materials. For example, if a letting report indicated that 67 cubic yards of Item 265.2 (2) was needed and— by specification Section 28 DMS-8900 Fly Ash— 20 percent of that amount could be substituted with fly ash class F, then a market opportunity of 13 cubic yards (0.2 x 67 cubic yards) of fly ash class F would be generated by that one bid item on that one letting report.

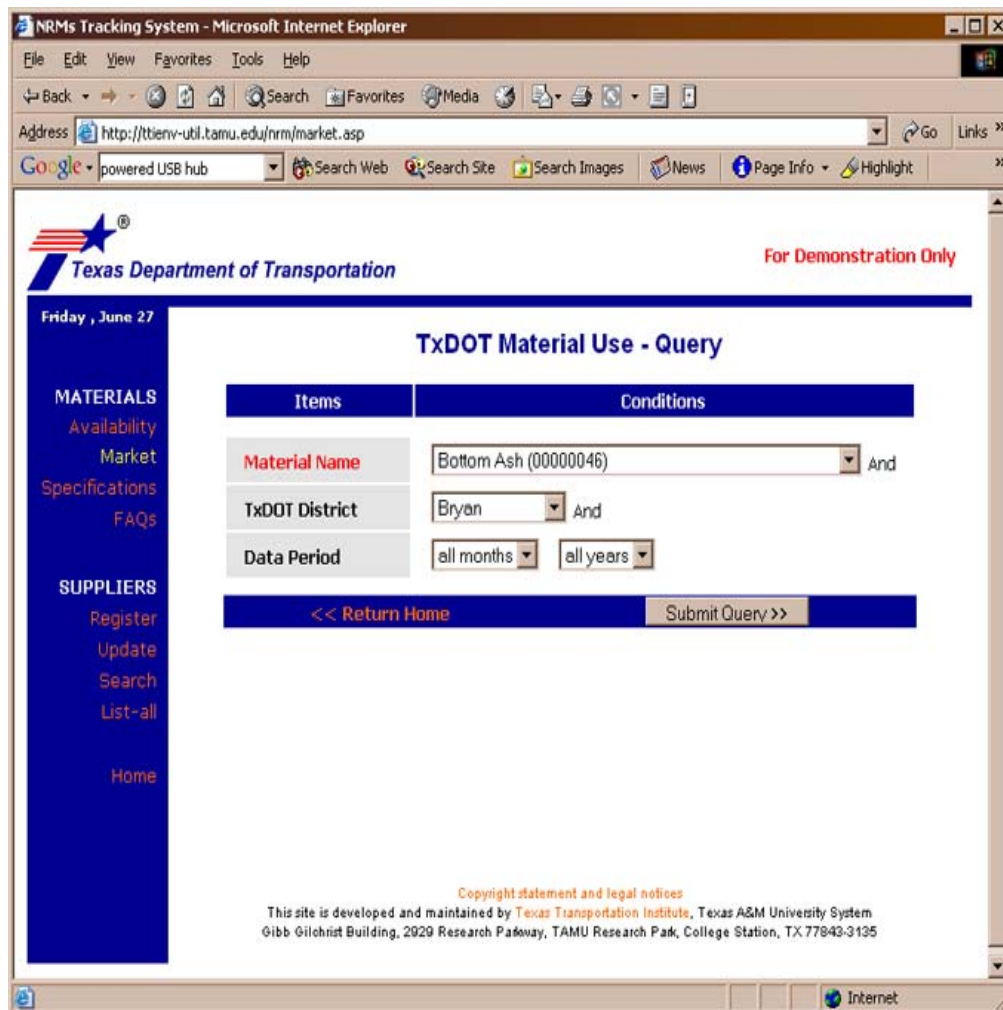


Figure 8. TxDOT Material Use Query Page.

A material market query (Figure 9) is returned as a table including the month, year, total bid item quantity, minimum and maximum multiplier range, and minimum and maximum market volume for the material queried. The total volumes are provided at the bottom of the table in a yellow-shaded row. A function for updating the multiplier numbers is made available for system administrators and is protected by login and password.

Each NRM that may be used to substitute for virgin materials in construction has a set of specifications describing the conditions and levels of substitution that must be met in any given situation. These specifications are readily available on the TxDOT web site. The specifications/material quality page (Figure 10) lists all the nonhazardous recyclable materials currently accepted for substitution of other materials.

By following the links attached to the magnifying glasses arranged on the page to the right of the material name, the user can first access all the bid items (Figure 11) in which the NRMs can be used and, subsequently, the written specifications (Figure 12).

TxDOT Material Use

Material: Bottom Ash, Bottom Ash Code #: 00000046 TxDOT
District: Bryan

No	Month	Year	Amount (CY)	Min. Multiplier	Max. Multiplier	Min. Need (CY)	Max. Need (CY)
1	Apr	97	67	0.2	0.4	13.4	26.8
2	Jul	97	3	0.2	0.4	0.6	1.2
3	Nov	98	5	0.2	0.4	1	2
4	Mar	98	22	0.2	0.4	4.4	8.8
5	Jul	00	2	0.2	0.4	0.4	0.8
6	Nov	00	32	0.2	0.4	6.4	12.8
7	Mar	00	45	0.2	0.4	9	18
8	Jul	02	7	0.2	0.4	1.4	2.8
Total			183			36.6	73.2

[<< Return to Query](#) [\[Check Multipliers \]](#)

Multiplier: the ratio of the amount of construction material that can be replaced by NRM (Non-hazardous Recycling Material).

Copyright statement and legal notices
 This site is developed and maintained by Texas Transportation Institute, Texas A&M University System
 6100 Redwood Building, 2000 Research Parkway, TAMU Research Park, College Station, TX 77703-2125

Figure 9. Material Market Use Table.

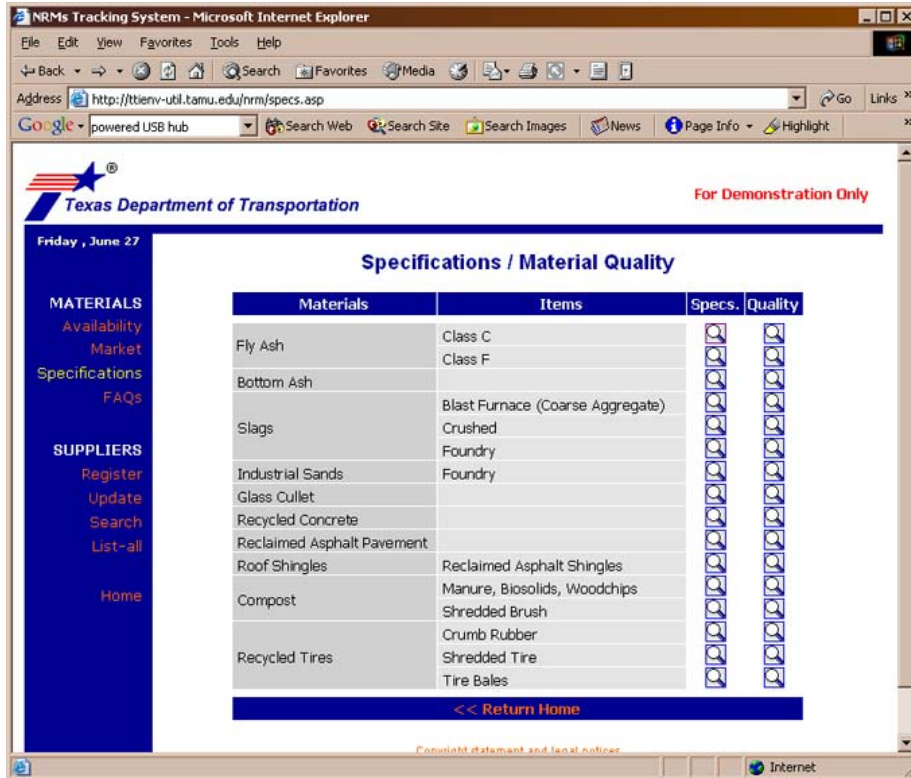


Figure 10. Specifications and Material Quality Page.

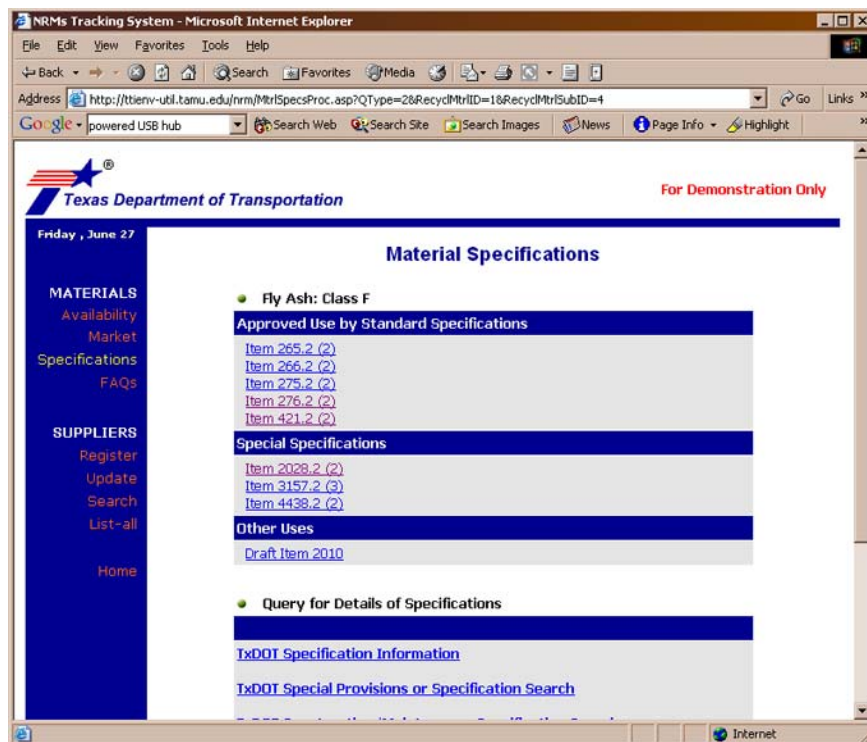


Figure 11. Materials Specifications Page with Bid Items.

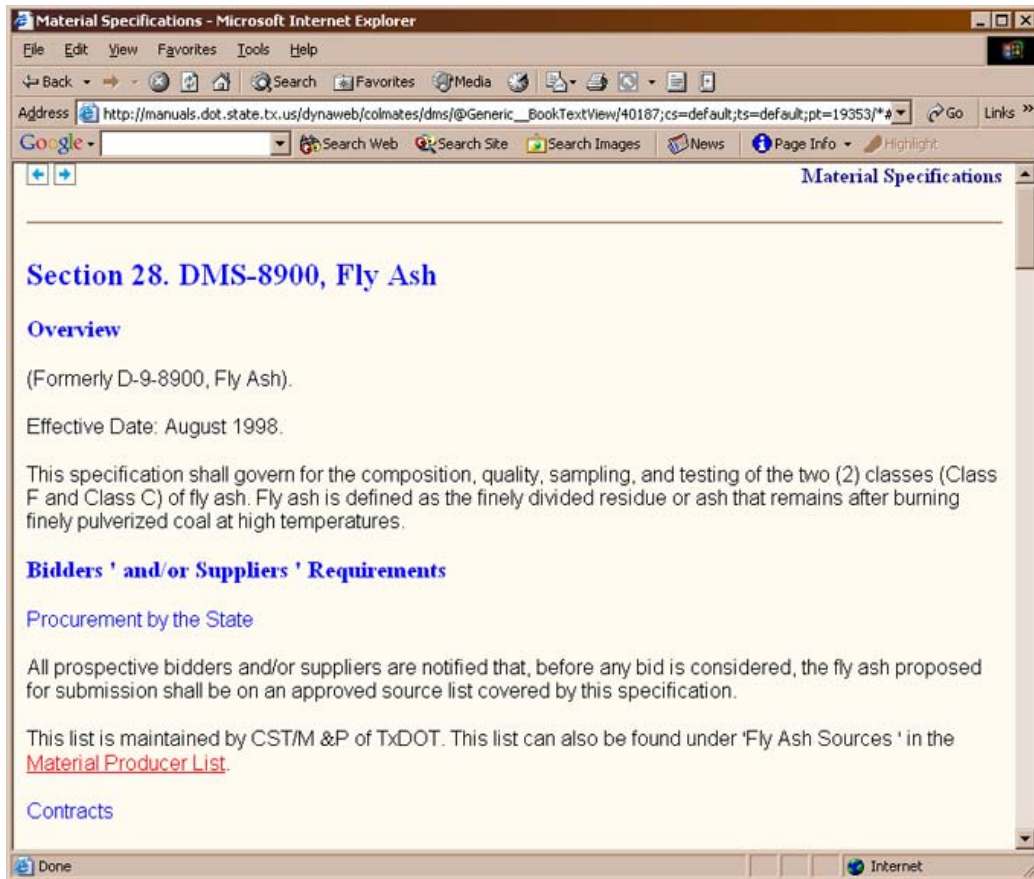


Figure 12. TxDOT Online Materials Specifications.

This organization of disparate information from multiple references into a single accessible location is expected to be an important resource to designers, contractors, and suppliers alike. Designers and contractors can quickly identify which bid items have materials that can be substituted with NRMs. Suppliers and contractors can identify quality requirements to determine if a particular source of NRMs is fit for substitution. This level of accessibility is not currently available for NRMs and is thought to be one of the stumbling blocks that are preventing widespread use of NRMs in TxDOT construction projects.

The final link under the materials module is to FAQs (Figures 13 and 14). These are organized into three categories including NRM supplier-related questions, NRM user-related questions, and TxDOT specification-related questions. Each category has a drop-down list of questions and a go button to lead users directly to the answer for the question that is chosen. All the questions and answers are printed below the drop-down query section and can be scrolled through if desired.

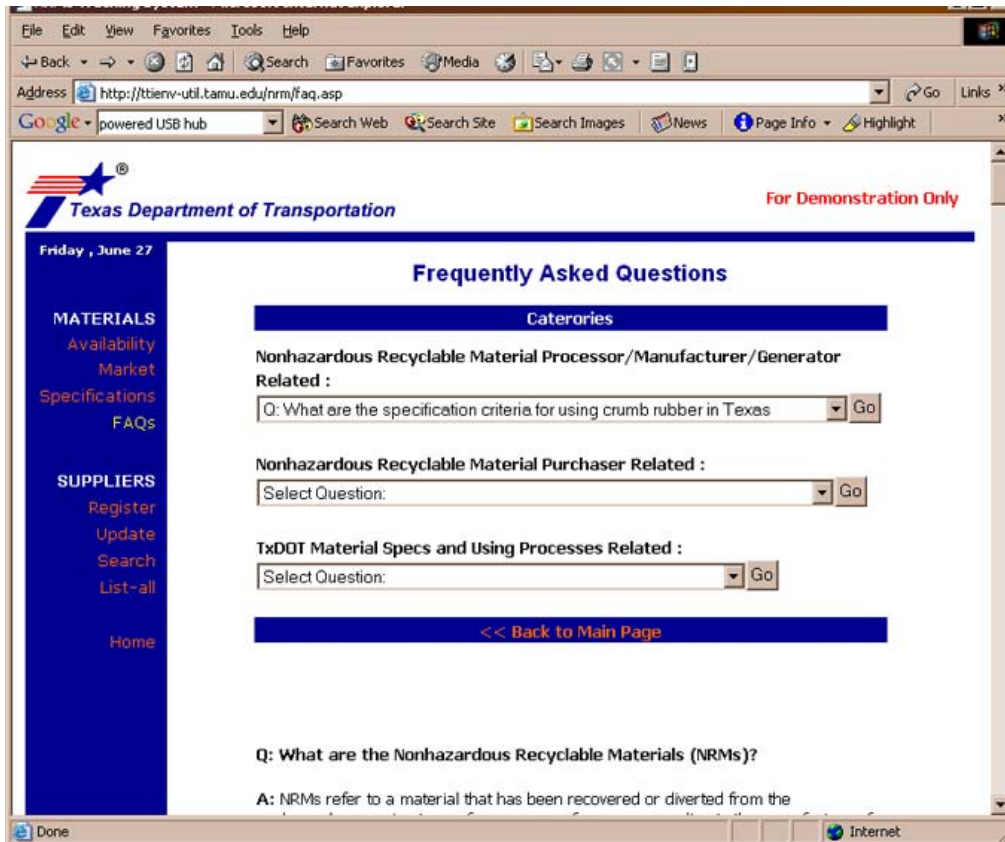


Figure 13. Frequently Asked Questions Page.

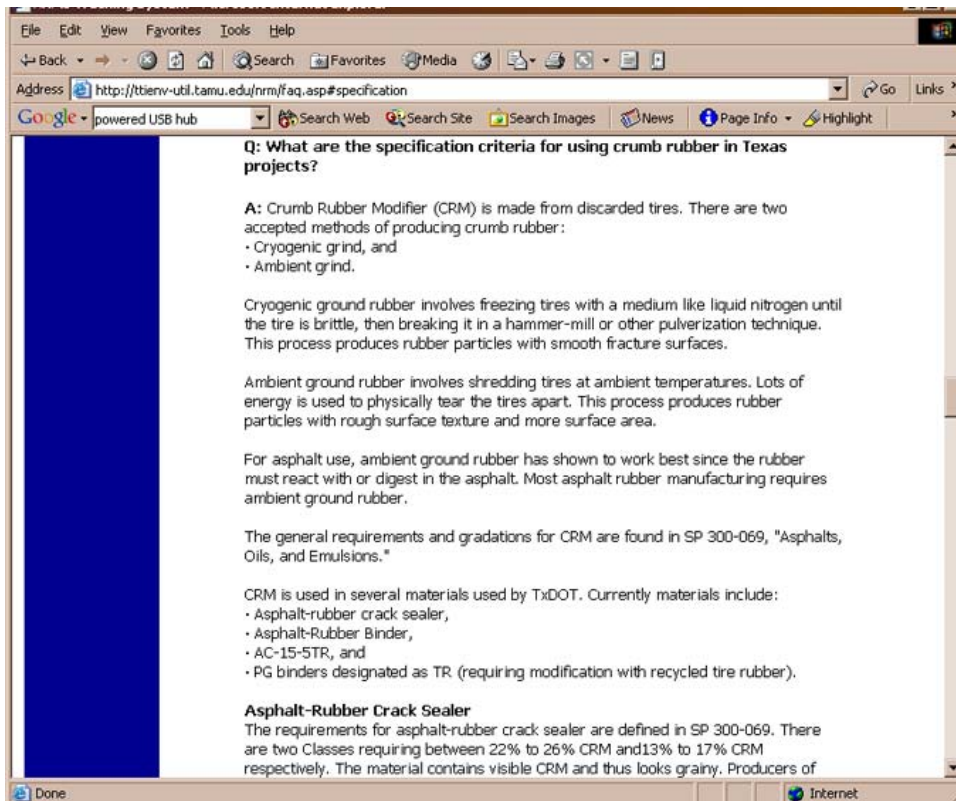


Figure 14. Example Question and Answer to a Frequently Asked Question.

Suppliers Module

The Suppliers Module is an interface designed to help new NRM suppliers register with the system or to help registered suppliers update their existing registration information. It also enables all users to search for suppliers by attribute information or by geographic location. A “list all” option is also available. One critical attribute of a supplier’s registration (Figure 15) is the e-mail address. With this information, TxDOT can automatically send a monthly or annual batch e-mail to all suppliers requesting that they update their materials availability information. Suppliers that do not respond to the automated e-mail and do not update their availability information within a specified time period can be automatically listed in the database as “inactive” so that designers and contractors can filter them from queries as needed. Updating information on the registration form or material availability database requires a user to log in. All relevant information associated with any user logging into the system can easily be retrieved from the database using the login ID.

The screenshot shows a web browser window displaying the 'New Registration' form for the Texas Department of Transportation. The browser's address bar shows the URL 'http://tbienv-util.tamu.edu/nrm/registration.asp'. The page header includes the Texas Department of Transportation logo and the text 'For Demonstration Only'. The date 'Friday, June 27' is displayed. The left sidebar contains navigation links for 'MATERIALS' (Availability, Market, Specifications, FAQs) and 'SUPPLIERS' (Register, Update, Search, List-all, Home). The main form area is titled 'New Registration' and contains several sections: 'Organization Information' with fields for Company Name, Plant Name, Address, and City, State, Zip Code; 'Business Type' with a section for selecting applicable materials and business types (5 rows of 'Select Material' and 'Biz Type' dropdowns); 'Delivery Method' with a text input field and a note '(ex. Truck, Rail, Truck & Rail, etc.)'; and 'Company Website' with a text input field. The form is partially filled out, with 'Texas' selected in the state dropdown and 'http://' in the website field. The browser status bar at the bottom shows 'Done' and 'Internet'.

Figure 15. New User Registration Form.

TxDOT Module

Because of the sensitive nature of some of the mapped information, the TxDOT module is protected by login ID and password. After logging in, users can link to a series of map layers showing the locations of all identified active NRM producers as well as active and inactive quarries in the State of Texas (Figure 16). This module is expected to grow after implementation as additional links to useful resources are identified and as other maps are produced.

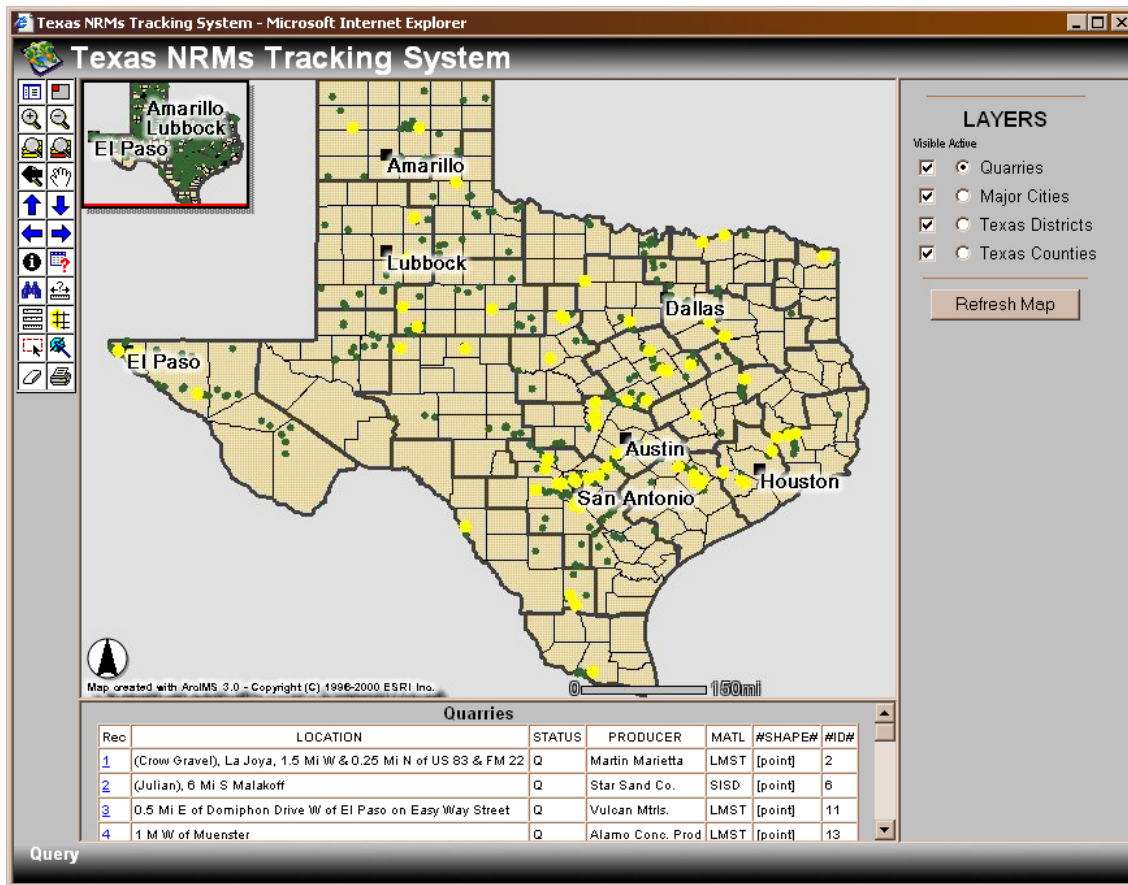


Figure 16. Map of Active and Inactive Quarries in the State of Texas.

CONCLUSIONS

SYSTEM FEASIBILITY

The system design and structure work well, but circumstances of competition and the relative immaturity of the recycling infrastructure make full implementation of the system impractical. The web-based automated data collection module for updating the system information pioneers a very useful technology for almost any data collection need. Likewise, the data extraction modules that convert lettings to potential markets for NRMs and the ability to estimate the amount of RAP or RCM from the pavement management system show how this information can be generated and made available to users.

However, the original idea of being able to provide data about the quantity and availability of both virgin and NRM-based materials has proved to be impractical, because of the competitive nature of the building materials industry. This is not likely to change in the future. While numerous avenues for developing the information were explored, in the final analysis, researchers are forced to conclude that for reasons of competition and confidentiality, this information simply is not available.

The lack of data in and of itself does not make the system impractical, for in fact, a good up-to-date list of generators, processors, and suppliers of NRM-based materials may be sufficient for users looking for particular products. However, when taken together with the volatile nature of the infrastructure for recycling and the sporadic nature of the collection, questions of quality and material processing must be taken into account when considering implementation.

USEFUL DATA AND SYSTEM PARTS

What was initially designed to be the materials data collection part of the database could easily be converted to simply update the list of processors and suppliers contact information. It was clear that this information, if current, might address the needs of field personnel better than having quantities posted that may or may not be accurate.

The automated data collection module in the system could also be modified slightly and be implemented to collect reporting data for the General Services Division Recycling Program. Likewise, the well-documented data maps showing the locations and associated data for quarries and pits and NRM production facilities can be easily integrated into the TxDOT geographic

information system. These maps and the associated data will be useful to the materials section, the recycling program, as well as district and area offices of TxDOT.

It should be noted that the base information for these maps was obtained from TxDOT and that no other source in the state has this amount of detailed information. For this reason, it could be politically sensitive if released. The sensitivity of the data should be assessed further by TxDOT staff before making the information public.

COST EFFECTIVENESS

Cost effectiveness is a term that must be used with caution in regard to recycled products. Much of the feasibility for use of NRMs depends on the relative availability and cost of both virgin and recycled products. Each market region will have different circumstances that affect the relative cost of using any material. Whether a material is virgin or recycled, much of the in-place cost hinges on transportation costs and local material availability. Each of the NRMs considered in this study has different sets of economic conditions for processing and use. Overall, fly ash, RAP, RCM, and compost have reasonably well-developed market regions in Texas. Other materials such as glass, rubber, asphalt shingle waste, and toner tend to be useful only regionally due to the location or market conditions. Therefore, implementation of useful parts of the information system as presented here could assist in creating better markets for NRMs in the future.

RECOMMENDATIONS

SEEK JOINT PARTICIPATION

While full implementation by TxDOT may not be practical at this time, there appears to be overlap in the TxDOT mission to increase the use of recycled materials and that of the Texas Commission on Environmental Quality (TCEQ). TCEQ promotes recycling and has collected a range of information similar to that collected by TxDOT. This information is currently outdated, and neither TxDOT nor TCEQ have a means to quickly update the data. TxDOT is encouraged to explore some type of joint implementation of a data collection system for keeping recycling information up to date.

In the presentation of the system to the Transportation Research Board Committee on Recycling, there was considerable interest exhibited in the automated system portion of the application, as well. For this reason, TxDOT and TCEQ may also wish to explore the potential for obtaining federal support for a demonstration implementation of the system.

POTENTIAL MARKET INFORMATION

The module that produces the potential market information from the monthly lettings could be of value in stimulating suppliers and processors of NRM-based material to market more effectively to TxDOT contractors. TxDOT should consider implementing that section as part of the recycling portion of the TxDOT web site.

FURTHER RESEARCH

Further research on developing an information system for recycled material use would serve no purpose without a system trial to see if it would be used. The project was initiated with the idea that the recycling industry and its infrastructure were in place and that the use of NRM-based materials would be practical in transportation construction. This assumption proved to be wrong. It appears that there needs to be more and better technical documentation of past project work, including careful documentation of the costs and how they might be reduced by greater volume use and better technology. More research is essential for those NRMs where there is a potentially continuous high-volume waste stream, such as glass containers and scrap tires. This research needs to span the gap between mere possibilities and explore the means to make reuse a practical, cost-effective part of the material production process.

BIBLIOGRAPHY

Coal Combustion Products

Saylak, D., C. Estakhri, R. Viswanathan, D. Tauferner, and H. Chimakurthy. 1996. *Evaluation of the Use of Coal Combustion By-Products in Highway and Airfield Pavement Construction*. Research Report 2969-1F, Texas Transportation Institute, Texas A&M University, College Station, Texas.

Ground Granulated Blast Furnace Slag

American Concrete Institute. 1995. *Ground Granulated Blast Furnace Slag as a Cementitious Constituent in Concrete*.

Chesner Engineering, P.C. 2000. Waste and Recycled Materials Use in the Transportation Industry: NCHRP 4-21 Information Database User's Manual: Version 1.0.8.

U.S. Geological Survey. 2001. Mineral Industry Surveys: Directory of Principal Aggregates Producers in the Conterminous United States in 1999.

Morse, A., P. Nash, S. Senadheera, A. Jackson, R. Tock, J. Leggoe, and T. Mollhagen. 2001. Environmental Characteristics of Traditional Construction and Maintenance Materials: Final Report. Lubbock, Texas: Multidisciplinary Research in Transportation. Report No. 4974-1.

Partridge, B., J. Allman, and B. Huber. 1997. "Perspectives on Liability for Constructive Reuse of High-Volume Waste Streams," Transportation Research Record No. 1577: Soils, Geology, and Foundations: Pavement Base and Foundation Materials, Deformation Characteristics of Subgrade, and Properties of Unconventional Aggregates. Washington, D.C.: National Academy Press.

U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance, Office of Compliance. 1998. EPA Office of Compliance Sector Notebook Project: Profile of the Steel Industry. Washington, D.C.: Office of Enforcement and Compliance Assurance. Metal Casting Industry Sector Notebook Project EPA/310-R-97-004.

U.S. Federal Highway Administration, Office of Engineering. 1996. *Technical Memorandum. Procurement of Products Containing Recovered Materials*. Washington, D.C.

Wilburn, D. and T. Goonan. 1998. Aggregates from Natural and Recycled Sources: Economic Assessments for Construction Applications – A Materials Flow Analysis. U.S. Geological Survey, Circular 1176.

Reclaimed Asphalt Pavement

Sullivan, J. 1996. *Pavement Recycling Executive Summary and Report*. Federal Highway Administration, Washington, D.C.

Epps, J., D. Little, and R. Holmgren. 1980. *Guidelines for Recycling Pavement Materials, Synthesis 224*, National Cooperative Highway Research Program, Transportation Research Board, National Research Council, Washington, D.C.

Recycled Concrete

Chesner, W., R. Collins, M. MacKay, and J. Emery. 2002. *User Guidelines for Waste Byproduct Materials in Pavement Construction: Recycled Concrete Material*. Turner-Fairbank Highway Research Center, Federal Highway Administration.

Chini, A., M. Filipe, and R. Monteiro. April 7-9 1999. Use of Recycled Concrete Aggregate as a Base Course. ASCE Proceedings 35th Annual Conference, California Polytechnic State University, San Luis Obispo, California, ASCE.

Mullenhorn, M. February 1990. Properties and Performance of Recycled Aggregates. Highways and Transportation.

Richardson, B. 1994. Use of Recycled Concrete as a Road Pavement Material within Australia. 17th ARRB Conference, Australian Road Research Board Ltd., Nunawading, Australia.

Muller, C. 1998. Requirements on Concrete for Future Recycling, Aachen University of Technology: 11.

Senior, S. 1994. New Development in Specification for Road Base Materials in Ontario. 45th Canadian Geotechnical Conference, Canadian Geotechnical Society.

Industrial Sands

Abichou, T., C. Benson, T. Edil, and B. Freber. Using Waste Foundry Sand for Hydraulic Barriers. Madison: University of Wisconsin – Madison.
<http://geoserver.cee.wisc.edu/buic/Public/FS%20K%20paper.htm>. June 28, 2002.

Chesner Engineering, P.C. 2000. Waste and Recycled Materials Use in the Transportation Industry: NCHRP 4-21 Information Database User's Manual: Version 1.0.8.

Foundry Industry Recycling Starts Today (F.I.R.S.T.). 2000.
<http://www.foundryrecycling.org/prjtdb/asphalt.html>. June 26, 2000.

Karin, A., C. Lovell, and R. Salgado. 1997. Building Highway Embankments of Fly/Bottom Ash. West Lafayette: IN. Joint Transportation Research Program. Report No. FHWA/IN/JTRP-97/1.

Kelly, T. 1998. Crushed Cement Concrete Substitution for Construction Aggregates – A Materials Flow Analysis. U.S. Geological Survey. Circular 1177.

LaFay, V. and S. Neltner. 2001. Understanding Emissions in Green Sand Molding. Hill and Griffith Company.

Mineral Industry Surveys: Crushed Stone and Sand and Gravel in the Second Quarter 2001. U.S. Geological Survey. 2001.

Mineral Industry Surveys: Directory of Industrial Sand and Gravel Producers in the United States in 2000. U.S. Geological Survey. 2001.

Mineral Industry Surveys: Directory of Principal Aggregates Producers in the Conterminous United States in 1999. U.S. Geological Survey. 2001.

Minerals Information Team, U.S. Geological Survey. Sand and Gravel Operations in the United States. U.S. Geological Survey, 2001.

Morse, A., P. Nash, S. Senadheera, A. Jackson, R. Tock, J. Leggoe, and T. Mollhagen. 2001. Environmental Characteristics of Traditional Construction and Maintenance Materials: Final Report. Lubbock, Texas: Multidisciplinary Research in Transportation. Report No. 4974-1.

Mlynarski, K. 2000. Survey Methods for Nonfuel Minerals. U.S. Geological Survey.

Nash, P., J. Priyantha, R. Tock, S. Senadheera, K. Viswanathan, and B. Woolverton. 1995. Use of Glass Cullet in Roadway Construction: Phase I. Literature Review and Identification of Sources and Suppliers. Lubbock, Texas: Texas Tech University. Research Study No. 0-1331-1.

Partridge, B., J. Allman, and B. Huber. 1997. "Perspectives on Liability for Constructive Reuse of High-Volume Waste Streams," Transportation Research Record No. 1577: Soils, Geology, and Foundations: Pavement Base and Foundation Materials, Deformation Characteristics of Subgrade, and Properties of Unconventional Aggregates. Washington D.C.: National Academy Press.

Saeed A. and W. Hudson. 1996. Evaluation and the Use of Waste Reclaimed Materials in Roadbase Construction. Austin, Texas: The University on Texas at Austin, Bureau of Engineering Research, Center for Transportation Research. Report No. FHWA/TX-97/1348-2F.

Smith, S. 2001. Statistical Summary. U.S. Geological Survey.

State of Arkansas Department of Environmental Quality, Solid Waste Management Division. 1998. Guidance for Foundry Sand Beneficial Reuse Projects. Little Rock, Arkansas: Department of Environmental Quality.

Texas Department of Transportation. 2001. The Year of the Recycled Roadway Materials. ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/pdf/yrr_aug.pdf . Updated April 27, 2001.

Texas Natural Resource Conservation Commission Regulatory Guidance, Waste Permits Division. 2001. Can I Recycle Some of My Industrial or Hazardous Wastes?. Austin: Texas Natural Resource Conservation Commission Regulatory Guidance. RG-240.

U.S. Environmental Protection Agency, Office of Enforcement and Compliance Assurance, Office of Compliance. EPA Office of Compliance Sector Notebook Project: Profile of the Metal Casting Industry. Washington: Office of Enforcement and Compliance Assurance, 1998. Metal Casting Industry Sector Notebook Project EPA/310-R-97-004.

U.S. Geological Survey and the University of Texas at Austin, Bureau of Economic Geology. 2001. The Mineral Industry of Texas. U.S. Geological Survey.

Wang, S. and C. Vipulanandan. 1998. Foundry Sand for Highway Applications. Houston: University of Houston, Department of Civil and Environmental Engineering.

Wilburn, D. and T. Goonan. 1998. Aggregates from Natural and Recycled Sources: Economic Assessments for Construction Applications – A Materials Flow Analysis. U.S. Geological Survey. Circular 1176.

Wilson, J. 1999. Flowable Fill as Backfill for Bridge Abutments: Final Report. Madison: Wisconsin Department of Transportation, Division of Transportation Infrastructure Development, Bureau of Highway Construction, Pavements Section, Technology Advancement Unit. Research Study No. 99-05. Report No. WI-16-99.

Reclaimed Asphalt Shingles

Button, J., D. Williams, and J. Scherocman. 1995. *Roofing Shingles and Toner in Asphalt Pavements*, Research Report 1344-2F, Texas Transportation Institute, Texas A&M University, College Station, Texas.

TxDOT Specification Item 3208. *Hot Mix Asphalt Concrete Pavement Containing Reclaimed Roofing Shingles*.

Glass Cullet

Ellen, W. 1995. Cost of Transporting Crushed Stone by Truck. GeoNews. Illinois State Geological Survey. 10:1.

Reclaimed Glass Information Kit, Minnesota Local Road Research Board, The Minnesota Technology Transfer (T²) Local Technical Assistance Program (TLAP), at the University of Minnesota's Center for Transportation Studies, The Minnesota Department of Transportation, Office of Environmental Assistance: 20.

Soil and Environmental Engineers, I. 1998. A Tool Kit for the Use of Post-Consumer Glass as a Construction Aggregate, CWC, A Division of the Pacific North West Economic Region: 97.

Tires

Ellen, W. 1995. Cost of Transporting Crushed Stone by Truck. GeoNews. Illinois State Geological Survey. 10:1.

Soil and Environmental Engineers, I. 1998. A Tool Kit for the Use of Post-Consumer Glass as a Construction Aggregate, CWC, A Division of the Pacific North West Economic Region: 97.

Compost

Ellen, W. 1995. Cost of Transporting Crushed Stone by Truck. GeoNews. Illinois State Geological Survey. 10:1.

McCoy, S. and B. Cogburn. 2001. Texas Makes Inroads with Highway Use of Compost, BioCycle.

Soil and Environmental Engineers, I. 1998. A Tool Kit for the Use of Post-Consumer Glass as a Construction Aggregate, CWC, A Division of the Pacific North West Economic Region: 97.

The State of Recycling Practice in Transportation

Ellen, W. 1995. Cost of Transporting Crushed Stone by Truck. GeoNews. Illinois State Geological Survey. 10:1.

Soil and Environmental Engineers, I. 1998. A Tool Kit for the Use of Post-Consumer Glass as a Construction Aggregate, CWC, A Division of the Pacific North West Economic Region: 97.

Data Availability and Sources

FHWA, Focus Newsletter, April/May 2001.

McCoy, S. and B. Cogburn. 2001. Texas Makes Inroads with Highway Use of Compost, **BioCycle**.

U.S. Geological Survey. 1999. Mineral Yearbook: The Mineral Industry of Texas.

U.S. Geological Survey. 2000. Mineral Yearbook: Silica.

U.S. Geological Survey. 2000. Mineral Industry Surveys: The Directory of Industrial Sand and Gravel Producers in the United States.

APPENDIX A
NONHAZARDOUS RECYCLABLE MATERIALS TRACKING SYSTEM
PROTOTYPE APPLICATION

1. MAJOR COMPONENTS

- Manufacturer Data Update: material manufacturers report the availability of materials on the monthly basis
- TxDOT Material Usage: TxDOT district offices report the usage of materials in highway construction projects
- Material Availability/Usage Query: clients (e.g., aggregate producers, contractors, waste producers/collectors, waste processors, etc.) query/search the availability of materials from recyclers and the usage by TxDOT projects
- Material Quality Requirements Query: clients query/search TxDOT specifications, relevant tests, and related environmental issues sequentially for each material to be used for TxDOT projects
- Recycler Search: search recycling companies of interest

2. SYSTEM REQUIREMENTS

2.1 Hardware Requirements

Server Computer

- RAM: 256 MB (Typical installation, all ArcIMS components)
- Operating System: Windows NT version 4.0 for Intel, Service Pack 6a
- Disk Space for the ArcIMS components: 110 MB (When GIS parts were attached)

Client Computers

- Desktop or laptop computer with at least a Pentium or higher Intel-based microprocessor and a hard disk
- 32 MB of RAM
- Windows 98 or Windows NT version 4.0 operating system

2.2 Software Requirements

Server Computer

- Web server: Microsoft's Internet Information Server (IIS) 4.0 for NT Server
- Microsoft Access 2000
- File upload component for Active Server Pages (ASP) application: AspUpload from Persits Software, Inc. (When TxDOT material use specifications are updated based on file uploading)
- Web browser for ArcIMS Manager: Microsoft Internet Explorer 4.0 or higher (automatically installed on most Windows NT-based computers)
- Servlet Engine: ServletExec for IIS from www.newatlanta.com or Jrun for IIS from www.livesoftware.com/products/jrun

- ArcIMS application server: ESRI ArcIMS 3.0 (www.esri.com)
- Java Runtime Environment (JRE): 1.2.2-004 with Java Plug-in (included in ArcIMS CD-ROM)

Client Computers

- Netscape Communicator 4.5 or Microsoft Internet Explorer 4.0
- Microsoft Access 2000 (for some users within TxDOT)
- ESRI ArcView 3.2 (for GIS personnel at TxDOT)

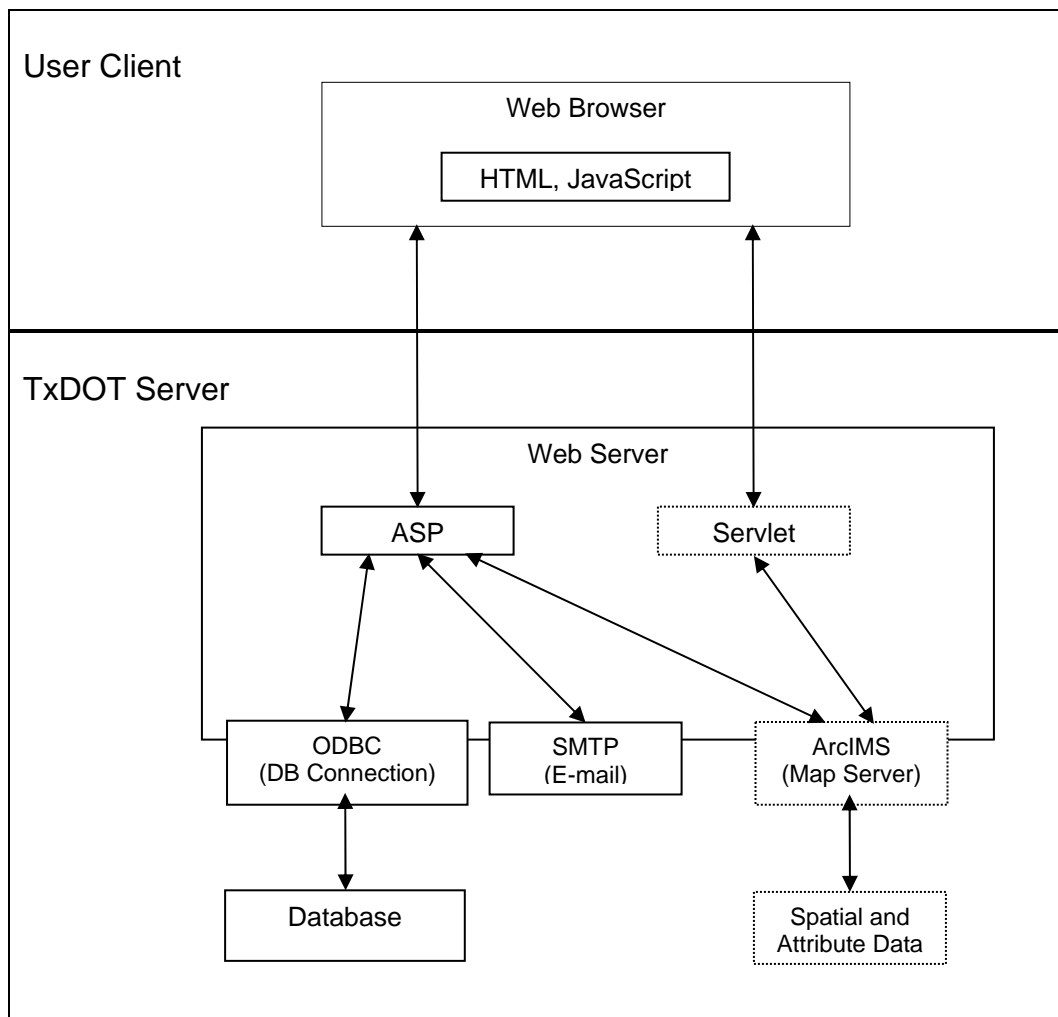


Figure A-1. Proposed System Architecture.

3. SYSTEM INSTALLATION PROCEDURE

Note: This manual assumes the manager of the server computer has system administration access and has a working knowledge of the web server management environment. The procedures described in this manual apply to the platform used by the researchers during the research project (which was experimental and pilot scale). The researchers designed the procedures to be as scalable and portable as possible, however, it is likely that some procedures may require adaptations to the enterprise Internet, GIS, and database platforms used by TxDOT.

NRMs Tracking System Installation

1. Installing Project Folder:
 - a. Select the hard drive with enough free space (at least 60 MB).
 - b. Copy and paste the NRM folder onto the hard drive (e.g., C:\NRM).
 - c. The project folder is composed of six folders (see [Figure A-2](#)):
 - | Default Folder: location of NRMs project files (.html, .htm & .asp).
 - | Data_Recycling: location of GIS shape files (.shp)
 - | DB: location of project database files (.mdb).
 - | Images: location of image files (.jpg & .gif).
 - | Lib: location of pages about title, copyright, and note of cookies.
 - | Tutorial: location of NRM project application tutorial pages.
2. Creating Virtual Folder for Project Folder:
 - a. Use the Microsoft Management Console (Choose Start / Programs / Windows NT Option Pack / Microsoft Internet Information Server / Internet Service Manager) to create a virtual folder: NRM.
 - b. To create the web site Virtual Folder,
 - * Highlight Default web site and click Action / New / Virtual Directory to display the New Virtual Directory Wizard.
 - * In the alias field, type “NRM” and click Next.
 - * Click Browse to select the physical “NRM” folder (e.g., C:\NRM).
 - * Check Allow Directory Browsing and click Finish.

ArcIMS Installation and Configuration

1. Installing the Servlet Engine: the installation process automatically designates a program file folder (e.g., C:\Program Files) and a working folder on the web server (e.g., D:\Inetpub).
2. Installing ArcIMS:
 - a. Select the typical installation option.
 - b. Installation folder: default setting or any folder you specify (e.g., C:\).
 - c. Web server host name: the host name of the server computer. (Note: make sure that the full domain name is included, e.g., “ttienv-util.tamu.edu”).

- d. Select a folder as ArcIMS web site working folder. By default, the folder is located on the web server drive and is called ArcIMS (e.g., C:\ArcIMS).
- e. The installation process automatically creates four folders on the ArcIMS working folder (Figure A-2):
 - | Axl: location of ArcIMS project files (maps).
 - | Manager: location of ArcIMS program files.
 - | Output: location of ArcIMS outputs.
 - | web site: location of ArcIMS web applications.
- f. Locate the Servlet folder on the web server (e.g., C:\Input\Servlet).

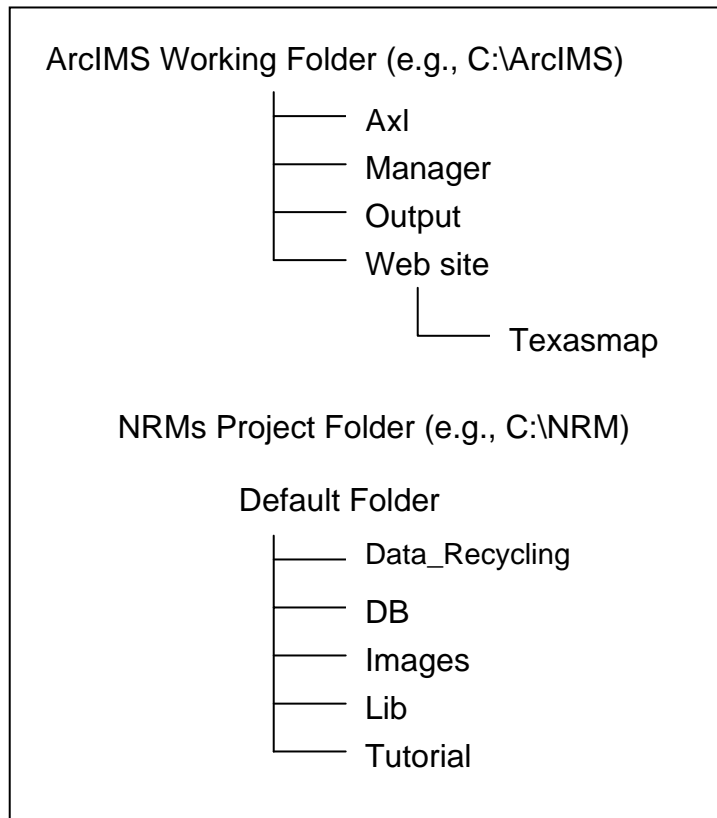


Figure A-2. Server Folder Structure.

3. Configuring the web server:
 - a. In the case of ServletExec for ISS: Copy the Com folder and the Esrimap_prop file from the web server folder (e.g., C:\Inetpub\Servlet) to the program file folder (e.g., C:\Program Files\New Atlanta\ServletExec ISAPI\Servlet).
 - b. Test the Servlet Connector.

4. Creating Virtual Folders for ArcIMS:
 - a. Use the Microsoft Management Console (Choose Start / Programs / Windows NT Option Pack / Microsoft Internet Information Server / Internet Service Manager) to create a virtual folder: NRM.
 - b. To create the web site Virtual Folder,
 - * Highlight Default web site and click Action / New / Virtual Directory to display the New Virtual Directory Wizard.
 - * In the alias field, type “Web site” and click Next.
 - * Click Browse to select the physical “NRM” folder (e.g., C:\ArcIMS\Web site).
 - * Check Allow Directory Browsing and click Finish.
 - c. To create the Output virtual folder,
 - * Repeat steps under “b” above replacing “Web site” with “Output.”
 - d. To create the Manager Virtual Folder,
 - * Repeat steps under “b” above replacing “Web site” with “Manager.”
 - * Highlight the “Manager” virtual folder and click Action / Properties.
 - * Click the File Security tab and click Edit to change the Anonymous Access and Authentication Control.
 - * Make sure Anonymous Access is checked. Uncheck Windows NT Challenge/Response and click OK.

Installing Additional Components

1. Microsoft IIS SMTP (Simple Mail Transfer Protocol):
 - a. This component is necessary for sending e-mail messages automatically from the web server.
 - b. To install, under Windows NT Option Pack | Windows NT Option Pack Setup,
 - * Click “Add/Remove” button.
 - * Highlight “Internet Information Server (IIS).”
 - * Click “Show Subcomponents.”
 - * Click “SMTP Service.”
2. Scheduled Collective E-mail Component (AspEvent by CinCare Software - www.cincare.com):
 - a. At the beginning of every month, the NRM company users (i.e., suppliers) are supposed to be contacted by the current system through scheduled monthly e-mail inquiry. Through the link contained in the contact e-mail, they enter the system and supply the availability (i.e., the total amount) of the NRM they had produced during the previous month.
 - b. For this process, this component is a requirement for retrieving e-mail addresses of NRM suppliers and sending scheduled monthly e-mails to them.
 - c. In the system, the AspEvent schedules monthly events to activate a specific ASP page that sends SQL-Script commands to Access DB and SMTP components.

- d. To install,
 - * Visit CinCare homepage (www.cincare.com).
 - * Download a free 20-day trial version of AspEvent 2.0 and install it into the hard drive.
 - * Purchase the key code to unlock the system. The key code will be e-mailed to the purchaser after the order is processed.
- e. To unlock the system,
 - * Launch ASPeCfg.exe, the ASPevent configuration program.
 - * Close any dialog windows that pop up on start of the program.
 - * Click the “Register” button.
 - * On the “Purchasing Info” window click the “Register Now” Button.
 - * Enter name and e-mail address (this is the address the key code is sent to).
 - * Enter the Proof of Purchase code.
 - * Click the “Register” Button. This will send the key request to the company.
 - * Wait until you receive a reply with your key code (typically same day).
 - * When you receive your key code via email, start ASPeCfg.exe again.
 - * Click the “Register” button | “Register Now” button | “Enter Registration Code” button.
 - * Enter the Key Code that was e-mailed to you.
 - * Click “Unlock.”

Connecting Web Server to Database

1. Create an ODBC (Open Database Connectivity) DSN (Data Source Name using the Data Sources (ODBC) | System DSN Window NT utility:
 - a. Under “Data Source Name,” type in “NRMs_db.” This alias is the same database alias used by related ASP pages.
 - b. Navigate through the folder hierarchy until finding the actual database schema file (e.g., C:\NRM\db\NRMs_db).

Initializing ArcIMS

1. Authoring map service:
 - a. ArcIMS Manager functions as a tool for creating a WebMap by adding data to the map and starting the map as a MapService.
 - b. To start ArcIMS Manager, click Start | Programs | Esri | ArcIMS | Manager.
 - c. Click “Set Up Web Site” in the sidebar.
 - d. Type the administration Login name and Password. By default, the Login is “admin,” and the Password is “admin.” Click “OK”.
 - e. Click “Author MapService” on the main page or click “Author MapService” on the sidebar.
 - f. Name of map service file: Type in “Texasmap.” This file is created in the ArcIMS\Axl folder.
 - g. Click “Next.”

- h. Click the “Add Layers” button on the toolbar.
 - i. Under Data Sources, double-click “Local.” Then click each folder to navigate to the GIS shape files at C:\NRM\Data_Recycling.
 - j. Choose layers: Add the following layers from the NRM\Data_Recycling folder: Compost Locations, Glass Locations, Quarry Locations, Tire Recyclers, Cnty24_dd, Cityname, Districts.
 - k. Check the box next to each layer in the legend to draw it on the map.
 - l. Click “Save” on the toolbar to save the work done so far. The work is saved into a file named Texasmap.axl in C:\ArcIMS\Axl.
 - m. Draw each layer with a new set of symbols and colors.
 - n. May service name: Type in “Texasmap” (to maintain consistency with the file name). This name will be displayed on the Map Services window in ArcIMS Administrator.
 - o. Virtual Server type: “ImageServer1.”
 - p. Click “Save Site Configuration.” Then click “OK” on the message box.
2. Designing Web Site:
- a. Before designing a web site, make sure that the map server that has been created with Author is running (click on the Administrator Site link).
 - b. Click Administrator Site from the sidebar or click Administer then site from the main page. Click MapServices. A table lists all of MapServices created.
 - c. Click Design web site in the sidebar.
 - d. Type “Texasmap” as the name of the web site directory and “Texas NRMs Tracking System” for the title of the web page and browser window. Click Next.
 - e. Verify that the project MapService is listed.
 - f. Choose Texasmap from the Available MapServices list and click the right arrow button to add the MapService to the MapServices in web site list. Click Next.
 - g. Next choose the viewer to be used. The current system is set to be compatible with HTML Viewer. So, choose HTML Viewer. Click Next.
 - h. Choose toolbar functionality. The current system follows the default settings of ArcIMS, so check all buttons to provide toolbar functions to the users who view the project web site. Click Next.
 - i. Click Create web site.
 - j. Review the web site Summary. It lists the web site name, Directory Location, and the MapServices used. Click Finish.
3. Viewing the Project Web Site:
- a. Now, the web site is ready to be viewed.
 - b. Open the web site by typing its URL. The URL should contain:
http://<host name> / <web site root directory> / <web site directory>
For example, <http://ttienv-util.tamu.edu/Web site/Texasmap>.
 - c. Try out the page to ensure the look and functionality of page as designed.

APPENDIX B
TEXAS NRMS TRACKING SYSTEM
CD-ROM CONTENTS

Figure B-1 shows the structure of the system CD-ROM contents. A short description of the main folders follows.

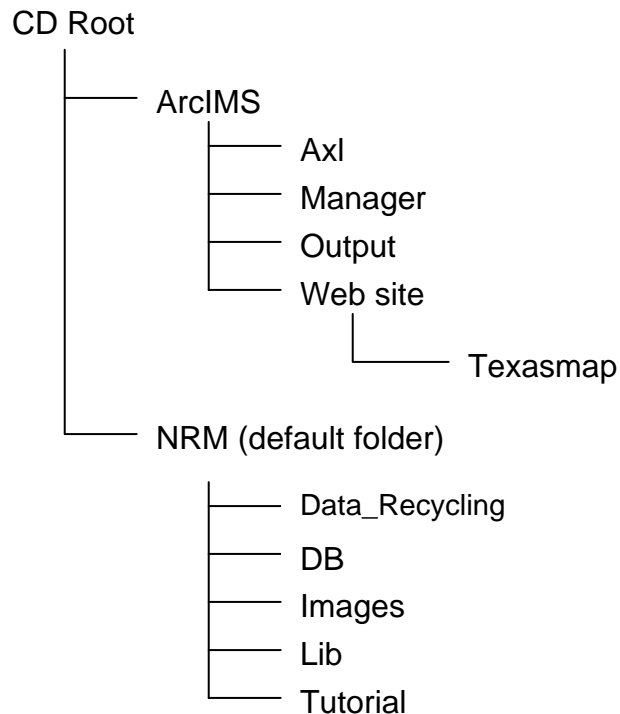


Figure B-1. NRMs Tracking System CD Folder Structure.

- ArcIMS \ Axl: location of ArcIMS project files (maps).
- ArcIMS \ Manager: location of ArcIMS program files.
- ArcIMS \ Output: location of ArcIMS outputs.
- ArcIMS \ Web site: location of ArcIMS web applications.
- NRM (Default Folder): location of NRMs project files (.html, .htm & .asp). It contains a copy of the ASP and HTML files that are required to process registrations and queries online. The folder contains five subfolders: Data_Recycling, DB, Images, Lib, and Tutorial.
- NRM \ Data_Recycling: location of GIS shape files (.shp). This folder contains sample ArcView shape files, including files: Suppliers Locations (Compost Locations, Glass Locations, Quarry Locations, Tire Recyclers), Cnty24_dd, Cityname, and Districts.
- NRM \ DB: location of project database files (.mdb). It contains a sample copy of Access 2000 database file with the information of actual Texas NRM suppliers and an empty copy of the Access 2000 database schema file.
- NRM \ Images: location of image files used for web page designs. (.jpg & .gif).
- NRM \ Lib: location of pages about title, copyright, and note of cookies.
- NRM \ Tutorial: location of NRM project application tutorial pages.

APPENDIX C
ASP, HTML, AND JAVASCRIPT FUNCTION QUICK REFERENCE

ASP FILE LISTING

Avail_email_send.asp

Called by Avail_email_view.asp
Calls Availability.asp
Description Displays a message box mentioning that the email was sent successful.
Sends an e-mail notification to NRMs personnel regarding the email successfully sent.

Avail_email_view.asp

Called by Availability_after_login.asp, Availability_after_login2.asp
Calls Avail_email_send.asp
Description Form for TxDOT personnel to fill out email contents for contacting selected NRMs supplier company.

Availability.asp

Called by Default.asp
Calls Availability_update.asp, Availability_query.asp
Description Opens a query window for the availability of NRMs manufactured by suppliers in Texas.

Availability_after_login.asp

Called by Availability_login_proc.asp
Calls Availability_query.asp, Availability_logout.asp, Avail_email_view.asp, Default.htm (Esri's ArcIMS default page)
Description Displays the supplier company's profile (when logged in first time).

Availability_after_login2.asp

Called by Availability_login_proc.asp
Calls Availability_query.asp, Availability_logout.asp, Avail_email_view.asp, Default.htm (Esri's ArcIMS default page)
Description Displays the supplier company's profile, when session(pass_CmpnyID) is not expired.

Availability_login.asp

Called by Availability_Query.asp
Calls Availability_update.asp, Note_Cookies.htm
Description TxDOT personnel login page

Availability_login_proc.asp

Called by Availability_login.asp
Calls Availability_after_login.asp
Description Executes the TxDOT personnel login procedure.

Availability_logout.asp

Called by Availability_after_login.asp, Availability_after_login2.asp
Calls Availability_login.asp
Description Executes the TxDOT personnel logout procedure.

Availability_query.asp

Called by Availability_update.asp
Calls Availability.asp, Availability_login.asp
Description Executes a query for NRMs availability based on the conditions selected on Availability.asp.

Availability_submitted.asp

Called by Availability_submitted.asp
Calls Javascript (closing the Internet browser), Availability_update.asp
Description Displays a message box mentioning that the submission of NRMs availability was successful.
Sends an e-mail notification to the supplier regarding the updated availability.

Availability_update.asp

Called by Availability_query.asp
Calls Availability_updateMain.asp
Description NRMs suppliers login page

Availability_update_login_proc.asp

Called by Availability_updatemain.asp
Calls Availability_updateMain.asp
Description Executes the NRMs suppliers login procedure.

Availability_updatemain.asp

Called by Availability_update_login_proc.asp
Calls Availability_updateproc.asp
Description Displays the supplier's list of NRMs.
The supplier is supposed to enter manufactured NRMs availability during last month.

Availability_updateproc.asp

Called by Availability_updateproc.asp
Calls Availability_submitted.asp
Description Confirms the NRMs amount entered by the supplier.

Default.asp

Called by Application
Calls Various files
Description Displays default page when users first access the system.

Edit.asp

Called by RegistrProc.asp
Calls Registration.asp, RegistrProc.asp
Description Deletes the registration process executed on RegistrProc.asp, and returns to Registration.asp.

Email_send.asp

Called by Email_view.asp
Calls Search.asp
Description Displays a message box mentioning that the email was sent successful.
Sends an e-mail notification to the e-mail sender regarding the successful email submission.

Email_view.asp

Called by Search_detail.asp
Calls Email_send.asp
Description Form for filling out email contents in contacting selected NRMs supplier company.

EmailQuery.asp

Called by Search.asp
Calls Search_detail.asp, Search.asp
Description Displays the query results of NRMs supplier companies according to the conditions on Search.asp.

Faq.asp

Called by Default.asp
Calls Default.asp
Description Contains a list of Frequently Asked Questions and appropriate answers about NRMs suppliers, purchaser (i.e., TxDOT), and NRMs specifications.

List_all.asp

Called by Default.asp
Calls Search_detail.asp, default.asp
Description Displays the total list of NRMs suppliers registered in the current system.

List_Rcl_Cos.asp

Called by Search.asp
Calls Search.asp, List_Rcl_Cos.asp (column sorting, page up), Search_detail.asp
Description Displays the total list of NRMs suppliers registered in the current system.

Market.asp

Called by Default.asp
Calls Default.asp, Market_query_1.asp
Description Opens a query window for the amount of NRMs needed by TxDOT.

Market_query_1.asp

Called by Market.asp
Calls Market.asp, Multiplier_login.asp
Description Executes a query for the amount of NRMs needed by TxDOT according to the conditions selected on Market.asp.

MtrlQtyProc.asp

Called by Specs.asp
Calls Specs.asp
Description Displays the quality requirements of NRMs for TxDOT projects.

MtrlSpecsProc.asp

Called by Specs.asp
Calls Item_*.htm, Spec_multiplier_login.asp
Description Displays a list of item numbers, item description of the track material selected on Specs.asp.
Contains several links to TxDOT websites for querying the details of Specifications.

MtrlSpecsProc_1.asp

Called by Specs.asp
Calls Item_*.htm, Spec_multiplier_login.asp
Description Displays a list of item numbers, item description of the track material selected on Specs.asp.
Contains several links to TxDOT websites for querying the details of Specifications.

Multiplier_login.asp

Called by Market_query_1.asp
Calls Multipliers_update_login_Proc.asp, Note_Cookies.htm
Description TxDOT personnel login page.

Multipliers_0.asp

Called by Multipliers_update_login_Proc.asp
Calls Multiplier_login.asp, Multipliers_1.asp
Description Displays a list of item numbers belonging to the category of the material name selected on Market.asp. This page, also, contains the minimum/maximum multiplier values varied according to item number.

Multipliers_1.asp

Called by Multipliers_0.asp
Calls Multipliers_0.asp, Multipliers_2.asp
Description Displays the item number and minimum/maximum multiplier values.
The TxDOT personnel access this page for updating the multiplier values as changes occur in the future.

Multipliers_2.asp

Called by Multipliers_1.asp
Calls Multipliers_1.asp, Multipliers_submit.asp
Description Confirms the multiplier values entered by the TxDOT personnel.

Multipliers_submit.asp

Called by Multipliers_2.asp
Calls Multipliers_0.asp
Description Executes the multiplier values update according to the changes on Multipliers_2.asp.
Sends an e-mail notification to the TxDOT personnel regarding the successful update of the multiplier values.

Multipliers_update_login_Proc.asp

Called by Multiplier_login.asp
Calls Multipliers_0.asp
Description Executes the TxDOT personnel login procedure.

Registration.asp

Called by Default.asp
Calls RegistrProc.asp, Default.asp
Description Registration form for the NRMs track system users whose company is not currently listed in the system.
Username & password are decided and entered by the applicant on this page.

RegistrProc.asp

Called by Registration.asp
Calls Edit.asp, Submit.asp
Description Performs the registration of a new company user as a NRMs supplier to the system database.
Displays a message box mentioning that the registration as a new NRMs supplier was successful.
Sends an e-mail notification to the supplier regarding the successful registration.

Search.asp

Called by Default.asp
Calls List_Rcl_COs.asp, Default.asp, EmailQuery.asp
Description Opens a query window for NRMs companies registered in the current system.

Search_detail.asp

Called by EmailQuery.asp, List_Rcl_Cos.asp
Calls Viewer.htm, Search_detail.asp, Email_view.asp
Description Displays the information of NRMs supplier selected either on EmailQuery.asp or List_Rcl_Cos.asp.

Spec_multiplier_login.asp

Called by MtrlSpecsProc.asp
Calls MtrlSpecsProc.asp, Spec_multipliers_update_login_Proc.asp
Description TxDOT personnel login page.

Specs_multipliers_0.asp

Called by Specs_multipliers_update_login_Proc.asp
Calls Specs_multiplier_login.asp, Specs_multipliers_1.asp
Description Displays a list of item numbers belonging to the category of the material name selected on Specs.asp. This page, also, contains the minimum/maximum multiplier values varied according to item number.

Specs_multipliers_1.asp

Called by Specs_multipliers_0.asp
Calls Specs_multipliers_0.asp, Specs_multipliers_2.asp
Description Displays the item number and minimum/maximum multiplier values. The TxDOT personnel access this page for updating the multiplier values as changes occur in the future.

Specs_multipliers_2.asp

Called by Specs_multipliers_1.asp
Calls Specs_multipliers_1.asp, Specs_multipliers_submit.asp
Description Confirms the multiplier values entered by the TxDOT personnel.

Specs_multipliers_submit.asp

Called by Specs_multipliers_2.asp
Calls Specs_multipliers_0.asp
Description Executes the multiplier values update according to the changes on Specs_multipliers_2.asp.
Sends an e-mail notification to the TxDOT personnel regarding the successful update of the multiplier values.

Specs_multipliers_update_login_Proc.asp

Called by Specs_multiplier_login.asp
Calls Specs_multipliers_0.asp
Description Executes the TxDOT personnel login procedure.

Specs.asp

Called by Default.asp
Calls Default.asp, MtrlSpecsProc.asp, MtrlQtyProc.asp
Description Displays a list of the specifications and quality of the items classified by track NRMs.

Submit.asp

Called by RegistrProc.asp, UpdateConfirm.asp
Calls Registration.asp, Default.asp
Description Performs either the registration of a new company user as a NRMs supplier to the system database or the update of already registered NRMs supplier's information.
Displays a message box mentioning that either the registration as a new NRMs supplier or the information update was successful.
Sends an e-mail notification to the supplier regarding either successful registration or successful information update.

Tutorial_1.asp

Called by Default.asp
Calls Tutorial_2.asp, Default.asp (exit demo)
Description Displays the first page of the System Tutorial.

Tutorial_10.asp

Called by Tutorial_9.asp
Calls Tutorial_10_search_detail.asp, Tutorial_9.asp
Description Displays the total list of NRMs suppliers registered in the current system.

Tutorial_10_email_send.asp

Called by Tutorial_10_email_view.asp
Calls Search.asp
Description Displays a message box mentioning that the email was sent successful.
Sends an e-mail notification to the e-mail sender regarding the successful email submission.

Tutorial_10_email_view.asp

Called by Tutorial_10_search_detail.asp
Calls Tutorial_10_email_send.asp
Description Form for filling out email contents in contacting selected NRMs supplier company.

Tutorial_10_emailQuery.asp

Called by Tutorial_10.asp
Calls Tutorial_10_search_detail.asp, Tutorial_10.asp
Description Displays the query results of NRMs supplier companies according to the conditions on Tutorial_10.asp.

Tutorial_10_search_detail.asp

Called by Tutorial_10_emailQuery.asp, Tutorial_10_list_Rcl_Cos.asp
Calls Viewer.htm, Tutorial_10_search_detail.asp,
Tutorial_10_email_view.asp
Description Displays the information of NRMs supplier selected either on Tutorial_10_emailQuery.asp or Tutorial_10_list_Rcl_Cos.asp.

Tutorial_2.asp

Called by Tutorial_1.asp
Calls Tutorial_3.asp, Tutorial_7.asp, Default.asp (exit demo)
Description Contains a tutorial page describing the contents of the two major subsections (i.e., Materials & Suppliers).

Tutorial_3.asp

Called by Tutorial_2.asp
Calls Tutorial_4.asp, Default.asp (exit demo)
Description Displays a tutorial page explaining about "Availability" button page. Includes a Try-it section for the first visitors to try the functions on "Availability" page at tutorial level.

Tutorial_3_availability_query.asp

Called by Tutorial_3_availability_update.asp
Calls Tutorial_3_availability.asp, Tutorial_3_availability_login.asp
Description Executes a query for NRMs availability based on the conditions selected on Availability.asp.

Tutorial_3_availability_submitted.asp

Called by Tutorial_3_availability_submitted.asp
Calls Javascript (closing the Internet browser),
Tutorial_3_availability_update.asp
Description Displays a message box mentioning that the submission of NRMs availability was successful.
Sends an e-mail notification to the supplier regarding the updated availability.

Tutorial_3_availability_update.asp

Called by Tutorial_3_availability_query.asp
Calls Tutorial_3_availability_updateMain.asp
Description NRMs suppliers login page

Tutorial_3_availability_update_login_proc.asp

Called by Tutorial_3_availability_updatemain.asp
Calls Tutorial_3_availability_updateMain.asp
Description Executes the NRMs suppliers login procedure.

Tutorial_3_availability_updatemain.asp

Called by Tutorial_3_availability_update_login_proc.asp
Calls Tutorial_3_availability_updateproc.asp
Description Displays the supplier's list of NRMs.
The supplier is supposed to enter manufactured NRMs availability during last month.

Tutorial_3_availability_updateproc.asp

Called by Tutorial_3_availability_updateproc.asp
Calls Tutorial_3_availability_submitted.asp
Description Confirms the NRMs amount entered by the supplier.

Tutorial_4.asp

Called by Tutorial_3.asp
Calls Tutorial_5.asp, Default.asp (exit demo)
Description Displays a tutorial page explaining about "Market" button page.
Includes a Try-it section for the first visitors to try the functions on "Market" page at tutorial level.

Tutorial_4_market_query.asp

Called by Tutorial_4.asp
Calls Tutorial_4.asp, Tutorial_4_multiplier_login.asp
Description Executes a query for the amount of NRMs needed by TxDOT according to the conditions selected on Tutorial_4.asp.

Tutorial_4_multiplier_login.asp

Called by Trial_4_market_query.asp
Calls Trial_4_multipliers_update_login_Proc.asp, Note_Cookies.htm
Description TxDOT personnel login page.

Tutorial_4_multipliers_update_login_Proc.asp

Called by Trial_4_multiplier_login.asp
Calls Trial_4_multipliers_0.asp
Description Executes the TxDOT personnel login procedure.

Tutorial_4_multipliers_0.asp

Called by Trial_4_multipliers_update_login_Proc.asp
Calls Trial_4_multiplier_login.asp, Trial_4_multipliers_1.asp
Description Displays a list of item numbers belonging to the category of the material name selected on Tutorial_4.asp. This page, also, contains the minimum/maximum multiplier values varied according to item number.

Tutorial_4_multipliers_1.asp

Called by Trial_4_multipliers_0.asp
Calls Trial_4_multipliers_0.asp, Trial_4_multipliers_2.asp
Description Displays the item number and minimum/maximum multiplier values. The TxDOT personnel access this page for updating the multiplier values as changes occur in the future.

Tutorial_4_multipliers_2.asp

Called by Trial_4_multipliers_1.asp
Calls Trial_4_multipliers_1.asp, Trial_4_multipliers_submit.asp
Description Confirms the multiplier values entered by the TxDOT personnel.

Tutorial_4_multipliers_submit.asp

Called by Trial_4_multipliers_2.asp
Calls Trial_4_multipliers_0.asp
Description Executes the multiplier values update according to the changes on Trial_4_multipliers_2.asp.
Sends an e-mail notification to the TxDOT personnel regarding the successful update of the multiplier values.

Tutorial_5.asp

Called by Tutorial_4.asp
Calls Tutorial_4.asp, Tutorial_5_mtrlSpecsProc.asp,
Tutorial_5_mtrlQtyProc.asp
Description Displays a list of the specifications and quality of the items classified by track NRMs.

Tutorial_5_spec_multiplier_login.asp

Called by Tutorial_5_mtrlSpecsProc.asp
Calls Tutorial_5_mtrlSpecsProc.asp,
Tutorial_5_spec_multipliers_update_login_Proc.asp
Description TxDOT personnel login page.

Tutorial_5_specs_multipliers_0.asp

Called by Tutorial_5_specs_multipliers_update_login_Proc.asp
Calls Tutorial_5_specs_multiplier_login.asp,

Description Tutorial_5_specs_multipliers_1.asp
Displays a list of item numbers belonging to the category of the material name selected on Tutorial_5.asp. This page, also, contains the minimum/maximum multiplier values varied according to item number.

Tutorial_5_specs_multipliers_1.asp

Called by Tutorial_5_specs_multipliers_0.asp
Calls Tutorial_5_specs_multipliers_0.asp,
Tutorial_5_specs_multipliers_2.asp
Description Displays the item number and minimum/maximum multiplier values.
The TxDOT personnel access this page for updating the multiplier values as changes occur in the future.

Tutorial_5_specs_multipliers_2.asp

Called by Tutorial_5_specs_multipliers_1.asp
Calls Tutorial_5_specs_multipliers_1.asp,
Tutorial_5_specs_multipliers_submit.asp
Description Confirms the multiplier values entered by the TxDOT personnel.

Tutorial_5_specs_multipliers_submit.asp

Called by Tutorial_5_specs_multipliers_2.asp
Calls Tutorial_5_specs_multipliers_0.asp
Description Executes the multiplier values update according to the changes on Tutorial_5_specs_multipliers_2.asp.
Sends an e-mail notification to the TxDOT personnel regarding the successful update of the multiplier values.

Tutorial_5_specs_multipliers_update_login_Proc.asp

Called by Tutorial_5_specs_multiplier_login.asp
Calls Tutorial_5_specs_multipliers_0.asp
Description Executes the TxDOT personnel login procedure.

Tutorial_7.asp

Called by Tutorial_5.asp
Calls Tutorial_7_registrProc.asp, Tutorial_5.asp
Description Registration form for the NRMs track system users whose company is not currently listed in the system.
Username & password are decided and entered by the applicant on this page.

Tutorial_7_edit.asp

Called by Tutorial_7_registrProc.asp
Calls Tutorial_7.asp, Tutorial_7_registrProc.asp
Description Deletes the registration process executed on Tutorial_7_registrProc.asp, and returns to Tutorial_7.asp.

Tutorial_7_registrProc.asp

Called by Tutorial_7.asp
Calls Tutorial_7_submit.asp
Description Performs the registration of a new company user as a NRMs supplier to the system database.
Displays a message box mentioning that the registration as a new NRMs supplier was successful.
Sends an e-mail notification to the supplier regarding the successful registration.

Tutorial_7_submit.asp

Called by Tutorial_7_registrProc.asp
Calls Tutorial_7.asp
Description Performs either the registration of a new company user as a NRMs supplier to the system database or the update of already registered NRMs supplier's information.
Displays a message box mentioning that either the registration as a new NRMs supplier or the information update was successful.
Sends an e-mail notification to the supplier regarding either successful registration or successful information update.

Tutorial_8.asp

Called by Tutorial_7.asp
Calls Tutorial_8_updateProc.asp, NoteCookies.htm
Description NRMs supplier's login page.

Tutorial_8_update_edit.asp

Called by Tutorial_8_update_edit.asp
Calls Tutorial_8_update.asp, Tutorial_8_updateConfirm.asp
Description Connects to Tutorial_8_updateMain.asp for NRMs supplier to edit his or her own information.

Tutorial_8_updateConfirm.asp

Called by Tutorial_8_updateMain.asp
Calls Tutorial_8_update_edit.asp, Tutorial_7_submit.asp
Description Confirms the information of NRMs supplier company edited on Tutorial_8_updateMain.asp.

Tutorial_8_updateMain.asp

Called by Tutorial_8_updateProc.asp
Calls Tutorial_8_update.asp, Tutorial_8_updateConfirm.asp
Description Displays the organization, contact, security information of NRMs supplier company.

Tutorial_8_updateProc.asp

Called by Tutorial_8.asp
Calls Tutorial_8.asp, Tutorial_8_updateMain.asp
Description Executes NRMs supplier's login procedure.

Tutorial_9.asp

Called by Tutorial_8.asp
Calls Tutorial_9_list_Rcl_COs.asp, Tutorial_8.asp,
Tutorial_9_emailQuery.asp
Description Opens a query window for NRMs companies registered in the current system.

Tutorial_9_email_send.asp

Called by Tutorial_9_email_view.asp
Calls Tutorial_9.asp
Description Displays a message box mentioning that the email was sent successful.
Sends an e-mail notification to the email sender regarding the successful email submission.

Tutorial_9_email_view.asp

Called by Tutorial_9_search_detail.asp
Calls Tutorial_9_email_send.asp
Description Form for filling out email contents in contacting selected NRMs supplier company.

Tutorial_9_emailQuery.asp

Called by Tutorial_9.asp
Calls Tutorial_9_search_detail.asp, Tutorial_9.asp
Description Displays the query results of NRMs supplier companies according to the conditions on Tutorial_9.asp.

Tutorial_9_search_detail.asp

Called by Tutorial_9_emailQuery.asp, Tutorial_9_list_Rcl_Cos.asp
Calls Viewer.htm, Tutorial_9_search_detail.asp,
Tutorial_9_email_view.asp
Description Displays the information of NRMs supplier selected either on Tutorial_9_emailQuery.asp or Tutorial_9_list_Rcl_Cos.asp.

TxDot_after_login.asp

Called by Txdot_login_proc.asp
Calls Viewer.htm, Default.asp
Description Displays the default page of TxDOT personnel site.

Txdot_login.asp

Called by Default.asp
Calls Default.asp, NoteCookies.htm, Txdot_login_proc.asp
Description TxDOT personnel login page into WebMaps and links.

Txdot_login_proc.asp

Called by Txdot_login.asp
Calls TxDot_after_login.asp
Description Executes the TxDOT personnel login procedure.

Update.asp

Called by Default.asp
Calls UpdateProc.asp, Default.asp, NoteCookies.htm
Description NRMs supplier's login page.

Update_edit.asp

Called by Update_edit.asp
Calls Update.asp, UpdateConfirm.asp
Description Connects to UpdateMain.asp for NRMs supplier to edit his or her own information.

UpdateConfirm.asp

Called by UpdateMain.asp
Calls Update_edit.asp, Submit.asp
Description Confirms the information of NRMs supplier company edited on UpdateMain.asp.

UpdateMain.asp

Called by UpdateProc.asp
Calls Update.asp, UpdateConfirm.asp
Description Displays the organization, contact, security information of NRMs supplier company.

UpdateProc.asp

Called by Update.asp
Calls Update.asp, UpdateMain.asp
Description Executes NRMs supplier's login procedure.

HTML FILE LISTING

Bottom.htm

Called by MapFrame.htm
Calls None
Description Originally generated by Esri's ArcIMS but modified.

Copyright.htm

Called by Various files
Calls
Description States copyright and legal notices of the current system including TTI address.

Default.htm

Called by Application
Calls Viewer.htm
Description Originally generated by Esri's ArcIMS but modified.
Detects browser type and checks its requirements.
Calls viewer.htm.

Item_*.htm

Called by MtrlSpecsProc.asp
Calls
Description Opens a pop-up window describing the material specifications of the item number selected on MtrlSpecsProc.asp.

LoginErr.htm

Called by Various pages
Calls
Description Displays an error screen if the login and/or password is (are) not on file.

MapFrame.htm

Called by Viewer.htm
Calls All JavaScript pages
Description Originally generated by Esri's ArcIMS but modified.
Includes JavaScript pages.
Calls proper function to handle access coordinate data type.

ModeFrame.htm

Called by Viewer.htm
Calls None
Description Originally generated by Esri's ArcIMS but modified.
Modified to complete the map layout.
Displays the tool mode.

NoteCookies.htm

Called by Various files
Calls
Description Opens a help window describing how to set cookies.

Toc.htm

Called by TOCFrame.htm
Calls None
Description Originally generated by Esri's ArcIMS but modified.
Displays the map layers and notice applications in TOCFrame.

Toolbar.htm

Called by Javascript functions
Calls None
Description Originally generated by Esri's ArcIMS but modified.
Displays and applies the functionality of custom tools.

Top.htm

Called by Viewer.htm
Calls None
Description Originally generated by Esri's ArcIMS but modified.
Displays map title.

Underconstruction.html

Called by Various files
Calls
Description Displays an under-construction screen if the page is not completely developed.

Viewer.htm

Called by Default.htm
Calls Top.htm, TocFrame.htm, Toolbar.htm,
ModeFrame.htm, MapFrame.htm.
Description Originally generated by Esri's ArcIMS but modified.
Calls five basic frames to form the default WebMap viewer page.

JAVASCRIPT LISTING

Function NoteCookiesWin()

Pages TxDot_login.asp, Availability_login.asp, Availability_update.asp, Multiplier_login.asp, Update.asp, Tutorial_4_multiplier_login.asp, Tutorial_8.asp

Category Event Handler

Description Opens up a pop-up window containing notes about setting Cookies based on Internet browser type.

Function validForm()

Pages Availability.asp, Registratin.asp, UpdateMain.asp, Search.asp, Email_view.asp, Avil_email_view.asp, Tutorial_3.asp, Tutorial_3_email_view.asp, Tutorial_7.asp, Tutorial_8.asp, Tutorial_9.asp, Tutorial_9_email_view.asp

Category Event Handler

Description Checks whether all required information are given before submitting the page.

Function WindowReview ()

Pages Txdot_after_login.asp, Availability_after_login_2.asp, Search_detail.asp, Tutorial_9_search_detail.asp

Category Event Handler

Description Opens up a pop-up window activating Viewer.htm which calls five frame pages: Top.htm, TocFrame.htm, Toolbar.htm, ModeFrame.htm, and MapFrame.htm.

