The Framework of a Multi-Level Database of Highway Construction Performance Times

Robert C. Williams

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Michael C. Vorster, Co-Chair
John C. Hildreth, Co-Chair
Jesús M. de la Garza

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(ABSTRACT)

Accurate and reasonable contract time is important to all aspects of a highway construction project. Unreasonably short contract times can raise the bid price, restrict qualified bidders from submitting bids, reduce the quality of the work, and increase the potential for legal disputes. Conversely, unreasonably long contract times encourage less qualified contractors to submit a bid and are a general inconvenience to the traveling public. The Federal Highway Administration (FHWA) recognizes this, and has recommended that all state highway agencies develop a standardized method for estimating contract performance time. To date, the Virginia Department of Transportation (VDOT) does not have an established method.

One major portion of this work is the development of the framework for a multi-level time estimating system to aid in the establishment of contract performance times. This system parallels the VDOT cost estimating process, refining estimates as design details become available along the Project Development Concurrent Engineering Process (PDCEP). Three distinct stages exist along the PDCEP that will facilitate the use of a tool for estimating contract time. Sufficient information to begin the conceptual estimate is known as the project enters the six year plan. The parametric estimate may commence as the project enters the scoping phase. Finally, details for the pre-advertisement time estimate are available upon project field inspection. The second major component of this work, the pre-advertisement estimating database system (*BIDDS – Bid Item Duration Data System*) was constructed during this work. *BIDDS* uses project information and characteristics to filter through historical performance time data, returning production data from similar projects. Production data is returned at the bid item level to assist in the estimation of production rates, for calculating activity durations.

For Nanny and Pop,

**Who could only tell me the importance of education through their words,
but who showed me the rewards of hard work through their lives.**

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I would also like to thank the Charles E. Via Jr. family, as well as the Virginia Department of Transportation for providing the funding necessary for me to pursue a Master's degree. Without their assistance, my time at Virginia Tech would not have been possible.

The employees of VDOT, especially those participating in the Partnership efforts, deserve special thanks for their cooperation, participation, and assistance with my research efforts.

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Chapter 1 – Introduction

This chapter discusses the overview, problem statement, focus, limitations, and benefits of this research. Additionally, the chapter highlights the contract performance time estimation process. An outline describing the format of the remainder of this document concludes the chapter.

1.1 Overview

This research is undertaken in partial fulfillment of the objectives of a partnership formed by Virginia Polytechnic Institute and State University and the Virginia Department of Transportation (VDOT). This three year project titled, "*Partnership for Project Scheduling*," hereafter known as "the Partnership."

One of the objectives of the Partnership is the establishment of a database of historical performance records that will allow VDOT to set more accurate contract times, provide a standard for reviewing proposed schedules, determine the reasonableness of submitted project schedules, and provide a benchmark for the measurement and improvement of contract performance times.

1.2 Contract Performance Time Estimates

Contract performance time is the time allotted, by the owner, for completion of all items of work within a contract. The process of establishing contract performance times involves several elements. The contract time estimate is a calendar-day estimate that is preceded by the pre-advertisement schedule, a work-day time estimate. The pre-advertisement schedule cannot be completed without the combination of activity duration and logic. Activity logic or sequence is established by considering project scope and constraints. Activity duration cannot be established without project quantities and production rates.

Typically, production rates are established from either printed materials or personal experience. The Federal Highway Administration (FHWA), however, recommends the maintenance and use of historical production rates as a means of estimating activity durations (FHWA T5080.15). Figure 1.1, below, illustrates the focus of this research within the contract performance time estimation process.

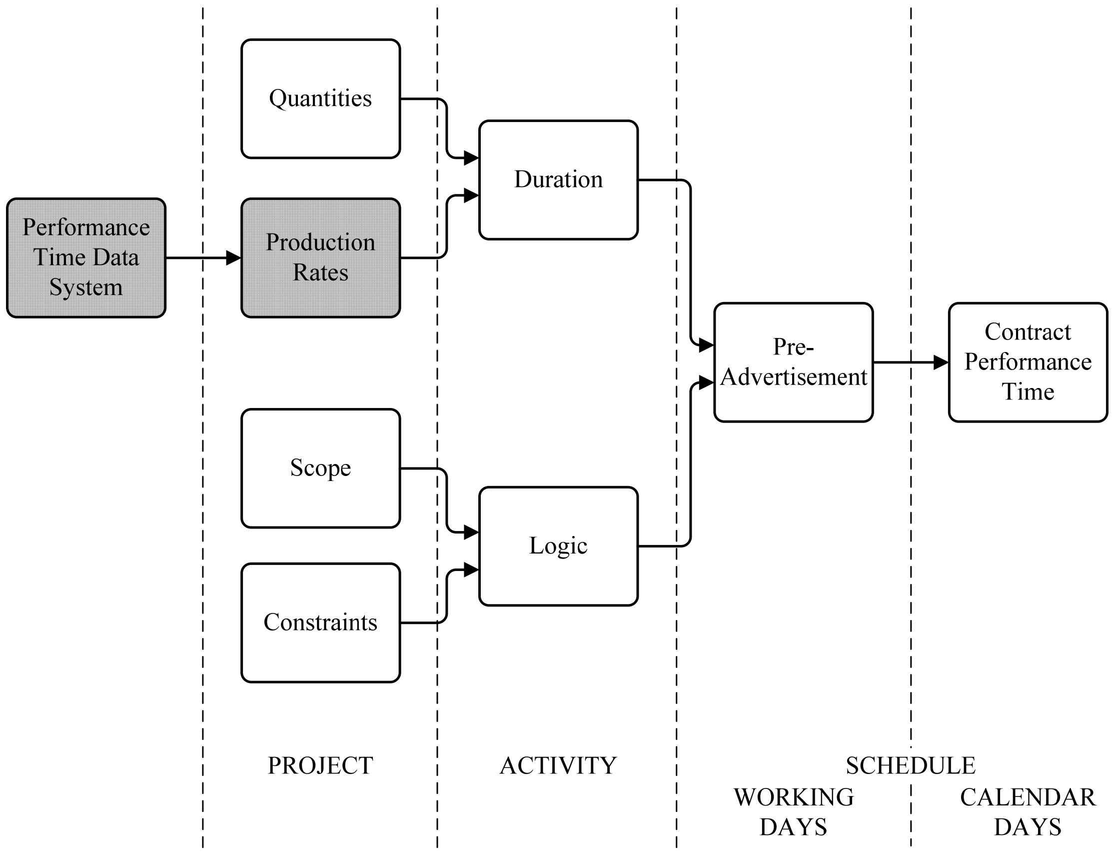


Figure 1.1 – Contract Performance Time Estimation Process

1.3 Statement of the Problem

Accurate contract performance time estimates are beneficial to the traveling public, construction workers, and the optimization of engineering costs and resources (FHWA T5080.15). To facilitate improvement, the FHWA has recommended the establishment of production rates based on historical performance data by all states. To date, Virginia does not have a method for collecting or storing their historical production data in a functional manner.

Cost estimation procedures have progressed through the advent of computer software and the understanding of the need for multi-level estimates. Software is available to store historical cost data, maintain individual company resource cost factors, and to assist in the preparation of a cost estimate using this data. The need for cost estimate progression in conjunction with project design completion has also been well documented in the past and is readily seen in all major construction contractors and state highway agencies such as VDOT (Peurifoy and Oberlender 2002, AACE 18R-97 1998). Estimate refinement in conjunction with design completion typically demonstrates marked improvements in estimate accuracy. Table 1.1 shows the cost estimation classifications for the Association for Advancement in Cost Engineering (AACE) and demonstrates the expected progression of accuracy as design progresses.

Table 1.1 – AACE Cost Estimation Classifications (18R-97)

Estimate Class	Level of Project Definition	Purpose of the Estimate	Expected Accuracy Range
Class 5	0% to 2%	Concept Screening	L: -20% to -50% H: +30% to +100%
Class 4	1% to 5%	Study or Feasibility	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget, Authorization, or Control	L: -10% to -20% H: +10% to +30%
Class 2	30% to 70%	Control or Bid/Tender	L: -5% to -15% H: +5% to +20%
Class 1	50% to 100%	Check Estimate or Bid/Tender	L: -3% to -10% H: +3% to +15%

Unfortunately, time estimation procedures have not been documented to the same detail. While a number of software packages allow the user to develop a schedule, this software is not intended to store historical performance time data to be used in schedule preparation. Within VDOT, the need for time estimate refinement in conjunction with design progression has also been neglected.

Without the development of tools and processes to mimic that of cost estimation, time estimation procedures cannot achieve the same level of accuracy at which project cost is now estimated.

1.4 Research Focus

This research focuses on the framework of a multi-level database of highway construction performance times that parallels the cost estimation process and will consist of conceptual, parametric, and pre-advertisement levels. The need for the multi-level structure is demonstrated in this work. Also, the thesis offers background information regarding the importance of setting accurate and reliable contract times. To show the specific need within VDOT, the methods used by other state highway agencies to set contract time, as well as those employed by VDOT are described.

To illustrate the collection and use of historical production data, the lowest level or the bid item level of the performance time database is developed. This prototype database, known as *BIDDS* (*Bid Item Duration Data System*), was developed using Microsoft *Access 2003*. *BIDDS* is one element of the larger Performance Time Data (PTD) System that will be implemented by VDOT.

The PTD System is the process by which the Partnership will implement the database and its complimenting components. The PTD System begins with VDOT defining a project as a demonstration project, on which, production data will be gathered. With the aid of trained production data collection inspectors, a *SiteManager* file is created that can be used to extract production data. This process will involve relatively few alterations to current practices or the existing software.

Once data is collected, a Virginia Tech analyst will convert the data file to a format useable by *BIDDS*. This data is then imported into *BIDDS*. *BIDDS* will be used to house production and project data, as well as, the user-interface for extracting production data. The aforementioned analyst will also make *BIDDS* accessible to VDOT statewide. Doing so will allow initial revisions and upgrades to take place. Figure 1.2 shows the PTD System, interactions between applications, protocols, and personnel, as well as the facilities which will manage this process.

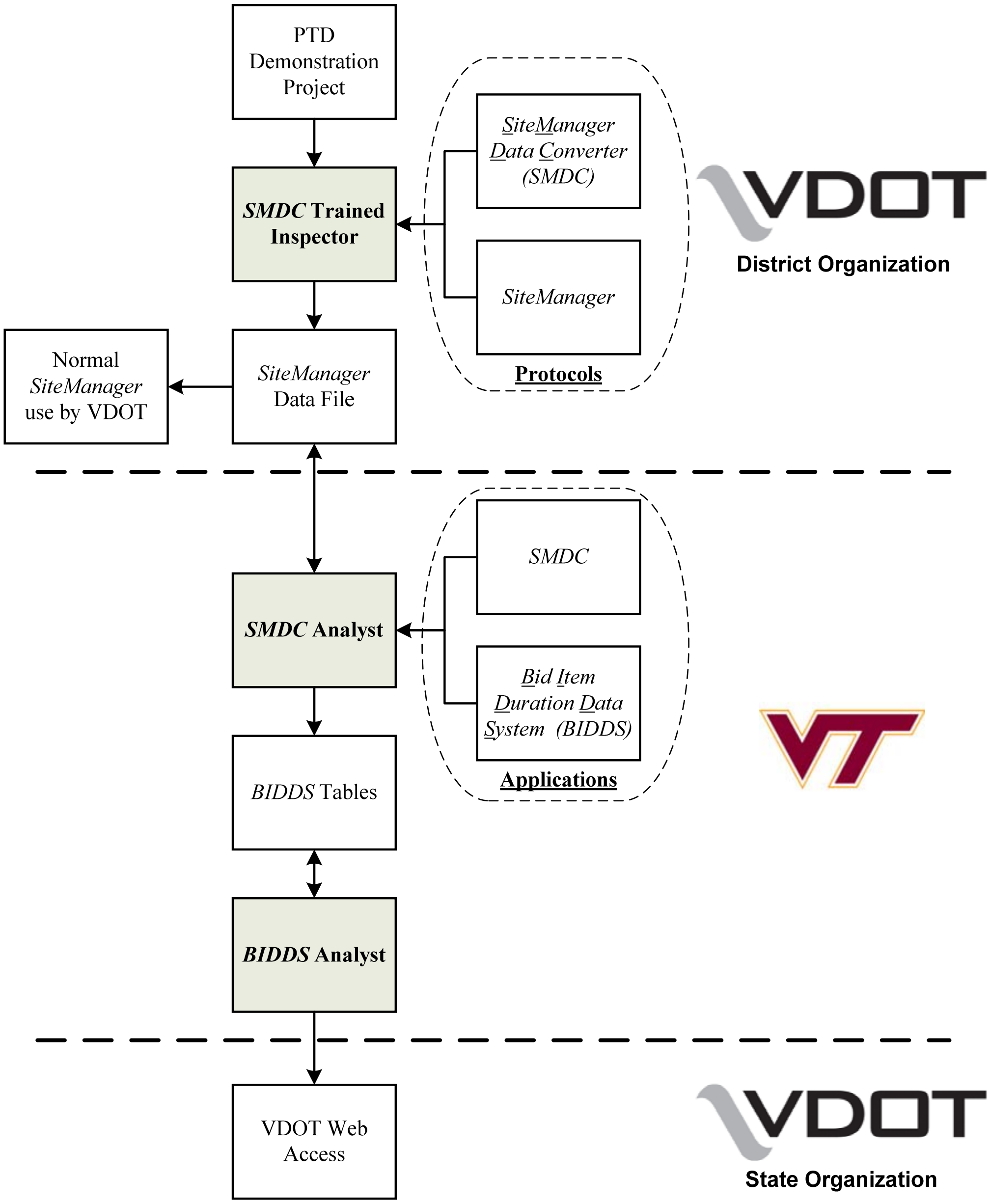


Figure 1.2 – Performance Time Data System

1.5 Scope and Limitations

This work develops a framework for a multi-level database of historical performance data suitable for time estimate refinement in coordination with project design progression. The database framework developed consists of three levels:

conceptual, parametric, and pre-advertisement. This work recommends the information that these estimate levels will use, as well as the stages along VDOT's design progression at which they may be made. The process by which design progresses within VDOT is the Project Development Concurrent Engineering Process (PDCEP). The multiple levels of the database coordinate directly with milestones along the PDCEP. The PDCEP is discussed in more detail in Chapter 3.

The most detailed level of this framework maintains historical bid item level performance data. The data maintained at this level will aid in the development of the pre-advertisement schedule. The pre-advertisement level database, *BIDDS*, is constructed as part of this work and is based on a number of recommendations made in the FHWA document (TA 5080.15) discussed in Chapter 2. *BIDDS* maintains monthly quantity installed data and monthly crew days worked to calculate and return an average daily crew production rate for driving bid items. Database levels incorporating details beyond the bid item level will not be considered within the database framework. These details include construction tasks and operations that are generally beyond the scope of the state highway agency scheduler.

As outlined above, there are two main parts of this work. Limitations exist with each of these parts that should be explicitly defined here. The key limitations to this work include:

1. The multi-level database framework is coordinated with the VDOT Project Development Concurrent Engineering Process. As mentioned, this work is prepared as part of the larger VDOT – VT Partnership program. The outcomes of this work are intended for VDOT and therefore, are coordinated to their procedures.

2. The pre-advertisement level database, *BIDDS*, is not designed to generate a project schedule or a contract time estimate. Rather, *BIDDS* is designed to retrieve historical driving bid item performance data that can be used to estimate driving bid item production rates. Driving bid items are those items whose measurement and analysis reflect activity or project progress. The production rates for these driving bid items can be used, in conjunction with known quantities, to estimate activity durations. Figure 1.3 shows the role of *BIDDS* in the larger contract time determination process.

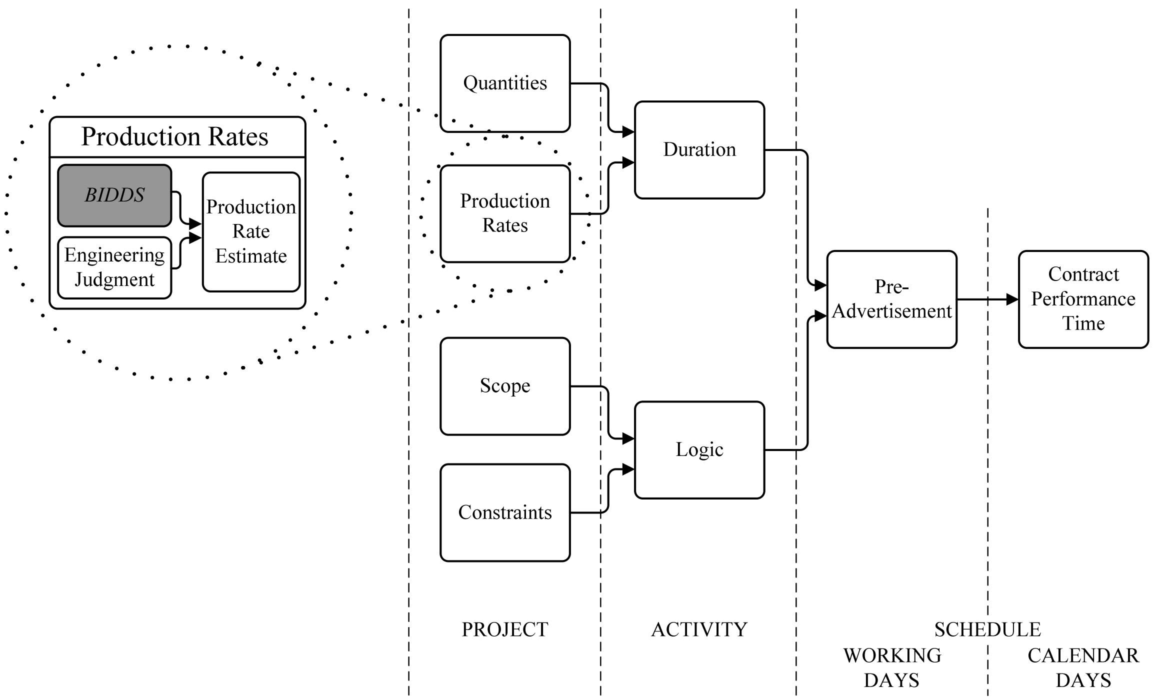


Figure 1.3 – *BIDDS* and the Contract Time Determination Process

3. Finally, historical field data was not available at the time of *BIDDS* development. Therefore, synthetic data was created using published data and several VDOT bid tabulation templates. This synthetic data was used to verify the database system functions. Because field data was not available, the system cannot be validated at this time. More information regarding synthetic data is available in Section 4.6.

1.6 Benefits of the Research

This research is pursued with the intent of contributing to the VDOT and highway construction body of knowledge. First, the research seeks to establish the need for collecting, maintaining, and using historical performance data in time estimation processes within VDOT. Cost estimation processes and historical information have been well documented and studied over the years. This research exhibits the benefits to VDOT of collecting, storing, and implementing time estimation data in the same way.

This research also draws parallels between cost estimate and time estimate progression with design completion throughout the VDOT Project Development Concurrent Engineering Process (PDCEP). This parallel solidifies the need for estimating both cost and time at the bid item level.

This research establishes the framework for a multi-leveled structure or database as a means for storing and using historical performance time data. This multi-level approach mimics the process used in cost estimation to further solidify the parallel between time and cost estimation and add to the highway construction body of knowledge.

This work illustrates the capability and practicality of a multi-level database of highway construction performance times by constructing the lowest level, or bid item level, of the database system. It is expected that this multi-level database system will be a useful prototype for VDOT and a template for the highway construction industry. The database segment for this level is known as *BIDDS* (*Bid Item Duration Data System).*

Finally, through this research and database development, a number of suggestions and questions for future research have arisen. Therefore, the final benefit of this research is the establishment of a series of research topics that may be pursued in the future to benefit not only VDOT but the construction industry at large.

1.7 Document Format

This document is formatted to meet the objectives set out above in a logical and intuitive order. Below is a list and brief description of the remaining chapters.

Chapter 2 – Background: A synopsis of research regarding the need for a better methods of establishing contract time, the need to progress time estimates similar to the progression of cost estimates, and the need for maintaining and using historical performance time data.

Chapter 3 – The Multi-Level Database Framework: The establishment of the framework for a multi-level database of highway construction performance times. This chapter discusses the need for such a system, its structure, why the structure was chosen, and its applicability within VDOT. Also, this section includes a background in database development.

Chapter 4 – Methodology for Developing *BIDDS*: An overview of the research and design methods employed in the development of *BIDDS*, the bid item level performance time database.

Chapter 5 – Conclusions: A discussion regarding the outcomes of the background research, as well as the database design and construction.

Chapter 6 – Recommendations for Future Research: A composition of recommendations arising during background research and database construction. This chapter is divided into research recommendations and database maintenance recommendations.

Chapter 7 – Bibliography & References: A list of the literature studied to prepare this document.

Appendices: Five appendices conclude this document.

Appendix A **–** Activity lists and definitions for each of the eight common VDOT project types.

Appendix B **–** Driving bid item lists assigned to each project type, categorized by the activity for which they are associated.

Appendix C **–** *BIDDS* User's Manual.

Appendix D **–** *BIDDS* Example to demonstrate the input, query, and output processes of *BIDDS*. This example demonstrates the use of *BIDDS*, as well as the work required to perform the data retrieval process manually.

Chapter 2 - Background

This chapter establishes the importance of scheduling and contract time determination. The contract time determination methods used by numerous states, including Virginia, are discussed. Finally, the importance of multi-level time estimates, estimating at the bid item level, and the role of activity duration in the establishment of contract performance time is discussed.

2.1 Importance of Scheduling

Planning and scheduling of construction projects involves concentration on four primary objectives (Newitt, 2005):

1. Creating a quality project
2. Completed on time
3. Completed within budget
4. Performed in a safe work environment

The optimum project schedule is one that balances these objectives (Newitt 2005). If emphasis is placed on one particular element, other project elements will suffer (Newitt 2005). Project schedules give the project direction, balance and budget resources, aid in procurement of materials, allow progress to be measured, and help managers and contractors visualize the work to be completed (Wickwire et al. 2002, Callahan et al. 1992).

Of particular interest to this work is the pre-advertisement schedule. Pre-advertisement schedules are prepared when project design is near completion and considers sequence of work, long lead items, type of work, and estimated start date.

Once prepared, the pre-advertisement schedule may be used to determine contract time, set contract provisions, and perform constructability reviews.

Once the project is awarded, the schedule serves other indirect purposes of the state highway agency. Schedules reinforce the fact that work should be completed in a timely and well organized manner. The timely completion of work benefits both the agency and the traveling public. This benefit is primarily the reduction of indirect costs. When work is completed in a timely manner, the state agency does not incur the additional administrative or inspection costs of delinquent projects. Also, the public does not incur the added road user costs associated with delayed projects. Road user costs include, but are not limited to, those associated with extended travel distance, decreased safety, and additional travel time.

When work begins, the state agency or owner can monitor project progress using an adequate pre-advertisement schedule. An adequate schedule also enables an owner to quantify the impact of delays and changes on the part of the contractor or themselves.

2.2 Contract Time

Contract time is essentially the time allotted for completion of all items within a contract. This is time that the owner must allow the contractor to perform his work. Contract time is generally based on an average competent contractor completing the work and is represented by working days, calendar days, or a fixed completion date. This time is not to be confused with construction completion time. Construction completion time is the contractor's planned or actual duration, the time it will take or actually took to complete his work (Fourie 2003). The only stipulation on this time is that it falls within the contract completion time (Fourie 2003). The contractor has the opportunity to finish early if he sees fit. However, an unimpeded late finish will result in delay damages to the contractor.

Legally, the contract time is the owner's "warranty of design" (Herbsman and Ellis 1995). A reasonable contract time entitles the owner to recover damages due to contractor delay. Consequently, the contractor is also entitled to additional time necessitated by unreasonably short contract time or owner interference. However, the contractor has the burden of proof. He must demonstrate that he has been delayed by an outside entity, uncontrollable conditions, or that the contract time was altogether unreasonable.

2.3 Importance of Accurate Contract Time

An accurate and reasonable contract time is important to all aspects of a project. Unreasonably short contract times raise the bid price, restrict qualified bidders from submitting bids, have potential to reduce the quality of the work, and increase the possibility for legal disputes. Conversely, unreasonably long contract times are a general inconvenience to the traveling public and encourage less qualified contractors to submit a bid.

For state agencies, it is imperative that an accurate and reasonable contract time be established. To do this, state agencies have developed their own methods for establishing accurate contract times. While there are many different methods, the goal is the same: establish a contract time that is accurate and reasonable.

The Federal Highway Administration (FHWA) emphasizes the importance of accurate contract time. Through 23 CFR 635.121, the FHWA requires individual states to develop and implement contract time determination procedures for construction projects. The *FHWA Guide for Construction Contract Time Determination Procedures* (TA 5080.15) offers suggestions to assist states in the development and implementation of these procedures.

The FHWA first suggests that state transportation agencies develop a database of production rates based on historical data of efficient contractors. It is recommended that the production rate data is based on an eight-hour crew day or per piece of equipment. Rates that are based on total time and total quantities are not recommended as they may yield unreliable results. To ensure reliability, it is suggested that the agency keep a data file of time, weather, production rates, etc. from the previous three to five years. This information can be gathered from site visits, well-documented project records, or interviews with construction industry representatives. Once collected, these production rates must be adapted for use on individual projects.

The FHWA suggests several factors to consider when adjusting these production rates. The relative urgency of the project, affected traffic volumes, effect of detours on traffic, and the project size and location must be used to adjust the database production rates for an individual project. If necessary, the effects of staging, working double shifts, nighttime operations, and lane closures should be analyzed. If large quantities of material are needed for a controlling item on the project, the production rates of these work items may also require adjustment.

The final suggestion of the FHWA report regards the contract time determination techniques used by state transportation agencies. The FHWA suggests the use of bar charts, the estimated cost method, or the critical path method. A short summary of these methods, an outline of the process, and their advantages and disadvantages are available in the report. In closing, the FHWA suggests that all states have written contract time procedures including suggestions for monitoring and documenting the production data for current projects. This will serve as a test for the existing data and also to further develop the database of production rates.

2.4 State Transportation Agency Methods for Determining Contract Time

As mentioned, state highway agencies employ a number of methods to establish contract time. To determine how the Virginia Department of Transportation compares to other state transportation agencies required a review of contract time determination methods from states around the country. This section discusses those.

In January 2005, Dr. John Hildreth performed a survey of contract time determination methods. In his research Dr. Hildreth contacted 35 highway agencies from various states and the District of Columbia. From that survey, Dr. Hildreth received documented methods from 18 states and methodology descriptions through conversation with four other states. An additional survey collected documented information from another four highway agencies and the methodologies of two agencies through telephone conversations. An outline of the research completed follows.

2.4.1 Production Rates. Many states have an established method for setting contract time comparable to that suggested by the FHWA. Nearly all states contacted have a table or collection of production rates based on historical data. This data ranges from project component level, low-level project information or characteristics, to project operations level, high-level activity and task data. States maintain this data at either the operations or bid item level.

To establish a contract time estimate, these production rates are applied to the typically controlling or critical work items. In these instances, the durations for each activity may be summed, resulting in a final contract time estimate. In other cases, the agencies apply these rates to all activities and leave it up to the scheduler to input the activity sequencing.

In accordance with FHWA recommendations, the state agencies with production rate data also have guidelines, or allude to the need, for adjustments to these rates that account for unique project characteristics. State highway agencies surveyed most commonly adjust for project location, type, conditions, and traffic implications. Less commonly, adjustments are made for project value or multiple seasons. The scheduler typically makes the necessary adjustments for these factors based on personal experience.

However, in Texas, quantitative factors are assigned for adjustments. Texas Department of Transportation (TxDOT) used surveys of their employees and others to develop a series of adjustment factors. TxDOT has established factors for project location, traffic conditions, project complexity, soil conditions, and quantity of work. These factors are assigned at the discretion of the scheduler and no more than two adjustment factors can be used for each work item.

A number of states adjust production rates based on project location. These adjustments are usually per the state highway agency district, however, Washington Department of Transportation (WADOT) is much broader, using east and west as the location factor.

Several states adjust production rates by classifying the project type. Adjustments for project type typically include factors for highway reconstruction, new highway construction, bridge replacement, and bridge resurfacing (rehabilitation). Adjustments for project conditions usually refer to the soil or site conditions. Finally, production rate adjustments are made for traffic volume on and around the site, as well as detours due to construction.

In an effort to accommodate changes due to fast-paced or accelerated work, New Jersey Department of Transportation (NJDOT) has developed a system of adjustment factors for projects that use the A+B bidding method, expect overtime work, or include an incentive/disincentive clause in the contract. NJDOT assigns a production rate factor of 1.20 for projects in which overtime work is expected. A 1.25 adjustment factor is assigned to production rates for projects using A+B bidding. And an adjustment factor of 1.33 is used for production rates for projects whose contracts include an incentive/disincentive clause. These types of projects usually require that the contractor work as efficiently as possible or accelerate the schedule to complete on time. When the project is accelerated, the average production rates may be invalid.

South Carolina Department of Transportation (SCDOT) adjusts their activity durations by assigning factors based on work item concurrence. Activity durations of concurrent work items, calculated using their historical production rates, are reduced by as much as 60 percent by SCDOT. SCDOT schedulers assign a factor between 0.60 and 1.00 to contemporaneous activities based on their knowledge and experience. This factor is applied to the total project duration after major work item durations have been totaled.

While it is important that state transportation agencies monitor and record their historical performance through production rate data, this information is of little value without proper schedule logic. While performance times and production rates are based on historical data, the schedule logic and the reasonableness of the schedule relies mainly on the experience, knowledge, and skill of the scheduler.

2.4.2 Scheduling. In order to set more accurate contract times, it is imperative that state transportation agencies establish a reasonable construction period that is logical and defensible. The methods recommended by the FHWA are estimated cost method, bar charts, and the critical path method (FHWA TA 5080.15).

The most basic contract time determination technique suggested by the FHWA is the estimated cost method. This method relies on historical data to draw correlations between project cost and duration. With this historical data, a contract time estimate is drawn directly from the engineer's preliminary cost estimate. According to the FHWA, this method is appropriate for non-complex projects or projects that do not involve high traffic flow. This method is not recommended for projects in which the completion time is of high consequence.

Of the states surveyed, none specifically mentioned the use of this method. That is not to say this method, or a variation of it, is not being used. For instance, states such as South Dakota and Arkansas both rely primarily on the records of previously completed projects, similar to the current project. Of these similarities, it is likely that cost, as well as location and size, is a major factor. Washington Department of Transportation (WADOT) demonstrates a variation of this method for bridge construction. WADOT has developed a plot of project cost vs. project time (Figure 2.1). Project time is measured in working days and project cost is measured in millions of dollars.

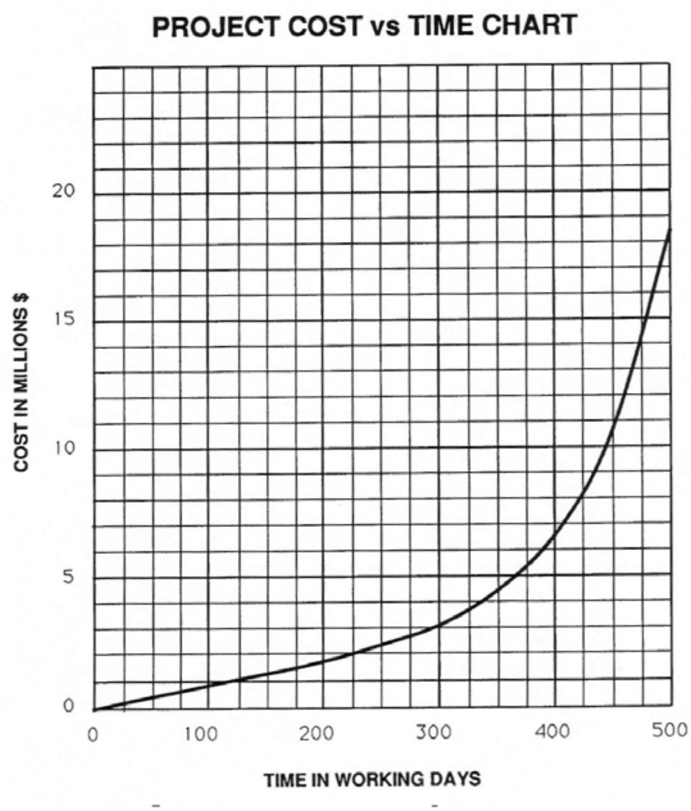


Figure 2.1 – Project Cost vs. Time Chart for Bridges (Washington DOT 2004)

Bar charts are an effective scheduling tool that can be generated using a moderate amount of project details. Using production rates and work item quantities, work item durations are established and graphically represented on a bar chart. The advantages of bar charts include their simplicity and visually comprehensible style. While bar charts are good visual aids, they are not the best scheduling tool. Bar charts, without fences or resource constraints, are misleading. Without fences to demonstrate subordination or precedence, project scheduling logic may be difficult to grasp and understand.

While bar charts have disadvantages in detailed scheduling, their simplicity and visually comprehensible style are well suited for conceptual contract time determination. State transportation agencies generally know their major work items and the succession of those items. Based on their experience and knowledge they can produce a reasonably accurate time estimate using bar charts.

Of the states surveyed several, including Arizona, Illinois, Idaho, and West Virginia, use bar charts to set their initial contract time. Texas also currently uses bar charts to estimate contract time for small projects, less than $1,000,000 in value. The bar chart used by TxDOT is demonstrated in Figure 2.2.

The final contract time determination technique outlined by the FHWA is the critical path method (CPM). This method is becoming increasingly popular for its accuracy and logical sequencing. The critical path method establishes a series of activities that progress toward project completion. The relationship of these activities is established to show precedence, duration, and completion time. Once the flow of work items from project start to project finish has been established, the series of activities making up the longest path is identified as the critical path. The activities along this path are those activities which cannot be delayed without delaying the project completion.

The critical path method is a very good scheduling tool. The breakdown or precedence diagram formed facilitates easy monitoring by project managers (Clough et al. 2000, Callahan et al. 1992). This practice helps to identify delays before they occur so that corrective action can be taken. To be used effectively, the critical path method must be regularly updated and maintained by experienced and knowledgeable schedulers (Callahan et al. 1992).

A number of states are currently using the critical path method to determine contract time. Though the critical path method can be somewhat involved and time consuming, requiring experienced schedulers to perform the process, states such as

Pennsylvania and Delaware use it to determine contract time for all highway construction projects. Michigan limits CPM usage somewhat, requiring use of the method on new construction, large reconstruction, unique projects, and projects extending beyond one construction season. TxDOT's use of the critical path method extends to include large projects with a multi-million dollar price tag.

2.4.3 State-Specific Tools. Of those surveyed, four states have developed their own unique method for determining contract time. Kentucky, Nebraska, South Carolina, and Texas have all developed spreadsheets with built-in schedule logic to develop a reasonable contract time. Generally, these spreadsheets ask the user to input material quantities while the logic within the spreadsheet sequences the activities.

Kentucky's system is based on six templates, one for each project classification. These templates rely on historical data and are adjusted per their classification. The six templates used by Kentucky include Open Access Reconstruction, Limited Access Reconstruction, New Route, Relocation, Bridge Rehabilitation, and Bridge Replacement. Once quantity information is input, the user is able to transfer the data into a template developed for Microsoft *Project*. The project logic for each of these templates is stored within this program and based on the commonly used major work items.

The contract time determination methods used by Nebraska (NDOT) and South Carolina (SCDOT) are similar. NDOT and SCDOT consider only major work items. The quantities and established production rates are used to generate durations. These durations are demonstrated by a bar chart. Typical major work item activities are added in succession, and the final contract duration determined.

TxDOT accounts for the concurrency in activities in their spreadsheet (Figure 2.2) by asking the scheduler to input the quantity, production rate, the work item's preceding activity, and the required percent complete for that item. This yields a bar chart that is more reliable than a simple summed total of major work item durations. TxDOT is in the process of changing over completely to the critical path method for contract time determination.

It is evident from the above discussion that state transportation agencies from around the country realize the need for more accurate, reliable, and responsive contract times. Many have followed the suggestions of the FHWA to implement better practices while others are going further to develop their own methods that are more easily adaptable and reliable in their states and districts.

2.4.4 Virginia DOT's Method for Determination of Contract Time. The practices of the Virginia Department of Transportation are not uncommon to those around the country. Information has been attained from several state districts. This information demonstrates the use of production rates, critical path method scheduling, and the use of precedence diagrams to assist in the determination of contract time. It appears the majority of contract time determination is the responsibility of the scheduler and based on his/her knowledge and experience.

While VDOT districts typically employ FHWA recommended guidelines for determination of contact time, there does not appear to be a consistent, standardized method across the state for determining these times. The methods employed are at the discretion of the district and vary across the state.

CONTRACT TIME ESTIMATE SHEET

ABILENE AREA OFFICE - 102 E. COLLEGE DRIVE ABILENE, TEXAS 79601
(915) 676-6930 / Fax # (915) 676-6933

CSJ NUMBER **0033-06-094**
Date: **3/15/2001**

PROJECT INFORMATION

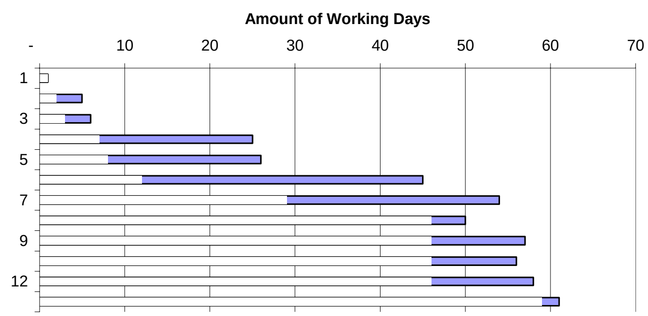
Descriptior FOR THE CONSTRUCTION OF DRIVEWAYS AND CONCRETE CURB AND GUTTE
County TAYLOR Project # CD 33-6-94 Highway # US 83
Designer/T SCOTT DARROW

Area Engineer
PAUL HOELSCHER, P.E.
Phone / FAX #
(915)676-6930 Fax#(915)676-6933
Address
102 E. COLLEGE DRIVE, ABILENE, TX 79601

Length of Project

TX Ref. Mark 328 - 1.151 km TO 329 + 0.127 km Sta. to Sta 8+488.631 TO 11+385.637

ID #'s	Work Description	Quantity	Units	Daily Production rate	Units	Duration of working days	Preceeding Activity's ID#'s & Percent Complete Req'd		Start Day	Finish Day
							Id#	%		
1	PLACE ALL SIGNS AND BARRICADES	1	LS	1	LS	1			1	1
2	PLANE ASPH CONC PAV (0-100MM)	10394	M2	3000	M2	4	1	100	#N/A	#N/A
3	EXCAVATION (SPECIAL)	7326	M3	2000	M3	4	2	25	#N/A	#N/A
4	CONC CURB & GUTTER (TY II)	3791	M	200	M	19	3	100	#N/A	#N/A
5	CEM STABIL BKFL	119	M3	10	M3	12	4	25	#N/A	#N/A
6	DRIVEWAYS	3369	M2	100	M2	34	4	25	#N/A	#N/A
7	COLORIZED TEXTURIZED CONCRETE (125MM)	3825	M2	150	M2	26	6	50	#N/A	#N/A
8	CONCRETE SIDEWALK (WHEELCHAIR RAMP)	208	M2	50	M2	5	6	100	#N/A	#N/A
9	ASPH CONC	559.9	MGR	50	MGR	12	6	100	#N/A	#N/A
11	FURN AND PLAC TPSL (CL-2)(100MM)	15573	M2	1500	M2	11	6	100	#N/A	#N/A
12	BLOCK SOD (PRAIRIE BUFFALO)	15573	M2	1200	M2	13	6	100	#N/A	#N/A
13	CLEANUP	1	LS	0.334	LS	3	12	100	#N/A	#N/A



**All time calculations are in accordance with Txdot Administrative Circular No. 17-93 Dated 7-7-93*
***Working Months are calculated utilizing a 18 Working Day Month*

***Total Contract Days** **#N/A**
****Total Working Months** #N/A

Figure 2.2 – Texas DOT ~ Contract Time Estimate Sheet

2.5 Multi-Level Estimates

Cost and time estimates are refined throughout the period of design completion. Because these acts are performed in parallel, the level to which the estimates have developed cannot exceed the degree to which the project design has progressed. This section describes cost and time estimate progression alongside project design.

2.5.1 Cost Estimate Progression. Cost estimates begin at the coarsest or magnitude level and proceed through the conceptual, preliminary, definitive, engineers, and bid estimates (Building Construction Handbook 1975). This progression increases precision while decreasing the need for cost contingencies. Keith Molenaar has demonstrated this concept as seen in Figure 2.3.

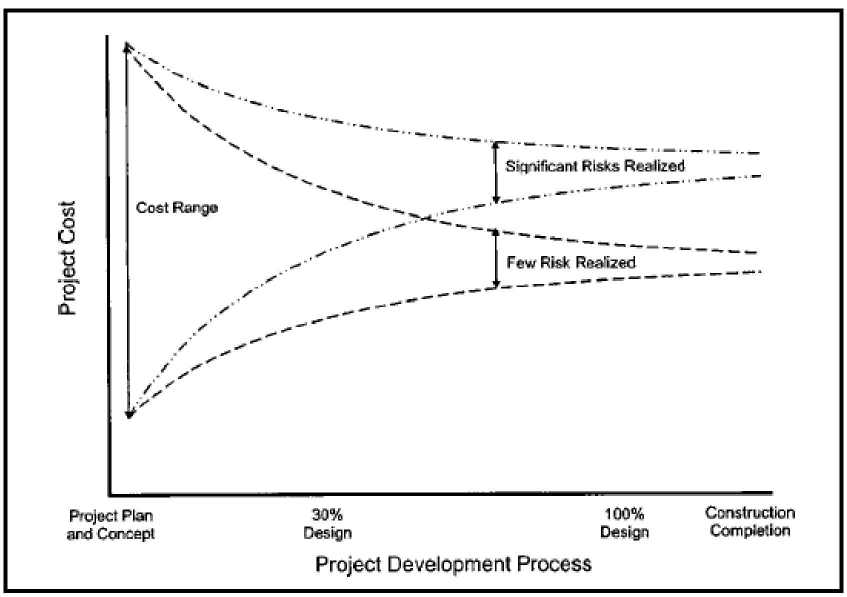


Figure 2.3 – Cost Estimate Refinement with Design (Molenaar 2005)

State agencies, such as VDOT, perform the various levels of estimates while design progresses so that adequate monies can be budgeted for the project. This process begins at project pre-scoping and concludes at project advertisement (VDOT Project Development Concurrent Engineering Process 2005). Actual project construction cost estimates are prepared by the winning bidder, but with their estimate, VDOT has a reference from which to base their decision to either select a bidder, let the project for bidding again, or abandon the project altogether.

2.5.2 Time Estimate Progression. Time estimation processes have also increased in accuracy for many entities willing to acquire the necessary personnel and technology. The importance of refining project time estimates and cost estimates throughout project design progression cannot be overstressed. VDOT has recognized this need, but still does not have a formal system of refining time estimates as design progresses and cost estimates are refined.

2.5.3 Cost and Time Estimates in Parallel. A number of authors have stressed the importance of integrating or paralleling cost and time estimation procedures. Initial estimates (both cost and time) contain a degree of uncertainty. Generally, this uncertainty is reduced as design details become available. In 1981, Glenn Sears commented that both time and cost estimates go through the same refinement transformations. This suggests that time estimates are refined as project design progresses, similarly to the refinement of cost estimates.

Figure 2.4, below, shows the concept of both time and cost estimates being refined in parallel as design progresses for the state highway agency. Notice that this figure is similar to Molenaar's representation of cost estimate refinement with design progression in Figure 2.3. One difference between the figures is that the vertical axis of Figure 2.4 represents both the cost and time estimate, whereas Molenaar's vertical axis represents only cost. The major difference between the figures is that Figure 2.4 shows the progression of design in phases. Also notice the significant curve transition at project bidding phase. Until contractors return their bid, the state highway agency cannot finalize their estimate. Once bids are submitted and the winning bidder selected, the time and cost estimates can be refined significantly. This accounts for the steep transition at the bid letting milestone. As the project is constructed, the estimate ranges decrease as the possibility for major changes decreases. The cost and time estimates are finalized upon project completion.

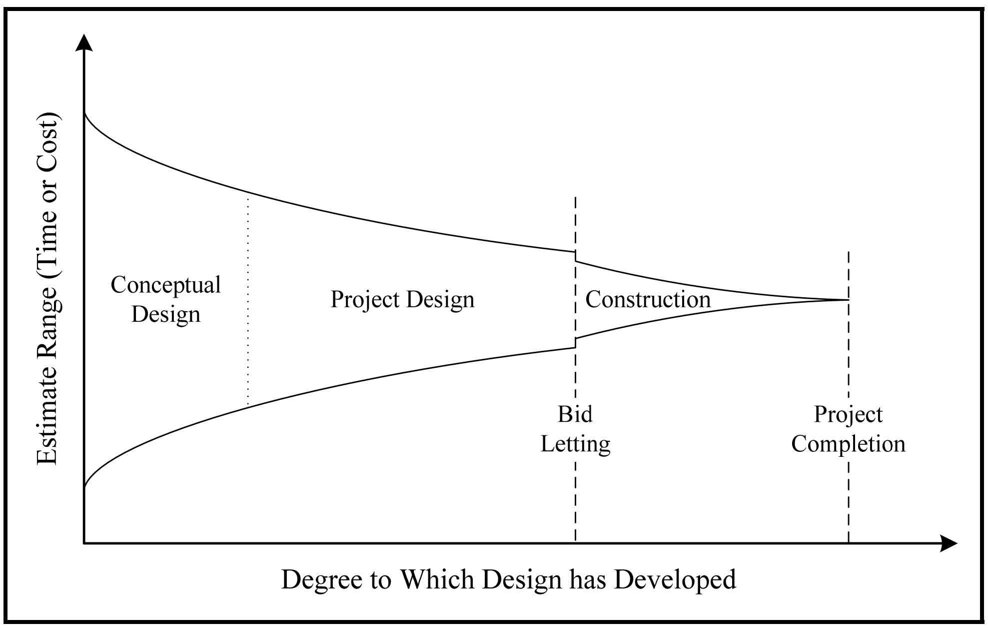


Figure 2.4 – Cost and Time Estimate Refinement with Design

To establish a parallel between the estimates, it is recommended that uniform work breakdown structure (WBS) codes or activity codes be used (Epstein 1985, Larson 2000, Rasdorf and Abudayyeh 1991). While VDOT does not have a uniform list of activity codes or WBS codes, they, like most state highway agencies, do have standardized lists of bid items for which project cost is now monitored.

2.6 Estimating at the Bid Item Level

The construction owner and the contractor have very different capabilities for developing cost and time estimates. The owner, through his own experience and dealings with numerous contractors, is able to estimate the cost of work performed before the project goes out to bid. While material costs are usually known, labor, equipment, and contingency costs often vary among contractors. For this reason, the contractor is able to prepare a much more precise estimate of his costs. These costs are then summarized as a list of bid items. Bid items are individual cost units that uniquely identify a quantity of work performed. Bid item costs, then, are a summary of the equipment, material, and labor costs associated with performing some quantity of work. The tabulation of bid items associated with the project, and any additional indirect costs, make up the contractor’s bid.

While the owner’s estimate is less precise than the contractor’s, a low level cost estimate similar to the contractor’s, must be performed for budgeting purposes. However, most state highway agencies do not monitor progress at the lowest level to which the cost estimate was performed. Instead, these agencies monitor project progress and pay the contractor for work performed by tracking and documenting the completion of bid items.

Time can be estimated and monitored in much the same way because project time estimates progress similarly to cost estimates, both requiring intimate project and resource knowledge from both the owner and the contractor. Doing so creates a common level in the cost and time estimation structures and solidifies the need for parallels between the two processes.

2.7 Role of Activity Duration in the Scheduling Process

A number of the scheduling options used by VDOT and other state highway agencies were detailed previously in this chapter. While many options are available, the critical path method is an excellent visual and organizational scheduling tool. Therefore, this section discusses the schedule in critical path method terms.

2.7.1 Scheduling Process Steps. The preparation of a schedule involves several steps. The initial step is the establishment of activity names and definitions. Having a concise list of project activities, as well as their scope and limitations, minimizes ambiguities. An activity should not be "so small as to complicate or lengthen the schedule or so large that the work cannot be controlled (Callahan et al., 1992)." Below, Clough et al., outline the schedule creation process once project activities and their sequence have been defined (2000).

1. Estimate activity durations
2. Estimate the time required for overall project completion
3. Establish activity time intervals
4. Identify critical activities
5. If possible, shorten the project duration to minimize costs
6. Minimize resource conflicts and smooth demands for equipment and labor using float
7. Publish a working schedule
8. Record all assumptions made during the schedule creation

2.7.2 Establishing Activity Duration. As seen from the discussion above, the definition of activities and the estimation of their durations are the first, and perhaps most vital, steps in the scheduling process. This section focuses on this importance by highlighting the steps necessary to establishing activity durations.

Several steps must be taken when establishing activity durations (Clough et al. 2000):

1. Evaluate activities independently
2. Assume a normal level of resources for each activity
3. Assume a normal working day
4. Focus on the activity duration, ignoring outside factors or considerations
5. Use consistent time units for each activity

While it is important to evaluate each activity individually, activity durations must take several elements into consideration. The quantity of work, type of work, resources available, number of shifts used, and environmental factors can all affect the activity duration estimate (Callahan et al., 1992). For production activities, the scheduler must have some basis for establishing progress or production rates. Production rates may be based on experience, interviews with contractors, published resources, or historical production data. With this information, activity duration is calculated by dividing the quantity of work involved by the daily production rate.

In a state highway agency like VDOT, project activities are composed of bid items that must be installed to fulfill the requirements of that activity. Therefore, the establishment of bid item durations and bid item level production rates can be seen as a fundamental step in the establishment of activity durations.

Chapter 3 – The Multi-Level Database Framework

The framework of the multi-level database to coincide with the VDOT Project Development Concurrent Engineering Process (PDCEP) is proposed in this chapter. To develop this framework, the PDCEP used by VDOT is described. This process begins at project pre-scoping and is complete at project advertisement, when design and pre-advertisement cost and time estimates are complete. Along this process, a number of interim milestones reveal changes in the level of design detail at which cost and time estimates may be performed. These milestones mark the stages in the process where it is proposed that time estimates be made.

3.1 VDOT Project Development Concurrent Engineering Process

The VDOT Project Design Concurrent Engineering Process, hereafter known as PDCEP, is the sequence of events or activities that must take place to progress a project from inception to advertisement. The PDCEP is established with three principles in mind: teamwork, flexibility, and milestones (VDOT IIM-LD-226.2 2005). Teamwork and flexibility are applicable to the internal VDOT structure, not necessarily the process. For the purposes of this work, only milestones will be discussed.

3.1.1 PDCEP Milestones. A milestone is a point in time identified as an important intermediate reference point to the accomplishment, generally the start or completion, of work (Clough et al. 2000). Typically milestones are used to mark significant construction progress. Because VDOT acts as the project owner, milestones throughout the PDCEP mark significant progress throughout project planning, scheduling, estimating, and design.

To monitor this progress, five key milestone meetings are held throughout the PDCEP. Below is a list of those meetings and a description of their purpose (VDOT IIM-LD-226.2 2005).

1. **Scoping Team Meeting –** Project Manager distributes the project Purpose and Needs Statement and other resources to the design team. Allows participants to define project elements, working budget, and schedule for design and development.

2. **Preliminary Field Inspection Team Meeting –** This meeting serves as a review and acceptance of the alignment and grade, the basic plan for maintenance of traffic and sequence of construction, and a check of project progression.

3. **Public Hearing Team Meeting –** This meeting serves as an evaluation of all concept plans and designs that may affect right of way and environmental permits, as well as allowing for coordination between disciplines and stakeholders prior to the public hearing.

4. **Field Inspection Team Meeting –** Allows further review and revision of construction plans for a project. After this meeting, the project team may begin the process of acquiring right of way and completion of final design.

5. **Pre-Advertisement Conference –** Allows further revision and finalizing of construction plans to make all disciplines aware of current project information, including the schedule and budget. It is at this point that the plans are "virtually complete where only minor adjustments to quantities may be required." Specifications are complete and the project assembly is ready for final constructability and bidability review at this point.

3.1.2 PDCEP Milestone Meeting Deliverables. Milestone meetings aid in communication and teamwork within VDOT as a project progresses. For each milestone meeting, there are several deliverables that should be completed before reaching that step of the process. These deliverables incorporate every aspect of the development and construction phases of the PDCEP. Below is a series of project deliverables and responsibility matrices involved with each of the milestone meetings. These matrices demonstrate the transition of not only responsibility throughout the process, but the increase in project details and availability of information.

● Responsible ✔ Participates ☐ Notified

✔	Deliverable	L&D	ENV	MAT	S&B	MM & TE	RW/ UTL	S&C	RE	ASSET MGT
	Scope, Schedule and Budget	●	●	●	●	●	●	●	●	●
	SERP	✔	●		✔				✔	

Figure 3.1 – Scoping team meeting responsibility matrix (VDOT 2004)

● Responsible ✔ Participates ☐ Notified

✔	Deliverable	L&D	ENV	MAT	S&B	MM & TE	RW/ UTL	S&C	RE	ASSET MGT
	Route Survey	●	☐	☐	☐		☐			
	Initial Roadway Design	●	✔	✔	✔	✔	✔	✔	✔	✔
	Initial Hydraulic Analysis	●	✔	✔						
	Initial E&S Calculations	●	✔	✔						
	Wetland Screening	☐	●				☐			
	Hazardous Material Screening	☐	●				☐			
	Preliminary Soil Report	☐	☐	●						

Figure 3.2 – Preliminary Field Inspection team meeting responsibility matrix (VDOT 2004)

● Responsible ✔ Participates ☐ Notified

✔	Deliverable	L&D	ENV	MAT	S&B	MM & TE	RW/ UTL	S&C	RE	ASSET MGT
	Preliminary Roadway Design	●	✔	✔	✔	✔	✔	✔	✔	✔
	Preliminary Hydraulic Design	●	✔	✔	✔					
	Prelim. Retaining Structure Design (standard)	●	✔	✔	✔					
	Preliminary E&S Control Design	●	✔							
	Bridge Hydraulic Analysis	●	✔	✔	✔					
	Preliminary Landscape Design	●	✔	✔	✔	✔	✔		☐	
	Preliminary Sound Barrier Design	✔	●	✔	✔		✔		☐	
	Environmental Document (DEIS, DEA, CE)	✔	●	✔	✔	✔	✔		☐	
	Major Structure Foundation Analysis			●	✔					
	Preliminary Str./Bridge Design	✔	✔		●	✔	✔			
	Prelim. Retaining Structure Design (special)	✔	✔	✔	●					
	Preliminary Traffic Control Device Design	●	✔	☐	✔	✔	☐	☐		
	Right of Way Assessment	✔	✔				●			
	Utility Assessment	✔	✔				●			

Figure 3.3 – Public Hearing team meeting responsibility matrix (VDOT 2004)

● Responsible ✔ Participates ☐ Notified

✔	Deliverable	L&D	ENV	MAT	S&B	MM & TE	RW/ UTL	CONS	RE	MAINT
	Roadway Design	●	✔	✔	✔	✔	✔	✔	✔	✔
	Hydraulic Design	●	✔	✔	✔					
	Retaining Structure Design	●	✔	✔	✔					
	Sound Barrier Specifications and Agreement	●	✔		☐					
	E&S Control Design	●	✔							
	Scour Analysis	●	✔	✔	✔					
	Stream Wetland Compensation & Mitigation	✔	●	✔			✔	✔		
	Landscape Design	●	✔	✔	✔		✔			
	Hazardous Materials Assessment/Mitigation	✔	●	✔	✔	✔	✔			
	Final Environmental Document (FEA, FEIS)	✔	●	✔	✔	✔	✔			
	Soil Report	☐	☐	●	☐					
	Major/Minor Structure Foundation Analysis	✔	☐	●	✔	✔				
	Structure or Bridge Design	✔	✔	✔	●	✔	✔			
	Coast Guard Permit		✔		●					
	Traffic Control Device & ITS Design	●	☐		✔	●				
	In-Plan Utility Design	✔	✔		✔		●			

Figure 3.4 – Field Inspection team meeting responsibility matrix (VDOT 2004)

● Responsible ✔ Participates ☐ Notified

✔	Deliverable	L&D	ENV	MAT	S&B	MM & TE	RW/ UTL	CONS	RE	ASSET MGT
	Final Roadway Design	●	✔	✔	✔	✔	✔	✔	✔	✔
	Final E&S Design	●	✔							
	Environmental Permit Acquisition	✔	●		✔					
	Streams/Wetland Mitigation & Compensation	✔	●	✔			✔	✔		
	Final Landscape Design	●	✔	✔	✔		✔			
	Hazardous Material Assessment/Mitigation	✔	●	✔	✔	✔	✔			
	Final Design Retaining Structure (Special)	✔	✔	✔	●	✔	✔	✔		
	Final Structure or Bridge Dgn.	✔	✔	✔	●	✔	✔	✔		
	Final TCD and ITS Design	●	✔		✔	●				
	Right of Way Acquisition	✔	✔				●			
	Right of Way Relocations	✔	✔				●			
	Utility Agreements	✔	✔		✔		●			
	Utility Easement Acquisition	✔	✔		✔		●	✔		
	Utility Relocations	✔	✔		✔		●	✔		
	Construction Specifications	✔	✔	✔	✔	✔	✔	●		

Figure 3.5 – Pre-Advertisement Conference responsibility matrix (VDOT 2004)

3.1.3 Cost Estimation and the PDCEP. Throughout the PDCEP, a number of transitions occur at which more detailed design, cost, and schedule information is available. The development of design details is shown in the PDCEP Meeting Checklists in Section 3.1.2. This section focuses on the progression of the cost estimate in conjunction with design progression.

Throughout the PDCEP, VDOT incorporates two main cost estimation tools: *Project Cost Estimating System* (*PCES*) and *Trns*Port*. *PCES* is a parametric estimating tool using statistical analysis and adjustment factors, based on historical data, to aid in the preparation of a cost estimate during the initial design stages of the PDCEP. *Trns*Port* is an estimating software that contains five software modules to assist the estimator in developing a project from design through construction. The module used to develop the pre-advertisement project cost estimate is *Proposal and Estimates System (PES)*. *PES* uses historical unit bid prices and quantities to develop the cost estimates.

The stages of the PDCEP at which these estimating tools may be used was ascertained through discussions with VDOT scheduling and estimating personnel. According to VDOT, *PCES* is often used upon project scoping, when few project specifics are known. This is done to establish an early estimate for use in a six year plan of projects. As design details become available, estimates made using *PCES* are refined. This continues until design is approximately 75 percent complete. This point in time corresponds roughly with the Field Inspection Meeting of the PDCEP and marks the point in time where final alignment, quantities, and construction plans are being developed.

When project design and the PDCEP approach these stages, work item information is input into *PES*. As design nears 100 percent completion, *PES* is updated and the pre-advertisement estimate refined. It is also in this application that the final, or rational, estimate is performed by VDOT. The rational estimate is a detailed cost estimate performed using completed design quantities, plans, and unit costs.

3.1.4 Time Estimation and the PDCEP. As the PDCEP progresses from project scoping to advertisement, construction time elements are identified and quantified. It is proposed that the time estimate be refined throughout this progression.

Currently, the VDOT scheduling process implements these details as they become available. While this process is not formally outlined in the PDCEP documents, it has been a topic of study for a member of the Partnership personnel. Mr. Frank Gbinije, VDOT State Construction Scheduler, has created a flowchart illustrating the relationship between scheduling and the PDCEP (Figure 3.6). This flowchart suggests that the planning phase may commence upon initial design completion. The more detailed CPM schedule development phase may begin upon design approval and continue through the pre-advertisement plan submission.

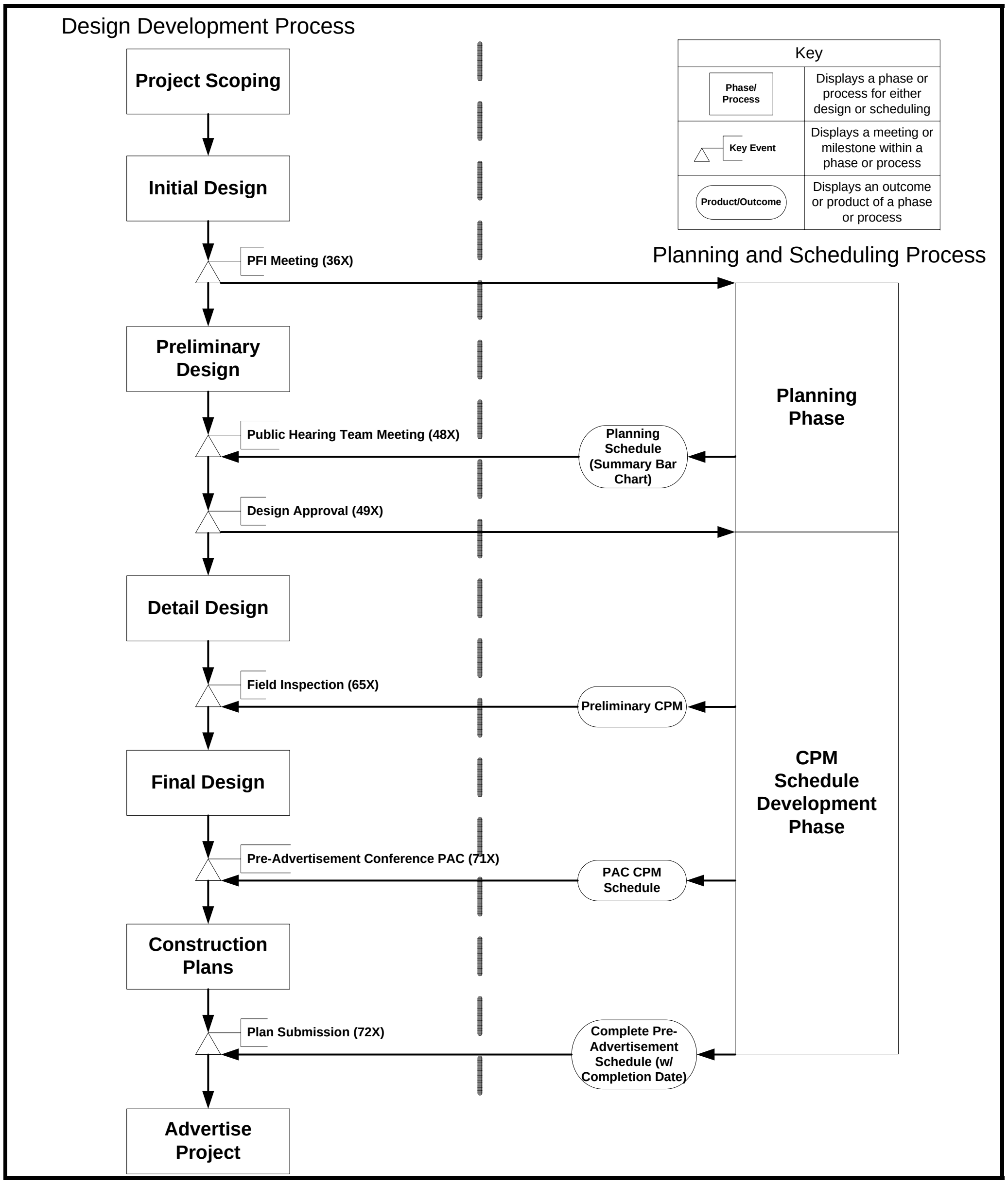


Figure 3.6 – Relationship between Scheduling and the VDOT PDCEP

3.2 Database Levels

This work postulates the development of three level database framework, a conceptual, parametric, and pre-advertisement level, to allow time estimates to progress alongside project design and cost estimates through the PDCEP. This is illustrated in Figure 3.7. The remainder of this section discusses the three proposed levels.

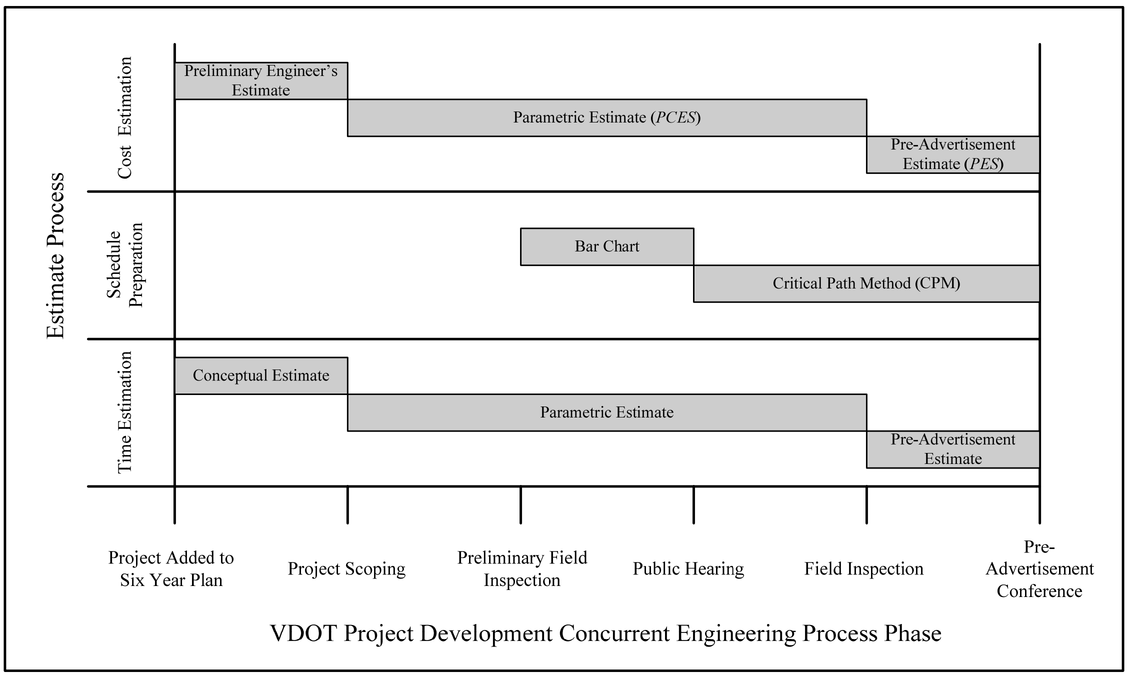


Figure 3.7 – Cost Estimate-Scheduling-Time Estimate Progression with PDCEP

3.2.1 Conceptual Level. The conceptual level time estimate is based on a minimal amount of project details. Information that is considered for the conceptual estimate is the project type, location, size (i.e. roadway or bridge length, number of lanes, etc.), existing traffic volume, geometric design standard, preliminary advertisement date and engineer's preliminary estimated cost. This information is typically known at, or prior to, project scoping when basic project information is known.

A database to maintain historical conceptual records must house this broad project data from completed projects, as well as the time to complete these projects in either working or calendar days. There are advantages and disadvantages to each.

Working days are difficult to ascertain without delving into project records, but estimating in working days emphasizes the use of engineering judgment in establishing project calendars on which the project would proceed. Calendar day data would be easier to gather than working days. The project calendar day duration is the time elapsed between project commencement and completion. Also, VDOT is currently pursuing the use of fixed-date project contracts. Therefore, calendar days would more likely be used. The database, then, would return a time estimate, or range of estimates, with weather and work conditions factored into the calendar days.

3.2.2 Parametric Level. The parametric time estimate considers the major project elements or components commonly associated with projects, as well as specific or unique items that affect the project duration. To facilitate such an estimate, historical performance time data must be gathered and analyzed. From this data, a base duration equation will be established for each project type. Next, the performance data will be analyzed to determine the factors most affecting project duration and the influence of those affects. To accomplish this, statistical regression analysis will be performed for each major project component. The project duration will then be estimated using the duration equation and the necessary adjustment factors.

This process is similar to that employed during the development of *PCES* by VDOT. *PCES* is a parametric level cost estimation program that considers typical project cost factors, as well as unique and specific cost factors. Currently, *PCES* considers project factors such as (Kyte et al, 2004):

- Project Location (District)
- Geometric Design Standard
- Advertisement Date
- Design Year Average Daily Traffic
- Current Average Daily Traffic
- Project Terrain
- Project Length (Miles)
- Shoulder or Curb & Gutter
- Median Type
- Number of Turning Lanes (Left & Right)
- Number of New Traffic Signals
- Number of Traffic Signals Adjusted
- Large Drainage Structures
- Additional Unusual Costs
- Utilities
- Right of Way Procurement
- Existing Bridge Complexity
- Existing Bridge Size
- Proposed Bridge Complexity
- Proposed Bridge Size
- Causeways or Cofferdams

These factors become known as the project transitions from scoping to design completion. Many of these factors will be used to develop the parametric level time estimating tool as well. However, a number of project factors and components may affect project duration and not project cost. For example, long-lead time procurement of materials, placement of large quantities of concrete (cure time), or subsurface geotechnical conditions. These factors are not found in *PCES*, but would be found in the parametric time estimating tool.

It is anticipated that VDOT will eventually integrate the parametric level time estimating tool into the *PCES* estimate. Doing so will simplify the estimating process performed by VDOT and show the effects of cost and time on the project as a whole.

3.2.3 Pre-Advertisement Level. The pre-advertisement estimate considers detailed work-item level project information. The pre-advertisement time estimate is prepared very near design completion when most preconstruction information is known.

In VDOT, this cost estimate is prepared in *PES* and summarizes the project cost through bid items.

This database level for time estimates has been developed as part of this research. This database maintains historical production data at the bid item level. The database created is known as the *Bid Item Duration Data System* (*BIDDS*) and is described in Chapter 4. The *BIDDS* user-interface forms allow the user to input project information and characteristics about a project being scheduled. *BIDDS* then queries the database for bid item production data related to similar projects, with similar components, and performed under similar conditions. In addition to the Chapter 4 discussion, additional information can also be found in the *BIDDS* User's Manual, located in Appendix C of this document.

The need for a multi-level database to maintain highway construction performance times has been developed but cannot be fully comprehended until the reader understands the basic database structure. As a prelude to the *BIDDS* discussion in Chapter 4, this section provides general database background.

3.3 Database Background

The previous section of this chapter described the multi-level database concept. A database is, "a usually large collection of data organized especially for rapid search and retrieval (as by a computer) (Merriam-Webster Dictionary 2005)." This work explores the use of a multi-level database system for storing and retrieving production data. This data will be used to assist the VDOT scheduler in the development of the pre-advertisement schedule. To show the capabilities of such a system within the highway construction project scheduling setting, this section outlines the basic database terminology and structure.

3.3.1 Database Introduction. In the modern computer age, there are endless possibilities for storing and manipulating data and information. Computer applications make complex functions such as graphing, calculating, storing, and formatting simple. Perhaps one of the most powerful tools in the modern computer age is the database.

Databases, in general, have been in existence for a number of years. Any collection of data is often referred to as a “database”. This collection of data may be as simple as a spreadsheet. While a spreadsheet of information can be considered a database, this work focuses on what is considered a database management system (DBMS). As evident from the name, a DBMS is not the actual database itself, but rather the operating application that makes database use possible. DBMSs are used “to add, delete, and update the data in a database,” as well as “to provide various ways to view the data in the database (Roman 2002).” For simplicity, the DBMS herein after is referred to as “the database” or *BIDDS*.

Database theory has advanced significantly over the past several decades (Commonwealth of Virginia 1992). The technology used to create and manage databases has also progressed dramatically in recent years. Today, there are a number of computer based applications available for users from the beginner to expert database administrator experience levels. To facilitate this research, one of these software packages was selected that was simple enough to be learned by the beginner, while being complex enough to accommodate the prototype database. The following paragraphs describe the components of a database management system, as well as the process and the criteria used to select a DBMS.

3.3.2 Database Tables. A database is a collection of related data, generally stored in a series of data tables. Data tables are very similar to spreadsheets or lists that might be seen in a word processing program. Tables are organized sets of data entities.

A database can be made up of any number of these tables. Flat databases are based on a single table. In some instances, this single table may be all that is necessary. A relational database is made up of multiple tables containing unique information or data related by a primary field. To build the most efficient and effective database, effort must be made to remove redundancy in these tables. Multiple entries of data regarding the same field is not only superfluous, but error prone.

The removal of redundant data often leads to the creation of a number of smaller tables. For example, a database of library books might include book, author, and publisher information. For each book, the library would likely want to store the ISBN, publication year, and title. For each author the library would seek to store, their name and address. Finally, for each publisher, the library would likely want to keep a name, address, and phone number on file. A single data table containing all such information is very simple to create. Unfortunately, this data table would not be easy or efficient to use.

Imagine the possibilities that exist for data redundancy and error in the above example. While book information such as ISBN, publication year, and title are unique to each record, it is likely that an author has written more than one book in the library. It is even more likely that the book publisher has hundreds of books in the library. If this were the case, for each book, the user would have to input not only the book information, but repetitive information about the author and publisher. The shear repetition of manual information input increases the possibilities for error drastically. Also, the large table created would require extensive sorting and reformatting with each use, just to be manageable.

To minimize this potential for error and maximize usefulness, the database can be broken down into a series of tables. For instance, book information can be stored in one table, author information in another, and publisher information in another. Supplementary tables can then be created to maintain a link between the tables. Doing so reduces the likelihood of error, and with a well designed database management system, increases the usefulness of the data.

Measures must be taken to maintain data relationships to facilitate this decrease in data redundancy. The multiple data tables created must be linked by some common field, called a primary or super key. A primary key is a set of attributes that uniquely identify an entity from all possible entities in the entity class (Roman 2002). Primary keys are links between tables. For instance, in a database of library books, the ISBN might be used as the primary key to link book information to author and publisher information. While there are many authors and publishers, each book is assigned a unique ISBN. This uniqueness makes its use ideal for a primary key. Social security numbers, account numbers, activity identification numbers, project numbers, or bid item numbers are all examples of unique data identifiers that may be used as primary keys. Figure 3.8 demonstrates the necessary library tables and the link between them.

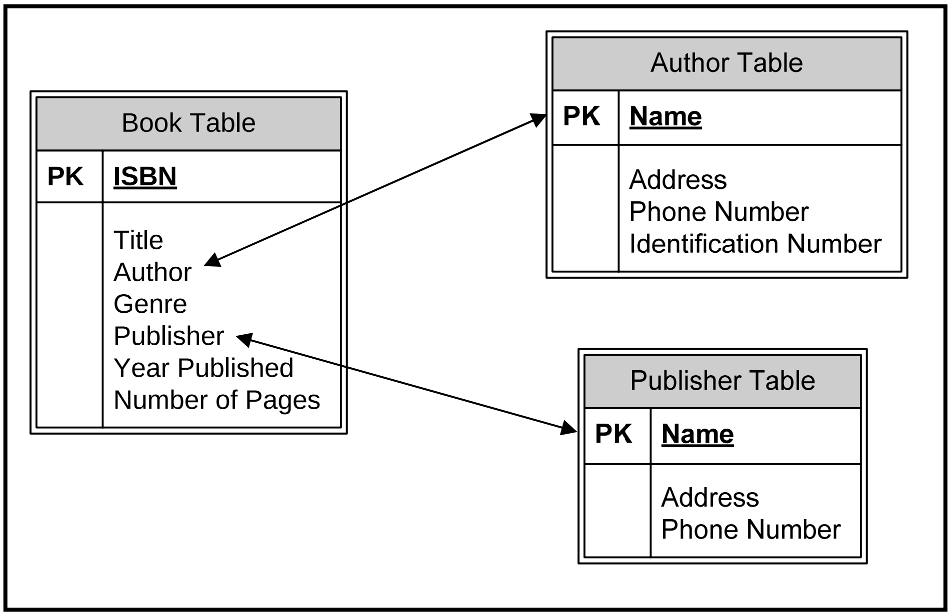


Figure 3.8 – Example Library Database Tables

3.3.3 Database Queries. While databases are useful tools, the data stored within them cannot be used to its fullest potential without the implementation of a DBMS. Perhaps the most basic element of the DBMS is the query. While data tables are used to store information, queries are used to draw this information out, making it useable.

Queries rely on the relationships and primary keys to perform data table operations. A query can be used to append information from a series of data tables, select information from multiple tables, update table information, or a host of other useful functions. Perhaps the most widely used query type is the select query. Select queries are used to retrieve information from a single table or multiple tables. These query types are useful when a number of data tables contain information pertinent to the user. Using a select query, the user can impose parameters that subsequently limit the information gathered until the final data list is achieved. The user may then save the query as an action for repetitive use.

Without the use of queries, the information in a database would be nothing more than a collection of data. Queries are useful tools that allow the user to interact with the data, reshape the data to fit his own needs, and request specific data most pertinent to his needs.

3.3.4 Database Programming. The next important element of a database management system is the ability to program the system. Without programming, DBMS functions would need to be performed manually, requiring database knowledge and training on the part of the user. Programming allows a DBMS to function in a more user-friendly way. Programming makes an intuitive user interface possible.

With the advancements in programming software such as Visual Basic for Applications, DBMS programming has also become more intuitive. Today's DBMS creator needs only minor programming knowledge to begin the creation of his own DBMS. In fact, many applications such as Microsoft *Access* have pre-programmed macros, or code segments, hard coded to perform a variety of tasks. As the creator's knowledge in programming increases, the possibilities for table and form creation, query development and population, and output generation greatly increase.

3.3.5 Selecting a Database Management System. Because this research focuses on the development of the framework for a multi-level database, as well as the construction of a prototype bid item level database, the DBMS needs of this research are much different than those of the subsequent versions. When the database is completed and relinquished to VDOT, a number of changes will be made to its design, coding, and structure. More importantly, changing the DBMS application will be required to facilitate statewide access to VDOT.

While the selection process of a DBMS is an important step toward database development, for the purposes of this research, the needs were relatively simple. A system that could be easily learned and used by beginning and experienced users would suffice. With the advances in computer technology, several software packages are available that would fit the needs of the research. However, the decision was made early in the research to use Microsoft *Access 2003* because it was readily available and intuitive in nature. *Access* also offers adequate space and programming capabilities to support a prototype database and database management system. Additionally, because of the popularity of Microsoft Office packages, *Access* is already installed on most personal computers at a relatively low cost.

Because the database will eventually be accessible statewide, the requirements for the DBMS will change rapidly as the research concludes. At that time, a new DBMS application will need to be selected. The specifications and selection process of this DBMS are outside the scope of this research.

Chapter 4 –Methodology for Developing *BIDDS*

This chapter focuses on the design and construction of *BIDDS* (*Bid Item Duration Data System*), a bid item level database of highway construction performance times. Initial sections describe the concept behind the database and the process of establishing data attributes. The final section describes the development of the input, query, and output structures of *BIDDS*.

4.1 *BIDDS* Conceptual Framework

The ability to easily query, filter, select, and append data in existing tables is what separates a database from a spreadsheet. This section describes the *BIDDS* conceptual framework as a preface to the development of *BIDDS*. Figure 4.1, below, outlines the basic *BIDDS* framework.

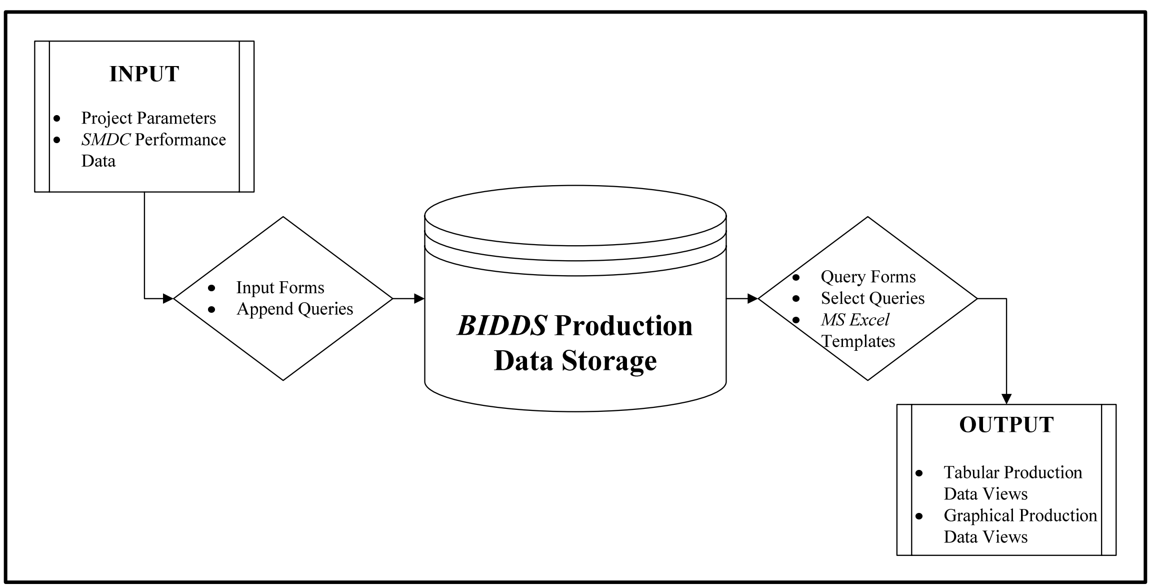


Figure 4.1 – The *BIDDS* Framework

As seen in Figure 4.1, project parameter and performance data is input using input forms and queries. *BIDDS* tables maintain this data. Production data can then be extracted from *BIDDS* using query forms, queries, and established MS *Excel* templates. This data may be viewed in a tabular or graphical format.

4.1.1 The *BIDDS* Concept. *BIDDS* is a relational database management system. In other words, *BIDDS* uses a series of interrelated tables of information that allow the user to limit or broaden the amount of data returned through the selection of specific project parameters. The amount of production data returned decreases as additional parameters are supplied. Alternatively, if fewer parameters are supplied, the amount of production data returned increases. Figure 4.2 exhibits this concept.

Within the collection of project and production data, a subgroup with similar project information parameters exists. Within that subgroup, a subgroup of equal or lesser size exists containing similar project information and project characteristics. As the user defines these parameters, the potential data field is continually reduced to only those projects with similar parameters.

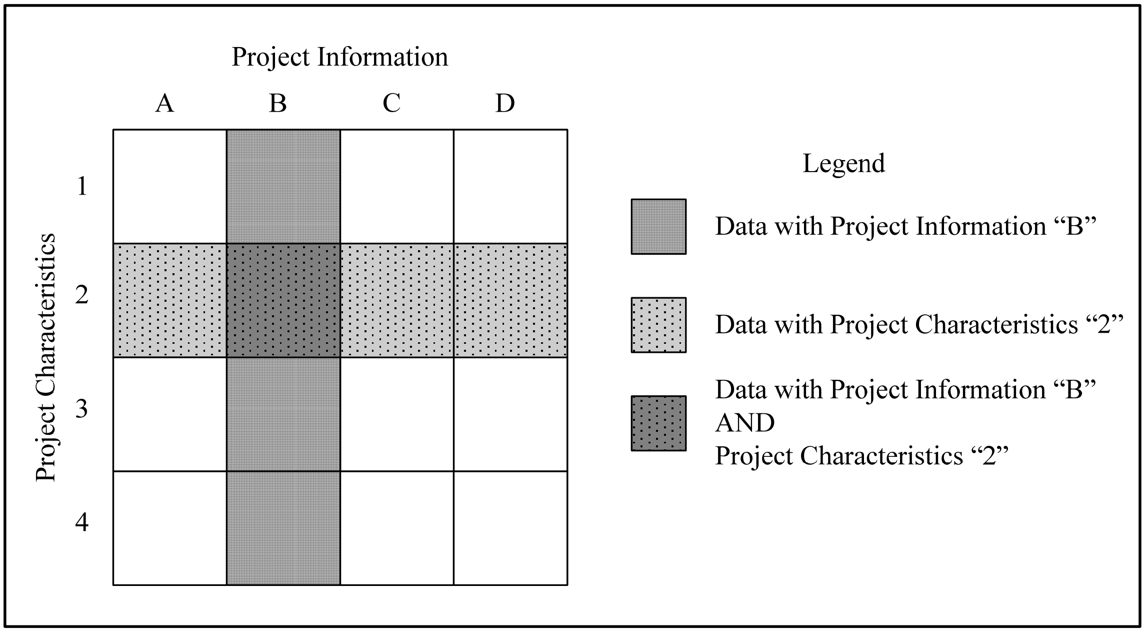


Figure 4.2 – Narrowing of Data Return in *BIDDS*

4.1.2 The *BIDDS* Process. The bulk of the work done in *BIDDS* is based on three tables: project information, project characteristics, and production data tables. Other tables contain supporting data such as location information, geometric design standard information, and supplementary information that initial queries use to populate pull down lists and the main queries themselves.

The second major element of database structure is the query. Queries allow the user to perform various operations, display data in a number of ways, and relate a series of tables into meaningful and useful information. The query structure of *BIDDS* draws from project parameters to select similar projects throughout Virginia and return their bid item production data to the user. Like data tables, there is a host of supporting queries to populate dropdown lists and join data.

While these queries are integral to the database structure, three main queries perform the bulk of the database work:

1. The project information query is populated by user supplied attributes on the project information form and retrieves the project number for similar projects in the database.

2. The project characteristics query uses these project numbers and the project characteristics supplied by the user on the project characteristics forms to further narrow the results.

3. The production data query returns the data in the appropriate results format, either tabular or graphical. Figure 4.3 illustrates this process. The components seen in this figure are further described in the final section of this chapter.

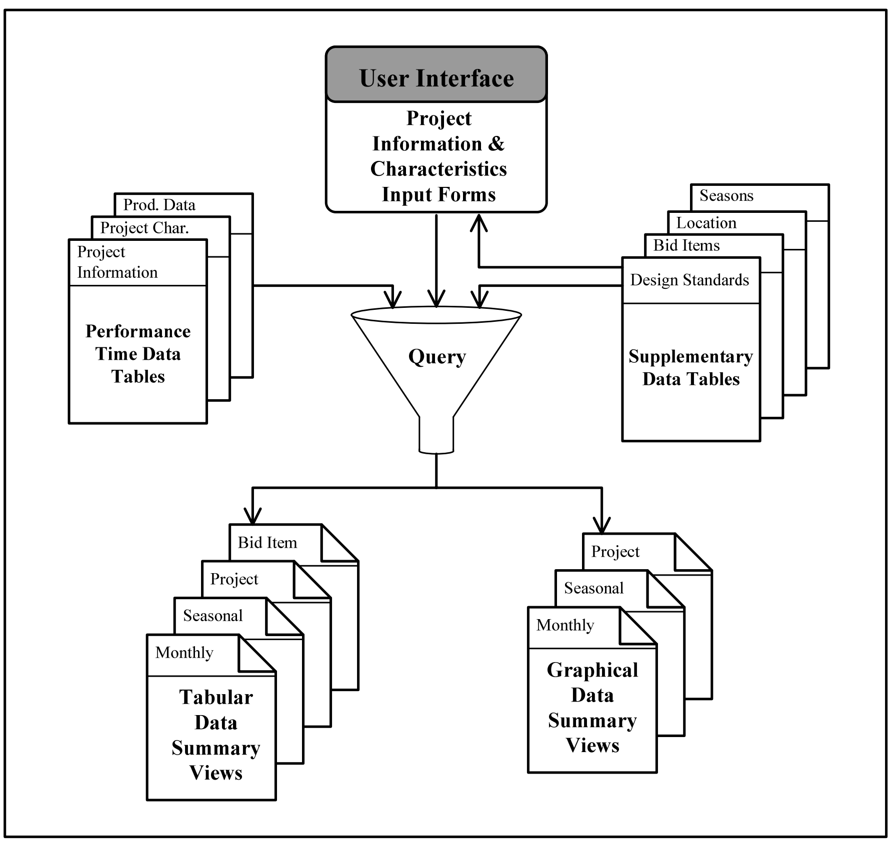


Figure 4.3 – *BIDDS* Query Process

4.2 Development of Common Project Types

The basic framework of *BIDDS* has been described. The remainder of this chapter discusses the process by which *BIDDS* was developed.

BIDDS was developed as a tool to assist VDOT schedulers in the estimation of production rates. The database is intended to offer the user a narrowed scope of production data from which to select daily production rates that can be used to calculate durations for project activities.

A series of search criteria that retrieve data from similar projects, in similar locations, with similar design standards, and with similar characteristics was developed to narrow the scope of the production data. These criteria are discussed in this and the following sections of this document.

The first and perhaps most critical filtering criteria is the project type. Projects of a similar type contain similar activities, bid items, and components. Although durations and costs may vary due to size and complexity, the basic components of the projects are essentially the same. While it is important for the database to contain pertinent information to assist the scheduler, the database cannot seek to encompass all projects across the VDOT system.

Therefore, a number of common project types were established to adequately reflect the majority of VDOT work. While these project types are broad enough to encompass the majority of VDOT construction work, they are also narrow enough to limit the production data collected to only that which is specific to a given project type. For instance, VDOT bridge projects often include work items that are treated separately as road projects. Therefore, the database must be capable of handling these as two separate projects with two separate project types.

As mentioned previously, a number of states are making similar efforts to establish more accurate and reliable contract times. In order to develop a preliminary list of project types for VDOT, the established project type lists of Kentucky, Louisiana, New Jersey, North Carolina, Texas, and West Virginia were analyzed. This list of potential project types was refined, through discussions with VDOT personnel, to the final list of eight common VDOT project types. Below is a list of these project types with a brief description of their scope.

1. **New Road Construction –** These projects include the construction of a new route, alternate route, or the addition of a roadway segment to an existing route. This project type would not include the demolition of an existing roadway or temporary detour, but rather the components of a new roadway such as clearing & grubbing, earthwork, and rock excavation.

2. **New Bridge Construction –** These projects include the construction of a new bridge structure as a portion of a new road construction project. As with New Road Construction, this project type does not encompass activities such as demolition or temporary detours, but rather components of a new bridge structure.

3. **Road Reconstruction –** These projects include the demolition and reconstruction of a roadway segment as well as the realignment of an existing roadway, either vertically or horizontally. Projects of this type generally include activities for demolition of existing roadways and temporary detours.

4. **Bridge Reconstruction –** These projects include the demolition and reconstruction of a bridge as a portion of a road reconstruction project. As with Road Reconstruction, this project type will generally include demolition

activities or the construction of a temporary or detour bridge structure to accommodate traffic.

5. **Road Rehabilitation –** These projects include the revitalization or restoration of a roadway segment. These projects would typically include sub-grade repairs, guardrail replacement, embankment stabilization, or shoulder reconstruction along the road segment.

6. **Bridge Rehabilitation –** These projects include the revitalization or restoration of a bridge along the roadway segment. Bridge maintenance, both substructure and superstructure, would typically be included in this project type. Other examples of this project type include drainage upgrades or full deck replacement. This project type differs from bridge reconstruction in that bridge rehabilitation projects do not include the complete demolition of an existing structure.

7. **Widening –** These projects include the addition or expansion of traveling or turning lanes for an existing roadway. Because bridge widening is uncommon, this project type is limited to components of an existing roadway.

8. **Overlay / Resurfacing –** These projects involve the surface replacement or reapplication of an existing roadway or bridge segment. Asphalt and concrete pavement items are included to accommodate both roadway and bridge overlays. This project type does not include sub-grade, substructure, or earthwork components. This project type does include activities for milling, sub-base repair, and traffic detours where necessary.

Currently, it is difficult to assess or quantify the number of projects matching each of the project type criteria outlined above. VDOT does not currently use this system of classifying project types so as to facilitate such a study. Through continued database use, the number of projects matching the above named project types can be ascertained.

Perhaps at that time, further research into the responsiveness of the above named project types will be assessed. This possibility for future research is further examined in Chapter 6 of this document.

4.3 Development of Project Parameters

The database of performance times allows the scheduler to perform two basic tasks: input project and production information or extract production data from similar projects completed by VDOT. This section discusses the parameters that allow the scheduler to limit the production data returned to that associated with projects similar to their own.

4.3.1 Project Information Parameters. In order to extract data from similar projects, the scheduler must first input basic information about the project being scheduled. This information, which is capable of narrowing a data sample significantly, is readily available and common to all project types during the pre-advertisement planning phase. Below is a list and description of the project information parameters used to narrow data return.

1. **Project Type –** The previously described minimum input required to query the database.

2. **Project Location –** Includes the project district, residency, county, and city where applicable. This field is used to account for the varying geology, weather, and other time-sensitive conditions across the state.

3. **Geometric Design Standard –** A classification of the roadway type. Twelve geometric design standards exist to allow the user to return production data from projects of similar design standards, complexity, and traffic implications.

4. **Advertised Month –** The month in which the project will be advertised for bid. Focuses data return on projects that experienced similar seasonal effects.

5. **Annual Average Daily Traffic Volume –** The average number of vehicles accommodated each day on the roadway. Focuses data return on projects with similar capacities, maintenance of traffic conditions, and requirements.

6. **Estimated Project Cost –** The anticipated cost to the state for completion of the project. This cost is estimated during the scoping phase and refined through project advertisement. The value inserted should reflect the most current cost estimate. Narrows data return to projects with similar value or magnitude.

These parameters were developed by analyzing typical VDOT contract documents and project drawings. The information requested during this step is available through these documents.

4.3.2 Project Characteristic Parameters. Project characteristics are those parameters that separate projects of a similar type from each other. In conjunction with the project information, characteristics help to focus the production data search of each project type to projects that are similar in size and complexity.

As mentioned, project characteristics vary depending on the project type. This is due to the nature of the work. For instance, a New Road Construction project is different than a Bridge Rehabilitation project and therefore, its complexity and size must be quantified and analyzed differently. Each project type has its own set of project characteristics that allow the user to narrow their scope. Below is a table showing the project characteristics for each project type.

Table 4.1 – Project Characteristics by Project Type

Project Type	Characteristics to Consider	Units
New Road Construction	Earthwork Volume	CY
	Lane Miles	MI
	Number of Lanes	EACH
	Rock Excavation Volume	CY
New Bridge Construction	Deck Surface Area	SF
	Deck Surface Material	
	Earthwork Volume	CY
	Height	FT
	Length	FT
	Number of Spans	EACH
	Pier Type	
	Rock Excavation Volume	CY
	Structure Type	
Road Reconstruction	Earthwork Volume	CY
	Lane Miles	MI
	Number of Lanes	EACH
	Rock Excavation Volume	CY
Bridge Reconstruction	Deck Surface Area	SF
	Deck Surface Material	
	Earthwork Volume	CY
	Height	FT
	Length	FT
	Number of Spans	EACH
	Rock Excavation Volume	CY
	Structure Type	
Road Rehabilitation	Lane Miles	MI
	Number of Lanes	EACH
	Surface Material	
Bridge Rehabilitation	Deck Surface Area	SF
	Deck Surface Material	
	Number of Lanes	EACH
	Structure Type	
Widening	Added Lane Miles	MI
	Earthwork Volume	CY
	Rock Excavation Volume	CY
Overlay / Resurfacing	Existing Surface Material	
	Lane Miles	MI
	Number of Lanes	EACH

These project characteristics are derived from a number of sources. Final revisions to the list have been made through conversations with VDOT and VT personnel as well as a survey of VDOT's *Project Cost Estimating Software* (*PCES*). This program is a cost estimation program that asks the user to input detailed project information, then uses a series of adjustment factors and statistical analysis to develop a cost estimate for a project. *PCES* asks the user to input several project characteristics also requested by *BIDDS*, as well as many additional characteristics that influence cost more so than performance time.

Using the project characteristics in conjunction with the project information, a user has the potential to narrow the search to a single project, or even to input parameters dissimilar to any project in the database. Because of the detailed nature of the project information and characteristics, it is necessary to search for a similar range of characteristics and information rather than an identical match. Section 4.7.2 discusses the search ranges programmed into the database search queries.

4.4 Development of Common Project Activities

Initial data collection efforts involved the analysis of completed project diaries for data regarding activities performed and quantities installed. In an effort to standardize the collection process and data collected, a list of common activities for each project type was developed.

Activity lists for each project type were developed in much the same way as the project types. Initial lists were propagated by surveying states that had established project types and activity lists, as well as personal construction knowledge. Subsequent lists were refined through discussions with Partnership personnel, and other VDOT construction personnel.

Much like the project types themselves, the activity lists created were not designed to encompass all activities that could be encountered for each project type. Rather, the goal was to develop a list of activities broad enough to encompass the major work activities associated with a project, while being narrow enough to limit data from irregularly used activities. Table 4.2 lists the activities by their respective project type. The definition and scope of each of these activities can be found in Appendix A.

While the development of common activity lists was important for future endeavors, including the development of a list of bid items that drive project progress, they are not used within the database system. Because work is typically monitored at the bid item level, not the activity level, attempting to attain data at the activity level is error prone and subject to ambiguity. This fact is further explored as driving bid items are introduced in the following section.

Table 4.2 – Common Activities by Project Type

New Road Construction	New Bridge Construction	Road Reconstruction	Bridge Reconstruction
Mobilization	Mobilization	Mobilization	Mobilization
Clearing & Grubbing	Clearing & Grubbing	Traffic Control	Erect Temporary Structure
Remove Structures	Remove Structures	Clearing & Grubbing	Clearing & Grubbing
Roadway Excavation	Cofferdams	Demolition	Cofferdams
Grading	Pile Driving	Milling	Remove Structures
Drain Pipes	Structural Excavation	Roadway Excavation	Pile Driving
Drop Inlets	Substructure Concrete	Grading	Structural Excavation
Curb, Curb & Gutter	Concrete Beams	Box Culverts	Substructure Concrete
Box Culverts	Structural Steel	Retaining Walls	Concrete Beams
Retaining Walls	Deck Joints	Sub-grade Stabilization	Structural Steel
Sub-grade Stabilization	Construct Deck	Stabilized Aggregate Base	Deck Joints
Stabilized Aggregate Base	Parapets & Railings	Base Stone	Construct Deck
Base Stone	Deck Grooving	Shoulders	Parapets & Railings
Shoulders	Slope Protection	Underdrain	Deck Grooving
Underdrain	Approach Slabs	Drain Pipes	Slope Protection
Utilities	Utilities	Drop Inlets	Approach Slabs
Asphalt Base Course	Guardrails & Barriers	Curb, Curb & Gutter	Utilities
Asphalt Intermediate Course		Utilities	Guardrails & Barriers
Asphalt Surface Course		Asphalt Base Course	Remove Temporary Structure
Approach Slabs		Asphalt Intermediate Course	
Signs		Asphalt Surface Course	
Signals		Approach Slabs	
Guardrails & Barriers		Pavement, Base, & Subgrade Repairs	
		Signs	
		Signals	
		Guardrails & Barriers	

Road Rehabilitation	Bridge Rehabilitation	Widening	Overlay / Resurfacing
Mobilization	Mobilization	Mobilization	Mobilization
Traffic Control	Traffic Control	Traffic Control	Traffic Control
Clearing & Grubbing	Clearing and Grubbing	Clearing and Grubbing	Milling
Excavation	Excavation	Demolition	Pavement & Base Repairs
Pavement, Base, & Subgrade Repairs	Demolition	Milling	Asphalt Base Course
Milling	Milling	Excavation	Asphalt Intermediate Course
Asphalt Base Course	Surface Patching	Relocate Drain Pipes	Asphalt Surface Course
Asphalt Intermediate Course	Deck Joints	Relocate Drop Inlets	Concrete Paving
Asphalt Surface Course	Substructure Rehabilitation	Relocate Utilities	Pavement Marking
Curb, Curb & Gutter	Asphalt Base Course	Retaining Walls	
Upgrade/Relocate Drain Pipes	Asphalt Intermediate Course	Grading	
Upgrade/Relocate Drop Inlets	Asphalt Surface Course	Base Stone	
Upgrade/Relocate Utilities	Concrete Paving	Shoulders	
Upgrade Signs	Upgrade/Relocate Utilities	Asphalt Base Course	
Upgrade Signals	Upgrade Barriers and Guardrail	Asphalt Intermediate Course	
Upgrade Barriers and Guardrail		Asphalt Surface Course	
		Curb, Curb & Gutter	
		Signs	
		Signals	
		Barriers and Guardrail	

4.5 Development of Driving Bid Items

The development of common activities for each project type proved beneficial in one key aspect of database creation: it revealed the need for and the development of a list of "driving" bid items.

A difference between controlling and driving should be noted here. Controlling bid items are those whose measurement and analysis do not reflect actual project progress. Driving bid items are items of work significant to project completion in that their measurement reflects project progress. This significance may be in terms of their proportional cost, duration, or influence on succeeding activities. For example, on a roadway project, a controlling item is the pavement markings, in that the project is not complete until these minor, yet important, items are completed. On the same project, asphalt pavement items would likely be considered driving items. This item would likely consume a significant portion of the scheduled working days. Further, by measuring the amount of asphalt pavement placed, project progress can be ascertained.

4.5.1 Tracking Progress by Bid Item. As work on *BIDDS* progressed, it was realized that the standardized activities established previously should have a list of typical bid items that must be installed to complete the activity. Without this list of bid items, the scope and limitations of activities are open to the interpretation of the user, as well as the data collector. Therefore, bid item level data collection had to be explored.

As mentioned in Section 2.7, it is at the bid item level that VDOT and most state highway agencies estimate project cost. It is proposed that project time can also be estimated at this level. Of course this level of cost and time estimation is only possible as design nears completion.

Besides being one of the fundamental components of project cost and schedule, using bid items to estimate time is also very beneficial to the data collection and processing procedures. Bid item numbers are designed to identify the item description, units, and general use. The VDOT system for categorization of bid items by their number identifier can be seen in Table 4.3. This list can be found in the VDOT *Trns*Port PES* User's Manual. This system of coded bid items reduces the ambiguity encountered when activities are used to analyze project performance. Bid items are the common language for schedulers, estimators, project managers, and inspectors alike. They are also the lowest level of detail at which project progress is currently tracked.

Maintaining and reporting activity level production data is possible. However, to do so would require using one of the two following options:

1. Creation of a new system for monitoring of project progress at the activity level. This system would either use *SiteManager* to request additional data from the inspector or be a standalone system that inspectors would operate separately. Either option would increase project inspector work load. Also, because there is not a uniform activity list used by all entities involved in the construction project, ambiguities would exist in activity classification and scope definition.

2. Retrospective analysis of project performance data. This analysis would entail the collection of historical bid item data, then applying the bid item data to the scheduled activities to determine their duration. While such a system would require little additional work from the project inspector, a significant amount of work is created for the data analyst. Such a system would also experience the ambiguities created in activity assignment and scope definition. Further, most projects performed by VDOT do not require the preparation of a CPM schedule. Without a detailed CPM diagram with finite activities, retrospective analysis using bid item production data would not be possible.

For these reasons, the bid item level is the most basic element of the database of performance times. Information about each bid item can be easily recorded and queried within the database without the risk of activity name misspellings or the need for creating uniquely coded project activities.

Table 4.3 – VDOT Bid Item Categories (Info-Tech and VDOT 2004)

Bid Item Number	Description
00001 - 00499	GRADING ITEMS
00500 - 09999	DRAINAGE ITEMS
10000 - 11999	PAVEMENT ITEMS
12000 - 13999	INCIDENTAL ITEMS
14000 - 19999	MAINTENANCE SCHEDULE ITEMS
20000 - 25999	PROTECTIVE ITEMS
26000 - 27999	EROSION CONTROL
28000 - 39999	PLANTING ITEMS
40000 - 41999	UTILITY ITEMS WATERMAIN
41000 - 49999	SANITARY SEWER
	TRAFFIC CONTROL & SAFETY SYSTEMS
50000 - 50999	TRAFFIC SIGNS
51000 - 53999	TRAFFIC SIGNALIZATION
54000 - 54999	PAVEMENT MARKING ITEMS
55000 - 59999	LIGHTING ITEMS
	BRIDGE ITEMS
60000 - 63999	BRIDGE SUPERSTRUCTURE
64000 - 66999	BRIDGE SUBSTRUCTURE
67000 - 67999	BRIDGE INCIDENTALS
	STRUCTURAL WIDENING OR REPAIR
68000 - 68999	SUPERSTRUCTURE
69000 - 69999	SUBSTRUCTURE
70000 - 72000	RIGHT OF WAY ITEMS
80000 - 99999	CONTRACT ADJUSTMENTS

4.5.2 Establishment of Driving Bid Items. While the use of bid items to track progress and production reduces ambiguity, their use must still be refined. VDOT currently has a bid item entry for 14,573 "Standard Bid Items" and 1,505 "Non-Standard Bid Items" (Standard Item Code Table & Non-Standard Item Code Table 2005). These lists are divided roughly in half according to their units, either English or Metric. Also, the list can divided in quarters based on their specification year, whether 1993, 1994, 2003, or 2004.

Like most state transportation agencies in the United States, VDOT is reverting to English units. Currently, VDOT has a limited number of ongoing metric projects and all projects under design are in English units. It was also noted that the bid items from 1994 coincided almost directly with those of 2004. With these findings the decision was made to use English unit bid items from the 2004 specifications. This narrowed the field to approximately 4,000 "Standard" and "Non-Standard" bid items.

While this significantly narrowed the scope of bid items, 4,000 bid items were not necessary for daily progress tracking and development of a performance time database. During the initial phase of assigning bid items to activities, many activities had more than 100 bid items directly associated with them. Unfortunately, most of these bid items were either rarely used, or their production rate could be estimated using a similar bid item production rate.

In an effort to simplify the data collection methods and the database output, the list of 4,000 bid items needed to be narrowed to only those which were the most commonly occurring and most likely to drive project progress.

The process of establishing a list of driving bid items for each activity began by classifying each bid item into divisions of:

1. **Always Driving –** Those items whose progress is generally or always critical to activity or project completion.

2. **Sometimes Driving –** Those items whose progress may be critical to activity or project completion.

3. **Never Driving –** Those items whose progress is never critical to activity or project completion.

With the assistance of Partnership personnel, initial revisions were made and further refined by meeting with VDOT cost estimators. Final revisions were made using a tabulation of VDOT bid item usage. This list was supplied by VDOT estimators and established to reflect cost parameters such as minimum, maximum, and average bid item costs from the previous two years. The data provided also included location information, such as the district and the quantity performed. This data was extracted from VDOT's *Business Objects Management* program, a data storage software that functions as a data warehouse for project information.

For the purposes of collecting performance times, it is important to capture quantity and location data. Once the list of bid items was formatted to demonstrate the frequency of use and the quantities installed for each bid item, it was easy to see which items were most commonly used and in which districts. Also, this tabulation yielded which bid items are rarely or never used, assisting in the classification of "Never Driving" bid items. Using this tabulation, the list of driving bid items for each activity for each project type was finalized. Doing so reduced the number of bid items tracked by 91 percent, on average. Currently, the highest number of bid items being tracked, for a single project type, is 107 for Road Reconstruction projects. Table 4.4 below is a tabulation of the number of driving bid items associated with each project type.

Table 4.4 – Number of Driving Bid Items by Project Type

Project Type	Number of Driving Bid Items
New Road Construction	96
New Bridge Construction	41
Road Reconstruction	107
Bridge Reconstruction	45
Road Rehabilitation	87
Bridge Rehabilitation	37
Widening	91
Overlay / Resurfacing	36

4.5.3 Driving Bid Item Notes. While the number of bid items being tracked within the current database model was significantly reduced, it is important to note that VDOT is afforded the capability of tracking different bid items. The database is designed to return bid item production data from projects with similar project information and characteristics. Therefore, VDOT would only need to change the list of driving bid items for which data is collected. There is no need for a change in the database structure. Possibilities for future changes and research into driving bid items will be discussed in greater detail in Chapter 6.

4.6 Development of Synthetic Data

As mentioned previously, initial data collection techniques relied on the analysis of hard-copy project records or diaries. This time-consuming process facilitated data collection from only three VDOT projects. To develop and adequately test a database of performance times required a much larger sample of data. To accomplish this, synthetic data was developed.

4.6.1 Developing Project Templates and Assigning Bid Items. Synthesis is, "to combine so as to form a new, complex product (Merriam-Webster Dictionary 2005)." This is what took place during the development of synthetic data. Daily production rates for each of the driving bid items under the established Road Reconstruction and Overlay / Resurfacing project types were taken from *RS Means Heavy Construction Cost Data* (2005) handbook. Because of the indefinite nature of bid items such as Mobilization, a number of the driving bid items could not be found within the *RS Means* handbook. For these bid items, personal experience was used to estimate the average daily production rate.

Once a standard production rate range was established, VDOT Construction Bid Tabulations were reviewed, selecting eight Overlay / Resurfacing projects and ten Road Reconstruction projects from which to base the synthetic data. The individual projects were then analyzed and their driving bid items and quantities noted. The pattern of driving bid item usage and quantities were used as templates for developing synthetic data. Using this technique, data was generated for 130 synthetic Overlay / Resurfacing projects and 150 synthetic Road Reconstructions. These numbers were arbitrarily selected. While their was a repeating pattern of bid item occurrences, the quantity for each bid item was generated randomly using the *RS Means* rates as an average and an arbitrarily selected standard deviation of 5 percent. Synthetic production data created was limited to within two standard deviations of the average.

4.6.2 Developing Project Information Data. The next step was to attach project information and characteristics to the newly created projects. This process was performed through *Visual Basic for Applications (VBA)* within Microsoft *Excel*. Because Overlay / Resurfacing and Road Reconstruction vary by nature, information and characteristic data for these project types needed to be generated separately. Below is a list of the synthetic project information generated along with a brief description of the procedure involved in its generation.

1. **Project Number –** The project numbers were generated, starting at SD 0001 and ending with SD 0280.

2. **Project Type –** The project types were simply designated in order as well. Synthetic projects SD 0001 through SD 0130 are Overlay / Resurfacing project types. SD 0131 through SD 0280 encompassed Road Reconstruction project types.

3. **Project District –** Each VDOT district is numbered one through nine. The project district was assigned by generating a random whole number between one and nine.

4. **Project Residency –** Efforts were taken to ensure that the randomly assigned residency was within its respective district. A macro was written to randomly generate a residency within the previously assigned district.

5. **Project County –** Project counties were based on their residency of occurrence. This data was generated using a macro to assign a county within the previously generated residency.

6. **Project City –** Project city locations are not nearly as commonly occurring within the synthetic data. A city was assigned to a project for less than 3% of the projects generated. This mimics data contained in the VDOT Project Tracking Database.

7. **Geometric Design Standard –** VDOT currently uses 12 geometric design standards to classify projects. Geometric design standards were assigned to each project randomly.

8. **Advertised Month –** Due to the differences between Overlay / Resurfacing and Road Reconstruction, this data had to be generated differently. Overlay / Resurfacing projects are typically performed between April and November, when most asphalt plants are in production. Road Reconstruction work, however, can be performed nearly year round. Therefore the parameters used to establish an advertised month differed. The largest impact of this difference was seen when creating as-built production data as described in section 4.6.4.

9. **Annual Average Daily Traffic –** Synthetic data used the geometric design standards and predefined ranges to assign a value to this field.

10. **Estimated Project Cost –** When developing the project templates, significant differences in the cost of Overlay / Resurfacing and Road Reconstruction work was noticed. Therefore, allowable price ranges for the project types were established separately. Both ranges use the number of working days to establish a price range for the synthetic project. Once the price range was established, an estimated project cost was randomly generated within the limits of that range.

4.6.3 Developing Project Characteristics Data. Once project information data was created, the final step in the development of synthetic project data was the creation of project characteristics data.

Table 4.1 shows that there are different characteristics used to quantify the size and complexity of each project type. For Overlay / Resurfacing projects, the database stores information regarding the existing surface material, lane miles, and number of lanes. For Road Reconstruction projects, on the other hand, the database stores information regarding the earthwork volume involved, lane miles, number of lanes, and the rock excavation volume. Therefore, data for each project type had to be generated separately.

The first characteristic of the Overlay / Resurfacing project type, existing surface material, was randomly selected as either asphalt or concrete. Because the number of lanes is often a function of the project setting and geometric design standard, a typical number of lanes for each geometric design standard were arbitrarily assigned and used to generate the number of lanes for each project. Lane miles were the final characteristic generated for Overlay / Resurfacing projects. Lane miles were generated using a trend noticed between the project award cost and the number of lanes involved in each of the Overlay / Resurfacing template projects. Using this correlation, lane miles were equal to (Award Price) / ($30,000 * Number of Lanes).

While Road Reconstruction project types require different characteristics, generation of synthetic data for the 150 projects was similar to that of generating 130 Overlay / Resurfacing project characteristic sets. As in Overlay / Resurfacing projects, the number of lanes was established by the geometric design standard. The lane miles for each project was based on this number and a trend noted in the Road Reconstruction project costs. Instead of using $30,000/mile/lane, Road Reconstruction projects demonstrated a value of nearly $1,000,000/mile/lane. Using this trend, lane miles were produced using the same formula used in Overlay / Resurfacing project types. Earthwork volumes were based on a trend noticed between the estimated project cost and the amount of earthwork involved with the project. To mimic this correlation, earthwork volume is equal to (Award Price) / ($135 / Unit Volume). Finally, the rock excavation volume was generated in a similar fashion. For the synthetic data, rock excavation volume is equal to (Award Price) / ($3,000 / Unit Volume).

4.6.4 Developing Production Data. As synthetic data was being produced, conceptual *BIDDS* output options were being finalized. These conceptual options facilitated the selection of the production data to be collected.

Each project production data record has a project number, bid item number, month performed, year performed, monthly quantity, and number of days performed associated with it. This translates into one bid item record for each month project work is performed, a decision made during the data collection process. Using this data, numerous output options can be explored.

Section 4.6.1 discussed the development of project templates, 280 synthetic projects, and production rates for each of the bid items associated with those projects. Because the database output options demonstrate trends between production rate, time and quantity, additional data was needed. It is not uncommon, especially on large projects, for bid items and work activities to span multiple months. The data generated for the database needed to mimic that fact.

To generate such data, the project templates were used once again. For each project template, total quantities for each bid item were recorded. A random number was then generated to fall within 15 percent of that quantity. Then, using the production rates from *RS Mean*s and an assumption of 22 working days per month, the number of months performed could be calculated as (Total Quantity) / (Avg. Daily Production Rate * 22).

If work using one bid item ran longer than one month, it was then assumed that all 22 working days of that month were used on the bid item. In subsequent months, the number of days performed was calculated by dividing the quantity remaining by the average daily production rate.

The last piece of information to be generated was the actual month performed. To demonstrate a trend throughout the year, it is necessary to attach this information to each bid item. The process of assigning the month performed to the bid item used an established advertised month generated for each project. For simplicity, the advertised month plus two months was used as the planned project start date. Then, a time frame in respect to project start date for each project activity and each bid item was established. While these time frames are based on assumptions, it is hoped that future research will investigate patterns in bid item performance for each project type.

Within these time frames, a bid item start date was generated and the month of that date taken as the first month in which work on the bid item was performed. Subsequent months were established as necessary.

The generation of these data fields concluded the data creation process and marked the beginning of the next process: development of the *BIDDS* structure.

4.7 *BIDDS* Structure

Through the evolution of data collection techniques and the development of synthetic data, the database has taken its prototype form and configuration. This section describes the design and construction of *BIDDS*: its tables, queries, forms, and output structure.

4.7.1 *BIDDS* Tables. Data input into *BIDDS* consists of two different types: project input and production data input. The difference between the two input types is their purpose within *BIDDS*.

Although data is returned to the user by bid item, the *BIDDS* query structure does not rely on the bid items. Instead, the queries rely on project information and characteristics to generate a list of the bid items and production information associated with similar projects within the database. Since *BIDDS* does not query the database by particular bid items, the database input tables can be separated into smaller, more efficient and unique tables.

There are two categories of tables in *BIDDS*: performance time data and supplementary data. Performance time data tables are those which house vital historical project and production data. Supplementary tables house information necessary to populate dropdown lists and queries. For the purposes of this discussion, only the design and construction of the performance time data tables will be discussed.

Three major table sets exist in *BIDDS*: project information, project characteristics, and historical production data tables. All project information is maintained in a single table. The project information table is populated through an input form completed for each project. The establishment of the information parameters included in this table was discussed in Section 4.3. Figure 4.4 is a screenshot of the project information table contained within *BIDDS*. Note that data contained in the table below is synthetic data, <u>not</u> historical project data.

Project Information : Table

Project Number	Project Type	District	Residency	County	City	GS Code	Traffic Volume (ADT)	Award Price	AdMonth
SD 0112	Overlay / Resurfacing	Richmond	South Hill	Mecklenburg		H	22000	$243,242	April
SD 0113	Overlay / Resurfacing	Bristol	Jonesville	Lee		2	18000	$506,600	July
SD 0114	Overlay / Resurfacing	Staunton	Verona	Highland		6	1000	$369,824	May
SD 0115	Overlay / Resurfacing	Hampton Roads	Waverly	Sussex		6	3000	$245,434	October
SD 0116	Overlay / Resurfacing	Culpepper	Culpepper	Madison		2	18000	$216,211	August
SD 0117	Overlay / Resurfacing	Fredericksburg	Fredericksburg	King George		A	52000	$398,663	August
SD 0118	Overlay / Resurfacing	Staunton	Luray	Page		4	9000	$431,772	August
SD 0119	Overlay / Resurfacing	Bristol	Wytheville	Grayson		6	2000	$475,176	April
SD 0120	Overlay / Resurfacing	Salem	Hillsville	Floyd		J	25000	$319,392	June
SD 0121	Overlay / Resurfacing	Bristol	Jonesville	Scott		6	3000	$380,330	May
SD 0122	Overlay / Resurfacing	Bristol	Jonesville	Scott		6	3000	$237,231	August
SD 0123	Overlay / Resurfacing	Lynchburg	Chatham	Pittsylvania		2	13000	$533,507	April
SD 0124	Overlay / Resurfacing	Salem	Bedford	Bedford		J	29000	$229,357	October
SD 0125	Overlay / Resurfacing	Bristol	Tazewell	Bland		H	27000	$222,450	June
SD 0126	Overlay / Resurfacing	Hampton Roads	Accomac	Accomack		H	24000	$453,589	April
SD 0127	Overlay / Resurfacing	Fredericksburg	Bowling Green	Essex		J	29000	$364,757	June
SD 0128	Overlay / Resurfacing	Hampton Roads	Tidewater Toll	Elizabeth City		2	19000	$200,989	October
SD 0129	Overlay / Resurfacing	Staunton	Lexington	Alleghany		H	25000	$286,391	June
SD 0130	Overlay / Resurfacing	Bristol	Jonesville	Lee		H	23000	$203,103	October
SD 0131	Road Reconstruction	Salem	Salem	Botetourt		I	31000	$2,494,120	February
SD 0132	Road Reconstruction	Culpepper	Culpepper	Madison		E	39000	$6,845,008	October
SD 0133	Road Reconstruction	Hampton Roads	Accomac	Northampton		2	19000	$1,063,003	April
SD 0134	Road Reconstruction	Richmond	Chesterfield	Chesterfield		A	48000	$3,393,877	August
SD 0135	Road Reconstruction	Salem	Christiansburg	Montgomery		3	7000	$2,952,374	May
SD 0136	Road Reconstruction	Culpepper	Warrenton	Fauquier		H	25000	$4,922,033	October
SD 0137	Road Reconstruction	Northern Virginia	Manassas	Prince William		H	22000	$1,668,659	September
SD 0138	Road Reconstruction	Hampton Roads	Waverly	Surry		E	42000	$892,727	June
SD 0139	Road Reconstruction	Bristol	Jonesville	Lee		J	28000	$2,862,426	February
SD 0140	Road Reconstruction	Culpepper	Charlottesville	Greene		1	23000	$2,921,123	May
SD 0141	Road Reconstruction	Richmond	Amelia	Amelia		I	36000	$1,028,932	July
SD 0142	Road Reconstruction	Hampton Roads	Franklin	Greensville		6	3000	$409,828	June
SD 0143	Road Reconstruction	Hampton Roads	Norfolk	Princess Anne		H	27000	$1,083,005	July
SD 0144	Road Reconstruction	Salem	Christiansburg	Pulaski		E	37000	$2,954,562	August
SD 0145	Road Reconstruction	Lynchburg	Halifax	Halifax		3	4000	$4,293,981	March
SD 0146	Road Reconstruction	Bristol	Wytheville	Grayson		I	34000	$5,994,334	November
SD 0147	Road Reconstruction	Fredericksburg	Saluda	King and Queen		A	52000	$5,577,206	October
SD 0148	Road Reconstruction	Salem	Rocky Mount	Franklin		1	27000	$6,829,326	September
SD 0149	Road Reconstruction	Northern Virginia	Fairfax	Fairfax		6	3000	$6,345,769	February
SD 0150	Road Reconstruction	Bristol	Jonesville	Lee		I	36000	$6,600,942	October
SD 0151	Road Reconstruction	Richmond	Amelia	Lunenburg		5	12000	$305,565	April
SD 0152	Road Reconstruction	Lynchburg	Halifax	Charlotte		H	26000	$3,766,613	June
SD 0153	Road Reconstruction	Staunton	Luray	Clarke		A	48000	$820,785	April
SD 0154	Road Reconstruction	Culpepper	Warrenton	Rappahannock		4	13000	$2,929,155	September

Record: 1 of 280

Figure 4.4 – *BIDDS* Project Information Table

Project characteristics collected for each project type vary widely. Therefore, a table for each project type was created to accommodate this data. Creation of these eight tables limits potential for confusion, inefficiency, and error. These eight tables are manually populated for each project using the project characteristics forms to be discussed in Section 4.7.3.

The final major table in *BIDDS* is the table of historical production data. This table contains production data for each bid item on every project. Currently, efforts are underway to extract this data from *SiteManager*, an American Association of State Highway and Transportation Officials (AASHTO) software used by VDOT for digital daily diary generation. It is important to mention, however, that this table may be populated by a number of other methods, given that the correct data is collected and imported in the correct format. The *BIDDS* User's Manual in Appendix C addresses the issue of data formatting.

The historical production data table consists of six fields which enable the unique identification of each production record. The six fields for which production data is collected include:

1. **Project Number –** Unique identifier applied to all VDOT projects. This field is the primary field of the historical production data table.

2. **Bid Item Number –** Cost accounting unit of work that represents some measure of work performed and quantity installed.

3. **Month Performed** – Production data will be imported monthly into *BIDDS*. Collecting this data will demonstrate production rate trends throughout the year.

4. **Year Performed –** Project data spanning more than one year can be sorted by collecting this data.

5. **Monthly Quantity** – Amount of work performed on each bid item during the month for which data is collected. The units correspond directly to the established bid item units.

6. **Number of Days Performed –** While work on a bid item spans a number of months, work may not take place every day during that month. Collecting this data allows *BIDDS* to filter non-working days from the data.

4.7.2 *BIDDS* Queries. The ability to query multiple data tables for certain information is what sets a database apart from a simple collection of datasheets. Queries are the heart of a relational database management system like *BIDDS*. While the information within the database is vitally important, it is of little consequence if there is no way for the user to extract the data in a meaningful format. This section describes how *BIDDS* uses the information and characteristics supplied by the user to narrow the data return to similar projects within the database.

Like the data tables discussed previously, *BIDDS* contains two categories of queries: major and supplementary. Supplementary queries are used in conjunction with the user-interface forms to populate drop-down lists and assist major query propagation. Major queries drive the *BIDDS* process.

Two major query types exist in *BIDDS*: project parameter queries and production data queries. Project parameter queries are populated with user-supplied project information and characteristics and return a list of similar projects. To allow the return of a number of similar projects, instead of exact matches, several of the fields in the project parameter queries were subjectively assigned ranges from which to search the database. These ranges are not based on actual construction data. Table 4.5 shows the ranges established for each applicable project parameter.

In the future, the predefined ranges should be statistically studied to determine the appropriate breaks in the data. For instance, instead of using a simple percentage to find a range for bridge height, a study into the common bridge heights may conclude that significant breaks exist at 50, 100, and 150 feet for newly built bridges in Virginia. This change would require merely replacing a text box with a dropdown menu box on the query form.

The second major query type in *BIDDS*, production data queries, uses the list of project numbers for similar projects established by the parameter queries to retrieve production data from the historical production data table. The results of these queries may be represented in a number of ways. These output options are discussed in Section 4.7.4.

Table 4.5 – Project Parameter Query Ranges

All Project Types		
	Project Information	**Search Criteria or Range (+/-)**
	Traffic Volume	15%
	Award Price	15%
New Road Construction		
	Project Characteristics	**Search Criteria or Range (+/-)**
	Earthwork Volume	20%
	Lane Miles	20%
	Number of Lanes	1 Lane
	Rock Excavation Volume	20%
New Bridge Construction		
	Project Characteristics	**Search Criteria or Range (+/-)**
	Deck Surface Area	20%
	Deck Surface Material	Asphalt, Concrete, or Timber
	Earthwork Volume	20%
	Height	33.3%
	Length	33.3%
	Number of Spans	2 Spans
	Rock Excavation Volume	20%
	Structure Type	Concrete or Steel
Road Reconstruction		
	Project Characteristics	**Search Criteria or Range (+/-)**
	Earthwork Volume	20%
	Lane Miles	20%
	Number of Lanes	1 Lane
	Rock Excavation Volume	20%
Bridge Reconstruction		
	Project Characteristics	**Search Criteria or Range (+/-)**
	Deck Surface Area	20%
	Deck Surface Material	Asphalt, Concrete, or Timber
	Earthwork Volume	20%
	Height	33.3%
	Length	33.3%
	Number of Spans	2 Spans
	Rock Excavation Volume	20%
	Structure Type	Concrete or Steel
Road Rehabilitation		
	Project Characteristics	**Search Criteria or Range (+/-)**
	Lane Miles	20%
	Number of Lanes	1 Lane
	Existing Surface Material	Asphalt or Concrete
Bridge Rehabilitation		
	Project Characteristics	**Search Criteria or Range (+/-)**
	Deck Surface Area	20%
	Deck Surface Material	Asphalt, Concrete, or Timber
	Number of Spans	2 Spans
	Structure Type	Concrete or Steel
Widening		
	Project Characteristics	**Search Criteria or Range (+/-)**
	Added Lane Miles	20%
	Earthwork Volume	20%
	Rock Excavation Volume	20%
Overlay / Resurfacing		
	Project Characteristics	**Search Criteria or Range (+/-)**
	Existing Surface Material	Asphalt or Concrete
	Lane Miles	20%
	Number of Lanes	1 Lane

4.7.3 *BIDDS* Forms. Three sets of forms make up the *BIDDS* user-interface: project parameter input, production data import, and production data query forms. When *BIDDS* is opened, the user first sees the "Entry Form", which allows them to enter one of the three user-interface processes mentioned above. These sets of forms are discussed in the order presented above.

Project parameter input forms are used to input project information and characteristics for a new project into *BIDDS*. This process is performed manually for each project entered into the database. These forms were created in *MS Access 2003* to allow the user to easily input project parameter data. A single project information input form and a set of eight project characteristics forms (one for each project type) are contained in *BIDDS*. Upon completion of the two forms, a project is "established" in the database. It is important at this step, that as many of the project parameters as possible are input. Figure 4.5, below, shows the forms that must be completed to establish a project within the database. The example below uses New Road Construction to demonstrate the project characteristics input form. This second form in the sequence varies based on the project type input on the project information form.

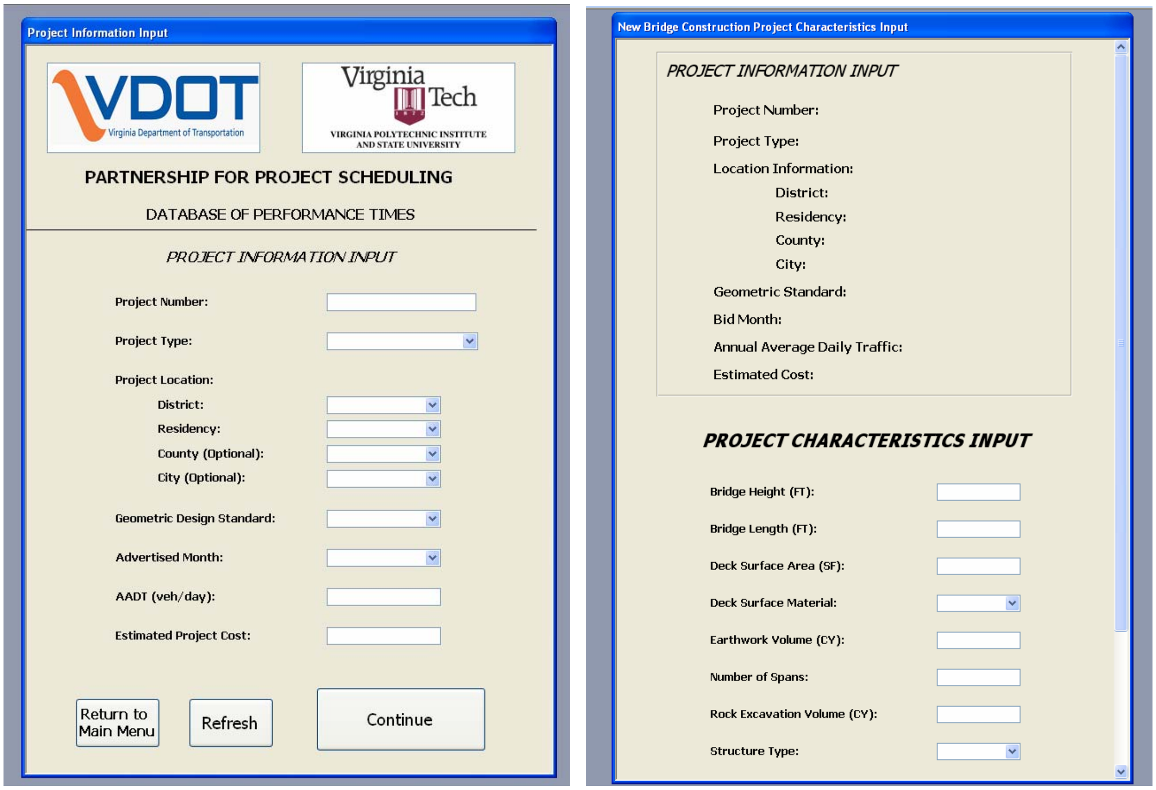


Figure 4.5 – New Road Construction Project Parameter Input Forms

Once a project has been established in *BIDDS*, historical production data may be imported from *SiteManager* or another data source using the production data import forms. It is important that this import occurs only after a project has been established. Production data queries rely on the list of project numbers of similar projects generated by the project parameter queries. Therefore, without the accompanying project parameters, production data may be orphaned in the database. To ensure that this does not happen, the user must input the project number when importing production data. This number is checked against a list of existing projects in *BIDDS*. If the project has not been established, the user is required to go back and input the necessary project parameters.

Once the project number is input, the user must complete a series of other fields to complete the import process. These additional fields can be seen in Figure 4.6 below.

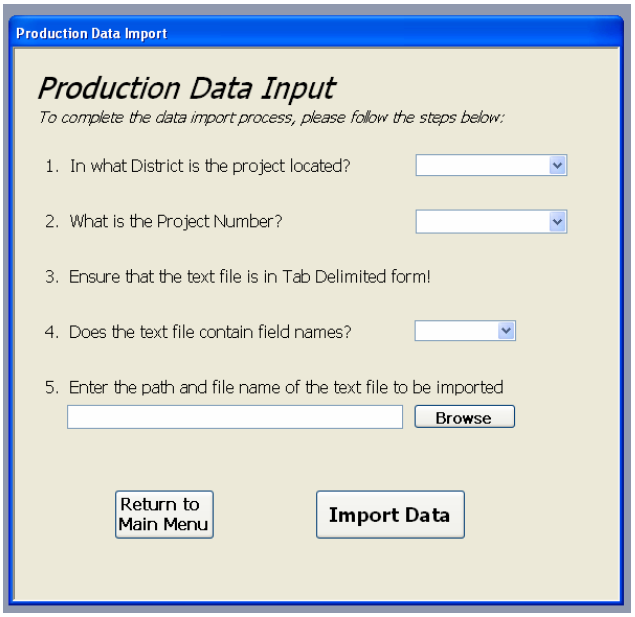


Figure 4.6 – Production Data Import Form

The final form set included in the *BIDDS* user interface is the production data query form sets. These forms are used to populate the project parameter and production data queries and progress the production data output process.

The first two forms in this set drive the actual data narrowing and return. These two forms look similar to the project parameter input forms shown in Figure 4.5. During the query process, however, the user is not asked for their project number. Also, after completing the project information query form and moving to the appropriate project characteristics form, the number of similar projects identified by the project information query is revealed. At this point, the user must decide whether to continue and limit or return and broaden their search criteria. If no similar projects exist, the user must return to the previous form and broaden their search criteria. Figure 4.7 shows the sequence of forms for Road Reconstruction project type queries.

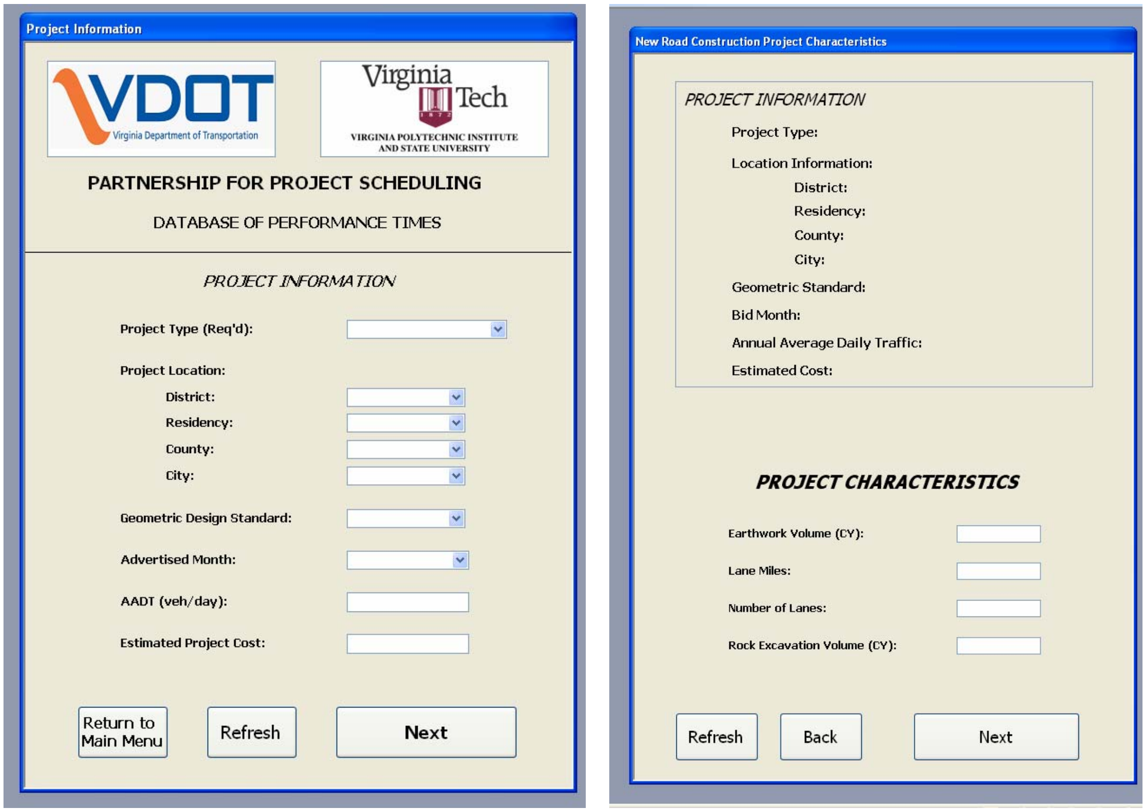


Figure 4.7 – Project Information and Characteristics Query Forms

Subsequent forms allow the user to select either a tabular or graphical output format. Also, the user may specify how they would like the data summarized. Four summary options exist as shown in Figure 4.8. Tabular views are pivot tables created in *MS Excel*, formatted to arrange production data in a number of ways. Graphical views are also generated in *MS Excel* and used to demonstrate production trends with the time of year work is performed, quantity installed, and frequency of use. An explanation of each output summary type and format is included in Section 4.7.4.

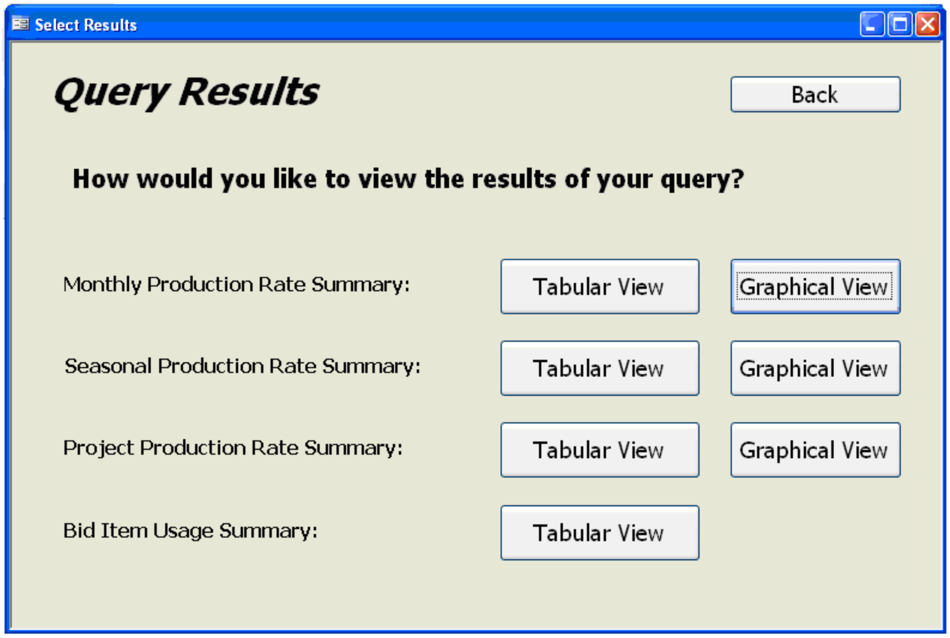


Figure 4.8 – Select Results Form

The final form in the production data query series is used when the user has selected to view production data graphically. The graphical view form offers the user three options for plotting data: Time vs. Production, Quantity vs. Production, or Frequency vs. Production. The form command buttons open an established *MS Excel* workbook and plot the production data retrieved through the query. The availability of the graphical output options is discussed in the following section. Figure 4.9, below, is the graphical view form in *BIDDS*.

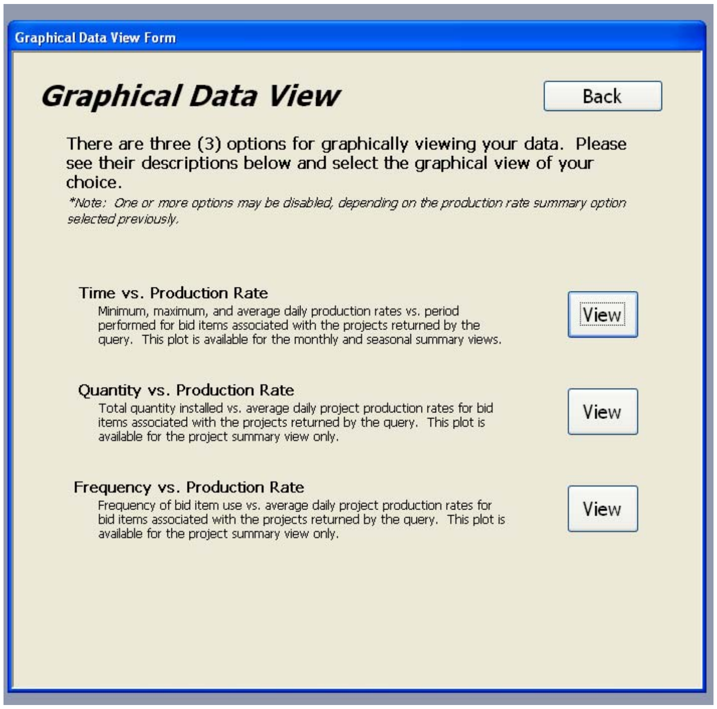


Figure 4.9 – Graphical View Form

For additional information regarding these forms and the BIDDS user interface, please see Appendix C: *BIDDS* User's Manual.

4.7.4 *BIDDS* Output Structure. The previous section introduced the concept of various output options presented to the user. Presenting the user with these options serves a number of purposes. First, the trends in production data demonstrate the effects of a number of factors on production, all of which are useful to the user in estimating production rates. Second, these options allow data to be demonstrated in a useful format, regardless of the number of records returned. Finally, these options force the user to employ engineering judgment when selecting a production rate to use in estimating activity durations. The list below describes each of the output options available in *BIDDS*, what they demonstrate, and their availability.

1. **Monthly Production Rate Summary –** Bid item production data presented in a manner that demonstrates production trends throughout the year, on a monthly basis. This option allows the user to see during which months bid items are used and a range of production rates for these months. This data is available in the tabular and graphical formats.

2. **Seasonal Production Rate Summary –** Bid item production data presented in a manner that demonstrates production trends throughout the year, on a seasonal basis. This option allows the user to see during which seasons bid items are used (if the exact month of expected use is not known) and a range of production rates for these seasons. This data is available in the tabular and graphical formats.

3. **Project Production Rate Summary –** Bid item production data presented in a manner that demonstrates production trends across projects in which bid items are used. The tabular option allows the user to see the projects for which a bid item is used, the total quantity used, the total number of days work was performed for these bid items, and an average daily production rate for individual project. Graphical views demonstrate trends between production rate and quantity, as well as production rate frequency.

4. **Bid Item Usage Summary –** Bid item production data presented in a manner that demonstrates key information for each bid item used in the projects queried. This information includes minimum, maximum, and average production rates, number of records (months used), minimum, maximum, average, and total quantity used for each bid item. This data is only available in the tabular format.

While these options allow the user many possibilities for data presentation, it is currently unclear when each option can be used to its fullest potential. It is speculated that all options are currently viable and that the possibilities and limitations for each output option will not manifest themselves until full implementation and population of

BIDDS by VDOT. This need for further research will be discussed again in Chapter 6 of this text.

Initially, two main assumptions have been made regarding output data viewing in *BIDDS*. The first assumption is that production data will contain outliers that should be removed prior to the output process. This is not to say that data will be removed from the system, but rather, not reported. Each time the user queries *BIDDS* and requests output, *BIDDS* filters through the data returned, and clears a percentage of the highest and lowest production data points for each bid item. It is anticipated that this data will better reflect the typical VDOT project with less emphasis on extraordinarily high or low production data points. Currently, ten percent (the highest and lowest five percent) of production data is being removed to limit outliers. Because historical field data was not available for this work, future works will analyze the field data to determine the appropriate percentage of outliers to remove. The percentage of outliers not reported by *BIDDS* can be easily altered to accommodate future needs.

The second assumption is that graphical output options should be restricted when little data is available for presentation. When querying the database, the number of matching projects is limited only to the amount of projects in the database. There is also the possibility, however, of returning one or no similar projects. Because the user cannot proceed beyond the project characteristics query form when no projects are returned, production data cannot be viewed in either the graphical or tabular format. Another possibility is that the user returns only one similar project. When this occurs, there is a limited amount of data available for viewing. On very large projects, there may be sufficient bid item production data to warrant plotting of monthly, seasonal, and project production data. However, the majority of projects performed by VDOT would likely not fit into this category. Plots of bid item production data would yield little to no useful information. For this reason, *BIDDS* is programmed to disallow the graphical view of results when only a single similar project is returned through the production data queries. If the production data queries return two or more projects, the possibility for meaningful and useful data plots is much higher. Therefore, all options are available to the user.

Below are screenshots of the tabular format views from a synthetic data query of Road Reconstruction projects. These views demonstrate the flexibility of pivot tables as well as the benefits of viewing the results in this format. The format of the pivot tables below have been coded into *BIDDS* so that data is presented in the same format each time. Again, note that the data presented in Figures 4.10 through 4.15 is synthetic data and <u>does not</u> represent historical production data.

A	B	C	D	E	F	G
Bid Item	Description	Units	Month Performed	Minimum Production	Average Production	Maximum Production
12600	STD. COMB. CURB & GUTTER CG-6	LF	January	617.0	654.3	696.7
			February	491.7	618.8	680.6
			March	520.3	575.2	639.8
			April	572.3	621.6	654.0
			May	588.8	601.7	609.1
			June	511.0	661.6	727.7
			July	652.0	652.0	652.0
			August	588.7	633.0	684.8
			September	526.0	635.5	721.5
			October	548.5	642.8	704.4
			November	614.1	644.8	675.5
			December	517.5	603.1	685.8
13320	GUARDRAIL GR-2	LF	January	652.0	1100.3	1254.0
			February	1192.5	1349.3	1684.0
			March	655.0	972.0	1111.5
			April	925.0	1427.5	1962.0
			May	1051.5	1323.6	1505.5
			June	591.0	1137.9	1489.0
			July	1107.5	1366.0	1602.5
			August	1248.0	1285.8	1307.5
			September	990.0	1273.9	1417.5
			October	647.0	988.1	1206.0
			November	716.0	1165.2	1774.0
			December	590.0	1011.6	1659.0

Figure 4.10 – Monthly Production Rate Summary (Tabular View)

Bid Item Number	Description	Units	Project Number	Total Quantity Installed	Avg. Daily Production Rate
12600	STD. COMB. CURB & GUTTER CG-6	LF	SD 0131	6913.0	628.5
			SD 0132	1818.0	606.0
			SD 0140	4469.0	638.4
			SD 0141	6055.0	672.8
			SD 0142	1609.0	536.3
			SD 0151	6371.0	637.1
			SD 0152	1766.0	588.7
			SD 0160	4609.0	658.4
			SD 0161	6804.0	680.4
			SD 0162	1933.0	644.3
			SD 0170	4913.0	614.1
			SD 0171	6477.0	588.8
			SD 0172	2194.0	548.5
			SD 0180	4264.0	609.1
			SD 0181	7287.0	607.2
			SD 0182	2081.0	520.2
			SD 0190	4612.0	658.9
			SD 0191	6968.0	633.5
			SD 0192	2070.0	517.5
			SD 0200	5164.0	645.5
			SD 0201	7664.0	696.7
			SD 0202	1962.0	654.0
			SD 0210	5445.0	680.6
			SD 0211	8656.0	665.8
			SD 0212	1717.0	572.3
			SD 0220	4661.0	665.9
			SD 0230	4411.0	630.1
			SD 0231	8902.0	684.8
			SD 0241	9829.0	702.1
			SD 0250	4170.0	695.0
			SD 0251	10566.0	704.4
			SD 0252	1578.0	526.0
			SD 0260	3839.0	639.8
			SD 0261	10287.0	685.8
			SD 0262	1351.0	675.5
			SD 0270	3279.0	655.8
			SD 0271	9255.0	617.0
			SD 0272	1304.0	652.0
			SD 0280	2828.0	565.6
13320	GUARDRAIL GR-2	LF	SD 0131	2264.0	1132.0
			SD 0132	1050.0	1050.0
			SD 0133	2685.0	1342.5

Figure 4.11 – Project Production Rate Summary (Tabular View)

Bid Item Number	Description	Units	Data	Total
12600	STD. COMB. CURB & GUTTER CG-6	LF	Minimum Daily Production Rate	517.5
			Maximum Daily Production Rate	704.4
			Average Daily Production Rate	630.9
			Number of Months Performed	39
			Minimum Quantity Installed	1304.0
			Maximum Quantity Installed	10566.0
			Average Quantity Installed	4873.9
			Total Quantity Installed	190081
13320	GUARDRAIL GR-2	LF	Minimum Daily Production Rate	645.0
			Maximum Daily Production Rate	1684.0
			Average Daily Production Rate	1202.1
			Number of Months Performed	80
			Minimum Quantity Installed	645.0
			Maximum Quantity Installed	3336.0
			Average Quantity Installed	1826.7
			Total Quantity Installed	146137

Figure 4.12 – Bid Item Usage Summary (Tabular View)

Additional information regarding the format of these pivot tables and how they may be altered can be found in the *BIDDS* User's Manual in Appendix C.

Three different types of plots make up the graphical view options of *BIDDS*. *BIDDS* is programmed to open a *MS Excel* application, transfer query results and format them as necessary for plotting.

Monthly and seasonal data summaries are viewed graphically in a time and production rate box plot. Box plots show minimum, maximum, and average values through time, in this case, monthly or seasonally. Figure 4.13, below, shows the capability of a box plot to represent time and production rate trends. Seasonal data is viewed in much the same way.

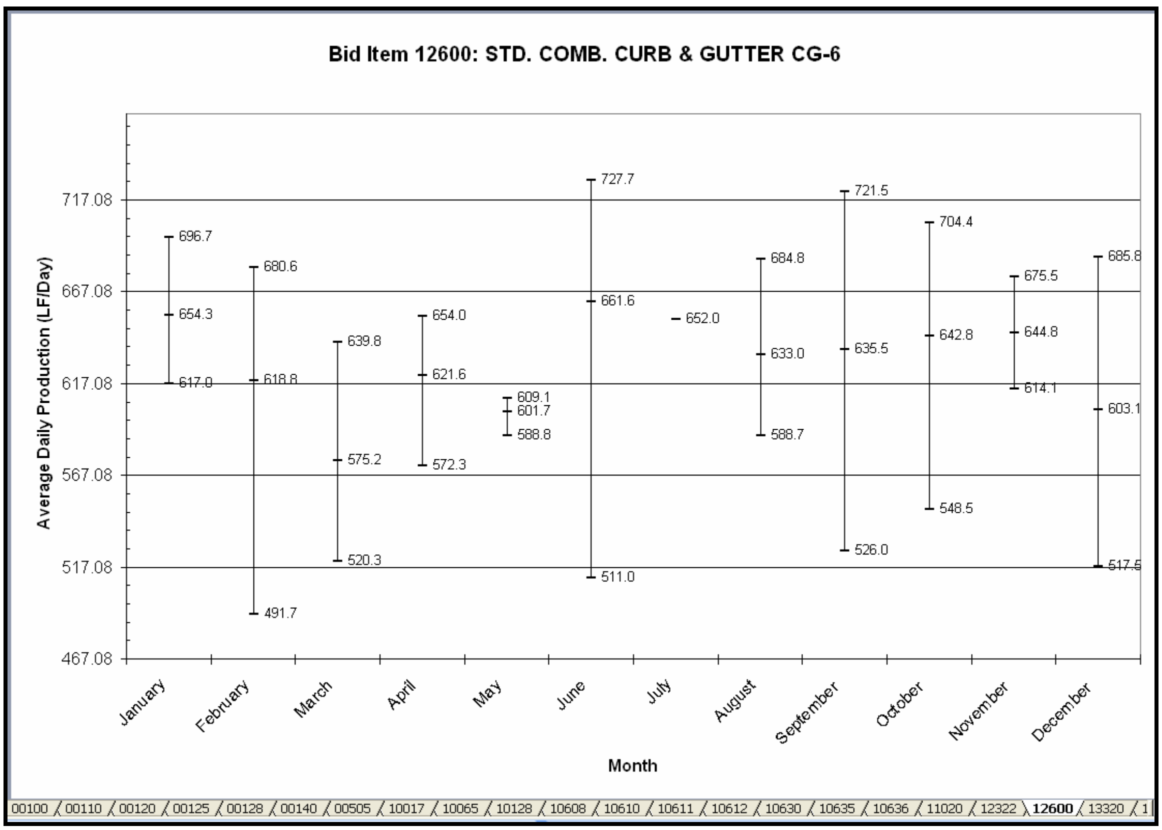


Figure 4.13 – Monthly Production Rate Summary (Graphical View)

The tabs along the bottom of the plot represent the bid items for which plots have been generated. The user has the ability to click each plot, viewing bid items individually as necessary. The individual plots also show the bid item number, name, and units.

Graphical project production rate summary data may be viewed as a quantity versus production rate scatter plot. Quantity and production rate plots show how each bid item compares over a number of different projects. For each bid item, the total quantity installed is plotted against the average daily production rate, yielding one point for each project.

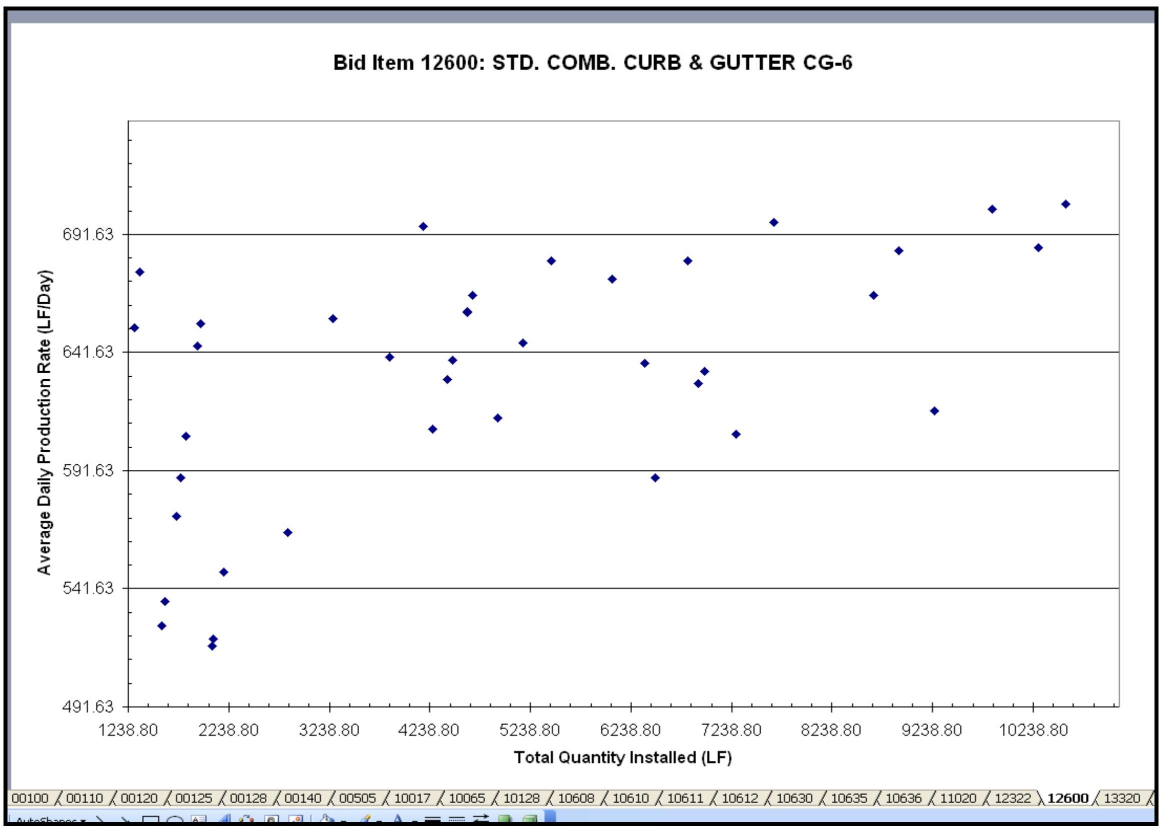


Figure 4.14 – Quantity vs. Production Rate Scatter Plot

The final output option offered by *BIDDS* is production histograms. These histograms demonstrate the number of times a bid item has been used on the similar projects returned and the production rate ranges for those uses. Similar to the tabular format, this data view details how often bid items are being used by VDOT. If frequency is relatively low, the user may decide to use the bid item production rate information only as a datum from which to base engineering judgment. Bid items that have been used and recorded frequently may offer a higher probability of accuracy. Below, Figure 4.15, is a screenshot of the same data set used above, viewed as a frequency and production rate histogram.

An example of the *BIDDS* query and output processes is available in Appendix D. This example demonstrates *BIDDS* usage and verifies that the system works as intended.

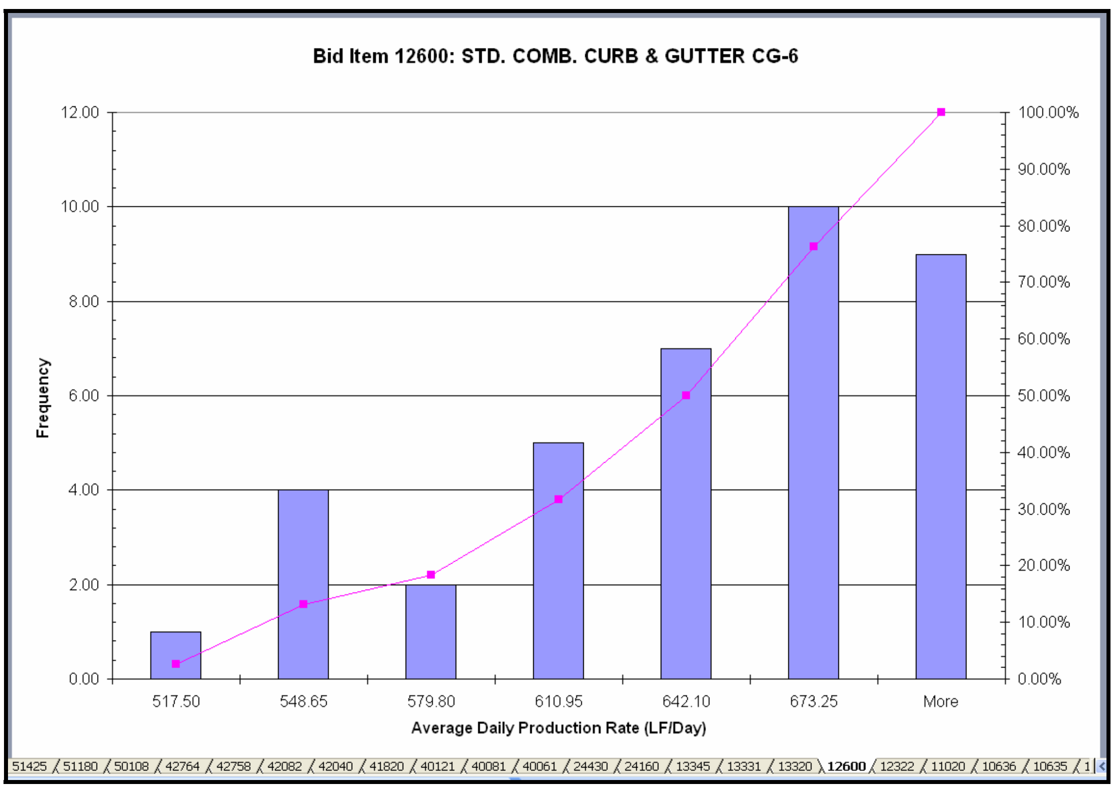


Figure 4.15 – Production Rate Histogram

Chapter 5 – Conclusions

This chapter briefly discusses the research and conclusions relating to the multi-level database framework and the development of the pre-advertisement level database.

5.1 Research Summary

From project scoping through pre-advertisement, project design and cost estimates are continuously refined to narrow project scope, reduce contingencies, and increase constructability and quality. Cost estimate progression procedures have been well documented in the past. Unfortunately, time estimate progression has not received the same level of attention.

Accurate and reliable contract time estimates are important to the traveling public, construction worker exposure, and the optimization of construction engineering costs and resources. An important element in the establishment of contract time is activity duration. The FHWA recommends establishing activity durations using historical production rates maintained in a state-wide database. When applying production rates, key project factors must be considered.

This work focuses on the necessity for, and ability to establish, more accurate contract times by refining the contract time estimate in conjunction with the VDOT Project Development Concurrent Engineering Process (PDCEP). This process begins when the project enters the six year plan and is completed upon project advertisement. The various stages along this process signify the evolution of design details. To aid in this refinement, the framework of a multi-level database of highway construction performance times is developed. These levels include the conceptual, parametric, and pre-advertisement levels.

The conceptual time estimating tool will provide a calendar-day time estimate based on general project information such as project type, location, estimated cost, and geometric design standard. Much of this information is known when the project enters the six year plan, beginning the VDOT PDCEP, or becomes available prior to project scoping.

The parametric time estimating tool will use VDOT construction data to develop project duration equations for each project type. Project data will then be analyzed to determine the factors most affecting project duration. It is anticipated that many of the factors currently used in the VDOT parametric cost estimating tool, *PCES*, will be used in the parametric time estimating tool. Information regarding these factors become available at project scoping and is finalized by the field inspection meeting.

The pre-advertisement level database (*BIDDS – Bid Item Duration Data System*) of performance times was constructed through this work. *BIDDS* maintains historical performance data for a series of driving bid items used by VDOT. Driving bid items are those whose measurement and analysis reflect project progress. To retrieve production data, the user inputs project information and characteristics which are used to query the data tables for similar projects. Production data associated with those projects is returned in either tabular or graphical format. Tabular outputs are presented as MS *Excel* pivot tables and may be summarized monthly, seasonally, by the project, or by the bid item. Graphical outputs can be summarized in MS *Excel* in three forms:

1. **Monthly or seasonal box plots** showing trends between production rate and the time of year performed.

2. **Project scatter plots** showing trends between quantity and production rate.

3. **Project histograms** showing production rate frequency.

The *BIDDS* prototype exhibits the potential usage for the lowest level of the multi-level system, aiding in the storage and use of production data. Future Partnership efforts will investigate the potential for statewide implementation.

5.2 Conclusions

The main conclusion of this work is that contract performance time can be continually refined in conjunction with project design and cost estimate progression. This work infers that this refinement will increase contract performance time estimate accuracy and reliability by beginning the estimate at the conceptual level, which is very coarse and based on few project details. The contract time estimate can then be refined through the parametric level, at which point many project design details and components are known. Final revisions may then be made by preparing a final estimate at the pre-advertisement level, when all design and many construction details are known.

This research also concluded that the process of refining contract performance time estimates can be aided by use of a multi-level database of historical performance data. By establishing databases of historical data at the conceptual, parametric, and pre-advertisement levels, the time estimator is afforded tools that utilize the project data known at various stages of the VDOT PDCEP.

Finally, this research verified the concept of a multi-level database of highway construction performance time. Potential use and functionality of such time estimating tools were explored. Also, the pre-advertisement level of the database system has been developed and constructed to demonstrate one such tool. In the future, this database will be implemented by VDOT for statewide use in estimating contract time at the pre-advertisement level. Implementing and propagating the database with historical performance data, will make data analysis possible. This analysis may include regression analysis to determine the influences of project parameters on bid item production rates, analysis of data outliers, or numerous other studies. Because the data is not currently collected, these studies are not currently possible.

5.3 Limitations of *BIDDS*

BIDDS maintains historical production data for VDOT highway construction projects. *BIDDS* also retains historical, project specific, information and characteristics about these projects. To retrieve production data, the scheduler inputs project information and characteristics about a project. *BIDDS* uses these parameters to assemble comparable projects. The user is then returned production data associated with the similar projects.

Throughout this process, the use of personal engineering judgment cannot be overstressed. *BIDDS* incorporates this need by returning a range of production rates, rather than a definitive figure. As outlined previously, this data is summarized in a number of formats that show production rate variation with respect to time and quantity. These summaries encourage the use of *BIDDS* as a tool for estimating production rates, rather than finding or "looking up" production rates.

These production rates may then be used to estimate activity duration. It is important to understand that *BIDDS* does not generate a schedule, or a complete contract time estimate. The estimation of activity duration, sequencing of activities, and final schedule generation is the responsibility of the scheduler. *BIDDS* is designed to assist the scheduler in this process at the pre-advertisement level.

While *BIDDS* is intended to aid VDOT in the establishment of the pre-advertisement schedule, there is also potential for *BIDDS* to be used during the construction phases to review and award additional time requests due to change orders. Though *BIDDS* may be a useful tool in these processes, it is imperative to note that production rates extracted from the system are based on historical performance time data (i.e. what has happened in the past). Construction projects are affected by a number of unforeseeable and uncontrollable incidents. While these incidents are a fact of the construction industry, their occurrence is too casual to warrant the effort necessary to quantify or implement their effects within a system such as *BIDDS*. Such effects must be considered by seasoned schedulers and construction experts. The scheduler must use engineering judgment to forecast what can and will happen during project construction. Production rates, provided by *BIDDS*, assist the scheduler in this forecast.

Chapter 6 – Recommendations

The purpose of this chapter is to identify areas of potential future research or study. Because *BIDDS* is a prototype database management system, a portion of this chapter pertains directly to its future implementation and upgrade. The final recommendations of this chapter pertain to topics arising through this work, the Partnership's future efforts, and future research into the multi-level database framework concept.

6.1 *BIDDS* Maintenance Recommendations

A major component of this work was the construction of the pre-advertisement level of the multi-level database of highway construction performance times (*BIDDS*). The *BIDDS* prototype relies on a number of premises established to demonstrate the potential for use within VDOT. While these premises are not arbitrary assumptions, it is felt that additional research into their use is warranted.

6.1.1 Driving Bid Items. Driving bid items were established to simplify data collection and focus data return to those bid items that are necessary for project completion. By establishing these restricted lists, superfluous data collection and storage has been minimized. Driving bid item lists were established by surveying VDOT personnel, personal construction knowledge, and tabulated bid item usage lists provided by VDOT.

In the future, it is anticipated that additional bid items will be added to the standard and non-standard bid item lists. With the addition of these bid items, current driving bid item lists, established by this work, may not reflect the actual work and needs of VDOT. Through the implementation and future use of *BIDDS*, the adequacy and accuracy of the bid items selected as driving should be analyzed to ensure the lists are responsive to VDOT. *BIDDS* readily accepts production data associated with any bid item. *BIDDS* also returns all bid item production data related to the similar projects returned through querying. Therefore, changes to driving bid item lists can be easily implemented into *BIDDS*.

6.1.2 Data Return Format. *BIDDS* offers a number of production data output options that allow the user to demonstrate bid item level data in a manner that is suitable for their needs. These output options also reinforce the need for personal engineering judgment during schedule development by offering a range of production rate values instead of a single, definitive value.

It is anticipated that these output options will serve their intended purpose and enhance the activity duration calculation process. However, future research is warranted in these output options. Production data can be presented in a number of ways using MS *Excel* and MS *Access*. To make *BIDDS* more efficient and functional for VDOT, it is proposed that future research focus on the *BIDDS* output options, their potential usage, and additions or enhancements to the options available.

6.2 Research Recommendations

In performing this work, four important areas of future research were recognized. These topics will compliment this work, the work of the Partnership, VDOT, and the construction industry in general.

6.2.1 Production Data Outliers. Currently, *BIDDS* is programmed to treat ten percent (10%) of production data reported as outliers. When generating data summaries, the highest five percent (5%) and lowest five percent (5%) of daily production rate records are neglected. This value was assumed in preparing this work because historical field data was not available for analysis. Therefore, future research is necessary to analyze historical field data to determine the appropriate percentage of outliers that should be neglected. The percentage of outliers neglected can be easily altered within *BIDDS* to accommodate the needs of VDOT.

6.2.2 *BIDDS* Data Analysis. Because contemporaneous research efforts have focused on the optimal method for collecting bid item level performance data, synthetic data was created to facilitate *BIDDS* construction and verification. Once *BIDDS* is implemented, historical bid item performance data will be available. This data should be analyzed at that time. This analysis may include the determination of bid item production trends, influence of project information and characteristic parameters on bid item production rates, as well as a host of other research studies. The data expected to be maintained by *BIDDS* will make this analysis possible.

6.2.3 Parameter Query Ranges. Project parameters are used to uniquely identify projects by their type, location, size, and complexity. Because no two projects are identical, query ranges were established to broaden the project parameter search criteria. While necessary, these search ranges were arbitrarily assigned to a number of the project parameters, as seen in Table 4.5.

The query ranges established are not based on any statistical analysis of existing project data. To better represent actual project parameters, it is important that additional research focus on the gaps existing in project parameter data. Doing so will enhance the *BIDDS* query process, yielding more representative results.

6.2.4 Bid Item Performance Time Frames. To establish synthetic data, a number of assumptions were made regarding bid item usage. To make possible time versus production rate output plots, a time frame for the usage of each bid item, in comparison to project start, was established. Using these time frames for each bid item, the month performed could be assigned to the synthetic data.

As demonstrated by the output structure of *BIDDS*, it is possible to monitor bid item usage on a monthly or seasonal basis. Using this feature, actual construction data may be analyzed to establish historical bid item performance time frames. It is proposed that future research investigate trends in historical bid item usage time frames in comparison with project commencement. This analysis should be performed for the eight project types established for this work.

Using the bid item time frame trends and the known project start date, the scheduler can determine the time of year each bid item will be installed. Using the time versus production rate output plots afforded by *BIDDS*, the scheduler can focus on the time frame in which the bid item is expected to occur. This will provide a more accurate basis for estimating production rates.

6.3 Performance Time Data System Recommendations

The Performance Time Data System is the system by which *BIDDS* will be implemented and used by VDOT as a tool for establishing activity durations, a step in the contract time determination process. This system is shown in Figure 6.1, below.

It is anticipated that *BIDDS* will be used by VDOT statewide. To make this possible, future work is needed on a number of the PTD System components. Personnel requirements for this future work are demonstrated in Figure 6.2 as "*SMDC* Analyst" and "*BIDDS* Analyst". It is proposed that these analysts are the same person who will be charged with the initial implementation of *BIDDS* and *SMDC* into the VDOT system. It is suggested that the software applications and data storage initially reside here at Virginia Tech and that VDOT is granted statewide web access of the *BIDDS* tools.

In order to make *BIDDS* accessible statewide, *BIDDS* will need to be transferred to a more robust database management system. At that time, it is recommended that Microsoft *SQL Server 2005* be investigated. *Access 2003* databases can be easily converted into *SQL Server 2005*, which offers adequate usability for statewide access. Also, *SQL Server 2005* excels in categories such as scalability and performance.

Another recommendation for the PTD system is a study into the necessary frequency of system calibration. The frequency of system calibration refers to how often system data is analyzed or replaced to ensure that the stored data, or coefficients and inferences drawn from said data, mimics current field data. While several possibilities exist, the advantages and disadvantages to each possibility are not yet known. Figure 6.1 shows the conceived calibration possibilities and a description the processes. As the PTD System is implemented, the data needed to facilitate such a study will become available.

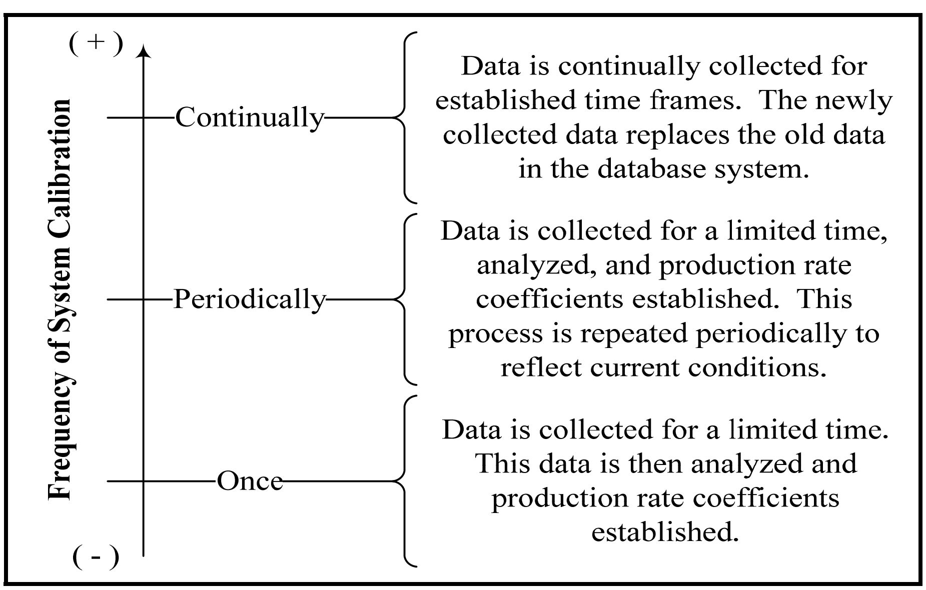


Figure 6.1 – PTD System Calibration Possibilities

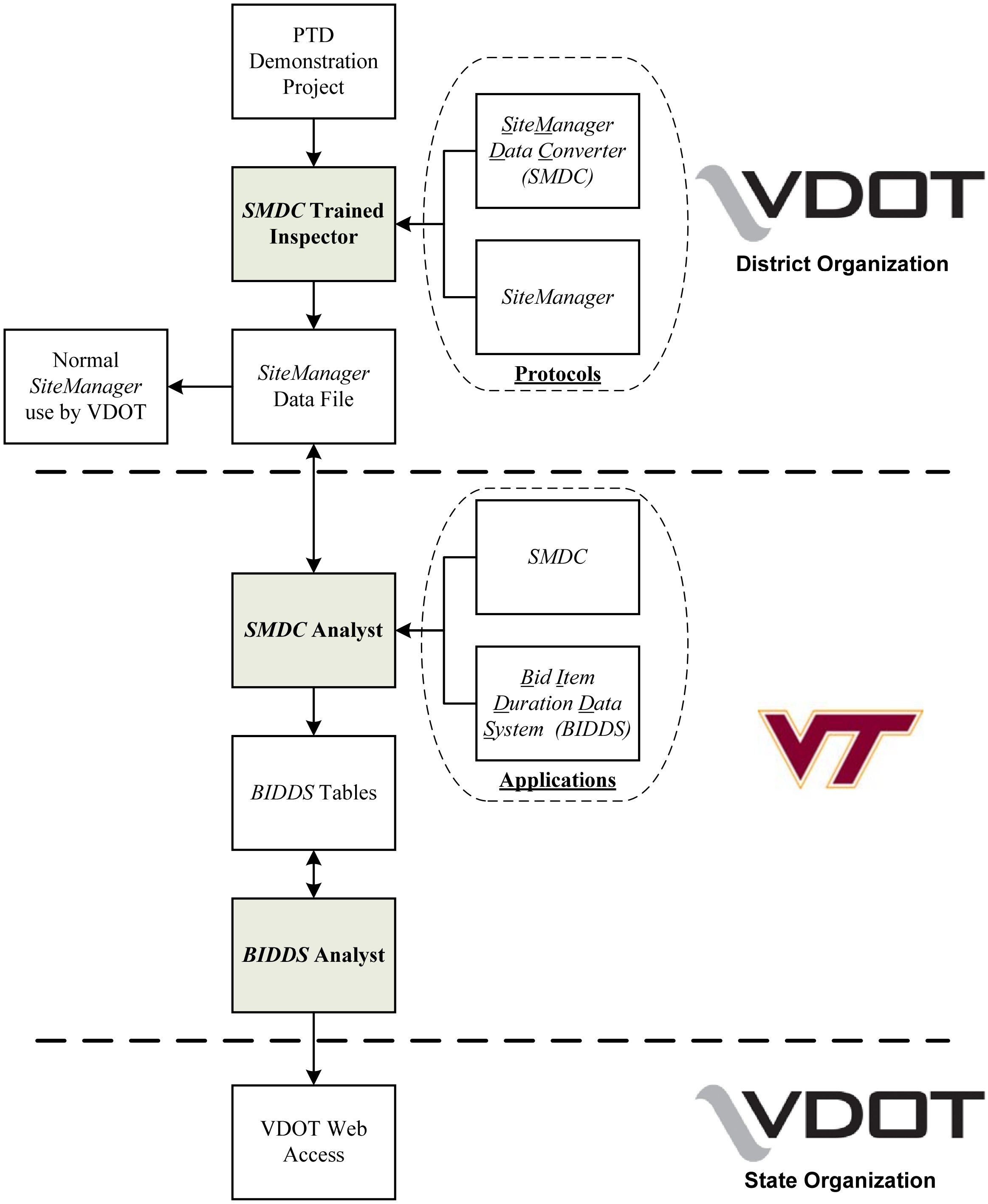


Figure 6.2 – Performance Time Data System

6.4 Development of the Parametric and Conceptual Database Levels

This work focuses on the framework of a multi-level database of highway construction performance times. Distinct transitions occur during the VDOT Project Development Concurrent Engineering Process (PDCEP) that demonstrate significant changes in the availability of project information. It is proposed that a database level exist at three of these points in the PDCEP. These database levels will aid in refining the project construction time estimate as design progresses and the cost estimate is refined.

The pre-advertisement level database (*BIDDS*) was developed through this work. Therefore, future work is necessary to develop and construct the remaining two database levels: the conceptual and parametric levels. Once developed, the multi-level database concept and system should be evaluated to ensure that the needs of VDOT are accommodated with the system and that the system serves its intended purpose. Also, the systems should be validated to ensure that their output depicts reality.

The conceptual time estimating tool will provide a calendar-day time estimate based on general project information known as the project proceeds from the six year plan inception to project scoping. The parametric time estimating tool will use statistical regression analysis of historical VDOT construction data to develop duration equations for each project type. These equations will consider the project factors that most affect the project duration. These factors are developed as the project proceeds from scoping through field inspection.

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Appendix A – Common Project Activities and Scopes

New Road Construction

a. Mobilization	Initial project startup including procurement of materials, equipment, office trailers, etc.
b. Clearing & Grubbing	Removal of all organic materials and refuse in preparation for work
c. Remove Structures	Demolition and removal of all structures
d. Roadway Excavation	Mass excavation performed along the proposed centerline
e. Grading	All grading activities, including fine grading in preparation of base stone or surface material
f. Drain Pipes	Placement of all drain piping
g. Drop Inlets	Placement of all draining structures or drop inlets
h. Curb, Curb & Gutter	Placement of curb, gutter, or combination curb and gutter including entrances
i. Box Culverts	Installation of box culverts
j. Retaining Walls	Erection of retaining walls, includes excavation and backfill
k. Sub-grade Stabilization	Sub-grade stabilization using geo-synthetic materials or hydraulic cement
l. Stabilized Aggregate Base	Aggregate base stabilization using geo-synthetic materials or hydraulic cement
m. Stone Base	Placement of roadway base in preparation for surface material
n. Shoulders	Placement of roadway shoulder stone
o. Underdrain	Installation of underdrains, including combination and modified

p. Utilities	Installation of water, sewer, and gas mains/pipes/lines and necessary manholes
q. Asphalt Base Course	Placement of bituminous asphalt concrete base course
r. Asphalt Intermediate Course	Placement of bituminous asphalt concrete intermediate course
s. Asphalt Surface Course	Placement of bituminous asphalt concrete surface course
t. Approach Slabs	Installation of bridge approach slabs included in the roadway portion scope of work
u. Signs	Installation of all roadway and intersection signs
v. Signals	Installation of all roadway and intersection signals
w. Guardrails & Barriers	Installation of all guardrails and/or barriers, including median and shoulder barriers

New Bridge Construction

a. Mobilization	Initial project startup including procurement of materials, equipment, office trailers, etc.
b. Clearing & Grubbing	Removal of all organic materials and refuse in preparation for work
c. Remove Structures	Demolition and removal of all structures
d. Cofferdams & Causeways	Construction and maintenance of all cofferdam and causeway structures
e. Pile Driving	Installation of all piles to support the bridge structure (includes all pile types)
f. Structural Excavation	All excavation essential for the installation of structural components, includes backfill
g. Substructure Concrete	Forming, curing, reinforcing, and placement of all substructure concrete components including footers, piers, pier caps, wing-walls, and abutments
h. Concrete Beams	Placement of all concrete beams
i. Structural Steel	Placement of structural steel beams
j. Deck Joints	Installation of all bridge deck expansion joints, both lateral and transverse
k. Construct Deck	Construction of concrete, timber, or steel grid bridge decking; includes forming, curing, reinforcing, and admixtures where applicable
l. Parapets & Railings	Construction of bridge parapets and railings
m. Deck Grooving	All concrete bridge deck grooving
n. Slope Protection	All armoring or protection of embankments or slopes around the bridge construction area, includes block and slab protection methods
o. Approach Slabs	Installation of concrete bridge approach slabs

p. Utilities	Placement of all water, sewer, and gas mains/pipes/lines and necessary manholes
q. Guardrails & Barriers	Installation of all guardrails and/or barriers, including median and shoulder barriers

<u>Road Reconstruction</u>

a. Mobilization	Initial project startup including procurement of materials, equipment, office trailers, etc.
b. Traffic Control	Installation and removal of all project traffic control systems or devices, including detours, barriers, guardrail, and attenuators
c. Clearing & Grubbing	Removal of all organic materials and refuse in preparation for work
d. Demolition	Demolition and removal of all structures or existing pavement
e. Milling	All flexible and rigid pavement milling along the existing roadway
f. Roadway Excavation	Mass excavation performed along the proposed or existing centerline
g. Grading	All grading activities, including fine grading in preparation of base stone or surface material
h. Drain Pipes	Placement of all drain piping
i. Drop Inlets	Placement of all draining structures or drop inlets
j. Curb, Curb & Gutter	Placement of curb, gutter, or combination curb and gutter including entrances
k. Box Culverts	Installation of all box culverts
l. Retaining Walls	Erection of all necessary retaining walls, includes excavation and backfill
m. Sub-grade Stabilization	Sub-grade stabilization using geo-synthetic materials or hydraulic cement
n. Stabilized Aggregate Base	Aggregate base stabilization using geo-synthetic materials or hydraulic cement
o. Stone Base	Placement of roadway base in preparation for surface material

p. Shoulders	Placement of all roadway shoulder stone
q. Underdrain	Installation of underdrains, including combination and modified
r. Utilities	Placement of water, sewer, and gas mains/pipes/lines and necessary manholes
s. Asphalt Base Course	Placement of bituminous asphalt concrete base course
t. Asphalt Intermediate Course	Placement of bituminous asphalt concrete intermediate course
u. Asphalt Surface Course	Placement of bituminous asphalt concrete surface course
v. Approach Slabs	Installation of bridge approach slabs included in the roadway portion scope of work
w. Pavement, Base, & Sub. Repairs	All repairs made to the existing pavement, base stone, or sub-grade material; including excavation, backfill, patchwork, and surface repairs
x. Signs	Installation of all roadway and intersection signs
y. Signals	Installation of all roadway and intersection signals
z. Guardrails & Barriers	Installation of all guardrails and/or barriers, including median and shoulder barriers

Bridge Reconstruction

a. Mobilization	Initial project startup including procurement of materials, equipment, office trailers, etc.
b. Erect Temporary Structures	Erection of temporary bridge structures to detour traffic, provide access, and facilitate construction operations
c. Clearing & Grubbing	Removal of all organic materials and refuse in preparation for work
d. Remove Structures	All demolition and removal of structures; including the existing bridge or portions thereof
e. Cofferdams & Causeways	Construction and maintenance of all cofferdam and causeway structures
f. Pile Driving	Installation of all piles to support the bridge structure; includes all pile types
g. Structural Excavation	All excavation essential for the installation of structural components, includes backfill
h. Substructure Concrete	Forming, curing, reinforcing, and placement of all substructure concrete components; including footers, piers, pier caps, wing-walls, and abutments
i. Concrete Beams	Placement of all concrete beams
j. Structural Steel	Placement of all structural steel beams
k. Deck Joints	Installation of all bridge deck expansion joints, both lateral and transverse
l. Construct Deck	Construction of concrete, timber, or steel grid bridge decking, includes forming, curing, reinforcing, and admixtures where applicable
m. Parapets & Railings	Construction of bridge parapets and railings
n. Deck Grooving	All concrete bridge deck grooving

o.	**Slope Protection**	All armoring or protection of embankments or slopes around the bridge construction area, includes block and slab protection methods
p.	**Approach Slabs**	Installation of concrete bridge approach slabs
q.	**Utilities**	Placement of all water, sewer, and gas mains/pipes/lines and necessary manholes
r.	**Guardrails & Barriers**	Installation of all guardrails and/or barriers, including median and shoulder barriers
s.	**Remove Temporary Structure**	Demolition and removal of temporary bridge structures installed at project commencement

Road Rehabilitation

a. Mobilization	Initial project startup including procurement of materials, equipment, office trailers, etc.
b. Traffic Control	Installation and removal of all project traffic control systems or devices, including detours, barriers, guardrail, and attenuators
c. Clearing & Grubbing	Removal of all organic materials and refuse in preparation for work
d. Excavation	All necessary earthwork performed
e. Pavement, Base, and Sub Repairs	All repairs made to the existing pavement, base stone, or sub-grade materials, including excavation, backfill, patchwork, and surface repairs
f. Milling	All flexible and rigid pavement milling along the existing roadway
g. Asphalt Base Course	Placement of bituminous asphalt concrete base course
h. Asphalt Intermediate Course	Placement of bituminous asphalt concrete intermediate course
i. Asphalt Surface Course	Placement of bituminous asphalt concrete surface course
j. Curb, Curb & Gutter	Placement of curb, gutter, or combination curb and gutter including entrances
k. Upgrade/Relocate Drain Pipes	Addition, replacement, or relocation of drain piping
l. Upgrade/Relocate Drop Inlets	Addition, replacement, or relocation of drop inlets
m. Upgrade/Relocate Utilities	Addition, replacement, or relocation of utilities such as water, sewer, and gas
n. Upgrade Signs	Addition or replacement of road signs
o. Upgrade Signals	Addition or replacement of roadway and intersection signals

p. Upgrade Barriers and Guardrail	Addition or replacement of barriers and guardrails, including median and shoulder barriers/guardrails

Bridge Rehabilitation

a. Mobilization	Initial project startup including procurement of materials, equipment, office trailers, etc.
b. Traffic Control	Installation and removal of all project traffic control systems or devices, including detours, barriers, guardrail, and attenuators
c. Clearing & Grubbing	Removal of all organic materials and refuse in preparation for work
d. Excavation	All necessary earthwork performed
e. Demolition	Demolition and removal of all structures
f. Milling	All flexible and rigid pavement milling on the existing bridge deck
g. Surface Patching	Bridge deck surface patching and crack repairs
h. Deck Joints	Installation of bridge deck expansion joints, both lateral and transverse
i. Substructure Rehabilitation	Substructure rehabilitation including crack, beam seat, and back wall repairs
j. Asphalt Base Course	Placement of bituminous asphalt concrete base course
k. Asphalt Intermediate Course	Placement of bituminous asphalt concrete intermediate course
l. Asphalt Surface Course	Placement of bituminous asphalt concrete surface course
m. Concrete Paving	Forming, curing, reinforcing, and placement of concrete bridge deck, includes necessary admixtures
n. Upgrade/Relocate Utilities	Addition, replacement, or relocation of utilities such as water, sewer, and gas
o. Upgrade Barriers & Guardrail	Addition or replacement of barriers and guardrails, including median and shoulder barriers/guardrails

Widening

a. Mobilization	Initial project startup including procurement of materials, equipment, office trailers, etc.
b. Traffic Control	Installation and removal of all project traffic control systems or devices, including detours, barriers, guardrail, and attenuators
c. Clearing & Grubbing	Removal of all organic materials and refuse in preparation for work
d. Demolition	Demolition and removal of all structures
e. Milling	All flexible and rigid pavement milling along the existing roadway
f. Excavation	All necessary earthwork performed
g. Relocate Drain Pipes	Relocation or replacement of drain pipes due to roadway expansion
h. Relocate Drop Inlets	Relocation or replacement of drop inlets due to roadway expansion
i. Relocate Utilities	Relocation or replacement of utilities, including water, sewer, and gas, due to roadway expansion
j. Retaining Walls	Erection of all necessary retaining walls, includes excavation and backfill
k. Grading	All grading activities, including fine grading in preparation of base stone or surface material
l. Stone Base	Placement of roadway base in preparation for surface material
m. Shoulders	Placement of all shoulder stone
n. Asphalt Base Course	Placement of bituminous asphalt concrete base course
o. Asphalt Intermediate Course	Placement of bituminous asphalt concrete intermediate course

p. Asphalt Surface Course	Placement of bituminous asphalt concrete surface course
q. Curb, Curb & Gutter	Placement of curb, gutter, or combination curb and gutter including entrances
r. Signs	Installation of all roadway and intersection signs
s. Signals	Installation of all roadway and intersection signals
t. Guardrails & Barriers	Installation of all guardrails and/or barriers, including median and shoulder barriers

Overlay / Resurfacing

a. Mobilization	Initial project startup including procurement of materials, equipment, office trailers, etc.
b. Traffic Control	Installation and removal of all project traffic control systems or devices, including detours, barriers, guardrail, and attenuators
c. Milling	All flexible and rigid pavement milling along the existing roadway or bridge deck
d. Pavement & Base Repairs	Repairs made to the existing pavement material or base stone, includes excavation, backfill, patch work, and surface repairs
e. Asphalt Base Course	Placement of bituminous asphalt concrete base course
f. Asphalt Intermediate Course	Placement of bituminous asphalt concrete intermediate course
g. Asphalt Surface Course	Placement of bituminous asphalt concrete surface course
h. Concrete Paving	Forming, curing, reinforcing, and placement of concrete bridge deck or roadway, includes necessary admixtures
i. Pavement Marking	All necessary pavement markings; includes symbols, stop lines, and linear dividing lines

Appendix B – Driving Bid Item Lists

NEW ROAD CONSTRUCTION			
Activity	**Bid Item Code**	**Description**	**Units**
Mobilization	00100	MOBILIZATION	LS
Clearing & Grubbing	00110	CLEARING AND GRUBBING	LS
Remove Structures	70000	NS DEMO. OF BLDG.	LS
Roadway Excavation	00120	REGULAR EXCAVATION	CY
	00128	EXTRA EXCAVATION	CY
	00140	BORROW EXCAVATION	CY
Grading	00125	GRADING	LS
Drain Pipes	00505	BEDDING MATL.AGGR.NO. 25 OR 26	TON
	01060	6" PIPE	LF
	01120	12" PIPE	LF
	01122	12" CONC. PIPE	LF
	01150	15" PIPE	LF
	01152	15" CONC. PIPE	LF
	01180	18" PIPE	LF
	01182	18" CONC. PIPE	LF
	01212	21" CONC. PIPE	LF
	01240	24" PIPE	LF
	01242	24" CONC. PIPE	LF
	01272	27" CONC. PIPE	LF
	01300	30" PIPE	LF
	01302	30" CONC. PIPE	LF
	01360	36" PIPE	LF
	01362	36" CONC. PIPE	LF
	01420	42" PIPE	LF
	01422	42" CONC. PIPE	LF
	01480	48" PIPE	LF
	01482	48" CONC. PIPE	LF
	01600	60" PIPE	LF
	01602	60" CONC. PIPE	LF
	01662	66" CONC. PIPE	LF
	01722	72" CONC. PIPE	LF
	02140	23" X 14" ELLIPTICAL PIPE	LF
	02142	23" X 14" ELLIPTICAL CONC. PIPE	LF
	02190	30" X 19" ELLIPTICAL PIPE	LF
	02192	30" X 19" ELLIPTICAL CONC. PIPE	LF
	04110	17" X 13" ARCH PIPE	LF
	04130	21" X 15" ARCH PIPE	LF
	04180	28" X 20" ARCH PIPE	LF

Drain Pipes (cont.)	06481	48" END SECTION ES-1	EA
	06485	54" END SECTION ES-1	EA
	06490	60" END SECTION ES-1 OR 2	EA
	06491	60" END SECTION ES-1	EA
	06500	23" X 14" END SECTION ES-1A	EA
	06502	30" X 19" END SECTION ES-1A	EA
	06513	21" X 15" END SECTION ES-3	EA
Drop Inlets	06740	DROP INLET DI-1	EA
	07506	DROP INLET DI-5	EA
	07508	DROP INLET DI-7	EA
	07510	DROP INLET DI-7A	EA
	09046	MANHOLE MH-1	LF
	09056	MANHOLE MH-1 OR 2	LF
	09057	FRAME & COVER MH-1	EA
Curb, Curb & Gutter	12322	ASPHALT CONCRETE CURB TY. MC-3B	LF
	12600	STD. COMB. CURB & GUTTER CG-6	LF
Box Culverts	00522	CONCRETE CLASS A4 BOX CULVERT	CY
	00523	NS PRECAST BOX CULVERT	LF
Retaining Walls	13530	RETAINING WALL RW-3	CY
	13556	NS RETAINING WALL	L.F.
	13565	RETAINING WALL EXCAVATION	CY
	13570	NS RETAINING WALL	S.F.
Sub-grade Stabilization	00355	GEOTEXTILE (SUBGRADE STABILIZATION)	SY
Stabilized Aggregate Base	10017	CEM.S.AGR.BAS.MATL.TY.I N.21A	TON
Stone Base	10065	AGGR. MATL. NO. 1	TON
	10128	AGGR. BASE MATL. TY. I NO. 21B	TON
Shoulders	16242	AGR.BASE MAT.TY.I OR II NO. 21A OR	TON
Underdrain	00588	UNDERDRAIN UD-4	LF
	00591	COMB. UNDERDRAIN CD-2	LF
	00592	COMB. UNDERDRAIN CD-1&2	LF
Utilities	40061	6" DI WATER MAIN	LF
	40081	8" DI WATER MAIN	LF
	40121	12" DI WATER MAIN	LF
	40161	16" DI WATER MAIN	LF
	41820	FIRE HYDRANT	EA
	42040	4" SAN. SEWER PIPE	LF
	42080	8" SAN. SEWER PIPE	LF
	42082	8" DI SANITARY SEWER PIPE	LF
	42758	MANHOLE FRAME & COVER WF & C-1	EA
	42764	MANHOLE FRAME & COVER F&C-1	EA
	49010	NS UTILITIES	LF
Asphalt Base Course	10612	ASPH.CONC.BASE CR. TY. BM-25.0	TON
Asphalt Intermediate Course	10610	ASPHALT CONCRETE TY. IM-19.0A	TON
	10611	ASPHALT CONCRETE TY. IM-19.0D	TON

Asphalt Surface Course	10607	ASPHALT CONCRETE TY. SM-12.5A	TON
	10608	ASPHALT CONCRETE TY. SM-12.5D	TON
	10635	ASPHALT CONCRETE TY. SM-9.5A	TON
	10636	ASPHALT CONCRETE TY. SM-9.5D	TON
Approach Slabs	11020	CONC. CL. A4 BRIDGE APPR. SLAB	CY
	11030	REINF. STEEL BRIDGE APPR. SLAB	LB
Signs	50108	SIGN PANEL	SF
	50502	CONC.FOUND.SSP-V A 1'9" DIA.X 4'6" D	EA
	50575	CONC.FOUND.O/H SIGN STRUCTURE	C.Y.
	50902	NS TRAFFIC SIGN	EA
Signals	51180	TRAF.SIGNAL HEAD SECT.12" STD.	EA
	51303	SIG. POLE MP-1 20' ONE ARM 16'	EA
	51425	NS SIGNAL POLE	EA
	51426	NS MAST ARM	EA
Guardrails & Barriers	13320	GUARDRAIL GR-2	LF
	13331	RAD. GUARDRAIL GR-2	LF
	13345	ALTERNATE BREAKWAY CABLE TERMINAL (GR-9)	EA
	13421	MEDIAN BARRIER MB-3	LF

NEW BRIDGE CONSTRUCTION			
Activity	**Bid Item Code**	**Description**	**Units**
Mobilization	00100	MOBILIZATION	LS
Clearing & Grubbing	00110	CLEARING AND GRUBBING	LS
Remove Structures	70000	NS DEMO. OF BLDG.	LS
Cofferdams	66120	COFFERDAM	EA
	66116	NS TEMP. CAUSEWAY	LS
Pile Driving	64110	STEEL PILES 10"	LF
	64112	STEEL PILES 12"	LF
	64424	PRESTR.CONCRETE PILES 24"	LF
Structural Excavation	64011	STRUCTURE EXCAVATION	CY
Substructure Concrete	65013	CONCRETE CLASS A3	CY
Concrete Beams	61221	PREST.CONC.BEAM,BULB-T 45" DEPTH +50'-60	EA
	61222	PREST.CONC.BEAM,BULB-T 45" DEPTH +60'-70	EA
Structural Steel	61750	STRUCT.STEEL HIGH STRG.PLT.GIRDERS	LS
	61812	STR.STEEL PLATE GIRDER ASTM A709 GRADE50	LS
	61813	STR.STEEL PLATE GIRDER ASTM A709 GRADEHP	LS
Deck Joints	62506	NS JOINT SEALER	LF
Construct Deck	60404	CONCRETE CLASS A4	CY
	61186	PRESTR. CONC. SLAB 4' X 18" X(+35' - 40'	EA
Parapets & Railings	62010	CONCRETE PARAPET	LF
	65700	CONCRETE PARAPET	LF
	68010	PARAPET, CONCRETE	LF
	69700	CONCRETE PARAPET	LF
Deck Grooving	60490	BRIDGE DECK GROOVING	SY
	68090	BRIDGE DECK GROOVING	SY
Slope Protection	00155	GEOTEXTILE (EMBANKMENT STABILIZATION)	SY
	26117	DRY RIPRAP CL. AI	TON
	26119	DRY RIPRAP CL.I 18"	TON
	26127	DRY RIPRAP CL.I 26"	TON
	66239	DRY RIPRAP CL.II 38"	TON
Utilities	40061	6" DI WATER MAIN	LF
	40081	8" DI WATER MAIN	LF
	40121	12" DI WATER MAIN	LF
	40161	16" DI WATER MAIN	LF
	41820	FIRE HYDRANT	EA
	42040	4" SAN. SEWER PIPE	LF

Utilities (cont.)	42080	8" SAN. SEWER PIPE	LF
	42082	8" DI SANITARY SEWER PIPE	LF
	42758	MANHOLE FRAME & COVER WF & C-1	EA
	42764	MANHOLE FRAME & COVER F&C-1	EA
	49010	NS UTILITIES	LF
Guardrails & Barriers	24290	TRAFFIC BARRIER SER. CONC.	LF
	24297	TRAF.BARR.SER.CONC.DOUBLE FACE	LF

ROAD RECONSTRUCTION			
Activity	**Bid Item Code**	**Description**	**Units**
Mobilization	00100	MOBILIZATION	LS
Traffic Control	24160	CONSTRUCTION SIGNS	SF
	24305	TEMPORARY DETOUR GS-10 TYPE A	LF
Clearing & Grubbing	00110	CLEARING AND GRUBBING	LS
Demolition	24430	DEMOLITION OF PAVEMENT (FLEXIBLE)	SY
Milling	10630	FLEXIBLE PAVEMENT PLANING	SY
	10632	RIGID PAVEMENT PLANING	SY
Roadway Excavation	00120	REGULAR EXCAVATION	CY
	00128	EXTRA EXCAVATION	CY
	00140	BORROW EXCAVATION	CY
Grading	00125	GRADING	LS
Box Culverts	00522	CONCRETE CLASS A4 BOX CULVERT	CY
	00523	NS PRECAST BOX CULVERT	LF
Retaining Walls	13530	RETAINING WALL RW-3	CY
	13556	NS RETAINING WALL	L.F.
	13565	RETAINING WALL EXCAVATION	CY
	13570	NS RETAINING WALL	S.F.
Sub-grade Stabilization	00355	GEOTEXTILE (SUBGRADE STABILIZATION)	SY
Stabilized Aggregate Base	10017	CEM.S.AGR.BAS.MATL.TY.I N.21A	TON
Base Stone	10065	AGGR. MATL. NO. 1	TON
	10128	AGGR. BASE MATL. TY. I NO. 21B	TON
Shoulders	16242	AGR.BASE MAT.TY.I OR II NO. 21A OR	TON
Underdrain	00588	UNDERDRAIN UD-4	LF
	00591	COMB. UNDERDRAIN CD-2	LF
	00592	COMB. UNDERDRAIN CD-1&2	LF
Drain Pipes	00505	BEDDING MATL.AGGR.NO. 25 OR 26	TON
	01060	6" PIPE	LF
	01120	12" PIPE	LF
	01122	12" CONC. PIPE	LF
	01150	15" PIPE	LF
	01152	15" CONC. PIPE	LF
	01180	18" PIPE	LF
	01182	18" CONC. PIPE	LF
	01212	21" CONC. PIPE	LF
	01240	24" PIPE	LF
	01242	24" CONC. PIPE	LF
	01272	27" CONC. PIPE	LF
Drain Pipes (cont.)	01300	30" PIPE	LF
	01302	30" CONC. PIPE	LF

	01360	36" PIPE	LF
	01362	36" CONC. PIPE	LF
	01420	42" PIPE	LF
	01422	42" CONC. PIPE	LF
	01480	48" PIPE	LF
	01482	48" CONC. PIPE	LF
	01600	60" PIPE	LF
	01602	60" CONC. PIPE	LF
	01662	66" CONC. PIPE	LF
	01722	72" CONC. PIPE	LF
	02140	23" X 14" ELLIPTICAL PIPE	LF
	02142	23" X 14" ELLIPTICAL CONC. PIPE	LF
	02190	30" X 19" ELLIPTICAL PIPE	LF
	02192	30" X 19" ELLIPTICAL CONC. PIPE	LF
	04110	17" X 13" ARCH PIPE	LF
	04130	21" X 15" ARCH PIPE	LF
	04180	28" X 20" ARCH PIPE	LF
	06481	48" END SECTION ES-1	EA
	06485	54" END SECTION ES-1	EA
	06490	60" END SECTION ES-1 OR 2	EA
	06491	60" END SECTION ES-1	EA
	06500	23" X 14" END SECTION ES-1A	EA
	06502	30" X 19" END SECTION ES-1A	EA
	06513	21" X 15" END SECTION ES-3	EA
Drop Inlets	06740	DROP INLET DI-1	EA
	07506	DROP INLET DI-5	EA
	07508	DROP INLET DI-7	EA
	07510	DROP INLET DI-7A	EA
	09046	MANHOLE MH-1	LF
	09056	MANHOLE MH-1 OR 2	LF
	09057	FRAME & COVER MH-1	EA
Curb, Curb & Gutter	12322	ASPHALT CONCRETE CURB TY. MC-3B	LF
	12600	STD. COMB. CURB & GUTTER CG-6	LF
Utilities	40061	6" DI WATER MAIN	LF
	40081	8" DI WATER MAIN	LF
	40121	12" DI WATER MAIN	LF
	40161	16" DI WATER MAIN	LF
	41820	FIRE HYDRANT	EA
	42040	4" SAN. SEWER PIPE	LF
	42080	8" SAN. SEWER PIPE	LF
	42082	8" DI SANITARY SEWER PIPE	LF
	42758	MANHOLE FRAME & COVER WF & C-1	EA
	42764	MANHOLE FRAME & COVER F&C-1	EA
	49010	NS UTILITIES	LF
Asphalt Base Course	10612	ASPH.CONC.BASE CR. TY. BM-25.0	TON

	10610	ASPHALT CONCRETE TY. IM-19.0A	TON
	10611	ASPHALT CONCRETE TY. IM-19.0D	TON
Asphalt Intermediate Course	10607	ASPHALT CONCRETE TY. SM-12.5A	TON
Asphalt Surface Course	10608	ASPHALT CONCRETE TY. SM-12.5D	TON
	10635	ASPHALT CONCRETE TY. SM-9.5A	TON
	10636	ASPHALT CONCRETE TY. SM-9.5D	TON
Approach Slabs	11020	CONC. CL. A4 BRIDGE APPR. SLAB	CY
	11030	REINF. STEEL BRIDGE APPR. SLAB	LB
Pavement, Base, & Subgrade Repairs	00120	REGULAR EXCAVATION	CY
	10065	AGGR. MATL. NO. 1	TON
	10128	AGGR. BASE MATL. TY. I NO. 21B	TON
	16242	AGR.BASE MAT.TY.I OR II NO. 21A OR	TON
Signs	50108	SIGN PANEL	SF
	50502	CONC.FOUND.SSP-V A 1'9" DIA.X 4'6" D	EA
	50575	CONC.FOUND.O/H SIGN STRUCTURE	C.Y.
	50902	NS TRAFFIC SIGN	EA
Signals	51180	TRAF.SIGNAL HEAD SECT.12" STD.	EA
	51303	SIG. POLE MP-1 20' ONE ARM 16'	EA
	51425	NS SIGNAL POLE	EA
	51426	NS MAST ARM	EA
Guardrails & Barriers	13320	GUARDRAIL GR-2	LF
	13331	RAD. GUARDRAIL GR-2	LF
	13345	ALTERNATE BREAKWAY CABLE TERMINAL (GR-9)	EA
	13421	MEDIAN BARRIER MB-3	LF

BRIDGE RECONSTRUCTION			
Activity	**Bid Item Code**	**Description**	**Units**
Mobilization	00100	MOBILIZATION	LS
Erect Temporary Structure	60125	NS BRIDGE	LS
	24305	TEMPORARY DETOUR GS-10 TYPE A	LF
Clearing & Grubbing	00110	CLEARING AND GRUBBING	LS
Cofferdams & Causeways	66120	COFFERDAM	EA
	66116	NS TEMP. CAUSEWAY	LS
Remove Existing Structure	67900	NS DISM.& REM. EXIST. STR.	LS
Pile Driving	64110	STEEL PILES 10"	LF
	64112	STEEL PILES 12"	LF
	64424	PRESTR.CONCRETE PILES 24"	LF
Structural Excavation	64011	STRUCTURE EXCAVATION	CY
	69011	STRUCTURE EXCAVATION	CY
Substructure Concrete	65013	CONCRETE CLASS A3	CY
Concrete Beams	61221	PREST.CONC.BEAM,BULB-T 45" DEPTH +50'-60	EA
	61222	PREST.CONC.BEAM,BULB-T 45" DEPTH +60'-70	EA
Structural Steel	61750	STRUCT.STEEL HIGH STRG.PLT.GIRDERS	LS
	61812	STR.STEEL PLATE GIRDER ASTM A709 GRADE50	LS
	61813	STR.STEEL PLATE GIRDER ASTM A709 GRADEHP	LS
Construct Deck	60404	CONCRETE CLASS A4	CY
	61186	PRESTR. CONC. SLAB 4' X 18" X(+35' - 40'	EA
Parapets & Railings	62010	CONCRETE PARAPET	LF
	65700	CONCRETE PARAPET	LF
	68010	PARAPET, CONCRETE	LF
	69700	CONCRETE PARAPET	LF
Deck Grooving	60490	BRIDGE DECK GROOVING	SY
	68090	BRIDGE DECK GROOVING	SY
Slope Protection	00155	GEOTEXTILE (EMBANKMENT STABILIZATION)	SY
	26117	DRY RIPRAP CL. AI	TON
	26119	DRY RIPRAP CL.I 18"	TON
	26127	DRY RIPRAP CL.I 26"	TON
	66239	DRY RIPRAP CL.II 38"	TON
Utilities	40061	6" DI WATER MAIN	LF
	40081	8" DI WATER MAIN	LF

Utilities (cont.)	40121	12" DI WATER MAIN	LF
	40161	16" DI WATER MAIN	LF
	41820	FIRE HYDRANT	EA
	42040	4" SAN. SEWER PIPE	LF
	42080	8" SAN. SEWER PIPE	LF
	42082	8" DI SANITARY SEWER PIPE	LF
	42758	MANHOLE FRAME & COVER WF & C-1	EA
	42764	MANHOLE FRAME & COVER F&C-1	EA
	49010	NS UTILITIES	LF
Guardrails & Barriers	24290	TRAFFIC BARRIER SER. CONC.	LF
	24297	TRAF.BARR.SER.CONC.DOUBLE FACE	LF
Remove Temporary Structure	67900	NS DISM.& REM. EXIST. STR.	LS
	68900	NS REM. PORT.OF EX.STR.	LS

ROAD REHABILITATION			
Activity	**Bid Item Code**	**Description**	**Units**
Mobilization	00100	MOBILIZATION	LS
Traffic Control	24160	CONSTRUCTION SIGNS	SF
	24305	TEMPORARY DETOUR GS-10 TYPE A	LF
Clearing & Grubbing	00110	CLEARING AND GRUBBING	LS
Excavation	00120	REGULAR EXCAVATION	CY
	00128	EXTRA EXCAVATION	CY
	00140	BORROW EXCAVATION	CY
Pavement, Base, & Sub-grade Repairs	10017	CEM.S.AGR.BAS.MATL.TY.I N.21A	TON
	10065	AGGR. MATL. NO. 1	TON
	10128	AGGR. BASE MATL. TY. I NO. 21B	TON
	15305	PATCH.CEM.CONC.PAVE.TY. IV-A	SY
Milling	10630	FLEXIBLE PAVEMENT PLANING	SY
Asphalt Base Course	16375	ASPHALT CONCRETE TY. BM-25.0	TON
Asphalt Intermediate Course	16365	ASPHALT CONCRETE TY. IM-19.0A	TON
	16370	ASPHALT CONCRETE TY. IM-19.0D	TON
Asphalt Surface Course	16335	ASPHALT CONCRETE TY. SM-9.5A	TON
	16340	ASPHALT CONCRETE TY. SM-9.5D	TON
	16355	ASPHALT CONCRETE TY. SM-12.5D	TON
Curb & Gutter	12322	ASPHALT CONCRETE CURB TY. MC-3B	LF
	12600	STD. COMB. CURB & GUTTER CG-6	LF
	14416	COMB. CURB & GUTTER CG-6	LF
Upgrade/Relocate Drain Pipes	00505	BEDDING MATL.AGGR.NO. 25 OR 26	TON
	01060	6" PIPE	LF
	01120	12" PIPE	LF
	01122	12" CONC. PIPE	LF
	01150	15" PIPE	LF
	01152	15" CONC. PIPE	LF
	01180	18" PIPE	LF
	01182	18" CONC. PIPE	LF
	01212	21" CONC. PIPE	LF
	01240	24" PIPE	LF
	01242	24" CONC. PIPE	LF
	01272	27" CONC. PIPE	LF
	01300	30" PIPE	LF
	01302	30" CONC. PIPE	LF
	01360	36" PIPE	LF
	01362	36" CONC. PIPE	LF
	01420	42" PIPE	LF
Upgrade/Rel. Drain	01422	42" CONC. PIPE	LF
	01480	48" PIPE	LF

Pipes (cont).	01482	48" CONC. PIPE	LF
	01600	60" PIPE	LF
	01602	60" CONC. PIPE	LF
	01662	66" CONC. PIPE	LF
	01722	72" CONC. PIPE	LF
	02140	23" X 14" ELLIPTICAL PIPE	LF
	02142	23" X 14" ELLIPTICAL CONC. PIPE	LF
	02190	30" X 19" ELLIPTICAL PIPE	LF
	02192	30" X 19" ELLIPTICAL CONC. PIPE	LF
	04110	17" X 13" ARCH PIPE	LF
	04130	21" X 15" ARCH PIPE	LF
	04180	28" X 20" ARCH PIPE	LF
	06481	48" END SECTION ES-1	EA
	06485	54" END SECTION ES-1	EA
	06490	60" END SECTION ES-1 OR 2	EA
	06491	60" END SECTION ES-1	EA
	06500	23" X 14" END SECTION ES-1A	EA
	06502	30" X 19" END SECTION ES-1A	EA
	06513	21" X 15" END SECTION ES-3	EA
Upgrade/Relocate Drop Inlets	06740	DROP INLET DI-1	EA
	07506	DROP INLET DI-5	EA
	07508	DROP INLET DI-7	EA
	07510	DROP INLET DI-7A	EA
	09046	MANHOLE MH-1	LF
	09056	MANHOLE MH-1 OR 2	LF
	09057	FRAME & COVER MH-1	EA
Upgrade/Relocate Utilities	40061	6" DI WATER MAIN	LF
	40081	8" DI WATER MAIN	LF
	40121	12" DI WATER MAIN	LF
	40161	16" DI WATER MAIN	LF
	41820	FIRE HYDRANT	EA
	42040	4" SAN. SEWER PIPE	LF
	42080	8" SAN. SEWER PIPE	LF
	42082	8" DI SANITARY SEWER PIPE	LF
	42758	MANHOLE FRAME & COVER WF & C-1	EA
	42764	MANHOLE FRAME & COVER F&C-1	EA
	49010	NS UTILITIES	LF
Upgrade Signs	50108	SIGN PANEL	SF
	50502	CONC.FOUND.SSP-V A 1'9" DIA.X 4'6" D	EA
	50575	CONC.FOUND.O/H SIGN STRUCTURE	C.Y.
Upgrade Signals	51180	TRAF.SIGNAL HEAD SECT.12" STD.	EA
	51303	SIG. POLE MP-1 20' ONE ARM 16'	EA
	51425	NS SIGNAL POLE	EA
	51426	NS MAST ARM	EA
Upgrade Barriers and	13320	GUARDRAIL GR-2	LF

Guardrail	13331	RAD. GUARDRAIL GR-2	LF
	13345	ALTERNATE BREAKWAY CABLE TERMINAL (GR-9)	EA
	13421	MEDIAN BARRIER MB-3	LF

BRIDGE REHABILITATION			
Activity	**Bid Item Code**	**Description**	**Units**
Mobilization	00100	MOBILIZATION	LS
Traffic Control	24160	CONSTRUCTION SIGNS	SF
	24305	TEMPORARY DETOUR GS-10 TYPE A	LF
Clearing and Grubbing	00110	CLEARING AND GRUBBING	LS
Excavation	64011	STRUCTURE EXCAVATION	CY
	69011	STRUCTURE EXCAVATION	CY
Demolition	67900	NS DISM.& REM. EXIST. STR.	LS
	68900	NS REM. PORT.OF EX.STR.	LS
Milling	68258	REMOVAL OF ASPHALT CONCRETE OVERLAY	SY
	68314	TYPE A MILLING (1" DEPTH)	SY
Surface Patching	14380	PAVEMENT RESTORATION	TON
	68320	TYPE B PATCHING	SY
	68330	TYPE C PATCHING	SY
	68600	CONC. SUPERSTR. SURFACE REPAIR	SY
Deck Joints	68570	EXPANSION JOINT REMOVAL	LF
Substructure Rehabilitation	68162	BEAM SEAT REPAIR	EA
	69500	CONCRETE SUBSTRUCT. SURFACE REPAIR	SY
Asphalt Intermediate Course	16370	ASPHALT CONCRETE TY. IM-19.0D	TON
Asphalt Surface Course	16335	ASPHALT CONCRETE TY. SM-9.5A	TON
	16340	ASPHALT CONCRETE TY. SM-9.5D	TON
	16355	ASPHALT CONCRETE TY. SM-12.5D	TON
Concrete Paving	60404	CONCRETE CLASS A4	CY
	65014	CONCRETE CLASS A4	CY
Upgrade/Relocate Utilities	40061	6" DI WATER MAIN	LF
	40081	8" DI WATER MAIN	LF
	40121	12" DI WATER MAIN	LF
	40161	16" DI WATER MAIN	LF
	41820	FIRE HYDRANT	EA
	42040	4" SAN. SEWER PIPE	LF
	42080	8" SAN. SEWER PIPE	LF
	42082	8" DI SANITARY SEWER PIPE	LF
	42758	MANHOLE FRAME & COVER WF & C-1	EA
	42764	MANHOLE FRAME & COVER F&C-1	EA
	49010	NS UTILITIES	LF
Upgrade Barriers and Guardrail	13383	FIXED OBJECT ATTACH. GR-FOA-1 TY. I	EA
	13421	MEDIAN BARRIER MB-3	LF
	17323	GUARDRAIL BEAM	LF
	17325	RADIAL GUARDRAIL BEAM	LF

WIDENING			
Activity	**Bid Item Code**	**Description**	**Units**
Mobilization	00100	MOBILIZATION	LS
Traffic Control	24160	CONSTRUCTION SIGNS	SF
	24305	TEMPORARY DETOUR GS-10 TYPE A	LF
Clearing and Grubbing	00110	CLEARING AND GRUBBING	LS
Demolition	24601	NS REMOVE EXIST. GUARDRAIL	LF
Milling	10630	FLEXIBLE PAVEMENT PLANING	SY
Excavation	00120	REGULAR EXCAVATION	CY
	00128	EXTRA EXCAVATION	CY
	00140	BORROW EXCAVATION	CY
Relocate Drain Pipes	00505	BEDDING MATL.AGGR.NO. 25 OR 26	TON
	01060	6" PIPE	LF
	01120	12" PIPE	LF
	01122	12" CONC. PIPE	LF
	01150	15" PIPE	LF
	01152	15" CONC. PIPE	LF
	01180	18" PIPE	LF
	01182	18" CONC. PIPE	LF
	01212	21" CONC. PIPE	LF
	01240	24" PIPE	LF
	01242	24" CONC. PIPE	LF
	01272	27" CONC. PIPE	LF
	01300	30" PIPE	LF
	01302	30" CONC. PIPE	LF
	01360	36" PIPE	LF
	01362	36" CONC. PIPE	LF
	01420	42" PIPE	LF
	01422	42" CONC. PIPE	LF
	01480	48" PIPE	LF
	01482	48" CONC. PIPE	LF
	01600	60" PIPE	LF
	01602	60" CONC. PIPE	LF
	01662	66" CONC. PIPE	LF
	01722	72" CONC. PIPE	LF
	02140	23" X 14" ELLIPTICAL PIPE	LF
	02142	23" X 14" ELLIPTICAL CONC. PIPE	LF
	02190	30" X 19" ELLIPTICAL PIPE	LF
	02192	30" X 19" ELLIPTICAL CONC. PIPE	LF
	04110	17" X 13" ARCH PIPE	LF
	04130	21" X 15" ARCH PIPE	LF
	04180	28" X 20" ARCH PIPE	LF

Relocate Drain Pipes (cont.)	06481	48" END SECTION ES-1	EA
	06485	54" END SECTION ES-1	EA
	06490	60" END SECTION ES-1 OR 2	EA
	06491	60" END SECTION ES-1	EA
	06500	23" X 14" END SECTION ES-1A	EA
	06502	30" X 19" END SECTION ES-1A	EA
	06513	21" X 15" END SECTION ES-3	EA
Relocate Drop Inlets	06740	DROP INLET DI-1	EA
	07506	DROP INLET DI-5	EA
	07508	DROP INLET DI-7	EA
	07510	DROP INLET DI-7A	EA
	09046	MANHOLE MH-1	LF
	09056	MANHOLE MH-1 OR 2	LF
	09057	FRAME & COVER MH-1	EA
Relocate Utilities	40061	6" DI WATER MAIN	LF
	40081	8" DI WATER MAIN	LF
	40121	12" DI WATER MAIN	LF
	40161	16" DI WATER MAIN	LF
	41820	FIRE HYDRANT	EA
	42040	4" SAN. SEWER PIPE	LF
	42080	8" SAN. SEWER PIPE	LF
	42082	8" DI SANITARY SEWER PIPE	LF
	42758	MANHOLE FRAME & COVER WF & C-1	EA
	42764	MANHOLE FRAME & COVER F&C-1	EA
	49012	NS UTILITIES	EA
Retaining Walls	13520	RETAINING WALL RW-2	CY
	13530	RETAINING WALL RW-3	CY
Grading	00125	GRADING	LS
Base Stone	10065	AGGR. MATL. NO. 1	TON
	10128	AGGR. BASE MATL. TY. I NO. 21B	TON
Shoulders	16242	AGR.BASE MAT.TY.I OR II NO. 21A OR	TON
Asphalt Base Course	10612	ASPH.CONC.BASE CR. TY. BM-25.0	TON
Asphalt Intermediate Course	10610	ASPHALT CONCRETE TY. IM-19.0A	TON
	10611	ASPHALT CONCRETE TY. IM-19.0D	TON
Asphalt Surface Course	10607	ASPHALT CONCRETE TY. SM-12.5A	TON
	10608	ASPHALT CONCRETE TY. SM-12.5D	TON
	10635	ASPHALT CONCRETE TY. SM-9.5A	TON
	10636	ASPHALT CONCRETE TY. SM-9.5D	TON
Curb, Curb & Gutter	12322	ASPHALT CONCRETE CURB TY. MC-3B	LF
	12600	STD. COMB. CURB & GUTTER CG-6	LF
Signs	50108	SIGN PANEL	SF
	50502	CONC.FOUND.SSP-V A 1'9" DIA.X 4'6" D	EA
	50575	CONC.FOUND.O/H SIGN STRUCTURE	C.Y.
	50902	NS TRAFFIC SIGN	EA
Signals	51180	TRAF.SIGNAL HEAD SECT.12" STD.	EA

Signals (cont.)	51303	SIG. POLE MP-1 20' ONE ARM 16'	EA
	51425	NS SIGNAL POLE	EA
	51426	NS MAST ARM	EA
Barriers and Guardrail	13320	GUARDRAIL GR-2	LF
	13331	RAD. GUARDRAIL GR-2	LF
	13345	ALTERNATE BREAKWAY CABLE TERMINAL (GR-9)	EA
	13421	MEDIAN BARRIER MB-3	LF

OVERLAY / RESURFACING			
Activity	**Bid Item Code**	**Description**	**Units**
Mobilization	00100	MOBILIZATION	LS
Traffic Control	24160	CONSTRUCTION SIGNS	SF
	24305	TEMPORARY DETOUR GS-10 TYPE A	LF
Milling	10630	FLEXIBLE PAVEMENT PLANING	SY
	10632	RIGID PAVEMENT PLANING	SY
	68258	REMOVAL OF ASPHALT CONCRETE OVERLAY	SY
	68314	TYPE A MILLING (1" DEPTH)	SY
Pavement & Base Repairs	00120	REGULAR EXCAVATION	CY
	00128	EXTRA EXCAVATION	CY
	00140	BORROW EXCAVATION	CY
	10065	AGGR. MATL. NO. 1	TON
	10128	AGGR. BASE MATL. TY. I NO. 21B	TON
	10416	LIQUID ASPHALT	GAL
	10478	COVER MATL. AGGR. NO. 78	TON
	16242	AGR.BASE MAT.TY.I OR II NO. 21A OR	TON
	24260	CR. RUN AGGR. NO. 25 OR 26	TON
	68308	TYPE A PATCHING	SY
	68312	TYPE A PATCHING (HES)	SY
	68320	TYPE B PATCHING	SY
	68322	TYPE B PATCHING (HES)	SY
	68330	TYPE C PATCHING	SY
	68332	TYPE C PATCHING (HES)	SY
Asphalt Base Course	10612	ASPH.CONC.BASE CR. TY. BM-25.0	TON
Asphalt Intermediate Course	10610	ASPHALT CONCRETE TY. IM-19.0A	TON
	10611	ASPHALT CONCRETE TY. IM-19.0D	TON
Asphalt Surface Course	10607	ASPHALT CONCRETE TY. SM-12.5A	TON
	10608	ASPHALT CONCRETE TY. SM-12.5D	TON
	10635	ASPHALT CONCRETE TY. SM-9.5A	TON
Asp. Surf. Crse. (cont.)	10636	ASPHALT CONCRETE TY. SM-9.5D	TON
	68205	ASPHALT CONCRETE TY. SM-12.5	TON
Concrete Paving	60404	CONCRETE CLASS A4	CY
Pavement Marking	54020	TY. A PAVEMENT LINE MARKING 4"	LF
	54032	TY.B CL.I PAVE. LINE MARK. 4"	LF
	54044	TY.B CL.II PAVE. LINE MARK. 6"	LF
	54049	TY.B CL.III PAVE.LINE MARK.4"	LF
	54075	TY.B CL.VI PAVE. LINE MARK. 4"	LF
	54217	SNOW PLOW.RAISED PAVE.MARK.ASPH.CONC	EA

Appendix C– *BIDDS* User’s Manual

Partnership for Project Scheduling

BID ITEM DURATION DATA SYSTEM

"BIDDS"

Version 1.0

A database management system to support the establishment of bid item production rates for the pre-advertisement schedule

User's Manual
Spring 2006

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Part 1 – *BIDDS* Overview

1.1 What is BIDDS?

BIDDS is a pre-advertisement level database of highway construction performance times. From scoping through advertisement, project design, cost estimates, and time estimates are continually refined. This refinement minimizes errors, omissions, and unnecessary contingencies.

At project advertisement, project cost is summarized as a list of bid items necessary to complete the project work. It is at this level that project cost is monitored. Therefore, *BIDDS* uses these bid items to gather and maintain historical production data for VDOT projects.

1.2 BIDDS Usage

BIDDS has two main functions:

1. Storing historical project data including project information, project characteristics, and production data
2. Retrieving and demonstrating production data associated with projects similar to that being scheduled

1.3 BIDDS Limitations

BIDDS maintains historical production data for VDOT highway construction projects. *BIDDS* also retains historical, project specific, information and characteristics about these projects. To retrieve production data, the scheduler inputs project information and characteristics about a project. *BIDDS* uses these parameters to assemble comparable projects. The user is then returned production data associated with the similar projects.

Throughout this process, the use of personal engineering judgment cannot be overstressed. *BIDDS* incorporates this need by returning a range of production rates, rather than a definitive figure. As outlined previously, this data is summarized in a number of formats that show production rate variation with respect to time and quantity. These summaries encourage the use of *BIDDS* as a tool for estimating production rates, rather than finding or "looking up" production rates.

These production rates may then be used to estimate activity duration. It is important to understand that *BIDDS* does not generate a schedule, nor a complete contract time estimate. The estimation of activity duration, sequencing of activities, and final schedule generation is the responsibility of the scheduler. *BIDDS* is designed to assist the scheduler in this process at the pre-advertisement level.

While *BIDDS* is intended to aid VDOT in the establishment of the pre-advertisement schedule, there is also potential for *BIDDS* to be used during the construction phases to review and award additional time requests due to change orders. Though *BIDDS* may be a useful tool in these processes, it is imperative to note that production rates extracted from the system are based on historical performance time data (i.e. what has happened in the past). Construction projects are affected by a number of unforeseeable and uncontrollable incidents. While these incidents are a fact of the construction industry, their occurrence is too casual to warrant the effort necessary to quantify or implement their effects within a system such as *BIDDS*. Such effects must be considered by seasoned schedulers and construction experts. The scheduler must use engineering judgment to forecast what can and will happen during project construction. Production rates, provided by *BIDDS*, assist the scheduler in this forecast.

Part 2 – Technical Specifications

2.1 Application Requirements

BIDDS has been designed and constructed in Microsoft *Access 2003*. *Access 2003* was chosen because of its ease of use, accessibility, and intuitive design. The *BIDDS* output structure uses Microsoft *Excel* to generate tabular data summaries and graphical data plots. Therefore, these two applications are required to run the *BIDDS* database.

2.2 Space Requirements

BIDDS Database	20 Megabytes
MS *Excel* Output Files	+ 15 Megabytes
Total Space Required	= 35 Megabytes

Part 3 – Installing *BIDDS*

BIDDS is installed by copying and pasting the MS *Access* and MS *Excel* templates to the hard-drive. It is recommended that *BIDDS* components are stored directly in the root directory, as opposed to the desktop or documents folders where the components may be accidentally deleted or separated.

For *BIDDS* to execute properly, ALL FILES MUST BE STORED IN THE SAME LOCATION! Code controlling the *BIDDS* output necessitates that the accompanying Microsoft *Excel* templates are stored with the same directory as the main Microsoft *Access BIDDS* file!

To install *BIDDS*:

1. Insert the *BIDDS* CD into the CD Drive.

2. If auto-run does not automatically open the CD directory, locate and **Double-Click** the CD Drive in "**My Computer**".

3. Once Open, the *BIDDS* folder is displayed. This folder contains the Microsoft *Access BIDDS* file, as well as, <u>two</u> Microsoft *Excel* template files.

4. **Right-Click** the *BIDDS* **Folder**.

5. From the menu, highlight and Click "**Copy**".

6. Relocate the computer hard-drive through "**My Computer**". The hard-drive is typically labeled "**C**" or "**D**", however, names may vary.

7. In the hard-drive, **Right-Click** an empty area.

8. From the menu, select "**Paste**".

9. Once the folder has been pasted, **Double-Click** the folder to **Open**.

10. Ensure that three files exist within this folder:

    a. *BIDDS* (Microsoft *Access* Database)

    b. Tabular Views (Microsoft *Excel* Template File)

    c. Graphical Views (Microsoft *Excel* Template File)

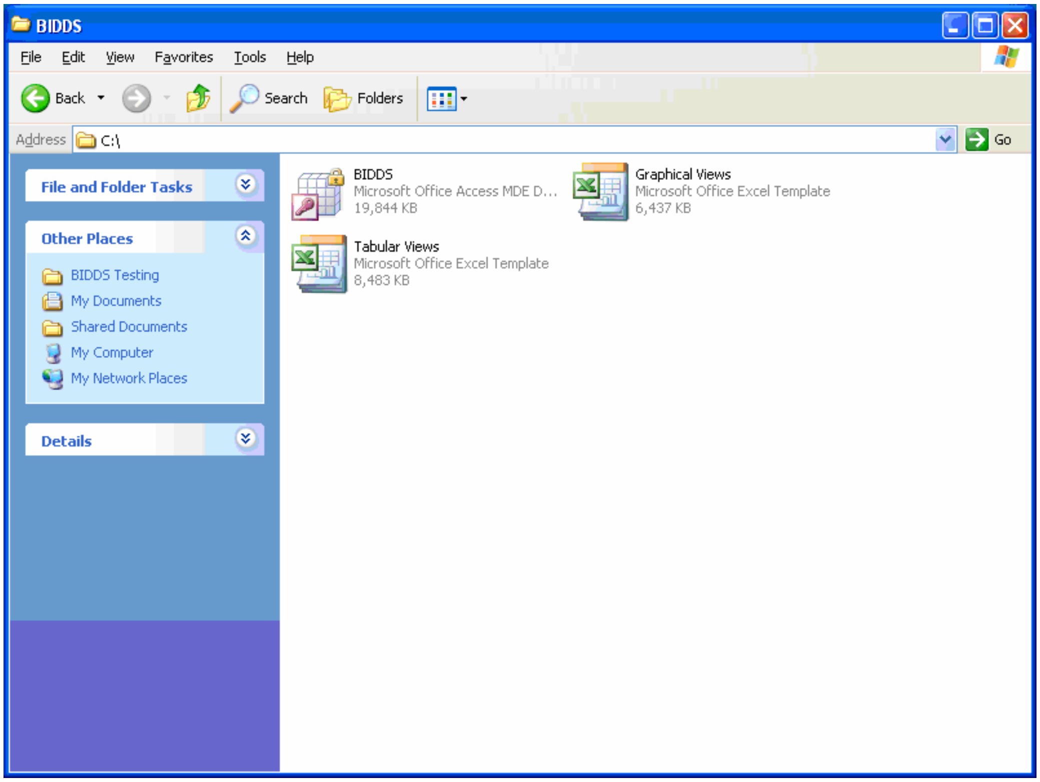

Figure 3.1 – *BIDDS* Folder

Part 4 – *BIDDS* Architecture

BIDDS is comprised of storage tables, queries, and the user interface. These parts work together to perform the three basic functions of *BIDDS*: new project establishment, monthly production data import, and production data output. The schematic below shows the *Bid Item Duration Data System* and its components.

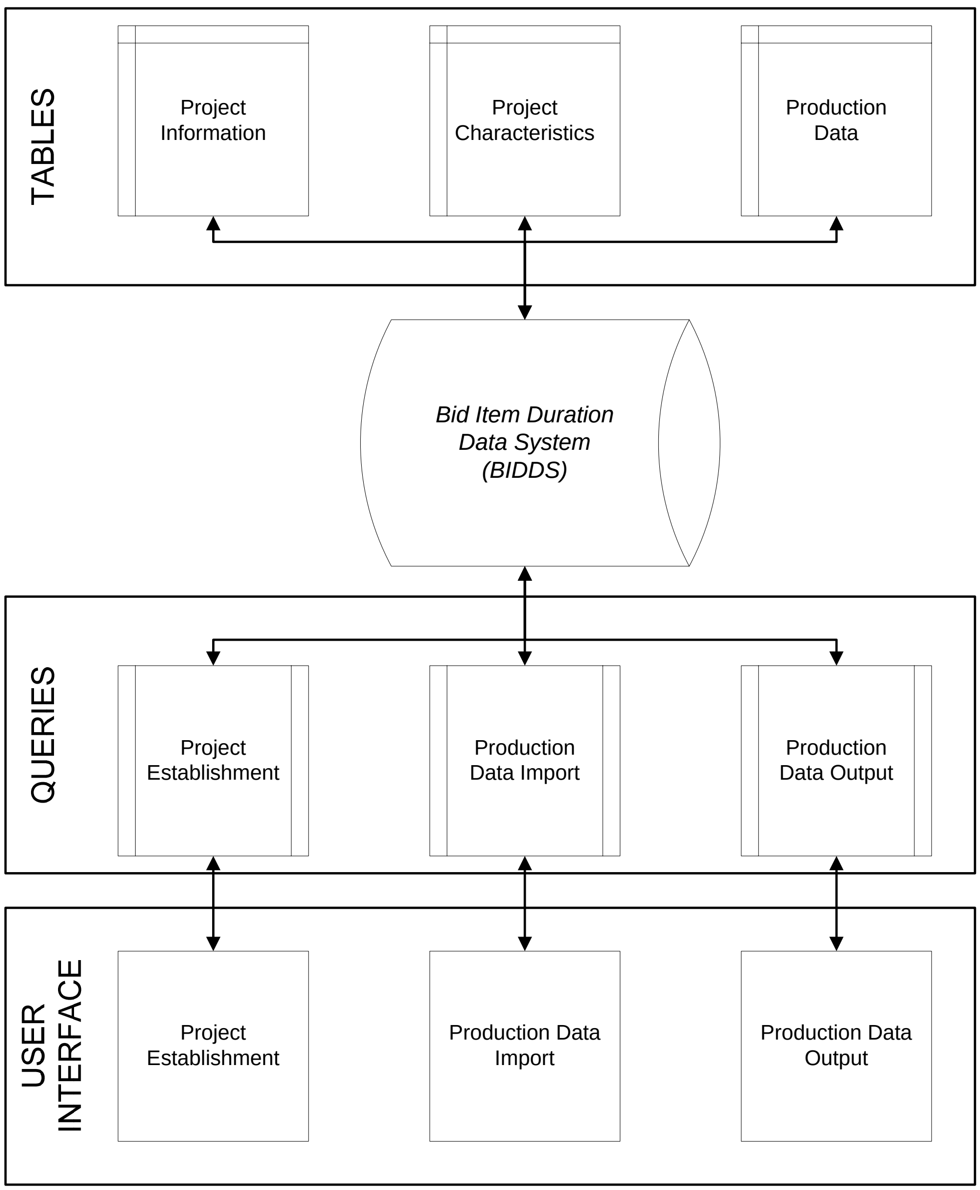

Figure 4.1 – *BIDDS* Components

Part 5 – Beginning *BIDDS*

5.1 Opening BIDDS

At this point, the *BIDDS* folder and its contents should be installed on the computer hard-drive and prepared for use. If the *BIDDS* folder and its contents are not located on your computer, please refer to Part 3 for information regarding the installation of *BIDDS*.

To open *BIDDS*:

1. Navigate to the hard-drive by clicking "**My Computer**", then the hard-drive name.

2. **Locate** and **Click** the folder labeled "*BIDDS*".

3. Once open, the folder should display the *BIDDS* database, as well as the supporting MS *Excel* template files. **Double-click** the *BIDDS* database file to **Open**.

4. If the macro security level on your computer is set to "Medium" or "High", you will receive the messages in Figure 5.1 and 5.2. For security reasons, it is important that the macro security level be maintained at "Medium".

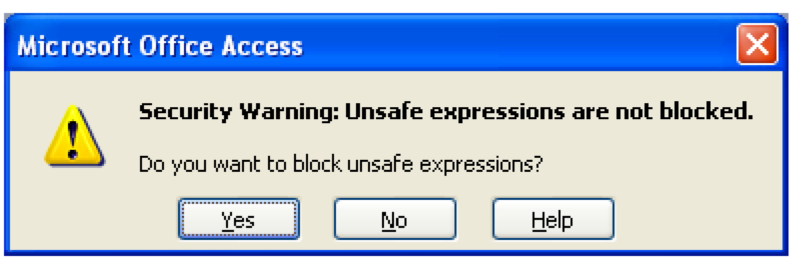

Figure 5.1 – Block Unsafe Expressions

If you would like to maintain security levels, unsafe expressions can be blocked by **Clicking "Yes"** in the Figure 5.1 message box. This will not affect the integrity or functionality of *BIDDS*. You may proceed beyond the

Macro Security Warning message by **Clicking "Open"** in the Figure 5.2 message box. For more information on these topics, see your computer administrator or Microsoft *Access* Frequently Asked Question webpage.

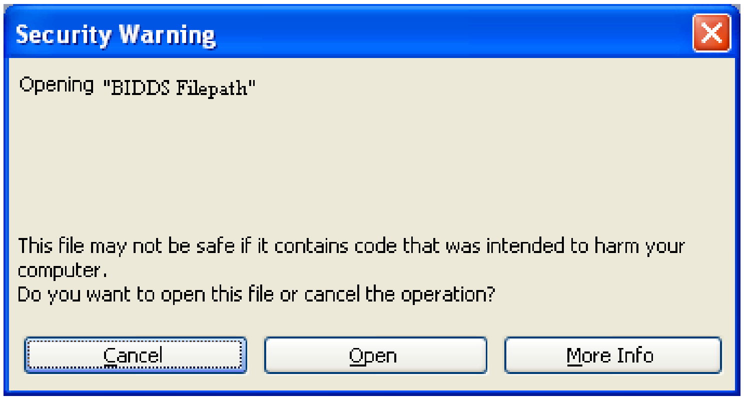

Figure 5.2 – Macro Security Level Warning Message

5. Once the security warnings have been accommodated, *BIDDS* will open to the "**Entry Form**" (Figure 5.3 below). From here, you may select your next action. Refer to Part 5.2 to continue.

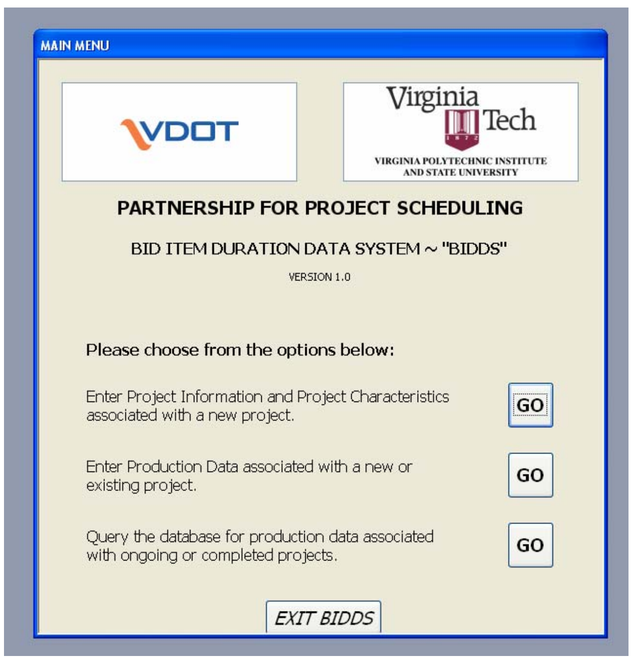

Figure 5.3 – *BIDDS* Main Menu

5.2 BIDDS Functions

There are three options for proceeding beyond the *BIDDS* Main Menu:

1. **“Enter Project Information and Project Characteristics associated with a new project.”** Allows the user to “establish” a project within the database. To do so, the user will input project parameters that serve to uniquely identify projects. For more on this option, see Part 6.

2. **“Enter Production Data associated with an existing project.”** Allows the user to import as-built production data gathered through SiteManager or manual collection. For more on this option, see Part 7.

3. **“Query the database for production data associated with ongoing or completed projects.”** Allows the user to search for production data associated with projects similar to that being scheduled currently. For more on this option, see Part 8.

Part 6 – Establishing a New Project in *BIDDS*

Once a project has been identified as a data collection project, but before monthly production data can be imported, the project must be "established" in *BIDDS*. This means that the Project Information and Characteristics have been collected and stored, so as to uniquely identify the project.

To establish a project in *BIDDS*:

1. **Click "GO"** next to the caption, "Enter Project Information and Project Characteristics associated with a new project."

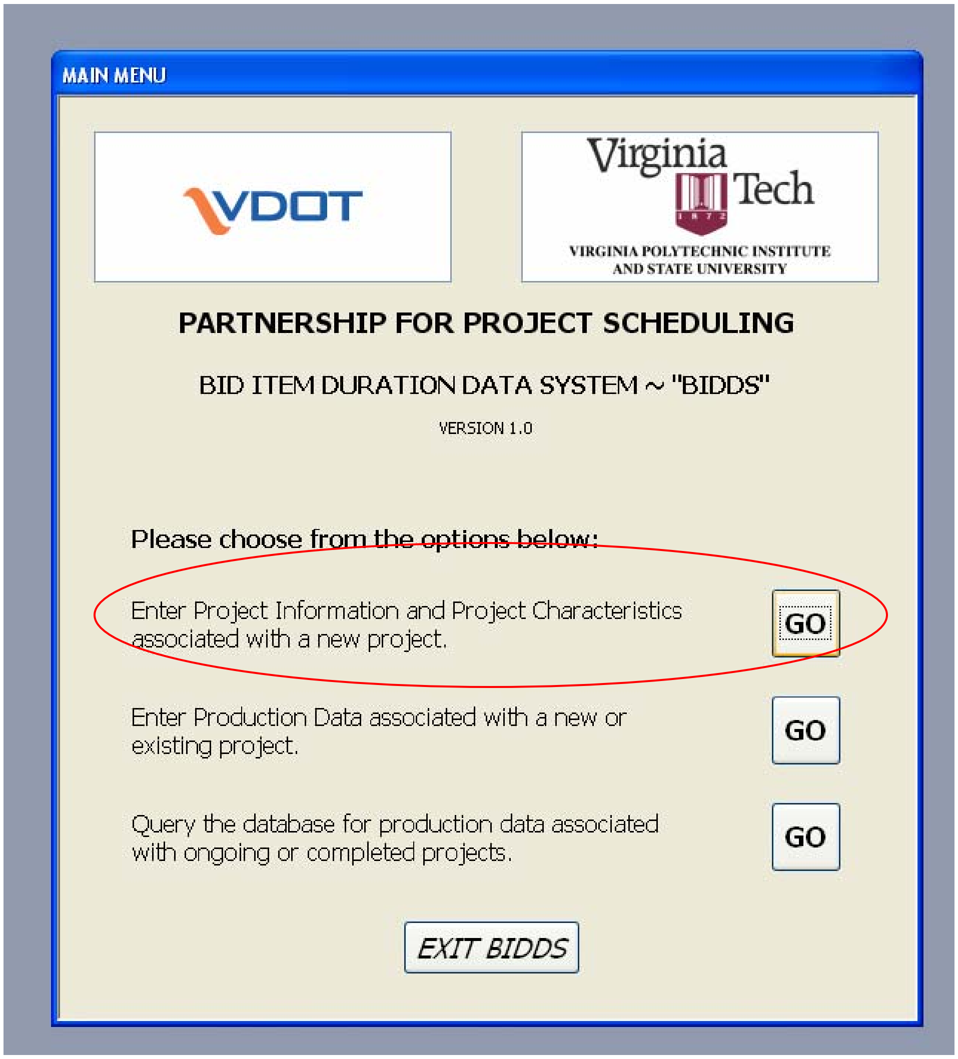

Figure 6.1 – *BIDDS* Main Menu Form

2. Next, the **Project Information Input Form** is displayed, prompting you to input information about the project. To complete this form, the user **MUST** complete **ALL** fields except the Project County and City. This information can be found on the project contract documents or plans.

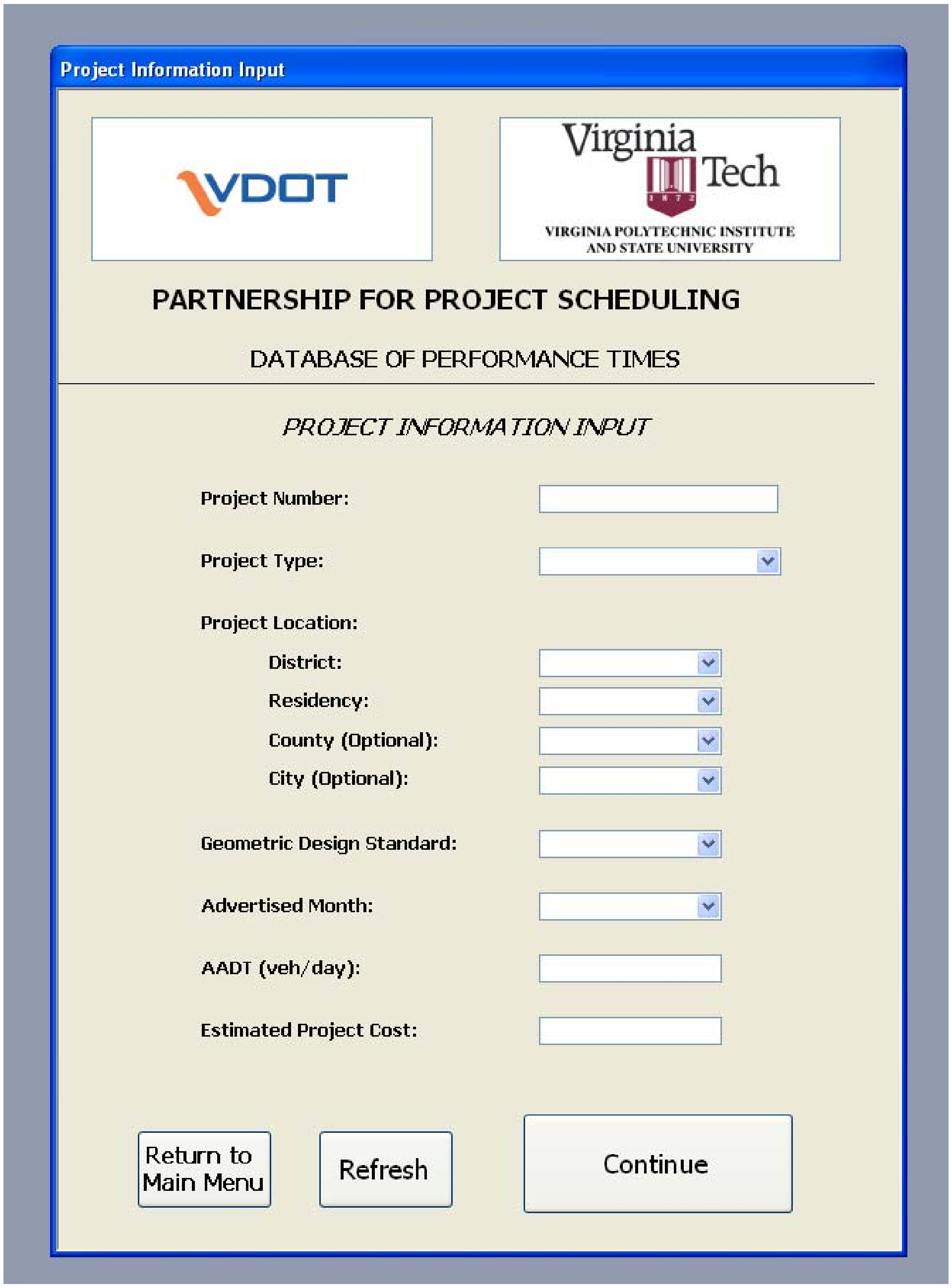

Figure 6.2 – Project Information Input Form

3. Once you've completed the Project Information form, **Continue** to the **Project Characteristics Form** and supply the necessary Project Characteristic parameters. (The form layout varies based on the project type.) These characteristics are optional and vary depending on the Project Type.

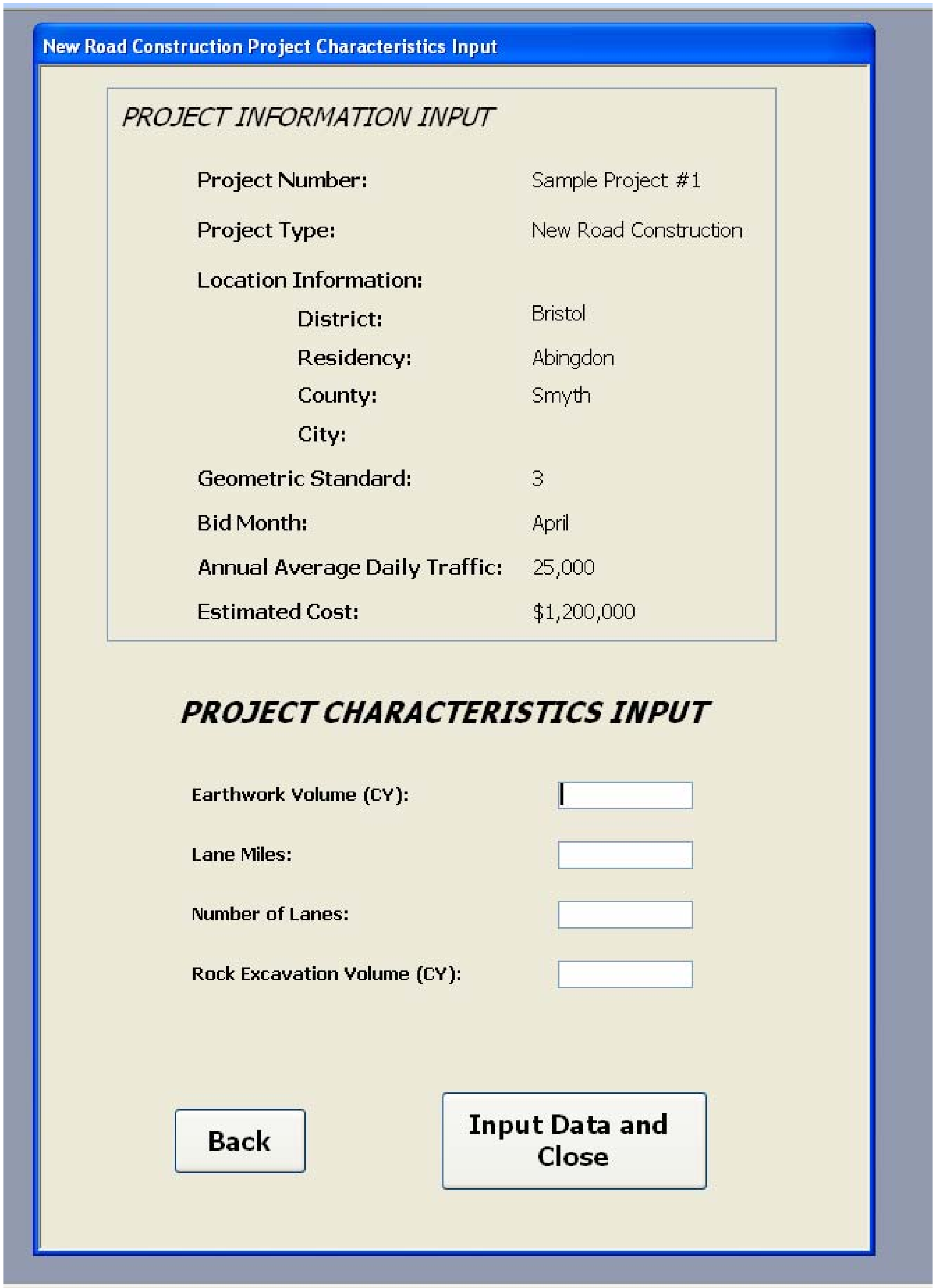

Figure 6.3 – Project Characteristics Input Form

4. **Review** the Project Information summarized at the top of this form. If the Project Information is incorrect, **Return** to the Project Information Input Form by **Clicking "Back"**. Otherwise, continue to the following step.

5. Once the appropriate parameters have been supplied, this process is ended by **Clicking "Input Data and Close"**. This establishes the project by inserting project parameters into the appropriate tables. You will be returned to the Main Menu.

6. At this point, production data may be imported from *SiteManager* and associated with the project. You may also choose to query the database for production data about another existing project.

Part 7 – Importing Production Data

Once a project has been "established" in *BIDDS* (see Part 6 for details), production data may be gathered and associated with the project. Production data may be collected in *SiteManager* or manually. The following section describes the formatting required for data input.

7.1 Production Data Format

Production data may only be imported into *BIDDS* in a **TAB-DELIMITED TEXT FILE!** Other file types are not currently supported by BIDDS and will not transfer correctly into *BIDDS*. The *SiteManager Data Converter* (*SMDC*) can be used to extract data from SiteManager, filter the data for the appropriate bid items, and format the data into the appropriate form.

If data is not formatted by *SMDC*, production data may be formatted in Microsoft *Excel* and saved as a Tab-Delimited Text File. When formatted in *Excel*, the file should resemble that in Table 7.1 below. The file **may** or **may not** contain column headings. You will be asked during the import process to specify whether column headings are included. However, columns **MUST** be in the order (left to right) demonstrated below! Otherwise, data imported will be invalid.

Table 7.1 – Production Data Import Format

Project Number	Bid Item Number	Month Performed	Year Performed	Quantity Installed	Number of Days Performed
SD 0001	00100	September	2001	1	4
SD 0001	10607	September	2001	59	1
SD 0001	10630	October	2001	1022	1
SD 0001	54020	October	2001	2156	1
SD 0001	68320	October	2001	78	1
SD 0001	68330	September	2001	31	1

7.2 Production Data Import

Once production data has been formatted into a Tab-Delimited Text File, the file is prepared for import. Data may be imported into *BIDDS* at any time during the project or upon its completion. It is suggested that data be imported monthly to eliminate the potential for errors and omissions, as well as to minimize the time required.

To import production data into *BIDDS*:

1. From the *BIDDS* Main Menu, **Click "GO"** to the right of the second caption, **"Enter Production Data associated with an existing project."** This will open the Production Data Import Form (Figure 7.2).

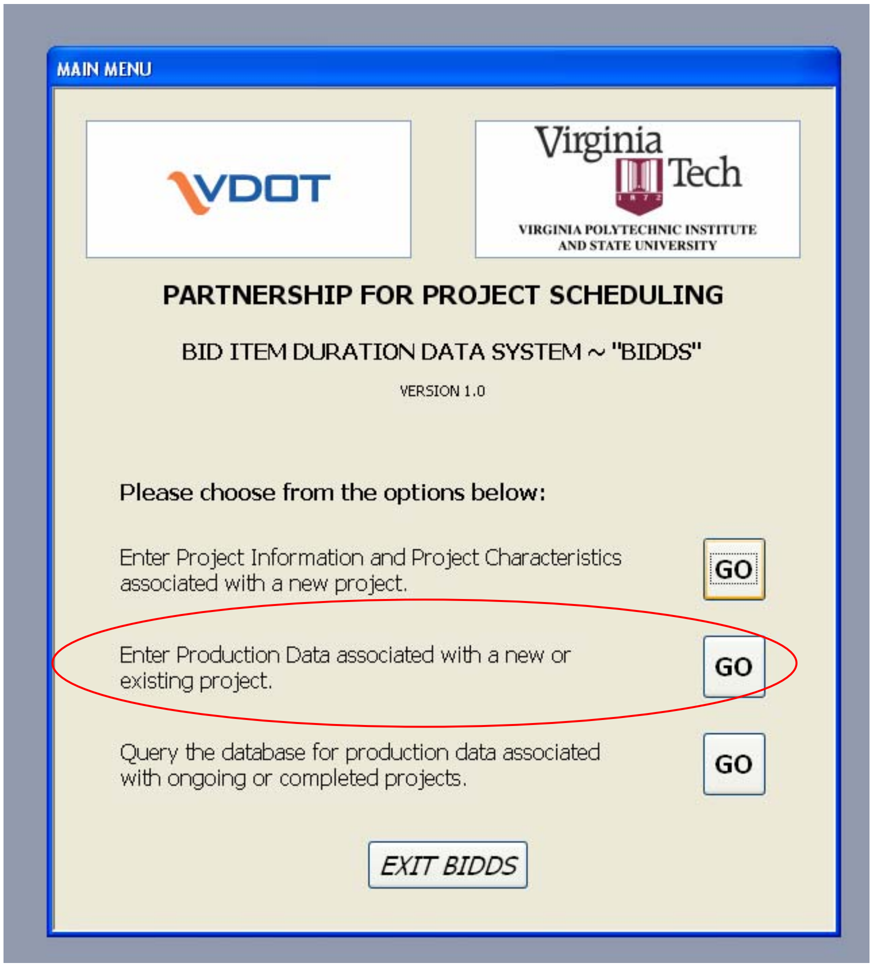

Figure 7.1 – *BIDDS* Main Menu Form

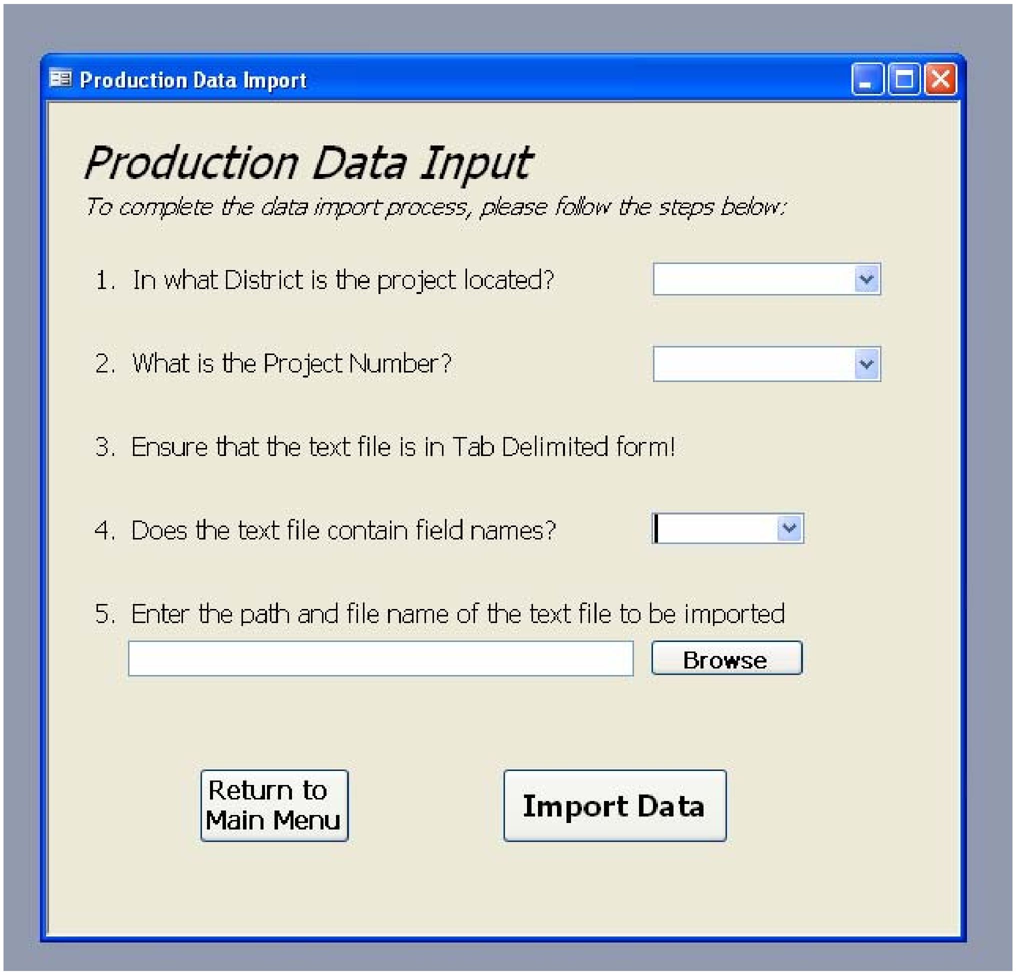

Figure 7.2 – Production Data Import Form

2. First, **Select** the **District** in which the project is being completed. This information should be readily available from a number of sources.

3. Next, **Select** the **Project Number** associated with the production data. The project number selected here **MUST** be the same project number used to establish the project originally! The project number selected during this step will be attached to the production data upon import.

4. Once the project number has been selected, **Select** the **Field Name** status of the import file. These field names refer to the column headings of the import

file. As mentioned earlier, these headings may be included or excluded from the file by completing this field.

5. Finally, insert the **File Path** for the file to be imported by **Clicking** the **“Browse”** button.

6. Before continuing, ensure that the information supplied on this form is accurate!

7. **Click** the **“Import Data”** button to import production data and complete this process. You will be returned to the **Main Menu**.

Part 8 – Querying for Production Data

BIDDS affords the user a tool in the establishment of production rates for the calculation of activity durations. This section outlines the process for querying *BIDDS*, as well as, using the output supplied by *BIDDS*.

To query *BIDDS* for production data associated with projects similar to your own:

1. From the main menu, **Click "GO"** to the right of the third caption, **"Query the database for production data associated with ongoing or completed projects."**

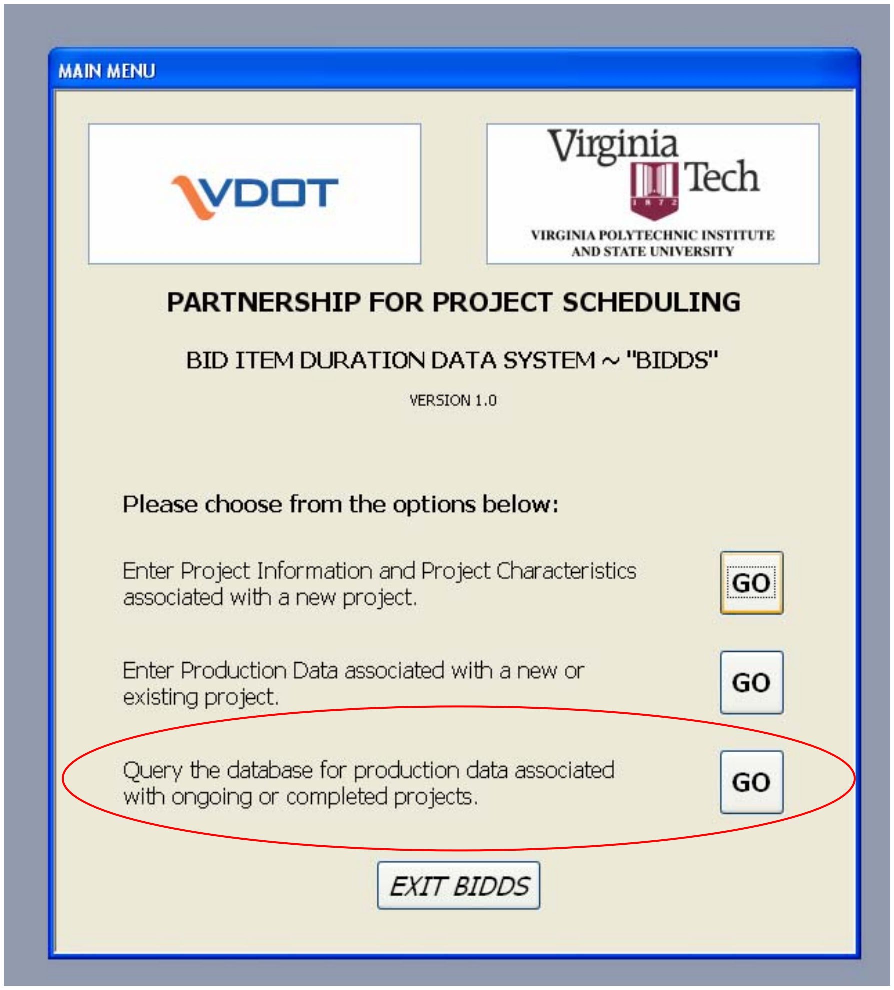

Figure 8.1 – *BIDDS* Main Menu Form

2. The Project Information query form will open. Use this form to **Input** as much Project Information as possible regarding the project being scheduled. The only field *required* is the Project Type, all other fields are optional.

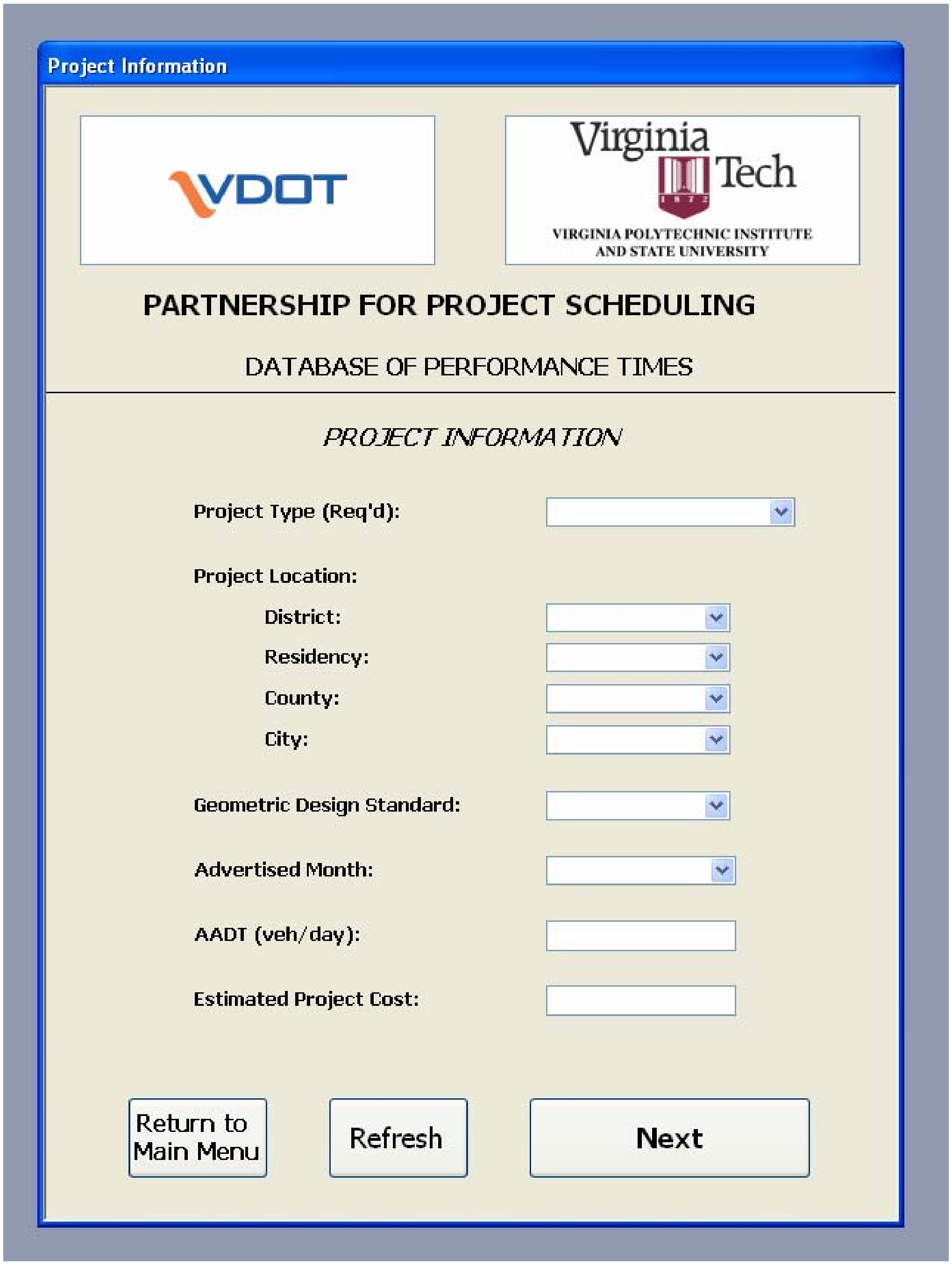

Figure 8.2 – Project Information Query Form

3. Once this form is completed, **Select "Next"** to continue on to the Project Characteristics query form (Figure 8.3).

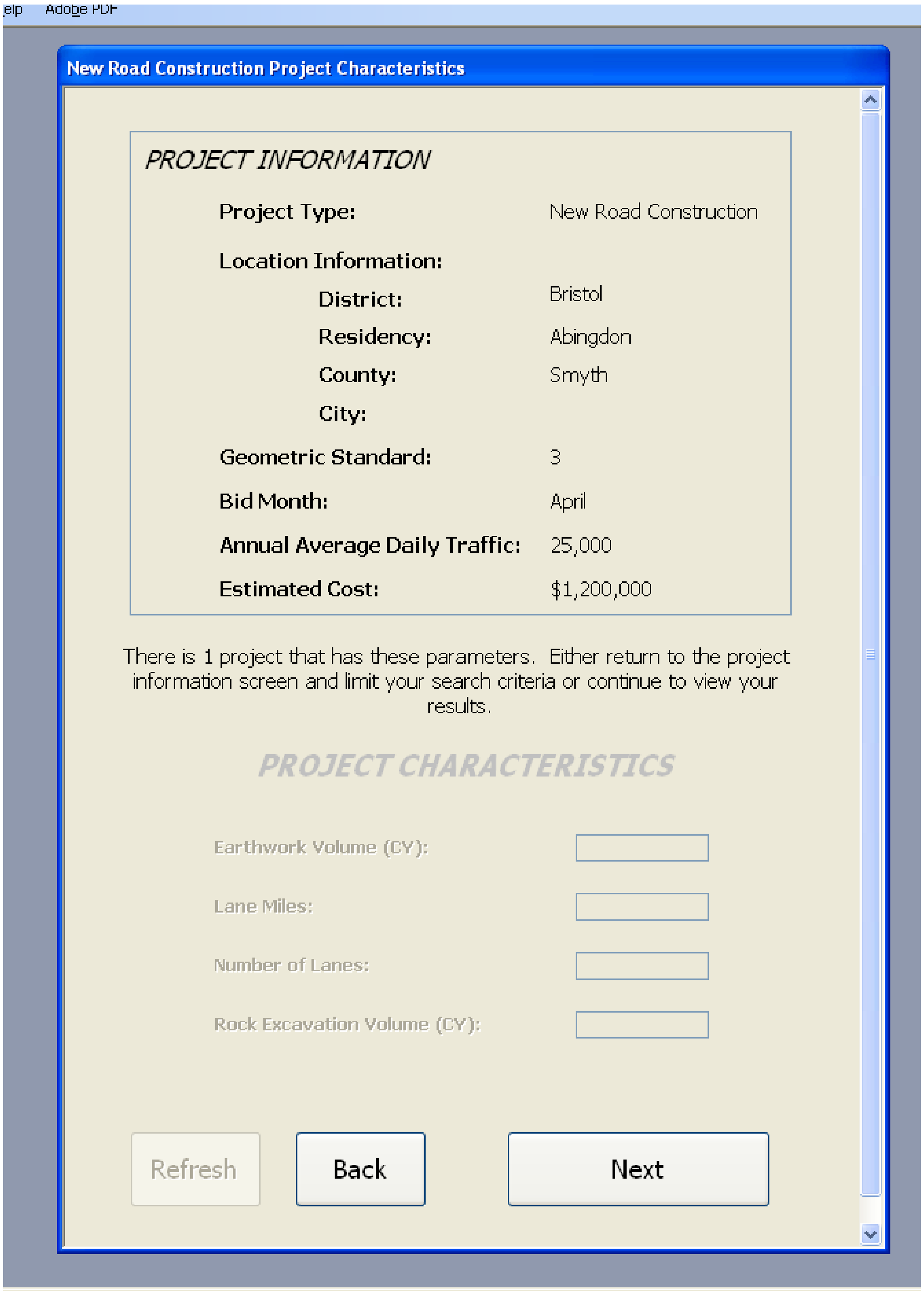

Figure 8.3 – Project Characteristics Query Form (One Match)

4. Notice the features of this form. A Project Information Summary is included at the top of the form. This information should be reviewed for accuracy. If information is incorrect, **Return** to the Project Information query form and correct any errors by **Clicking "Back"**. Also, this form shows the number of projects contained in the database having similar Project Information.

    a. If **NO** projects have similar information parameters, you **WILL NOT** be able to supply additional Project Characteristics or continue to the output steps (Figure 8.4 below).
    b. If **ONE** project has similar information parameters, you will not be able to supply additional Project Characteristics, but will be able to continue to the output steps (Figure 8.3 above)
    c. If **TWO** or **MORE** projects have similar information parameters, you will be able to supply additional Project Characteristics to further narrow your search or continue on to the output steps (Figure 8.5 below).

5. The amount of data returned can be significantly increased by reducing the amount of Project Information and Characteristics input on these forms. As queries become more specific, the potential for months and seasons without bid item production data is increased.

6. Once the Project Characteristics Form has been completed, you may continue on to the Select Results Form by **Clicking "Next"**. See Part 9 for output instructions.

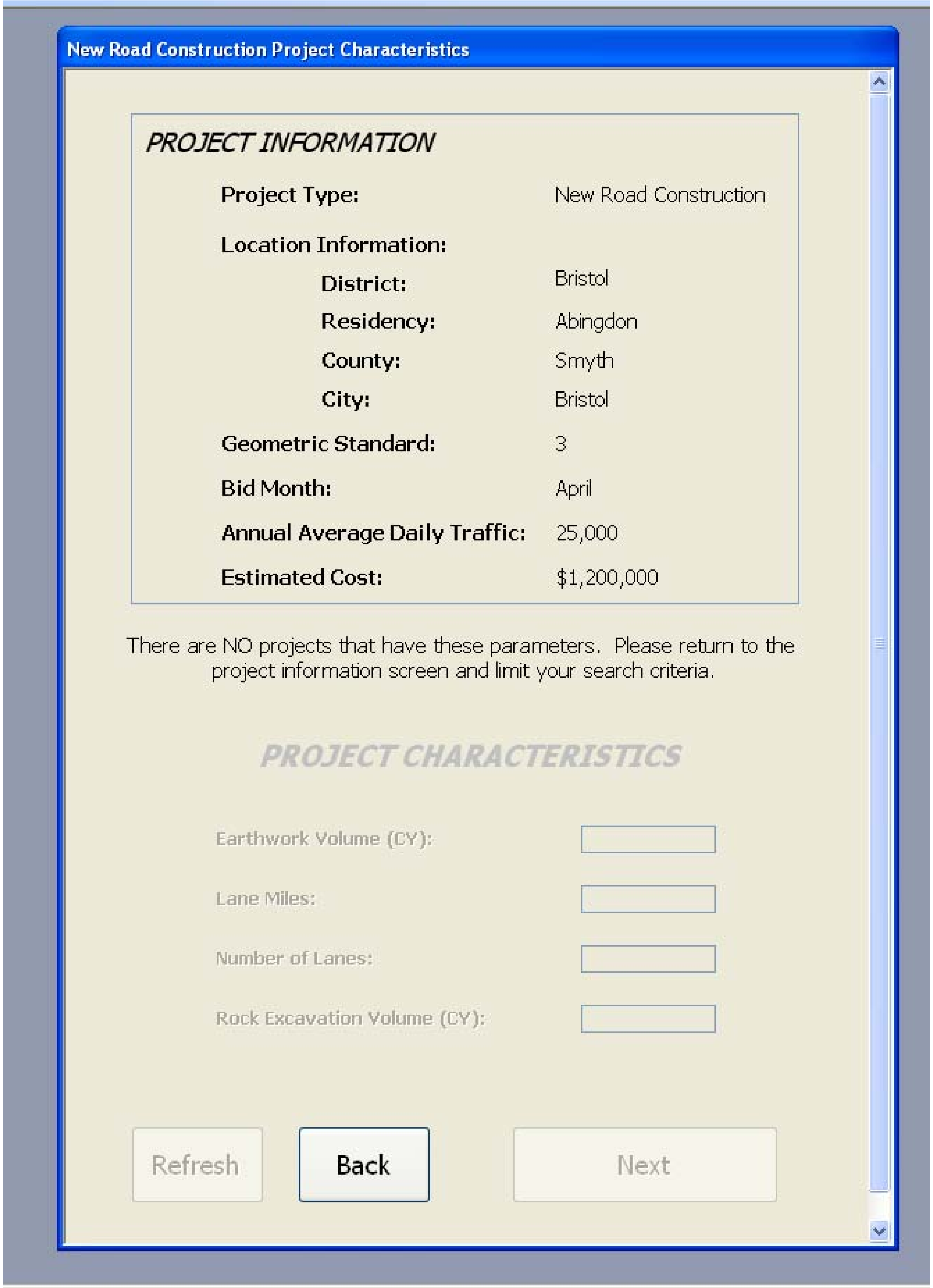

Figure 8.4 – Project Characteristics Form (No Matches)

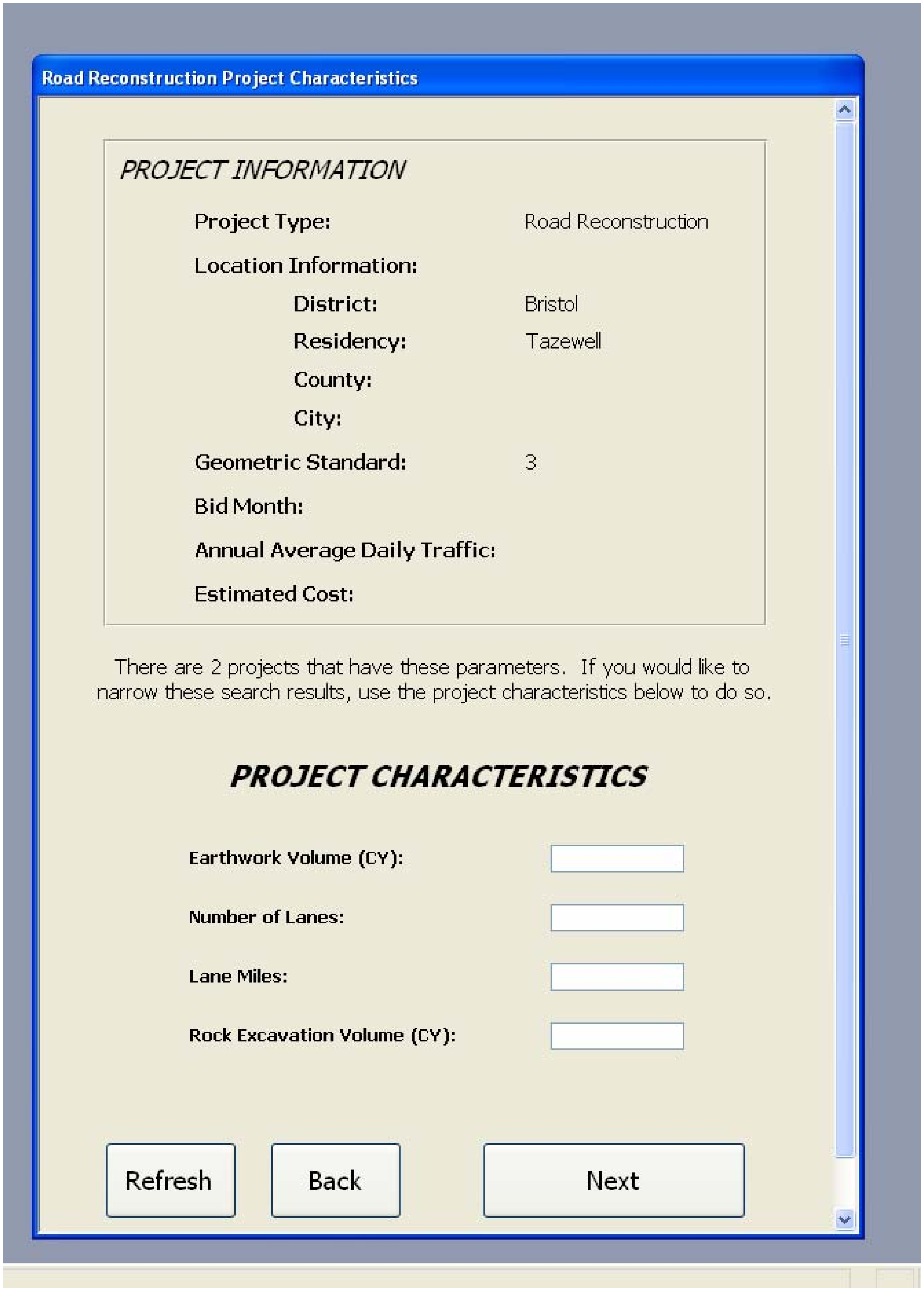

Figure 8.5 – Project Characteristics Form (Two or More Matches)

Part 9 – Data Output Process

9.1 BIDDS Output Options

Once *BIDDS* has been queried for similar projects, the user may view data in two formats: tabular or graphical. **Tabular views** are MS *Excel* pivot tables that summarize data in a number of ways. These pivot tables have been pre-formatted to demonstrate data in a useful manner. **Graphical views** are MS *Excel* plots that visually depict production data trends between time, quantity, and frequency.

These viewing formats are summarized four ways:

A. **Monthly Production Rate Summary –** Bid item production data presented in a manner that demonstrates production trends throughout the year, on a month-by-month basis. In addition, this option allows the user to see during which months bid items are used and a range of production rates for these months. This data is available in the tabular and graphical formats.

B. **Seasonal Production Rate Summary –** Bid item production data presented in a manner that demonstrates production trends throughout the year, on a season-by-season basis. In addition, this option allows the user to see during which seasons bid items are used and a range of production rates for these seasons. This option is useful when the user does not know the specific month in which a bid item will be installed. This data is available in the tabular and graphical formats.

C. **Project Production Rate Summary –** Bid item production data presented in a manner that demonstrates production trends across projects in which bid items are used. This option allows the user to see the projects for which a bid item is used, the total quantity used, the total number of days work was performed for these bid items, and an average daily production rate for the entire project. This data is available in the tabular and graphical formats.

D. **Bid Item Usage Summary** – Bid item production data presented in a manner that demonstrates key information for each bid item used in the projects queried. This information includes minimum, maximum, and average production rates, number of records (months used), minimum, maximum, average, and total quantity used for each bid item. This data is only available in the tabular format.

To query *BIDDS* for project similar to your own, please see Part 8 (Querying for Production Data). Once this process is completed, you are now ready to explore the various data viewing formats of *BIDDS*.

Section 9.2 discusses the tabular views, while Section 9.3 describes the various graphical views.

To begin the data output process:

1. From the Project Characteristics Form, **Click "Next"**. This will open the Select Results Form seen below (Figure 9.1).

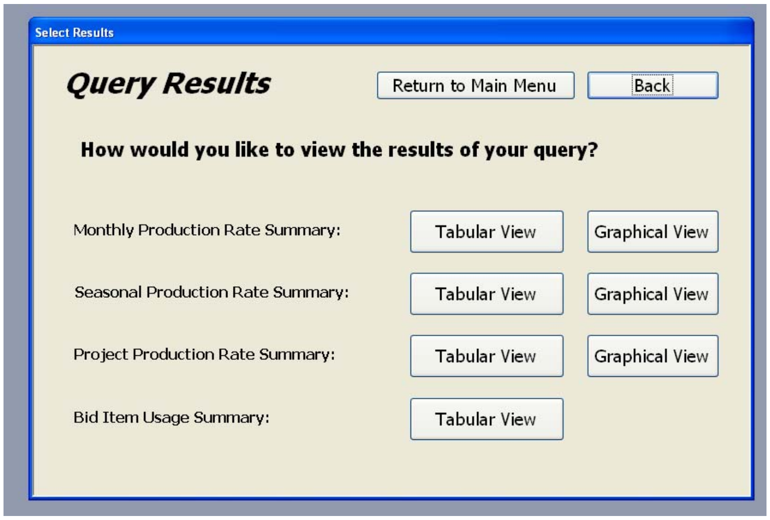

Figure 9.1 – Select Results Form

2. On this form, the various data summaries and output formats can be seen. If you would like to revise the project information or characteristics supplied, **Click "Back"**. Also, you may **Return to the Main Menu** to reset Project

Information and Characteristics or begin a new production rate query. Otherwise, you are now ready to navigate through the output process.

9.2 Tabular Data Views

Production data can be viewed in the tabular format for ALL summary options. Tabular views are MS *Excel* **Pivot Tables** that allow data summarization in a number of ways. Below, each tabular output summary is shown.

9.2.1 Monthly Production Rate Summary

To access the *Monthly Production Rate Summary* tabular view:

1. From the Select Results Form, **Click "Tabular View"** to the Right of the caption. Below is a screenshot from the pivot table.

2. To **Close** this view, **Click** the **Close Window ""** button in the upper-right hand corner of the *Excel* Application. You will be asked if you would like to save this application.

3. If you would like to save the file, you will be asked to rename the file and browse to the folder in which to save. Please **DO NOT** save these files in the *BIDDS* folder. Doing so may lead to confusion later on. It is recommended that a separate folder be created so that personalized results may be stored.

Bid Item	Description	Units	Month Performed	Minimum Production	Average Production	Maximum Production
12600	STD. COMB. CURB & GUTTER CG-6	LF	January	617.0	654.3	696.7
			February	491.7	618.8	680.6
			March	520.3	575.2	639.8
			April	572.3	621.6	654.0
			May	588.8	601.7	609.1
			June	511.0	661.6	727.7
			July	652.0	652.0	652.0
			August	588.7	633.0	684.8
			September	526.0	635.5	721.5
			October	548.5	642.8	704.4
			November	614.1	644.8	675.5
			December	517.5	603.1	685.8
13320	GUARDRAIL GR-2	LF	January	652.0	1100.3	1254.0
			February	1192.5	1349.3	1684.0
			March	655.0	972.0	1111.5
			April	925.0	1427.5	1962.0
			May	1051.5	1323.6	1505.5
			June	591.0	1137.9	1489.0
			July	1107.5	1366.0	1602.5
			August	1248.0	1285.8	1307.5
			September	990.0	1273.9	1417.5
			October	647.0	988.1	1206.0
			November	716.0	1165.2	1774.0
			December	590.0	1011.6	1659.0
13331	RAD. GUARDRAIL GR-2	LF	January	12.0	226.0	517.0

Figure 9.2 – Monthly Production Rate Summary Tabular View

9.2.2 Seasonal Production Rate Summary

To access the *Seasonal Production Rate Summary* tabular view:

1. From the Select Results Form, **Click "Tabular View"** to the Right of the caption. Below is a screenshot from the pivot table.

2. To **Close** this view, **Click** the **Close Window ""** button in the upper-right hand corner of the *Excel* Application. You will be asked if you would like to save this application.

3. If you would like to save the file, you will be asked to rename the file and browse to the folder in which to save. Please **DO NOT** save these files in the *BIDDS* folder. Doing so may lead to confusion later on. It is recommended that a separate folder be created so that personalized results may be stored.

A	B	C	D	E	F	G	H
				Season			
Bid Item Number	Description	Units	Data	Spring	Summer	Fall	Winter
12600	STD. COMB. CURB & GUTTER CG-6	LF	Minimum Production Rate	536.3	588.7	526.0	513.3
			Maximum Production Rate	654.0	705.8	721.5	695.0
			Average Production Rate	601.3	657.4	640.8	631.3
			Number of Months Performed	9	9	9	12
			Total Quantity Installed	34452	46097	40762	65850
13320	GUARDRAIL GR-2	LF	Minimum Production Rate	925.0	916.5	661.0	624.0
			Maximum Production Rate	1674.0	1668.0	1501.0	1659.0
			Average Production Rate	1271.9	1296.1	1133.1	1157.8
			Number of Months Performed	15	17	23	23
			Total Quantity Installed	27931	38665	42132	35047
13331	RAD. GUARDRAIL GR-2	LF	Minimum Production Rate	10.0	12.0	72.0	12.0
			Maximum Production Rate	448.0	403.0	452.0	459.0
			Average Production Rate	143.8	207.5	268.1	189.5
			Number of Months Performed	16	14	17	18
			Total Quantity Installed	2300	2905	4557	3411

Figure 9.3 – Seasonal Production Rate Summary Tabular View

9.2.3 Project Production Rate Summary

To access the *Project Production Rate Summary* tabular view:

1. From the Select Results Form, **Click “Tabular View”** to the Right of the caption. Below is a screenshot from the pivot table.

2. To **Close** this view, **Click** the **Close Window “”** button in the upper-right hand corner of the *Excel* Application. You will be asked if you would like to save this application.
3. If you would like to save the file, you will be asked to rename the file and browse to the folder in which to save. Please **DO NOT** save these files in the *BIDDS* folder. Doing so may lead to confusion later on. It is recommended that a separate folder be created so that personalized results may be stored.

Bid Item Number	Description	Units	Project Number	Total Quantity Installed	Avg. Daily Production Rate
12600	STD. COMB. CURB & GUTTER CG-6	LF	SD 0131	6913.0	628.5
			SD 0132	1818.0	606.0
			SD 0140	4469.0	638.4
			SD 0141	6055.0	672.8
			SD 0142	1609.0	536.3
			SD 0151	6371.0	637.1
			SD 0152	1766.0	588.7
			SD 0160	4609.0	658.4
			SD 0161	6804.0	680.4
			SD 0162	1933.0	644.3
			SD 0170	4913.0	614.1
			SD 0171	6477.0	588.8
			SD 0172	2194.0	548.5
			SD 0180	4264.0	609.1
			SD 0181	7287.0	607.2
			SD 0182	2081.0	520.2
			SD 0190	4612.0	658.9
			SD 0191	6968.0	633.5
			SD 0192	2070.0	517.5
			SD 0200	5164.0	645.5
			SD 0201	7664.0	696.7
			SD 0202	1962.0	654.0
			SD 0210	5445.0	680.6
			SD 0211	8656.0	665.8
			SD 0212	1717.0	572.3
			SD 0220	4661.0	665.9
			SD 0230	4411.0	630.1
			SD 0231	8902.0	684.8
			SD 0241	9829.0	702.1
			SD 0250	4170.0	695.0
			SD 0251	10566.0	704.4
			SD 0252	1578.0	526.0
			SD 0260	3839.0	639.8
			SD 0261	10287.0	685.8
			SD 0262	1351.0	675.5
			SD 0270	3279.0	655.8
			SD 0271	9255.0	617.0
			SD 0272	1304.0	652.0
			SD 0280	2828.0	565.6
13320	GUARDRAIL GR-2	LF	SD 0131	2264.0	1132.0
			SD 0132	1050.0	1050.0
			SD 0133	2685.0	1342.5

Figure 9.4 – Project Production Rate Summary Tabular View

9.2.4 Bid Item Usage Summary

To access the *Bid Item Usage Summary* tabular view:

1. From the Select Results Form, **Click "Tabular View"** to the Right of the caption. Below is a screenshot from the pivot table.

2. To **Close** this view, **Click** the **Close Window ""** button in the upper-right hand corner of the *Excel* Application. You will be asked if you would like to save this application.

3. If you would like to save the file, you will be asked to rename the file and browse to the folder in which to save. Please **DO NOT** save these files in the *BIDDS* folder. Doing so may lead to confusion later on. It

is recommended that a separate folder be created so that personalized results may be stored.

Bid Item Number	Description	Units	Data	Total
12600	STD. COMB. CURB & GUTTER CG-6	LF	Minimum Daily Production Rate	517.5
			Maximum Daily Production Rate	704.4
			Average Daily Production Rate	630.9
			Number of Months Performed	39
			Minimum Quantity Installed	1304.0
			Maximum Quantity Installed	10566.0
			Average Quantity Installed	4873.9
			Total Quantity Installed	190081
13320	GUARDRAIL GR-2	LF	Minimum Daily Production Rate	645.0
			Maximum Daily Production Rate	1684.0
			Average Daily Production Rate	1202.1
			Number of Months Performed	80
			Minimum Quantity Installed	645.0
			Maximum Quantity Installed	3336.0
			Average Quantity Installed	1826.7
			Total Quantity Installed	146137
13331	RAD. GUARDRAIL GR-2	LF	Minimum Daily Production Rate	11.0
			Maximum Daily Production Rate	477.0
			Average Daily Production Rate	203.9
			Number of Months Performed	67
			Minimum Quantity Installed	11.0
			Maximum Quantity Installed	477.0
			Average Quantity Installed	203.9
			Total Quantity Installed	13664

Figure 9.5 – Bid Item Usage Summary Tabular View

9.3 Graphical Data Views

To represent data visually, *BIDDS* offers graphical data summaries. These summaries are available when **TWO OR MORE** similar projects are returned through the project information and characteristics queries. If less than two similar projects are found, you will only be able to view production data in the tabular summary formats. Production data can be viewed graphically for **THREE** summary options:

1. Monthly Production Rate Summary
2. Seasonal Production Rate Summary
3. Project Production Rate Summary

9.3.1 Monthly Production Rate Summary

The *Monthly Production Rate Summary* graphical view is presented as a Box Plot, depicting the minimum, maximum, and average production rate for each bid item returned by query.

To view the *Monthly Production Rate Summary* plot:

1. From the Select Results Form, **Click "Graphical View"** to the Right of the caption.

2. Next, the Graphical Data View form opens, asking you to select which plot type you would like to view (Figure 9.6). (For Monthly and Seasonal summaries, only the Time vs. Production plot is viewable.)

3. When clicked, *BIDDS* calls an application of MS *Excel* and the Graphical Views file installed with during *BIDDS* installation (Figure 9.7).

4. In MS *Excel*, a separate plot for each bid item containing production data is returned. To navigate through these plots, **Click** the **Tabs**

along the bottom of the plot. Each tab is labeled with the **Bid Item Number**.

5. If **insufficient data** is available for any bid item, you will receive a message alerting you to this fact, and suggesting that you **view the other output options for more information**. Figure 9.8 (below) is a demonstration of such a message.

6. To **Close** this view, **Click** the **Close Window** **“ ”** button in the upper-right hand corner of the *Excel* Application. You will be asked if you would like to save this application.

7. If you would like to save the file, you will be asked to rename the file and browse to the folder in which to save. Please **DO NOT** save these files in the *BIDDS* folder. Doing so may lead to confusion later on. It is recommended that a separate folder be created so that personalized results may be stored.

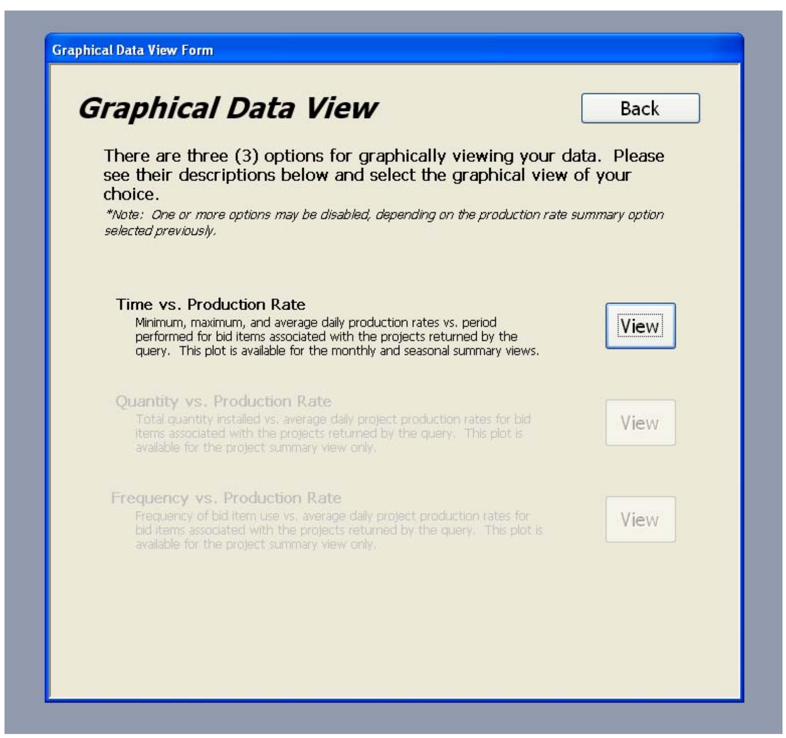

Figure 9.6 – Graphical Data View Form (Monthly / Seasonal Summaries)

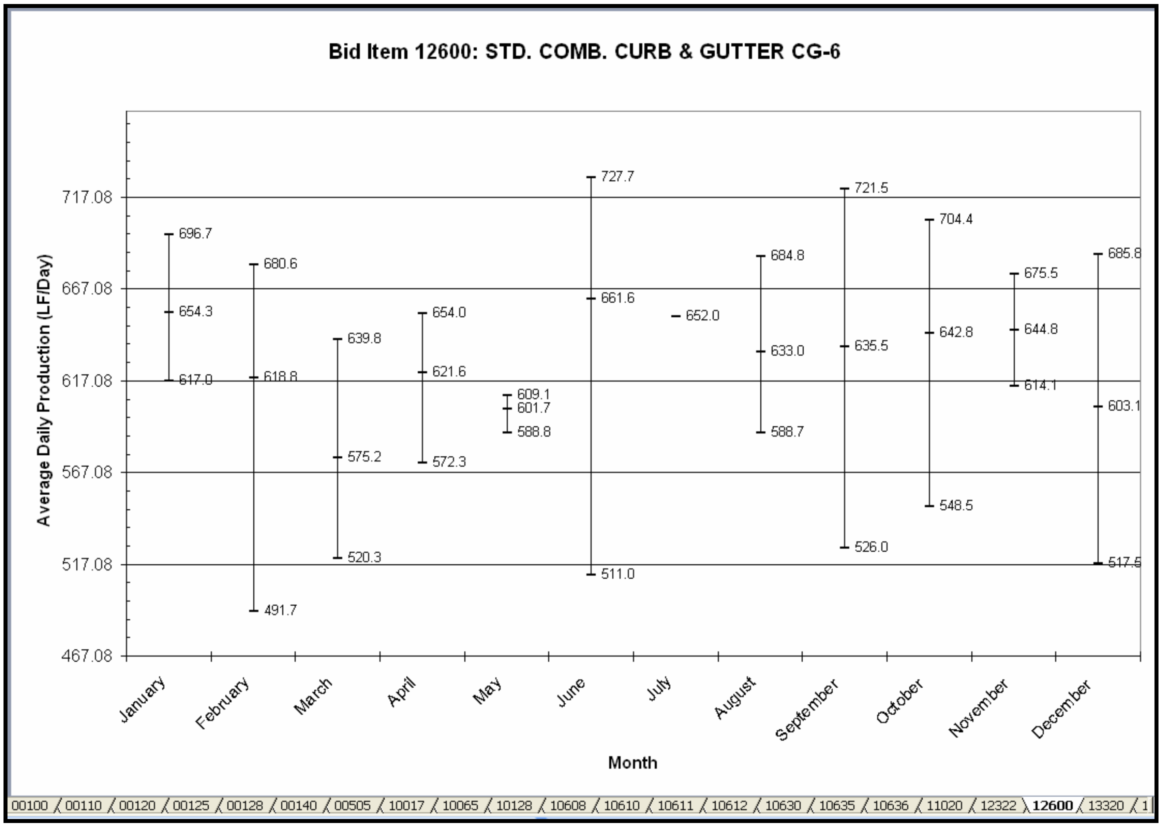

Figure 9.7 – Monthly Production Rate Summary Graphical View

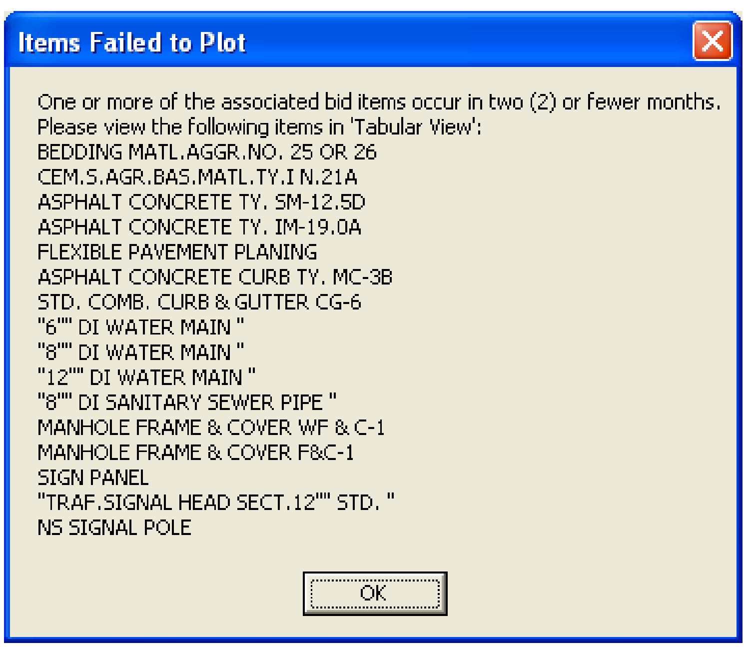

Figure 9.8 – Insufficient Data Warning

9.3.2 Seasonal Production Rate Summary

The *Seasonal Production Rate Summary* graphical view is presented as a Box Plot, depicting the minimum, maximum, and average production rate for each bid item returned by query.

To view the *Seasonal Production Rate Summary* plot:

1. From the Select Results Form, **Click "Graphical View"** to the Right of the caption.

2. Next, the Graphical Data View form opens, asking you to select which plot type you would like to view (Figure 9.9). (For Monthly and Seasonal summaries, only the Time vs. Production plot is viewable.)

3. When clicked, *BIDDS* calls an application of MS *Excel* and the Graphical Views file installed with during *BIDDS* installation (Figure 9.10).

4. In MS *Excel*, a separate plot for each bid item containing production data is returned. To navigate through these plots, **Click** the **Tabs** along the bottom of the plot. Each tab is labeled with the **Bid Item Number**.

5. If **insufficient data** is available for any bid item, you will receive a message alerting you to this fact, and suggesting that you **view the other output options for more information**. Figure 9.8 (above) is a demonstration of such a message.

6. To **Close** this view, **Click** the **Close Window ""** button in the upper-right hand corner of the *Excel* Application. You will be asked if you would like to save this application.
7. If you would like to save the file, you will be asked to rename the file and browse to the folder in which to save. Please **DO NOT** save these

files in the *BIDDS* folder. Doing so may lead to confusion later on. It is recommended that a separate folder be created so that personalized results may be stored.

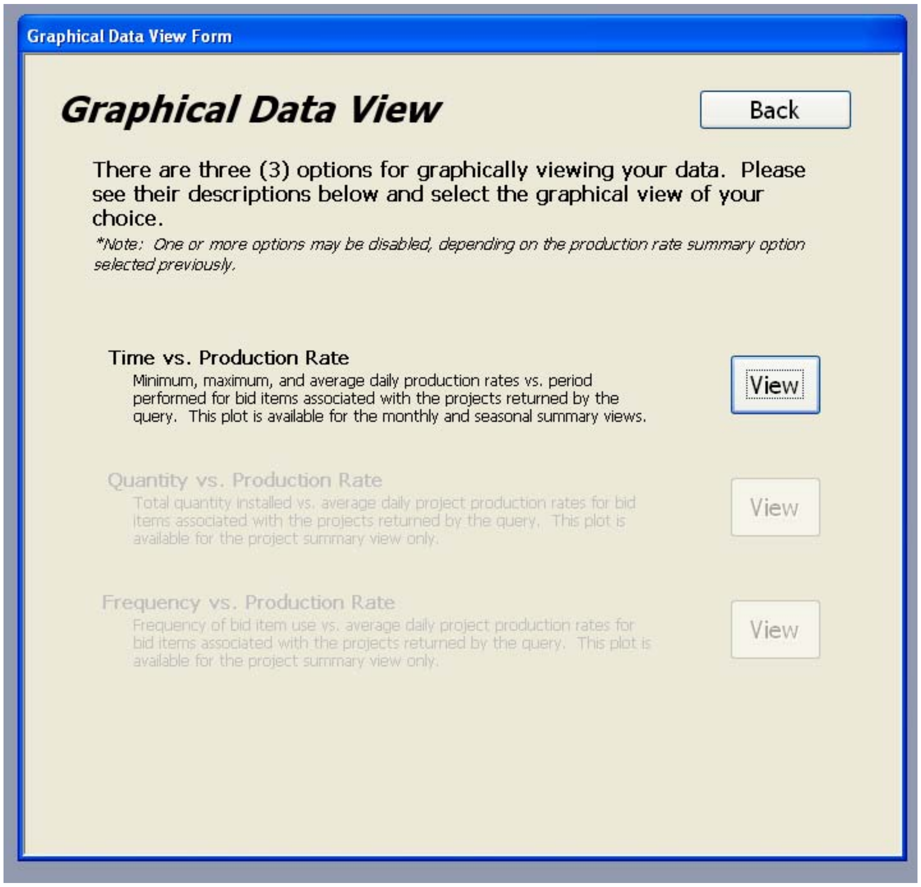

Figure 9.9 – Graphical Data View Form (Seasonal Summary)

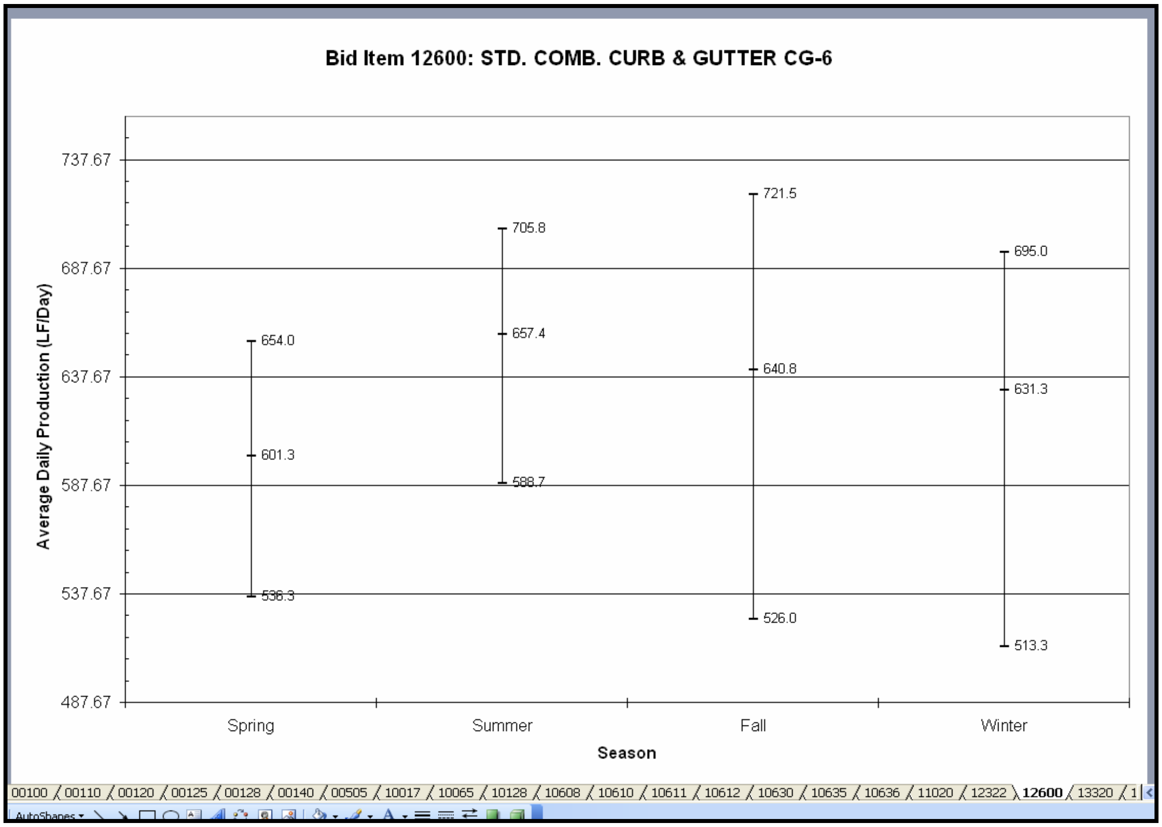

Figure 9.10 – Seasonal Production Rate Summary Graphical View

9.3.3 Project Production Rate Summary

The *Project Production Rate Summary* may be presented in two ways:

1. **Quantity vs. Production Scatter Plots**, showing trends between production rate and the quantity installed. See Section 9.3.3.1.

2. **Production Rate Frequency Histogram**, showing the most commonly occurring production figures. See Section 9.3.3.2.

9.3.3.1 Quantity vs. Production Scatter Plots

The Quantity vs. Production Scatter Plots demonstrate trends existing between the bid item quantity installed and the average daily production rate occurring for each project returned.

To view the *Quantity vs. Production Rate Summary* plot:

1. From the Select Results Form, **Click "Graphical View"** to the Right of the caption.

2. Next, the Graphical Data View form opens, asking you to select which plot type you would like to view (Figure 9.11). (For Project summaries, the Time vs. Production plot is not viewable.)

3. When clicked, *BIDDS* calls an application of MS *Excel* and the Graphical Views file installed with during *BIDDS* installation (Figure 9.12).

4. In MS *Excel*, a separate plot for each bid item containing production data is returned. To navigate through these plots, **Click** the **Tabs** along the bottom of the plot. Each tab is labeled with the **Bid Item Number**.

5. To **Close** this view, **Click** the **Close Window ""** button in the upper-right hand corner of the *Excel* Application. You will be asked if you would like to save this application.

6. If you would like to save the file, you will be asked to rename the file and browse to the folder in which to save. Please **DO NOT** save these files in the *BIDDS* folder. Doing so may lead to confusion later on. It is recommended that a separate folder be created so that personalized results may be stored.

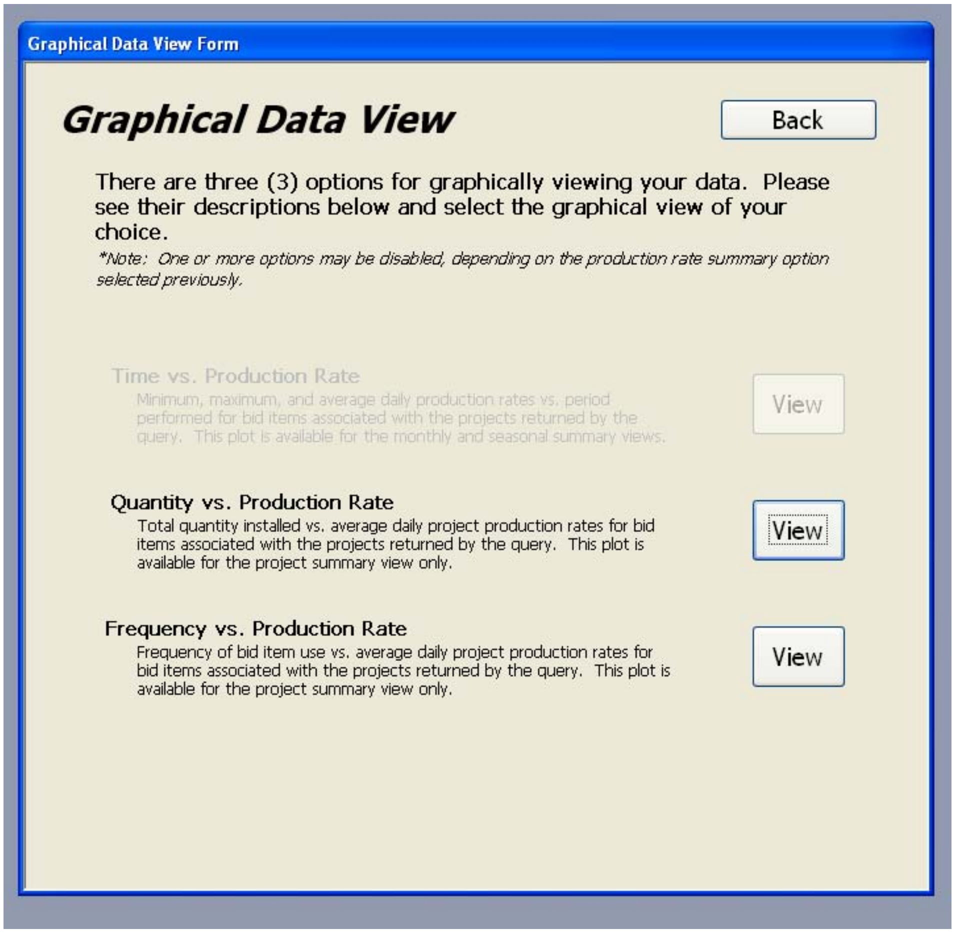

Figure 9.11 – Graphical Data View Form (Project Summaries)

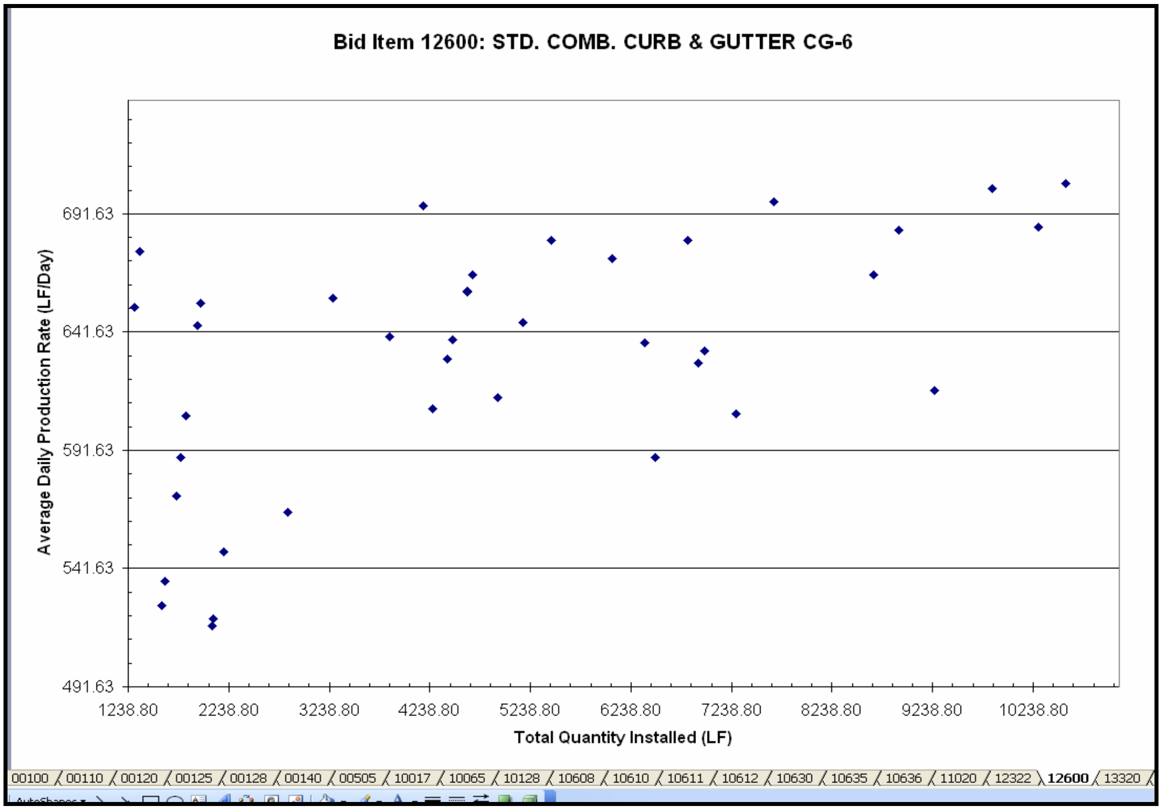

Figure 9.12 – Quantity vs. Production Scatter Plot (Project Summary)

9.3.3.2 Production Rate Frequency Histograms

The Production Rate Frequency Histograms show the outline the most commonly occurring production rates found, for each bid item, on each project returned by the query.

To view the *Production Rate Frequency Histogram:*

1. From the Select Results Form, **Click "Graphical View"** to the Right of the caption.

2. Next, the Graphical Data View form opens, asking you to select which plot type you would like to view (Figure 9.11). (For Project summaries, the Time vs. Production plot is not viewable.)

3. When clicked, *BIDDS* calls an application of MS *Excel* and the Graphical Views file installed with during *BIDDS* installation (Figure 9.13).

4. In MS *Excel*, a separate plot for each bid item containing production data is returned. To navigate through these plots, **Click** the **Tabs** along the bottom of the plot. Each tab is labeled with the **Bid Item Number**.

5. To **Close** this view, **Click** the **Close Window “”** button in the upper-right hand corner of the *Excel* Application. You will be asked if you would like to save this application.

6. If you would like to save the file, you will be asked to rename the file and browse to the folder in which to save. Please **DO NOT** save these files in the *BIDDS* folder. Doing so may lead to confusion later on. It is recommended that a separate folder be created so that personalized results may be stored.

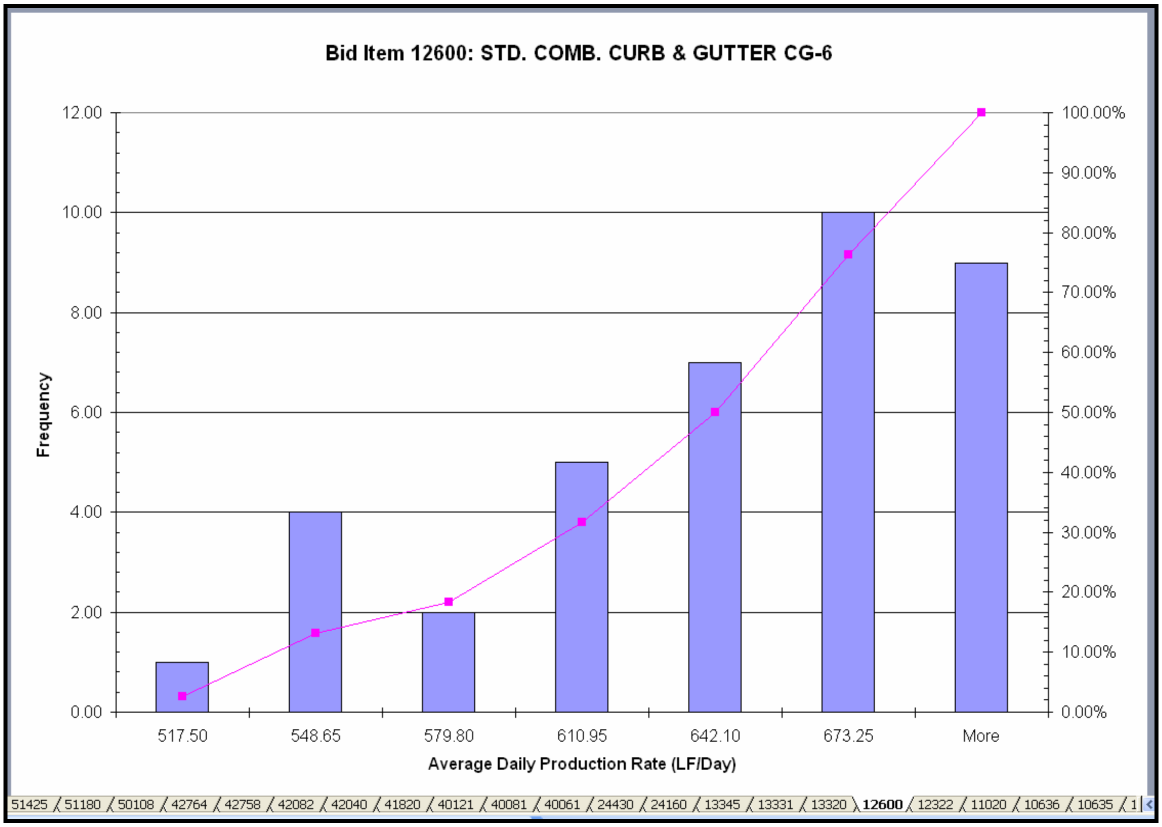

Figure 9.13 – Production Rate Frequency Histogram

Part 10 – Exiting *BIDDS*

Once you are finished using *BIDDS*, you may exit the application by navigating back to the **Main Menu** and **Clicking "Exit *BIDDS*"**. This will close *BIDDS* and the current Microsoft *Access* application.

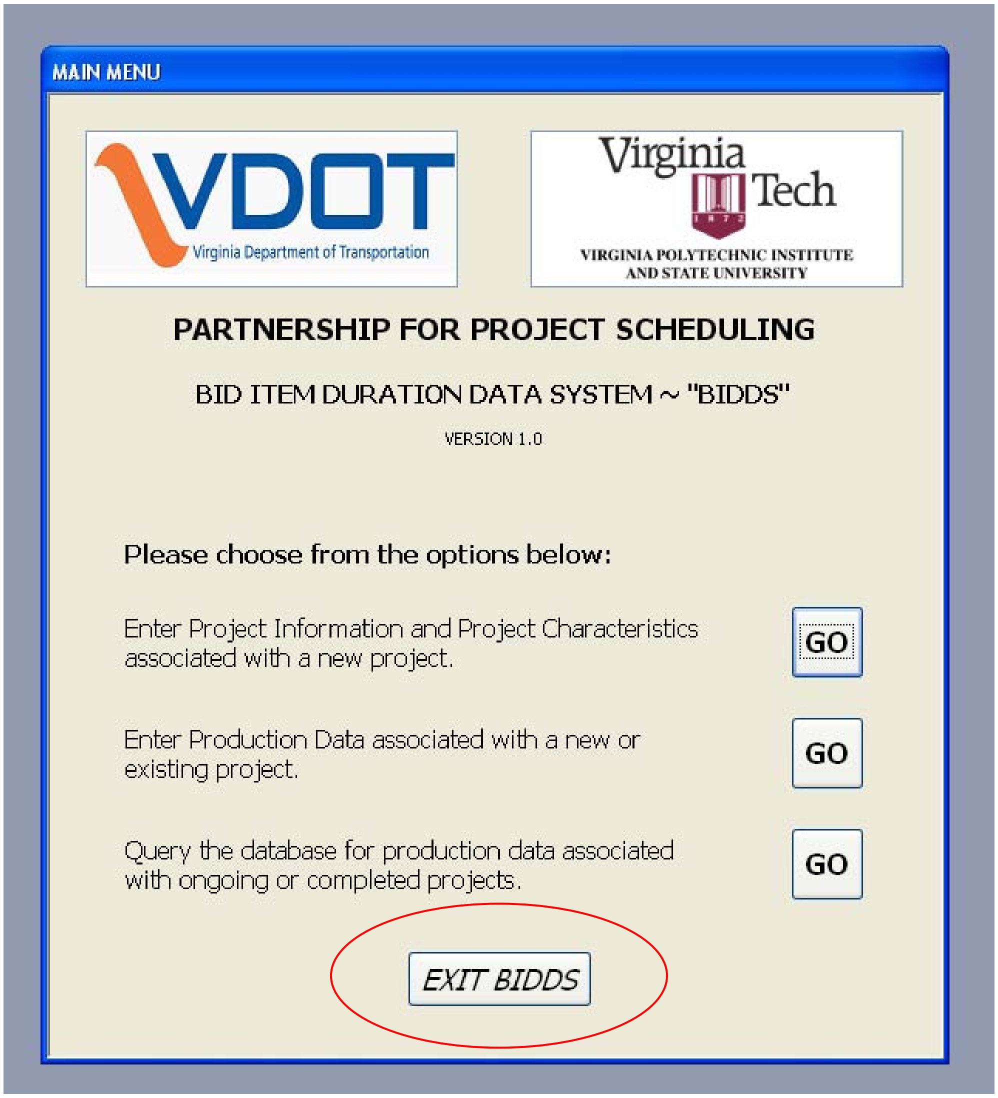

Figure 10.1 – Exiting *BIDDS* from the Main Menu

Appendix D– *BIDDS* Example

BIDDS Example

Note: All data represented as an output of *BIDDS* in this example is synthesized data and is not to be used as historical field data.

Objective:

Use *BIDDS* to search for and retrieve a production rate estimate for Borrow Excavation (bid item 00140). This production rate should be based on historical data from projects similar to the one being scheduled. Confirm the production rate data returned by *BIDDS* using the historical data provided.

Background:

The design process of a Road Reconstruction project has just completed the Field Inspection meeting and is moving toward design completion and project advertisement. Before advertising the project, VDOT must prepare a contract time estimate. One of the activities that must be considered involves the excavation of material from a borrow site located near the project.

In addition to project type, the factors expected to influence the pace of work are its location (Salem District) and estimated cost ($2,600,000). The 2-lane roadway is currently operating at a satisfactory level of service. Therefore, no lane additions will be made to the roadway.

While the project advertisement date is known, the VDOT estimator is not sure whether the contractor will perform the necessary excavation in the coming Spring or Summer. That fact will not be determined until project award.

A production rate estimate for Borrow Excavation (bid item 00140) is needed in order to calculate the duration of the borrow site excavation activity.

***BIDDS* Solution:**

First, *BIDDS* will be used to retrieve historical, bid item level production data for Borrow Excavation (bid item 00140). To understand the trends in production with time as well as the range of values, both the tabular and graphical seasonal summary views will be used. There are a few short steps involved with using *BIDDS*:

1. Input Project Information about the project being scheduled. For this example, these parameters include:
   a. Project Type – Road Reconstruction
   b. Project District – Salem
   c. Estimated Project Cost - $2,600,000

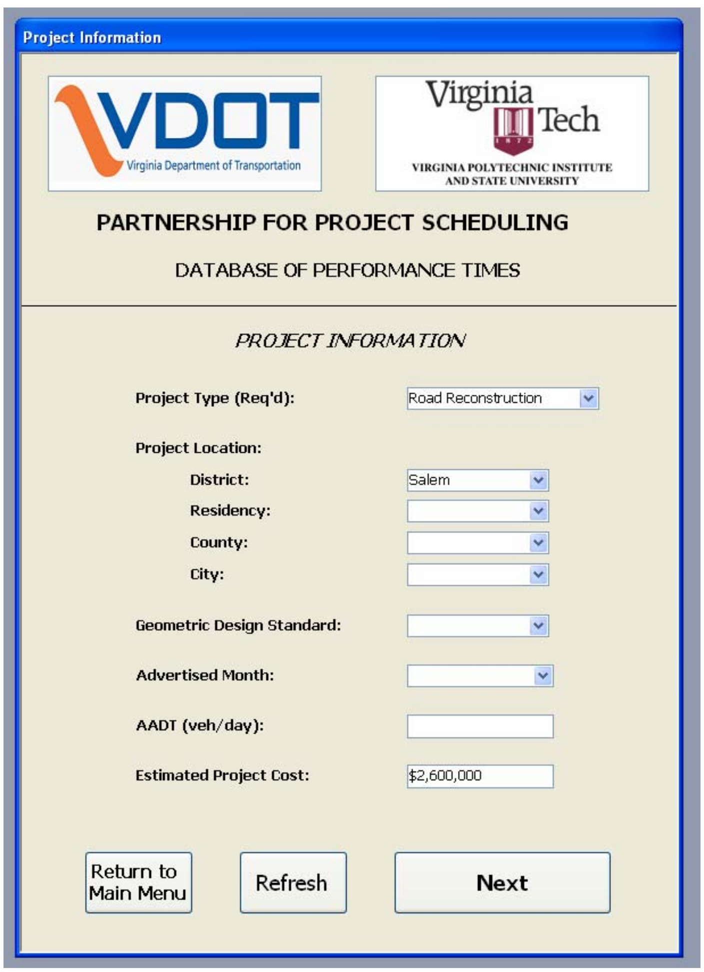

Figure 1 - Project Information Input

2. Input Project Characteristics associated with the project being scheduled. For this example, these parameters include:
   a. Number of Lanes – 2

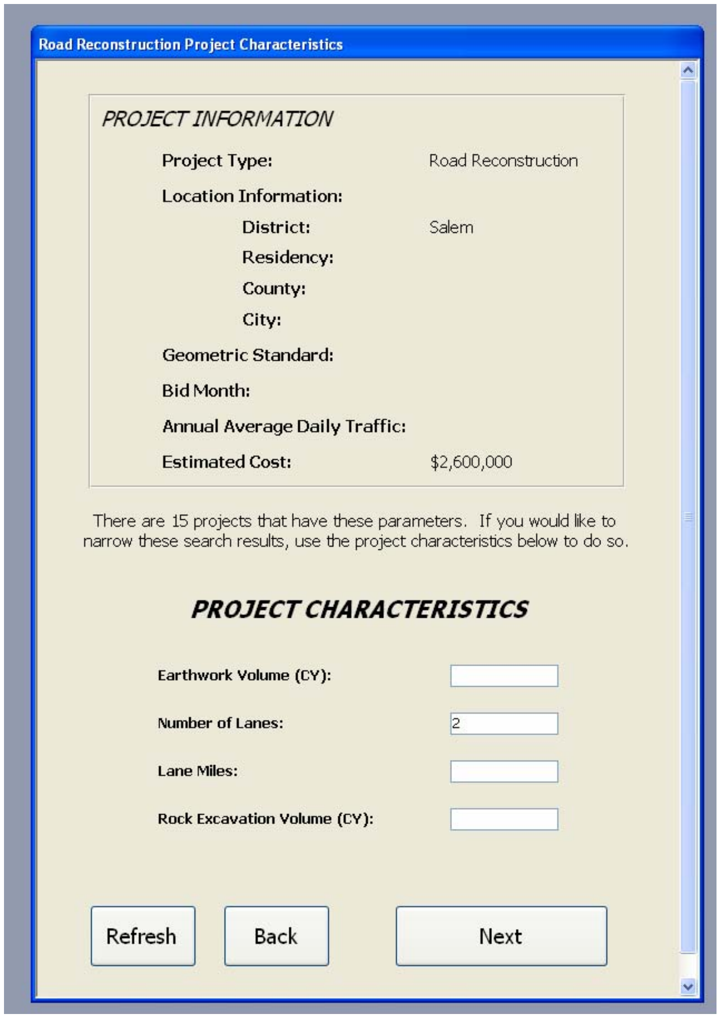

Figure 2 - Project Characteristics Input

Notice *BIDDS* offers the number of projects that have similar project information associated with them. For this example, there are 15 projects with similar project information parameters. This fact will be confirmed during the manual solution.

3. Select the Summary View and Output Format. There are a number of options available through *BIDDS* and all should be explored in order to understand the data. For this example, the Seasonal Production Rate Summary views will be used.

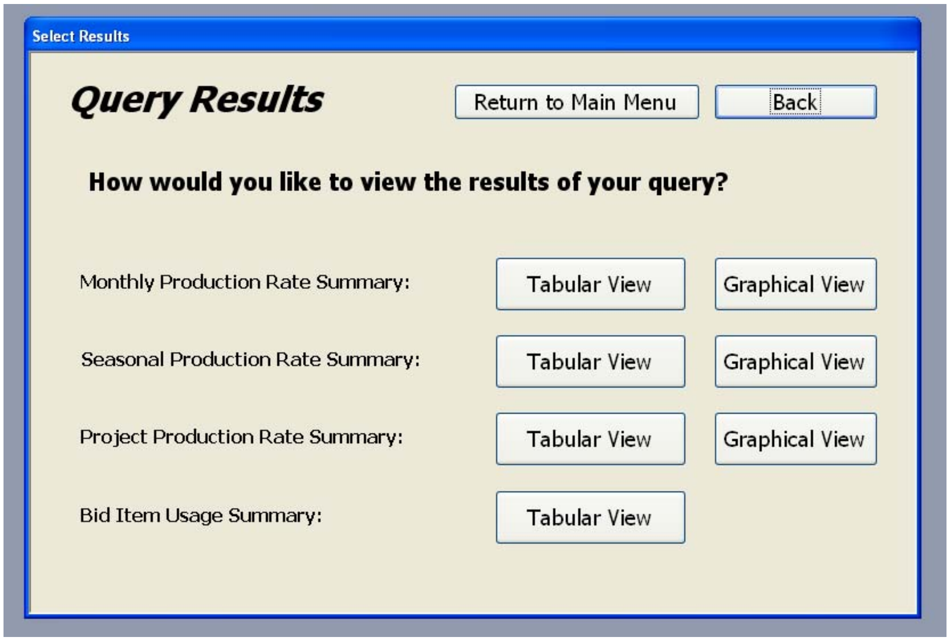

Figure 3 - Select Results Form

Selecting the Tabular View option for the Seasonal Production Rate Summary yields the following table. It is important to note that only a small portion of the actual table is presented. Please see *BIDDS* for other bid item production data.

				Season			
Bid Item Number	Description	Units	Data	Spring	Summer	Fall	Winter
00140	BORROW EXCAVATION	CY	Minimum Production Rate	633.4	503.4	419.9	486.0
			Maximum Production Rate	1424.3	1434.6	1465.2	1358.6
			Average Production Rate	1062.6	1011.5	940.9	821.3
			Number of Months Performed	23	20	17	11
			Total Quantity Installed	334796	290385	189940	103630

Figure 4 - Borrow Excavation Seasonal Data Summary (Tabular View)

To view the production data graphically, select the Graphical View option for the Seasonal Production Rate Summary. When selected, the form in Figure 5 will appear. For monthly and seasonal data views, only the Time vs. Production plot view is available. Selecting this option will yield the box plot in Figure 6.

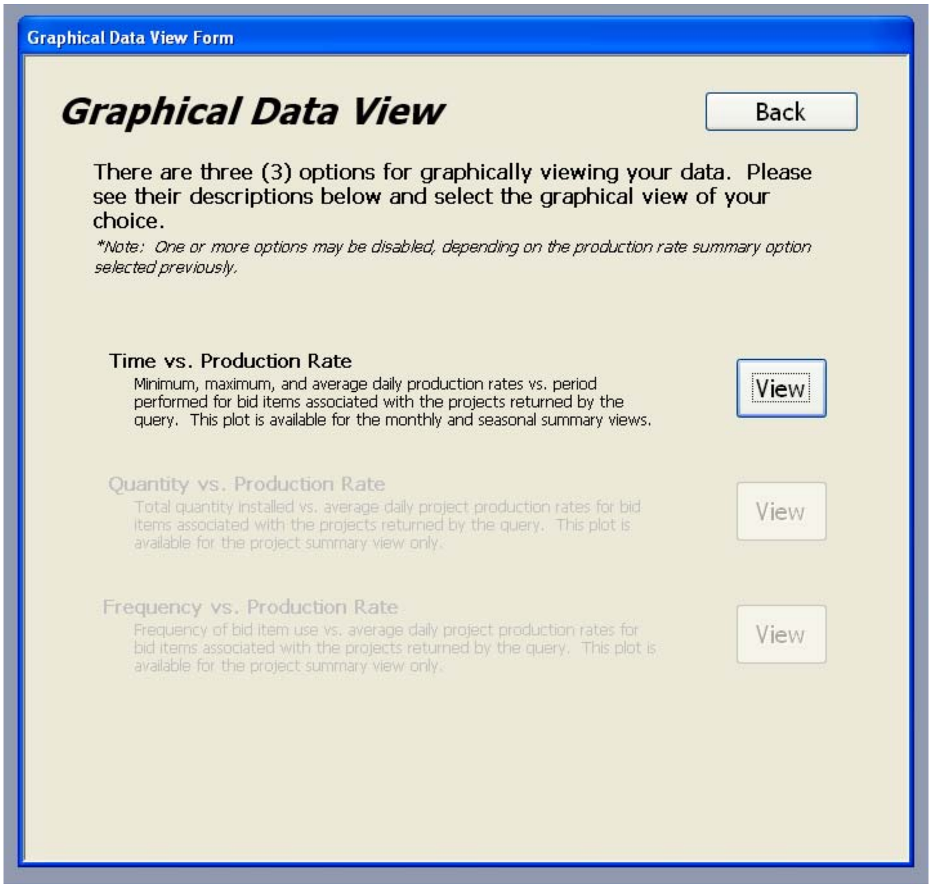

Figure 5 - Graphical Data View Form

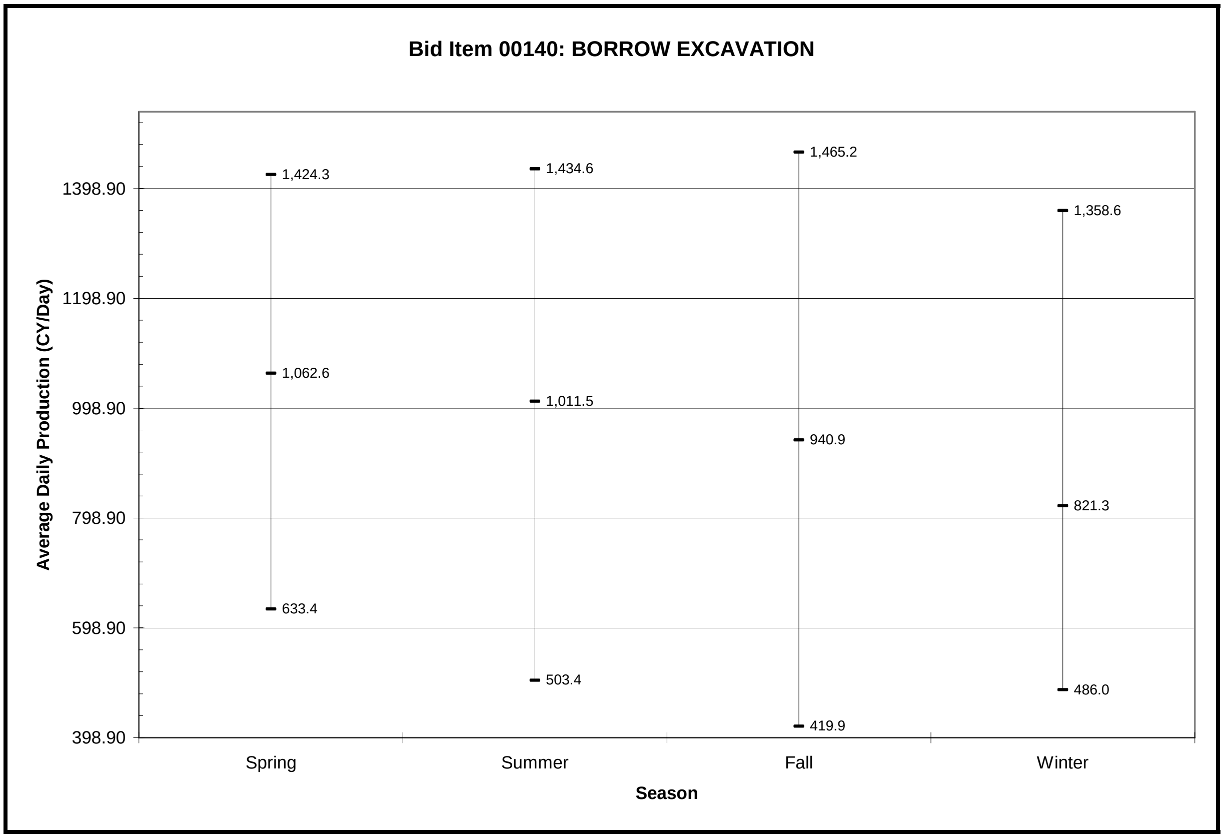

Figure 6 - Borrow Excavation Seasonal Summary Data (Graphical View)

Notice the production rates represented in Figure 4 and Figure 6 are identical. It is important to note, again, that the data represented is synthesized data for representation purposed only. The data represented in the above example is <u>not</u> for use as historical field data.

Figure 7 below shows the *BIDDS* input, query, and output processes for this instance. Notice how data available is refined or filtered three times before a concise list of bid item production data associated with projects having similar parameters to the one in question is compiled. After the final query or filter, production data is exported to the MS *Excel* templates where data is organized for viewing.

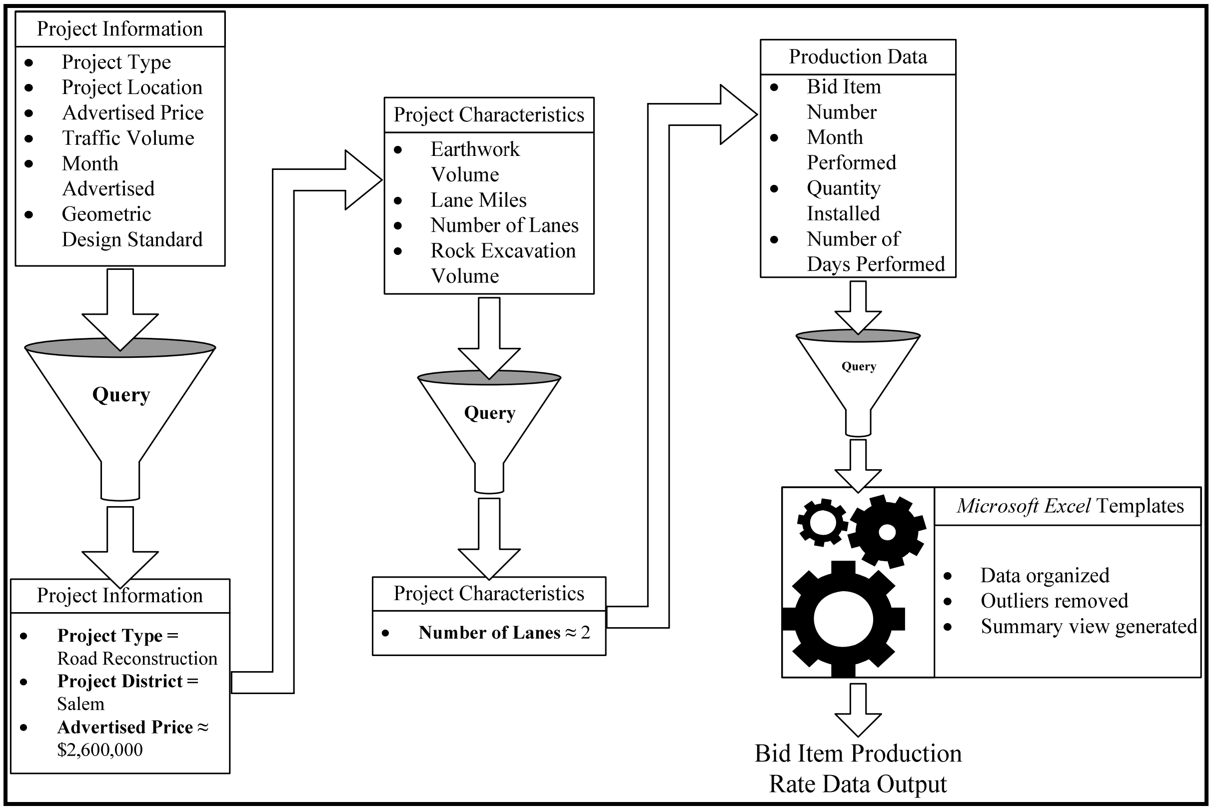

Figure 7 - *BIDDS* Input, Query, and Output Processes

Manual Solution:

The manual solution to this example uses synthesized data extracted from *BIDDS*. Microsoft *Excel* is used to organize the data for viewing purposes. This solution demonstrates the processes performed by *BIDDS* and confirms the data presented in the *BIDDS* solution above. Below, several steps outline the manual data search process.

1. Use the project information data provided in Figure 8 to filter and find the projects having similar project information. The project information parameters established earlier are:
    a. Project Type – Road Reconstruction
    b. Project District – Salem
    c. Estimated Project Cost – $2,600,000

To demonstrate the process of filtering and focusing on the similar project information, the data in Figure 8 has been sorted by Project Type, then District, then Award Price. This process yields 23 projects with the same type, 17 of those projects are within the Salem district, and only 15 of the project list are within 15% of the $2.6M estimated cost of the project being scheduled. The projects with similar project information parameters are bordered by the inner black box in Figure 8.

2. Use the project characteristics data provided in Figure 9 to find projects with similar project characteristics parameters as the project being scheduled. The project characteristic parameters established earlier are:
    a. Number of Lanes – 2

The projects with similar project information parameters are listed in Figure 9. The projects having similar project characteristics parameters (2 Lanes, ± 1 Lane) are bordered by the black box in Figure 9. Notice this process refines the list of projects to 10. These projects represent the projects completed by VDOT that have similar project information and characteristics parameters associated with them.

3. Once the list of projects with similar information and characteristics has been established, the production data table can be sorted, and bid item production data records for those projects extracted. In this instance, there is an interest in Borrow Excavation (bid item 00140). Therefore, only production data for that bid item will be extracted. Also, for simplicity, the data extracted is presented in Figure 10. This data has been organized by the season in which they have been performed and sorted by the average daily production rate.

4. Next, outliers from the data are removed. This process eliminates some of the unreasonably high and unreasonably low data points. *BIDDS* is programmed to remove 10% (5% high, 5% low) of data points presented. This is done in Figures 10, 11, 12, and 13 by multiplying the number of records for each season by 0.05 and rounding up to the nearest whole number. That number of

data points is then not considered for the remainder of the analysis. The outliers are highlighted within each season.

5. Finally, because the lists have been sorted in ascending order, the Minimum and Maximum Daily Production Rates are the extremes of the list. The Average Daily Production Rate can be easily calculated. See Figures 10, 11, 12, and 13 for these results.

Conclusion:

The manual solution above demonstrates the query and output process performed by *BIDDS*. The value of *BIDDS* is recognized by performing the search, filter, and analysis manually. Comparing the data displayed in Figures 4 and 6, which are both *BIDDS* output views, to the data displayed in Figures 10, 11, 12, and 13 shows that the two processes yield identical results. Also notice the Total Quantity Installed for the *BIDDS* and the manual solution are identical. The results of *BIDDS* are confirmed.

Using real historical performance data, rather than the synthesize data used in this example, the VDOT time estimator could easily estimate a daily production rate for Borrow Excavation (bid item 00140). This estimate would be made using not only the data presented, but their own experience, knowledge of the project, and engineering judgment.

Project Number	Project Type	District	Residency	County	City	GS Code	Traffic Volume (ADT)	Award Price	AdMonth
SD 0130	Overlay / Resurfacing	Bristol	Jonesville	Lee		H	23000	$203,103.00	October
SD 0125	Overlay / Resurfacing	Bristol	Tazewell	Bland		H	27000	$222,450.00	June
SD 0011	Overlay / Resurfacing	Bristol	Tazewell	Bland		A	49000	$399,228.00	May
SD 0007	Overlay / Resurfacing	Bristol	Tazewell	Bland		I	32000	$440,365.00	April
SD 0006	Overlay / Resurfacing	Culpepper	Charlottesville	Albemarle		J	29000	$364,625.00	June
SD 0008	Overlay / Resurfacing	Culpepper	Warrenton	Rappahannock		6	2000	$383,746.00	August
SD 0280	Road Reconstruction	Northern Virginia	Fairfax	Arlington		H	27000	$5,512,726.00	August
SD 0292	Road Reconstruction	Richmond	Ashland	Goochland		1	26000	$2,354,280.00	August
SD 0283	Road Reconstruction	Richmond	Sandston	Charles City		2	18000	$2,801,114.00	June
SD 0134	Road Reconstruction	Richmond	Chesterfield	Chesterfield		A	48000	$3,393,877.00	August
SD 0238	Road Reconstruction	Richmond	Ashland	Hanover		B	47000	$6,361,663.00	November
SD 0242	Road Reconstruction	Salem	Martinsville	Henry		2	19000	$270,899.00	January
SD 0284	**Road Reconstruction**	**Salem**	**Christiansburg**	**Pulaski**		**1**	**23000**	**$2,241,474.00**	**May**
SD 0289	**Road Reconstruction**	**Salem**	**Rocky Mount**	**Franklin**		**6**	**3000**	**$2,281,930.00**	**April**
SD 0297	**Road Reconstruction**	**Salem**	**Martinsville**	**Patrick**		**J**	**32000**	**$2,315,268.00**	**July**
SD 0287	**Road Reconstruction**	**Salem**	**Christiansburg**	**Montgomery**		**1**	**24000**	**$2,340,920.00**	**March**
SD 0291	**Road Reconstruction**	**Salem**	**Christiansburg**	**Giles**		**B**	**48000**	**$2,369,017.00**	**April**
SD 0298	**Road Reconstruction**	**Salem**	**Rocky Mount**	**Franklin**		**6**	**3000**	**$2,377,981.00**	**February**
SD 0286	**Road Reconstruction**	**Salem**	**Bedford**	**Bedford**		**3**	**5000**	**$2,416,971.00**	**June**
SD 0131	**Road Reconstruction**	**Salem**	**Salem**	**Botetourt**		**I**	**31000**	**$2,494,120.00**	**February**
SD 0296	**Road Reconstruction**	**Salem**	**Rocky Mount**	**Franklin**		**A**	**52000**	**$2,582,354.00**	**June**
SD 0281	**Road Reconstruction**	**Salem**	**Rocky Mount**	**Franklin**		**I**	**36000**	**$2,720,312.00**	**August**
SD 0282	**Road Reconstruction**	**Salem**	**Rocky Mount**	**Franklin**		**2**	**10000**	**$2,731,052.00**	**April**
SD 0241	**Road Reconstruction**	**Salem**	**Hillsville**	**Carroll**		**H**	**23000**	**$2,801,365.00**	**November**
SD 0293	**Road Reconstruction**	**Salem**	**Salem**	**Roanoke**		**6**	**3000**	**$2,934,755.00**	**June**
SD 0135	**Road Reconstruction**	**Salem**	**Christiansburg**	**Montgomery**		**3**	**7000**	**$2,952,374.00**	**May**
SD 0144	**Road Reconstruction**	**Salem**	**Christiansburg**	**Pulaski**		**E**	**37000**	**$2,954,562.00**	**August**
SD 0240	Road Reconstruction	Salem	Bedford	Bedford		1	25000	$3,796,554.00	June
SD 0237	Road Reconstruction	Staunton	Edinburg	Fredrick		3	4000	$2,963,602.00	January

Figure 8 - Project Information Data Filtering

Project Number	Earthwork Volume (CY)	Lane Miles	Number of Lanes	Rock Excavation Volume (CY)
SD 0131	18475	1.1	4	157
SD 0144	21886	1.5	4	945
SD 0287	20512	0.7	4	911
SD 0291	18596	0.6	4	554
SD 0297	21569	0.7	4	252
SD 0284	**16930**	**0.8**	**3**	**488**
SD 0135	**21869**	**1.9**	**2**	**171**
SD 0241	**20751**	**1.4**	**2**	**814**
SD 0281	**21577**	**1.5**	**2**	**225**
SD 0282	**19272**	**1.3**	**2**	**420**
SD 0286	**20748**	**1.4**	**2**	**114**
SD 0289	**20496**	**1.4**	**2**	**757**
SD 0293	**20346**	**1.4**	**2**	**603**
SD 0296	**19377**	**1.3**	**2**	**256**
SD 0298	**16522**	**1.1**	**2**	**3**

Figure 9 - Project Characteristics Data Filtering

Summary	
Season: SPRING	
Number of Records:	27
5% Outliers:	1.35
Rounding Up:	2
Number of Outliers to Remove (High and Low):	2
Number of Records Remaining:	23
Minimum:	633.4
Maximum:	1,424.3
Average (Cal'd):	1,062.6
Total Quantity Installed:	334,796

Project Number	Bid Item Number	Description	Units	Season	Quantity	Number of Days Performed	Production
SD 0298	00140	BORROW EXCAVATION	CY	Spring	2537	6	422.8
SD 0298	00140	BORROW EXCAVATION	CY	Spring	6466	12	538.8
SD 0296	00140	BORROW EXCAVATION	CY	Spring	10768	17	633.4
SD 0296	00140	BORROW EXCAVATION	CY	Spring	7804	12	650.3
SD 0282	00140	BORROW EXCAVATION	CY	Spring	13235	18	735.3
SD 0284	00140	BORROW EXCAVATION	CY	Spring	13265	15	884.3
SD 0298	00140	BORROW EXCAVATION	CY	Spring	11828	13	909.8
SD 0286	00140	BORROW EXCAVATION	CY	Spring	10190	11	926.4
SD 0286	00140	BORROW EXCAVATION	CY	Spring	11137	12	928.1
SD 0298	00140	BORROW EXCAVATION	CY	Spring	4689	5	937.8
SD 0298	00140	BORROW EXCAVATION	CY	Spring	16237	17	955.1
SD 0284	00140	BORROW EXCAVATION	CY	Spring	9220	9	1024.4
SD 0298	00140	BORROW EXCAVATION	CY	Spring	9230	9	1025.6
SD 0286	00140	BORROW EXCAVATION	CY	Spring	17406	16	1087.9
SD 0241	00140	BORROW EXCAVATION	CY	Spring	24008	22	1091.3
SD 0241	00140	BORROW EXCAVATION	CY	Spring	24008	22	1091.3
SD 0296	00140	BORROW EXCAVATION	CY	Spring	19855	18	1103.1
SD 0286	00140	BORROW EXCAVATION	CY	Spring	10184	9	1131.6
SD 0284	00140	BORROW EXCAVATION	CY	Spring	13382	11	1216.5
SD 0296	00140	BORROW EXCAVATION	CY	Spring	8892	7	1270.3
SD 0281	00140	BORROW EXCAVATION	CY	Spring	26931	21	1282.4
SD 0281	00140	BORROW EXCAVATION	CY	Spring	19166	14	1369.0
SD 0282	00140	BORROW EXCAVATION	CY	Spring	10990	8	1373.8
SD 0286	00140	BORROW EXCAVATION	CY	Spring	13885	10	1388.5
SD 0286	00140	BORROW EXCAVATION	CY	Spring	28486	20	1424.3
SD 0282	00140	BORROW EXCAVATION	CY	Spring	14806	10	1480.6
SD 0296	00140	BORROW EXCAVATION	CY	Spring	26897	18	1494.3

Figure 10 - Borrow Excavation Seasonal Production Data (SPRING)

Summary	
Season: SUMMER	
Number of Records:	24
5% Outliers:	1.2
Rounding Up:	2
Number of Outliers to Remove (High and Low):	2
Number of Records Remaining:	20
Minimum:	503.4
Maximum:	1,434.6
Average (Cal'd):	1,011.5
Total Quantity Installed:	290,385

Project Number	Bid Item Number	Description	Units	Season	Quantity	Number of Days Performed	Production
SD 0296	00140	BORROW EXCAVATION	CY	Summer	6349	16	396.8
SD 0298	00140	BORROW EXCAVATION	CY	Summer	7755	19	408.2
SD 0293	00140	BORROW EXCAVATION	CY	Summer	4027	8	503.4
SD 0298	00140	BORROW EXCAVATION	CY	Summer	10218	19	537.8
SD 0293	00140	BORROW EXCAVATION	CY	Summer	4665	8	583.1
SD 0296	00140	BORROW EXCAVATION	CY	Summer	10204	14	728.9
SD 0284	00140	BORROW EXCAVATION	CY	Summer	14630	19	770.0
SD 0298	00140	BORROW EXCAVATION	CY	Summer	15682	19	825.4
SD 0281	00140	BORROW EXCAVATION	CY	Summer	5011	6	835.2
SD 0282	00140	BORROW EXCAVATION	CY	Summer	6869	8	858.6
SD 0286	00140	BORROW EXCAVATION	CY	Summer	5953	6	992.2
SD 0298	00140	BORROW EXCAVATION	CY	Summer	12032	12	1002.7
SD 0241	00140	BORROW EXCAVATION	CY	Summer	22044	21	1049.7
SD 0281	00140	BORROW EXCAVATION	CY	Summer	18693	17	1099.6
SD 0281	00140	BORROW EXCAVATION	CY	Summer	16763	14	1197.4
SD 0282	00140	BORROW EXCAVATION	CY	Summer	21059	17	1238.8
SD 0298	00140	BORROW EXCAVATION	CY	Summer	24865	20	1243.3
SD 0284	00140	BORROW EXCAVATION	CY	Summer	12555	10	1255.5
SD 0286	00140	BORROW EXCAVATION	CY	Summer	23882	19	1256.9
SD 0282	00140	BORROW EXCAVATION	CY	Summer	8384	6	1397.3
SD 0286	00140	BORROW EXCAVATION	CY	Summer	21287	15	1419.1
SD 0284	00140	BORROW EXCAVATION	CY	Summer	31562	22	1434.6
SD 0296	00140	BORROW EXCAVATION	CY	Summer	8926	6	1487.7
SD 0298	00140	BORROW EXCAVATION	CY	Summer	28388	19	1494.1

Figure 11 - Borrow Excavation Seasonal Production Data (SUMMER)

Summary	
Season: FALL	
Number of Records:	19
5% Outliers:	0.95
Rounding Up:	1
Number of Outliers to Remove (High and Low):	1
Number of Records Remaining:	17
Minimum:	419.9
Maximum:	1,465.2
Average (Cal'd):	940.9
Total Quantity Installed:	189,940

Project Number	Bid Item Number	Description	Units	Season	Quantity	Number of Days Performed	Production
SD 0298	00140	BORROW EXCAVATION	CY	Fall	4454	12	371.2
SD 0281	00140	BORROW EXCAVATION	CY	Fall	7978	19	419.9
SD 0281	00140	BORROW EXCAVATION	CY	Fall	5542	13	426.3
SD 0296	00140	BORROW EXCAVATION	CY	Fall	11913	20	595.7
SD 0293	00140	BORROW EXCAVATION	CY	Fall	10654	17	626.7
SD 0286	00140	BORROW EXCAVATION	CY	Fall	7358	11	668.9
SD 0286	00140	BORROW EXCAVATION	CY	Fall	7716	11	701.5
SD 0282	00140	BORROW EXCAVATION	CY	Fall	4123	5	824.6
SD 0293	00140	BORROW EXCAVATION	CY	Fall	11825	14	844.6
SD 0296	00140	BORROW EXCAVATION	CY	Fall	16342	17	961.3
SD 0282	00140	BORROW EXCAVATION	CY	Fall	10622	11	965.6
SD 0135	00140	BORROW EXCAVATION	CY	Fall	11000	10	1100.0
SD 0289	00140	BORROW EXCAVATION	CY	Fall	11301	10	1130.1
SD 0298	00140	BORROW EXCAVATION	CY	Fall	10492	9	1165.8
SD 0289	00140	BORROW EXCAVATION	CY	Fall	25819	20	1291.0
SD 0298	00140	BORROW EXCAVATION	CY	Fall	6880	5	1376.0
SD 0286	00140	BORROW EXCAVATION	CY	Fall	17188	12	1432.3
SD 0282	00140	BORROW EXCAVATION	CY	Fall	13187	9	1465.2
SD 0296	00140	BORROW EXCAVATION	CY	Fall	7333	5	1466.6

Figure 12 - Borrow Excavation Seasonal Production Data (FALL)

Summary	
Season: WINTER	
Number of Records:	13
5% Outliers:	0.65
Rounding Up:	1
Number of Outliers to Remove (High and Low):	1
Number of Records Remaining:	11
Minimum:	486.0
Maximum:	1,358.6
Average (Cal'd):	821.3
Total Quantity Installed:	103,630

Project Number	Bid Item Number	Description	Units	Season	Quantity	Number of Days Performed	Production
SD 0286	00140	BORROW EXCAVATION	CY	Winter	7255	17	426.8
SD 0296	00140	BORROW EXCAVATION	CY	Winter	2430	5	486.0
SD 0298	00140	BORROW EXCAVATION	CY	Winter	9409	19	495.2
SD 0289	00140	BORROW EXCAVATION	CY	Winter	7387	13	568.2
SD 0286	00140	BORROW EXCAVATION	CY	Winter	5824	10	582.4
SD 0284	00140	BORROW EXCAVATION	CY	Winter	4706	8	588.3
SD 0298	00140	BORROW EXCAVATION	CY	Winter	6169	10	616.9
SD 0286	00140	BORROW EXCAVATION	CY	Winter	6925	10	692.5
SD 0296	00140	BORROW EXCAVATION	CY	Winter	15437	15	1029.1
SD 0298	00140	BORROW EXCAVATION	CY	Winter	9151	7	1307.3
SD 0296	00140	BORROW EXCAVATION	CY	Winter	13096	10	1309.6
SD 0282	00140	BORROW EXCAVATION	CY	Winter	23096	17	1358.6
SD 0286	00140	BORROW EXCAVATION	CY	Winter	29858	21	1421.8

Figure 13 - Borrow Excavation Seasonal Production Data (WINTER)

VITA

Robert C. Williams was born February 21, 1982 in Bluefield, West Virginia. He was raised in the southern West Virginia town of Coalwood. He is the son of David and Jan Williams, who reside in Coalwood, WV. Robert has an older brother, Joshua, who resides in Athens, WV with his wife Heather.

Robert graduated Valedictorian from Big Creek High School in 2000. He graduated Magna Cum Laude with a Bachelor of Science degree in Civil Engineering from West Virginia University Institute of Technology in 2004. Robert then pursued his Master of Science in Civil Engineering as a Charles E. Via Masters Scholar at Virginia Polytechnic Institute and State University. There, he was under the direction of Dr. Michael C. Vorster and Dr. John C. Hildreth. Robert and his wife, Jillian, reside in Blacksburg, Virginia while he pursues his doctoral studies under the direction of Dr. Michael C. Vorster and Dr. John C. Hildreth.